SUBMISSION BY THE FUEL COMPANIES TO THE ASHBURTON DISTRICT COUNCIL DRAFT STORMWATER BYLAW

To:

Draft Stormwater Bylaw
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Hereafter referred to as the Fuel Companies

Date: 18 September 2022

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Attention: Mark Laurenson

LAND. PEOPLE. WATER.

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[1] On behalf of the wider Z Group, including the Z and Caltex operations in New Zealand.

INTRODUCTION

1. Ashburton District Council (*Council*) is seeking feedback on its draft Stormwater Bylaw (*the Bylaw*).

2. The Fuel Companies receive, store, and distribute refined petroleum products around New Zealand. In Ashburton, the Fuel Companies' core business relates to the storage and distribution of petroleum products and operation of retail fuel outlets, including service stations and truck stops.

3. The Fuel Companies' interests in the Bylaw relate primarily to how it relates to the Canterbury Land and Water Regional Plan (*LWRP*) and addresses stormwater discharges from petroleum industry sites. The LWRP provides a permitted pathway for stormwater or construction-phase stormwater into a reticulated system as a permitted activity provided written permission is obtained from the owner of that system. The Bylaw has an important role to play in managing those approvals. The Fuel Companies seek clarity regarding a number of matters to provide certainty to all parties while ensuring protection of the environment and Council's infrastructure.

4. The Fuel Companies do not wish to be heard in relation to this submission.

5. The Fuel Companies would be pleased to discuss these matters further with Council.

STORMWATER

Background

6. Discharges from petroleum industry sites are addressed in the Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand (Ministry for the Environment, 1998, *the Guidelines*). The Guidelines provide specific measures to ensure water discharges from petroleum industry sites do not cause significant adverse effects on the environment. They were prepared by a working group comprising industry, central, and regional government and continue to be widely recognised as good practice. This is demonstrated by their wide recognition in RMA plans and bylaws around the country, including in the Aukland Unitary Plan and the Waikato Regional Plan which both provide a permitted pathway for stormwater discharges from Guideline compliant sites.

7. Discharges from service station forecourts are a Category 2 discharge under the Guidelines. This reflects that there is potential for stormwater to contain oil contaminants and that these require appropriate treatment prior to discharge. The Guidelines require that these areas be directed by appropriate surface grading into grated sumps/gutters/rain gardens leading to drainage systems or treatment devices prior to discharge. If not within the forecourt, tank fill points must be similarly treated. This layout is reflected in Figure 3.1 of the Guidelines.

8. The Guidelines set out detailed criteria for sizing of treatment devices based on rainfall and require that separators have the capacity to contain a 2,500 litre spill of hydrocarbons – the maximum credible spill. Devices which use gravity separation are recognised as the most practicable option to remove oil from water and achieve the desired discharge quality. Appendix 2 of the Guidelines explains the methodology and results of the trial of an American Petroleum Institute (*API*) separator. SPEL separators have been similarly

certified by the former Auckland Regional Council as being compliant with the Guidelines. Both SPEL and API are now widely used around the country.

9. The Guidelines recognise that the maximum levels of contaminants allowable in discharges are 15 and 100 milligrams per litre for total petroleum hydrocarbons (*TPH*) and total suspended solids (*TSS*) respectively (when averaged over the design storm event) and that operating within these limits will ensure minimal adverse toxic effects. The Guidelines draw parallels to roads and highlight that monitoring has demonstrated that discharges from such sites are no worse (and often better) than discharges from roads and high turnover car parks.

10. In terms of effects, the Guidelines refer to modelling work demonstrating that typical oil discharges will have no significant adverse effects on receiving water, except for at the most sensitive sites. Full detail of the study is provided at Appendix A1.3 of the Guidelines.

11. Coupled with the physical components at the Fuel Company sites to manage stormwater runoff quality and the risk to receiving environments from accidental spills are procedural documents specifying maintenance frequency for site stormwater systems and oil and water separator devices. Typically, these procedures document matters such as oil and water separator inspection and cleanout frequency as well as spill response procedures and requirement for clean out and disposal in the event of a spill.

12. In summary the Guidelines are embedded in the Fuel Companies' operations and are widely accepted as good practice for management of sites which store and use petroleum hydrocarbons. This means that Fuel Companies activities are mitigating those risks through the following key mechanisms:
    1. Segregation of fuel transfer activities from balance site areas using site contouring and dedicated drainage systems;
    2. The operation and maintenance of oil and water separators designed to treat TPH and TSS entrained in stormwater runoff to a maximum discharge standard of 15mg/L and 100mg/L respectively while also providing for spill containment up to 2,500L; and
    3. Site practice and procedures documenting matters such as inspection, maintenance and clean out frequency for separators and steps that should be taken in the event of a spill.

Section 5: Protection of Stormwater System

13. Section 5.5.1 of the Bylaw states that no person may cause or allow any prohibited substance (broadly defined as a contaminant in stormwater that has not been expressly authorised by the Council) to enter the network or be stored, handled, or transferred in a manner that may enter the network, including in the event of spillage or as a result of rain. It also states that prevention may require measures such as secondary containment, bunding and spill kits. This is supported, but further direction is important to provide for efficient management of the network for all parties and discussed further below in relation to section 7 of the Bylaw and risk classification.

Section 6: Conditions of New and Continued Acceptance of Discharge

14. Section 6.2 addresses stormwater quality standards and states that the Council may, by resolution, specify standards for discharges to the stormwater network, including for specific situations, activities, or industries. An explanatory note records that any such

resolution will require consideration of affected persons. The Fuel Companies therefore expect further opportunities to input re the same and ensure that the measures are appropriate for management of discharges from petroleum industry sites.

Section 7: Management of Stormwater Discharges from Non-Residential Sites

15. Similar to section 6.2, section 7 states that Council must, by resolution, adopt a register of Non-Residential Sites and assign a risk classification to them with Council to require monitoring commensurate to their risk.

16. The Fuel Companies support this approach in principle but consider what is critical is the risk classification of its sites and the detail of associated monitoring. To inform Council's risk classification work, the Fuel Companies emphasise that the draft risk matrix that has been prepared by Christchurch City Council (*CCC*) is not proportionate to risk from petroleum industry sites managed in accordance with the Guidelines. This is the subject of ongoing discussions with CCC.

17. The Fuel Companies seek that any risk classification system proposed by Council recognises that, unlike a range of other contaminants and industrial activities, the key contaminants at petroleum industry sites can be appropriately managed by way of oil-water separators and that well maintained API and SPEL devices have been demonstrated to achieve a high standard of mitigation for hydrocarbons and sediment (relative to the low sediment loads from the forecourts). This has been investigated and reported by PDP and URS (Refer **Appendix 1**), and the Auckland Council at catchment level. The degree of mitigation provided by these devices is recognised in a potential permitted activity pathway for Guideline compliant discharges in the majority of regional plans around the country, including the Auckland Unitary Plan. As the performance of Guideline compliant sites is well documented through numerous technical reports and a range of monitoring that has been undertaken over many years, ongoing monitoring of the same is not required. Rather, the focus should be on ensuring appropriate operation and maintenance of these sites, for instance by requiring operators to provide management plans and maintenance schedules. The Fuel Companies would support Council audits in this respect.

18. In line with the above, the requirement in the Bylaw for Stormwater Protection Plans is supported. Clause 7.2.2 addresses what these must include and is similarly supported, subject to the following amendments to two of the sub clauses to focus on stormwater (not wastewater), and identification of sources of contamination, as managed by subsequent requirements of the plan. Deletions are shown in strikethrough and additions in underline.

    7.2.2 The Stormwater Protection Plan must include:
    (a) A suitably scaled drawing showing the site layout, boundaries, ~~all~~ the private Stormwater system ~~and Wastewater drainage~~ including the point or points of connection to the Stormwater network ~~or discharge from the Site, relevant buildings, and outdoor spaces (including their use);~~and a catchment plan demonstrating how stormwater on site is directed;

    (b) ~~A site assessment identifying all actual and potential~~ Identification of sources of Stormwater contamination;

    ….

Section 8: Requirements for Earthworks

19. Section 8.1 addresses sedimentation and erosion protection and requires development be undertaken with adequate silt control measures in accordance with Canterbury Regional Council's Erosion and Sediment Control Toolbox. Sub clause 8.1.3 specifically requires that an Erosion and Sediment Control Plan must be prepared for any development areas for which the construction phase stormwater discharge is authorised by any Council Stormwater Network Discharge Consent.

20. The Fuel Companies periodically undertake earthworks (e.g. minor maintenance, tank removals, pipe upgrades) and acknowledge the need for the development, installation, and maintenance of erosion and sediment control measures for earthworks activities. Where works cannot be managed to avoid a potential discharge of construction phase stormwater to the network, the Fuel Companies seek clarity that submission of an Erosion and Sediment Control Plan in accordance with the toolbox is what is required for deemed approval from Council for these potential discharges. This is important to the application of Rule 5.93A of the LWRP which only provides for construction phase stormwater discharges as a permitted activity subject to permission from the owner of the reticulated system.

Signed on and behalf of Z Energy Limited, bp Oil New Zealand Limited, and Mobil Oil New Zealand Limited

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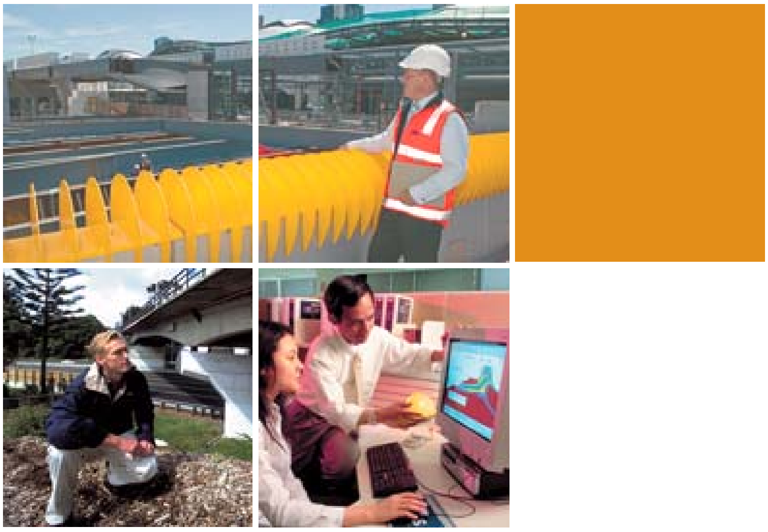
Mark Laurenson
Principal Planner

FINAL REPORT

Stormwater and Sediment Monitoring Data from Service Stations and Control Sites in the Auckland Region



Prepared for

Oil Industry Environmental Working Group

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7 February 2008

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Date:	7 February 2008
Reference:	R001c
Status:	Final Report

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Appendices

Section 1 Introduction

1.1 Project Background

This report has been prepared by URS New Zealand Limited (URS) on behalf of the Oil Industry Environmental Working Group (OIEWG)[1]. URS understands that the OIEWG wishes to use the findings of this investigation to review the manner in which Auckland Regional Council (ARC) proposes to regulate service station sites in the Auckland region.

Of particular concern to OIEWG are:

- the content, interpretation and implementation of various rules of the Proposed Auckland Regional: Air: Land and Water Plan (PARP: ALW) which relate to the discharge of stormwater from service stations;
- the thresholds used to define ‘high risk', 'medium risk' and 'low risk' activity areas under Schedule 3 of the PARP:ALW; and
- the content, use and application of certain elements of ARC Technical Publication 10 (ARC TP10) ‘Stormwater Treatment Devices: Design Guideline Manual’, in particular:
    - the requirement for 75% total suspended solids (TSS) removal efficiency for stormwater treatment;
    - the ability of existing stormwater treatment systems to achieve a 75% reduction in TSS; and
    - the applicability of the water and sediment quality data used in the development of ARC TP10 to the New Zealand context.

OIEWG members have had ongoing discussions with ARC regarding the above points and consider that the manner in which the ARC proposes to regulate service station sites may be based on limited, incomplete or inaccurate information, in particular with regard to:

- the design, manner of operation of, performance and achievable discharge quality from American Petroleum Institute (API) type interceptors;
- the physical segregation of forecourt and non-forecourt areas of service stations;
- the operation and maintenance practices that are typically employed in service stations;
- the activities that take place in non-forecourt areas of service stations; and
- the quality of stormwater discharges from non-forecourt areas of service stations.

Therefore the OIEWG members wish to gather information to better define the stormwater discharge quality from forecourt and non-forecourt areas (NFA) of service stations.

This report has been prepared in accordance with URS proposals dated 17 November 2005 (stormwater component) and 8 February 2006 (sediment sampling component).

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[1] OIEWG currently comprises representatives from the major New Zealand oil companies, namely Mobil Oil New Zealand Limited (Mobil), BP Oil New Zealand Limited (BP), Chevron New Zealand (Chevron), Shell New Zealand Limited (Shell) and Burton Consultants Limited.

1.2 Scope of Work

In order to achieve the study objectives, the following scope of works was undertaken by URS:

- preparation of a stormwater and sediment sampling protocol which details health and safety procedures, sampling locations, sampling conditions, sampling technique and sample storage and transport protocols (Appendix A).
- collection of stormwater samples from five service station sites in the Auckland region, which demonstrate the quality of:
    - stormwater entering the API separator;
    - treated stormwater discharging from the API separator; and
    - stormwater discharging from the NFA at each of the service stations.
- collection of stormwater samples from two control sites in the Auckland region, where control sites represent typical public/commercial car parks.
- collection of sediment samples from the API inlet chamber at each of the selected service stations to determine the quality of sediment retained by the API device.
- assessments of each of the selected service station sites to determine, as far as practical, whether on site drainage systems comply with the ‘Guidelines for Water Discharges from Petroleum Industry Site in New Zealand, Ministry for the Environment,1988’ (the MfE Guidelines).
- calculation of the total approximate annual contaminant load from all service stations in the Auckland region, based on average contaminant concentrations determined for the service station sites investigated and extrapolated across the number of known service station sites in the Region.
- preparation of a report detailing the findings of the investigation.

1.3 Report Structure

The report has been divided into the following sections:

Section 1: Introduction

Section 2: Sampling Methodology

Section 3: Sample Information and Other Relevant Data

Section 4: Analytical Results, Mass Load and Other Matters.

Section 5: Summary of Findings

Section 6: Conclusions

Section 2 Sampling Methodology

2.1 Site Selection Rationale

Choosing appropriate service station sites was an integral part of this project. Therefore, service station sites were selected based on the following criteria (as agreed with OIEWG):

- Company operated service stations, where site operations are managed and controlled by the oil company.
- Service stations sites that were located on high traffic count roads (i.e. roads with greater than 5,000 vehicles per day).
- Sites that appeared from as-built plans and site walkover, to have been designed and constructed in accordance with the MfE Guidelines e.g. with an oil/water separator (API) servicing the forecourt area.
- Sites with reasonable NFA (i.e. car parks, access ways and shop) where, based on evidence from as-built plans and site walkover it appeared that surface runoff did not discharge to the oil/water separator.
- Sites with clear drainage plans showing segregation of non-forecourt and forecourt drainage.
- Proximity of service station site to the URS office to enable staff to be on site within 15 minutes of a rain event to collect first flush samples.
- Staff safety during sampling.

As-built plans for several service stations were obtained from each of the four OIEWG companies. URS reviewed the plans provided to select sites which met the above criteria. The sites selected for this project were confirmed with OIEWG members. Table 2-1 provides information on age and size for each of the selected sites. As-built drainage plans for the selected sites, identifying sample location points at each service station, are provided in Appendix B.

Two public car parks were selected for this project to represent ‘control sites’ and are detailed in Table 2-2 below. The 'control sites' were selected to represent typical car parking areas that are not specifically regulated under the PARP: ALW and are therefore considered to represent a 'permitted baseline' scenario.

Site plans for the selected control sites are provided in Appendix B.

Table 2-1 Selected Service Station Sites

Oil Company	Service Station Name	Date of Service Station Development	Approximate Total Site Area (m^2)
BP	Site J	2000	2,630
	Site N	2001	2,930
Caltex	Site U	2001	5,426
Mobil	Site D	Redeveloped May-June 2005	3,270
	Site R[2]	Redeveloped in September 2004	2,360
Shell	Site A	Redeveloped in 1996	3,375

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[2] Stormwater and sediment samples from Site R were not able to be collected within the reporting period.

Table 2-2 Control Sites

Control Sites	Location	Approximate Site Area
Asda Plaza car park	4 Fred Thomas Drive, Takapuna (Lot 1 DP 150159)	Total site: 5,915m^2 car park area: ~3,900m^2
Museum car park	Domain car park (around main museum building). The sample may also contain road runoff from Football Road.	Total car park area : ~ 7900m^2

2.2 Sampling Methodology

Stormwater and sediment samples were collected in accordance with the Stormwater and Sediment Sampling Protocol prepared by URS and submitted to the ARC in April 2006. The Protocol was developed to reflect sampling requirements applied by the ARC at other sites. A copy of the sampling protocol is provided in Appendix A. Despite numerous requests by OIEWG, no formal approval of the Protocol has been provided by ARC. The specific elements of the Protocol and some initial sampling results were discussed with ARC technical representatives (Mike Timperley and Earl Shaver) at a meeting on 18 January 2007. No concerns were raised by ARC in relation to the sampling Protocol at this meeting. In the absence of any specific concerns, OIEWG considered this to be ARC's implied endorsement of the Protocol as presented.

Key aspects of the Stormwater and Sediment Protocol are discussed in the following Sections.

Stormwater samples were collected from five of the service stations and the two control sites identified in Section 2.1.

2.2.1 Sampling Location

Stormwater samples were collected from the following sampling points at each of the service stations and control sites:

Service Station

- API Separator
  - Two samples (first flush (FF) and mid storm sample (MS)) from the API inlet.
  - Two samples (FF and MS) from the outlet of the API.
- Two samples (FF and MS) from the non-forecourt area.

In total six stormwater samples were collected from each service station.

Control Sites

Two samples (FF and MS) were collected from each of the two selected car park locations. Samples were collected from manholes draining the majority of the car park area. Refer to Appendix B for specific sampling locations at the two control sites.

Sediment samples were collected from the API separator inlet chamber at each service station.

2.2.2 Sampling Conditions

The sampling protocol developed for this project specified that stormwater samples were to be collected at each site in accordance with ARC requirements for stormwater collection. Samples were to be collected following two to three days of dry weather followed by a heavy rain event (i.e. >5mm). First flush samples were to be collected within the first 15-20 minutes of a rain event, where practicable. The second sample (representing typical mid-storm conditions) was to be collected approximately 20-30 minutes after the first flush event had passed unless otherwise stated in the field sheet (refer to Appendix C).

As the project progressed, it became apparent that obtaining these ‘ideal’ sampling conditions during a working day was not always possible due to insufficient dry days prior to a storm event, or rain events occurring outside safe working (daylight) hours. OIEWG and URS discussed these concerns with ARC. An agreement was reached between Earl Shaver (ARC), Mike Timperley (ARC), Cameron Taylor (Mobil) and Ken Macdonald (URS) (meeting on 18 January 2007) that stormwater samples could be collected following one or two dry days and under any reasonably intense storm conditions, provided that approximate rainfall during the sampling event was recorded. The outcome of this agreement was that three service stations were sampled after 2 days of dry weather with the remainder, including control sites, after 3 or more days of dry weather. Dates and rainfall recorded during sampling events are provided in Section 3.1 of this report and in Appendix C.

2.2.3 Sampling Technique

Stormwater Samples

Stormwater samples were collected manually (grab samples) by placing a clean sample collection bottle at the end of the sampling pole and positioning immediately underneath the discharge pipe inside the manhole, where available. For stormwater manholes where the inlet or outlet pipe was not directly accessible with a sampling pole, a sandbag was placed inside the manhole to block the outlet which allowed the stormwater to accumulate. Sample bottles were filled with the runoff water collected by filling organic sample bottles first, followed by inorganic samples.

As URS completed the initial rounds of sampling and reviewed the results, it became apparent that some of the dissolved metal concentrations were higher than the total metal concentrations (although all concentrations were relatively low). It was suspected that this could be either due to dissolved metal and total metal results being transposed by the lab or the technique by which total and dissolved metal sample bottles were collected in the field or by small differences in sample make-up due to influences of individual sediment particles. URS sampling techniques were reviewed and determined to be robust and appropriate.

The technique involved the following:

Two one-litre bottles were first filled to represent either first flush samples or mid storm samples respectively. These were then decanted into the individual sample bottles. Sample bottles were filled to the top, leaving no headspace. The above process was repeated at each manhole. A new sample collection bottle was used for each storm event and manhole to avoid cross contamination. All samples were stored in a cool (<4ºC) chilly bin once collected to minimise photo-degradation and thermal effects on the samples. All samples collected were sent to R. J. Hills Laboratories within 48 hours of collection to conform to the holding time requirements for volatile organic compounds.

It was concluded that the most likely cause of the apparent anomaly was the minor difference in sample sediment content.

Sediment Samples

Sediment samples were collected from the API interceptor once all stormwater samples had been collected. The sediment samples were collected from the API separator using a stainless steel Ponar Sediment sampler in accordance with US EPA Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses (1991). The sediment sampler was lowered as slowly as possible into the API separator to avoid the possibility that fine sediments were displaced by the bow wave of the sampler. Two sub–samples were collected for each location. Glass sample containers were used for organic analytes and HDPE containers for metallic analytes. All containers were filled completely to avoid loss of any volatile components and minimise the effects of oxygen of the speciation of individual elements or compounds.

All sediment samples were stored in a cool (<4ºC) chilly bin as soon as they were collected to minimise photo-degradation and thermal effects on the samples. All samples collected were sent to R. J. Hill Laboratories within 48 hours of collection to conform to the holding time requirements of volatile organic compounds.

2.2.4 Contaminants of Concern

Stormwater samples were collected and analysed for the following contaminants of concern (COC), in accordance with the Protocol agreed with ARC and OIEWG:

- pH;
- Electrical conductivity;
- Suspended solids;
- Total and dissolved metals, in particular Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni) Lead (Pb) and Zinc (Zn);
- Polycyclic aromatic hydrocarbon (PAH);
- Total petroleum hydrocarbon (TPH) and
- Benzene, toluene, ethylbenzene and xylene (BTEX).

Sediment samples were analysed for:

- Total organic carbon (TOC)
- Total reactive phosphorous (TP);
- Heavy metals As, Cd, Cr, Cu, Ni and Pb.
- PAH;
- TPH; and
- BTEX.

2.2.5 Compliance with MfE Requirements

An assessment was conducted at each service station to determine, as far as practical, whether on-site drainage systems were compliant with the four categories listed in the Ministry for Environment (MfE) '*Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand', 1988.* Results of the survey are discussed in Section 3.2.3 and provided in Appendix C.

Section 3 Sample Information and Other Relevant Data

3.1 Sampling Events

Stormwater and sediment sampling were conducted at the five service station and two control sites between 12 June 2006 and 12 March 2007. Table 3-1 presents sampling dates, estimated rainfall during sampling and rainfall data prior and during sampling. Field observation sheets are provided in Appendix C for reference.

Table 3-1 Summary of Sampling Events

Site Name	Date of Sampling	Time of Rainfall	Collection time of First Sample	Rainfall Recorded during sampling	Rainfall Data*
Site J	30 November 2006	Light showers 15 minutes before heavy downpour at 9.40am	9.45am	~5-6mm over the 2 hour sampling period	No rainfall recorded for 2 days prior to sampling. Approximately 6mm of rainfall was recorded between 9.00am and 11.00am (sampling duration) and 12.6mm over the 24 hour period.
Site N	9 October 2006	Light showers followed by rain at 7.30pm	7.40pm	~3-4mm over the 3 hour period.	No rainfall recorded for 4 days prior to sampling. Approximately 3mm of rainfall was recorded between 7.00 and 10.00pm (sampling duration) and 3mm over the 24 hour period.
Site U	16 October 2006	Light showers for one hour followed by rain at 9.05am	9.05am	~3-4mm over the 3 hour sampling period.	No rainfall recorded for 5 days prior to sampling. Approximately 4mm of rainfall was recorded between 6.00am and 11.00am and 9.8mm over the 24 hour period. A few showers (<1-2mm) occurred prior to sample collection at 9.00am.
Site D	12 March 2007	Light showers (intermittent) and rain at 5.00pm	5.00pm	~2-3mm over 2 hours	No rainfall recorded for 2 days prior to sampling. Approximately 3.6mm of rainfall was recorded between 5.00pm and 8.00pm and 31mm over the 24 hour period.
Site A	30 November 2006	9.40am	9.45am	~5-6mm over the 2 hour sampling period	No rainfall recorded for 2 days prior to sampling. Approximately 8mm of rainfall was recorded between 9.00am and 11.00am (sampling duration) and 12.6mm over the 24 hour period.
Azda Plaza	12 June 2006	Light drizzle from approximately 7.30am. Heavy rain at 9.50am	9.50am	~4mm of rainfall over the one hour sampling period.	No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.

Site Name	Date of Sampling	Time of Rainfall	Collection time of First Sample	Rainfall Recorded during sampling	Rainfall Data*
Domain Carpark	12 June 2006	Light drizzle from approximately 7.30am. Heavy rain at 9.50am	9.50am	~4mm of rainfall over the one hour sampling period.	No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.

Source: (*) rainfall data recorded from the rain gauge at Humes Papakura (Data provided by Humes). Airport data as available from Metservice.

3.2 Field Observations

3.2.1 Site Drainage and Sampling

The following drainage information should be considered when comparing analytical results for each site.

Table 3-2 Site Drainage and Sampling Location Information

Site Name	Site Drainage and Sampling
Site J	NFA sample was collected from a manhole which is a combined stormwater and sewer line. Manual stormwater samples were collected from the stormwater outlet pipe, avoiding the sewer line. NFA sample represents runoff from the small carpark area, and driveway. No roof runoff enters this stormwater line. Refer to the site drainage plans provided in Appendix B for further details.
Site N	NFA includes roof runoff water from the site carwash building and small carpark next to the carwash (an area approximately 400m^2). The surface of the car park roof was painted. The API inlet sample was collected from the first API chamber as no other suitable sampling manhole was available upstream of the API. The API outlet sample was collected from a manhole which also collected runoff from the NFA. This was because the manhole originally selected for sampling was not present on site (as identified on the site drainage plan). Consequently, using the API outlet sample for this site to assess API performance must be done with some caution, as the discharge quality could be influenced by the presence of NFA runoff.
Site U	NFA sample was taken from a line that collects roofwater and water from two catchpits in landscaped areas at the rear of the shop. API Outlet sample was collected from the API outlet pipe, avoiding other stormwater inputs. Refer to Appendix B for further details.
Site D	NFA sample does not include roof runoff. API Inlet sample was collected from the API Inlet chamber (first manhole) which contained stagnant water. No sampling location upgradient of the chamber was available. API Outlet sample was collected from the API outlet pipe, avoiding other stormwater inputs. Refer to Appendix B for further details.
Site R	Stormwater sampling for this site was not able to be completed within the reporting timeframe.
Site A	NFA sample represents car park runoff. It is unclear from the site plans whether roof runoff enters this stormwater line. The surface of the roof was painted. The NFA at Site A was asphalt sealed. API Inlet sample was collected from the API Inlet chamber (first manhole) which contained

	stagnant water. No sampling location upstream of the chamber was available.

3.2.2 API Separator Maintenance Schedule

API maintenance/cleanouts for each of the four oil industry companies are conducted by Site Care, an independent contractor. The API separators are monitored and cleaned out by Site Care every six months following each of the oil company-specific management plans. Vacuum tankers are used to remove the sediment build up in the API separators.

API separator maintenance dates were obtained by URS for each of the service station sites sampled in order to determine at what stage of the maintenance regime the API was at the time of sampling. It was considered that this information would assist in the interpretation of the analytical results.

Table 3-3 API Separator Maintenance Schedule

Site Name	API Separator Maintenance Schedule Information
Site J	The API was maintained/cleaned on 28 December 2006 and six months prior to this date. URS collected sediment samples from the forecourt API inlet on 30 November 2006, four months after the June cleanout.
Site N	Information on maintenance was not available from site management.
Site U	The API was maintained/cleaned on 2 November 2006. Prior to this, it was cleaned out on 27 April 2006. URS collected sediment samples from the forecourt API inlet on 16 October 2006, six months after the April cleanout.
Site D	The API was last maintained/cleaned on 26 February 2007. Sediment samples were collected one month after the cleanout.
Site A	The API was last cleaned on 1 October 2006 and 10 January 2007. URS collected samples from the API inlet, one month after the October 2006 cleanout.

3.2.3 MfE Compliance

The Mfe Guidelines provide details on and specifications for the following four categories of drainage areas at service stations in New Zealand:

Category 1 - Drainage systems are dedicated to capture and dispose stormwater from roof areas, paved open areas and unpaved areas.

Category 2- Drainage systems are dedicated to capture and dispose stormwater and product spills from beneath the canopy where vehicle fuelling takes place and the slab around remote fill points.

Category 3 – Drainage systems on site are dedicated to the capture of wastes from car washes, toilets, ablutions and kitchens and similar wastes for disposal to sewers.

Category 4- Drainage systems are dedicated to the capture of washings and waste from workshops

As part of the process of selecting sites for sampling, as-built plans and a number of brief site walkovers were used to assess compliance with the MfE Guidelines. The purpose of these assessments was to identify sites where the drainage areas appeared to have been constructed in accordance with the MfE Guideline categories.

Table 3-4 presents the findings of these pre-sampling, site selection assessments for the service stations that were chosen as the final sampling sites. Refer to Appendix C, visual assessment checklist, for further details.

Table 3-4 MfE Category 1-4 Results

Site Name	Category 1			Category 2			Category 3			Category 4			Comments
	Y	**N**	**NA**	**Y**	**N**	**NA**	**Y**	**N**	**NA**	**Y**	**N**	**NA**	
Site J	✓			✓			✓					✓	
Site N	✓			✓			✓					✓	
Site U	✓			✓			✓					✓	
Site D	✓			✓			✓					✓	
Site A	✓			✓			✓					✓	Carwash not operational.

Site drainage at all five sites, appeared to be compliant with Categories 1 to 4 of the MfE service station drainage criteria.

Unfortunately, a number of areas of difference between as-built plans and constructed detail came to light during the sampling process. At two sites, these differences resulted in the drainage arrangements being partially non-compliant with the MfE Guidelines, and it is considered likely that this would have had a bearing on the stormwater quality results obtained at the sites. The two sites affected were:

- Site U – where drainage from a landscaped area to the rear of the shop building, part of which showed evidence of temporary storage of merchandising equipment (steel shelves), was found to connect to the service station NFA drainage; and
- Site A – where drainage from around the car wash area (although not the main drain from the car wash, which was connected to trade waste sewerage), was found to be connected to the NFA drainage

Section 4.3 presents further information on and discussion of these issues in the context of the stormwater results of analysis.

Section 4 Results

4.1 Analytical Results

Analytical results are presented in Tables 4-1 to 4.6 respectively. Analytical results have been compared for each service station, with the relevant guidelines and published data set out below. Results have also been conservatively compared to the lowest detected dissolved and total metal concentrations for the two control sites (first flush and mid storm samples). Table 4.7 presents the minimum and maximum concentrations measured in all samples.

Refer to Section 7 for specific limitation statements relevant to data interpretation. Refer to Table 3.1 and Table 3.2 for sampling conditions encountered during the monitoring.

4.2 Relevant Guidelines and Published Data

Available guidelines and published data which are relevant to this study comprise:

Stormwater

1) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (ANZECC), October 2000. Although results have been directly compared to the ANZECC guidelines, it should be noted that the ANZECC guidelines are receiving water guidelines and are not discharge standards. They are designed to be used after reasonable mixing in the environment (which is consistent with section 107 of the RMA (1991)). It should be noted that none of the samples collected represent concentrations in the environment following reasonable mixing.

2) Ministry for the Environment (MfE) Guidelines for Discharges from Petroleum Sites in New Zealand, December 1988 (MfE, 1998) Results from this study have been compared to the maximum concentrations of Total suspended solids (TSS) and TPH allowed by the MfE Guidelines. Data from an ARC study provided in Appendix 2 of the MfE Guidelines have also been used for comparing the monitoring data. It is worth noting that the TPH criterion presented in MfE 1998 is the same as that presented in ARC TP10.

3) Williamson et al, 1991. Urban Runoff Data Book. This report provides metal and total suspended solid concentrations in urban road runoff in New Zealand.

4) American Petroleum Institute Publication, API 1669. Published December 1994 (API, 1994). This study presents the results of a two-part study of constituents present in simulated stormwater runoff from six retail gasoline outlets and four commercial parking lots. Monitoring data from study conducted in USA has been provided for comparison only.

Sediment

1) Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ), 2000. Although these guidelines are provided in the results table, sediment quality data from this study have not been directly compared to the ANZECC sediment guidelines as they are designed for the protection of the ecosystem, in particular, macroinvertebrates. Given that the sediment content retained within the API chamber is pumped out using vacuum trucks (as part of the API maintenance regime), the ANZECC criteria are not applicable.

2) Excavation worker exposure limits used for this project are as indicated in the Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand, August 1999 (Tier 1 for maintenance and excavation workers) and MfE Timber Treatment Guidelines, 1997 for commercial land use.

3) ARC Technical Publication 10 Design Guideline Manual, 2003. Table 10-1 provides sediment quality data found in oil and water separators at U.S. petrol stations relative to other land uses.

4) J.N Brown, B.M Peake, 2005. Sources of heavy metals and PAHs in urban stormwater runoff (data from Dunedin studies). Science of the Total Environment.

4.3 Discussion of Results

4.3.1 Control Sites

Heavy Metals

Control Site 1 (Azda Plaza car park) FF and MS samples contained dissolved Cu and Zn concentrations that exceeded the ANZECC water quality criteria. All other dissolved metal concentrations were either below the analytical laboratory detection limit or within the ANZECC water quality standards.

Control Site 2 (Domain car park) FF and MS samples contained dissolved Cr, Cu, Zn and Pb that exceeded the ANZECC water quality criteria. All other dissolved metal concentrations were either below the analytical laboratory detection limit or within the ANZECC water quality standards.

TPH, BTEX and PAH

TPH, BTEX and PAH concentrations measured in the two control site samples were either below the analytical limit of detection or within the ANZECC water quality standards.

4.3.2 Service Station Stormwater Results

Heavy Metals

The water quality discharging from most of the five service stations monitored exceeded the ANZECC water quality guideline levels for dissolved Zn and dissolved Cu. There were also isolated exceedences of ANZECC levels for dissolved chromium and dissolved lead. However, the monitoring results show that the dissolved metals concentrations discharging from the API outlet (FF and MS) and NFA (FF and MS) were generally within the range of concentrations measured in the discharges from the two control sites.

The total Cu, total Pb and total Zn concentrations measured in the NFA and API outlet MS samples at the five service stations were less than or within the ranges measured in runoff from roads and car parks in New Zealand (refer to data from relevant studies, presented in the results table).

TSS

The TSS concentrations measured in the samples collected from the API inlet and API outlet (both FF and MS) at all five service stations clearly demonstrate the efficiency of the API separator with respect to these contaminants. The TSS concentrations measured for API inlet samples (both FF and MS) were generally an order of magnitude higher than the TSS concentrations measured at the API outlet. The TSS concentrations discharging from the API outlet (both FF and MS) at all five service stations were less than the MfE 1998 criterion of 100gm^{-3}. Furthermore, the TSS concentrations measured in samples from all sites were also less than, or within the range for, TSS concentrations measured at the two control sites, and data representing urban road runoff and car parks in New Zealand.

The TSS concentrations measured in the discharges from the NFA (both FF and MS) at Site J, Site A and Site U are generally comparable and within the range discharging from the two control sites. However, the TSS concentration measured in the discharge from the NFA at Site N and Site D are slightly higher (Site D: 69-62 gm^{-3}, Site N: 34 -52 gm^{-3}) than the control site TSS concentrations but are within the MfE 1998 criterion (100gm^{-3}), and within the range of data representing urban road runoff and car parks in New Zealand.

TPH

The TPH concentrations measured in the samples collected from the API outlet (both FF and MS) at all five service stations were less than the MfE 1998 criterion of 15gm^{-3}.

The TPH concentration of 13.8 gm^{-3} measured in the NFA MS sample at Site A, although elevated, was below the MfE 1998 criterion (15 gm^{-3}). A TPH concentration of 15.2 gm^{-3} was measured in the NFA MS sample at Site U. These elevated concentrations in mid-storm samples, compared with relatively low values in first flush samples from the same locations appear anomalous. Investigation of the TPH traces for these samples indicate the hydrocarbons in question to be similar in character to weathered diesel-range or lube oil range hydrocarbons. Further investigation at the sites identified the presence of drainage arrangements that are considered to be partially non-compliant with MfE Guidelines (refer to section 3.2.3 for details). At Site A, the connection of a catchpit from the vicinity of the car wash, to the NFA drainage line is considered to be the likely cause of elevated TPH concentrations. At Site U, the fact that stormwater from outside the service station may be entering the NFA drainage, is thought to be a possible factor in the elevated discharge TPH concentration.

BTEX

Low concentrations of BTEX (m &p xylene) were measured in the API inlet samples (FF and MS) at Site J but were below the analytical laboratory detection limit in the API outlet sample. BTEX concentrations measured at the other four service stations were below the analytical laboratory detection limit and/or within the ANZECC water quality standards.

PAH

Low concentrations of PAH (anthracene (FF sample only) & phenanthrene) were measured in the API inlet samples at Site U but were below the analytical laboratory detection limit in the API outlet sample. PAH concentrations measured at the other four service stations were below the analytical laboratory detection limit and/or within the ANZECC water quality standards.

4.3.3 Service Station Sediment Results

Heavy Metals

The sediment quality data for the five service stations indicate that all concentrations of heavy metals were significantly less than those reported for service stations in the ARC TP10 publication, regardless of the fact that the APIs at Site J and Site U were in the latter stages of the maintenance schedule (refer Table 3.3).

TPH

The TPH concentrations measured in samples of the API sediments at Site U and Site D are higher than those reported for service stations in the ARC TP10 publication.

A review of the maintenance records for Site U indicates that the API was cleaned out on 2 November 2006. Prior to this, it was cleaned out on 27 April 2006. URS collected sediment samples from the forecourt API inlet on 16 October 2006, which was six months after the April cleaning. It is possible that the results are a reflection of sampling in the late stage of the cleaning cycle. More importantly the results demonstrate that the API interceptor remained effective in removing TPH-impacted sediment as demonstrated by the API outlet stormwater results.

The sediment sample at Site D was collected approximately one month after the API cleanout. Although the TPH concentration in sediment is elevated, the TPH concentration measured in the API outlet stormwater sample is well within the 15 gm^{-3} criterion of MfE 1998, demonstrating the effectiveness of the API in capturing sediment and associated contaminants.

Therefore, regardless of the stage of the cleaning cycle, the API appears effective at capturing TPH contaminated sediments from the forecourt areas of service stations.

TPH concentrations measured in sediments at the other three service station sites were well below the figure reported for service stations in the ARC TP10 publication.

Total Phosphorus

The total phosphorus concentration measured in samples of the API sediments at Site U, Site N and Site A are higher than those reported for service stations in the ARC TP10 publication. It is possible that the results are a reflection of sampling in the late stage of the cleaning cycle. Refer to Table 3.3 for the maintenance schedule for when within the maintenance cycle the samples were collected.

The total phosphorus concentration measured in samples of the API sediments at the remaining service station sites monitored are within the range reported for service stations in the ARC TP10 publication.

PAH

The sediment quality data for the five service stations indicate that all concentrations of PAH were either below the analytical laboratory detection limit and/or within the ANZECC sediment quality standards.

Table 4-1: Surface Water Analytical Results Site J

Sample Details and Analytical Results												**Guidelines and Relevant Literature**									
URS Sample Reference		SWP623	SWP624	SWP625	SWP 626	SWP627	SWP628	SWG280	SWG281	SWG286	SWG287	ANZECC[1] Fresh Water 95% Level of Protection	MfE Environmental Guidelines for Water Discharges from Service Stations [2]	Data from Relevant Studies For Reference Only							
Laboratory Sample Reference		440498/3	440498/4	440498/5	440498/6	440498/1	440498/2	422002-1	422002-2	422002-3	422002-4			Urban Road Runoff NZ [3]	API 1669 [4]						
Date Sampled		30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	12-Jun-06	12-Jun-06	12-Jun-06	12-Jun-06										
Time of Sampling		9.45am	10.40am	10.25am	11.25am	10.00am	11.00am	8.50am	9.50am	8.50am	10.05am										
Rainfall Information		**Field Observations:**						**Rainfall Data:**													
		Approximately 5-6mm over the 2 hour sampling period.						No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.													
		Rainfall data:																			
		No rainfall recorded for 2 days prior to sampling. Approximately 8 mm of rainfall was recorded between 9.00am and 11.00am (sampling duration) and 12.6mm over the 24 hour period.																			
Sampling Locations		**Site J**						**Contol Sites**								MfE Publication - Dec 1988					
		API Inlet First Flush	**API Inlet Mid Storm**	**API Outlet First Flush**	**API Outlet Mid Storm**	**NFA(*[1])First Flush**	**NFA(*1)Mid Storm**	**Control 1 First Flush**	**Control 1 Mid Storm**	**Control 2 First Flush**	**Control 2 Mid Storm**					Pananma Rd	Mobil Service Station	Pakuranga	Pacific Steel	Hayman Park	Unitec Sand Filter
Heavy Metals	**Units**																				
Dissolved Arsenic	g.m-3	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	0.013									
Total Arsenic	g.m-3	0.02	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.002				>0.01						
Dissolved Cadmium	g.m-3	0.00016	0.00007	0.00007	< 0.00005	0.00007	< 0.00005	0.00007	0.00006	< 0.00005	< 0.00005	0.0002									
Total Cadmium	g.m-3	0.0097	0.00036	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00008	0.00153	0.00006				>0.005						
Dissolved Chromium	g.m-3	**0.0012**	0.0007	< 0.0005	< 0.0005	0.0005	0.0006	0.001	0.0005	**0.0031**	**0.0015**	0.001									
Total Chromium	g.m-3	0.316	0.0221	0.0017	< 0.0005	0.0008	0.0007	0.0014	0.0027	0.017	0.0042				>0.005-0.011						
Dissolved Copper	g.m-3	**0.0057**	**0.0145**	**0.0064**	**0.0025**	**0.0074**	**0.0046**	**0.0129**	**0.0056**	**0.0698**	**0.0617**	0.0014		0.001							
Total Copper	g.m-3	1.01	0.0889	0.0135	0.005	0.0119	0.0069	0.0084	0.0202	0.197	0.0869			0.0009-0.0021	0.011-0.056	0.024-0.05	0.015-0.05	0.003-.050	0.01-2.42	0.02-0.07	0.002-0.077
Dissolved Nickel	g.m-3	0.0026	0.0013	< 0.0005	< 0.0005	0.0006	< 0.0005	0.0007	< 0.0005	0.0006	< 0.0005	0.011									
Total Nickel	g.m-3	0.136	0.0104	0.001	< 0.0005	0.001	0.0006	0.001	0.0018	0.0125	0.0012				>0.1						
Dissolved Lead	g.m-3	**0.0063**	0.0017	0.0007	0.0004	0.0014	0.0008	0.001	0.0007	**0.0062**	**0.0052**	0.0034		0.00041							
Total Lead	g.m-3	1.86	0.148	0.0131	0.003	0.0049	0.0033	0.0068	0.0113	0.811	0.0258			0.0003-0.075	0.002-0.033	0.027-0.150	0.018-0.050	0.018-.050	0.017-1.660	0.021-1.51	0.005-0.094
Dissolved Zinc	g.m-3	**0.027**	**0.087**	**0.172**	**0.116**	**0.085**	**0.052**	**0.809**	**0.407**	**0.102**	**0.107**	0.008				0.03-0.129	0.01-0.150	0.028-0.321	0.005-.553	0.01-0.840	0.0080.022
Total Zinc	g.m-3	8.75	0.724	0.192	0.125	0.109	0.065	0.435	0.858	0.839	0.139			0.02-0.225	0.1-0.66	0.073-0.179	0.095-2.250	0.063-0.709	0.05-13.5	0.021-1.510	0.013-0.115
pH	pH Units	6.8	6.7	6.5	6.7	6.6	6.8	6.8	6.9	7.3	7.2										
Electrical Conductivity	mS/m	12.5	4.5	3.5	2.5	5.4	3.8	10.2	16.5	24.6	13										
Total Suspended Solids	g.m-3	4350	1070	15	12	7	8	11	20	21	21		100	50-470		35-286	8.0-26.0	2.0-95	1-1174	1-160	5-223
BTEX																					
Benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.95									
Toulene	g.m-3	< 0.001	0.005	< 0.001	< 0.001	0.002	0.001	< 0.001	< 0.001	0.001	0.003	ID									
Ethyl benzene	g.m-3	0.115	0.022	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	ID									
o-Xylene	g.m-3	0.121	0.034	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.35									
m & p-Xylene	g.m-3	**2.11**	**0.373**	< 0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.003	0.2									
Total Petroleum Hydrocarbons	g.m-3																				
C7-C9	g.m-3	2.78	0.6	< 0.03	< 0.03	< 0.03	< 0.03	< 0.05	< 0.05	< 0.05	< 0.05										
C10-C14	g.m-3	4.76	1.58	< 0.05	<0.05	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.1										
C15-C36	g.m-3	2	0.5	<0.1	<0.1	< 0.1	<0.1	< 0.3	< 0.3	< 0.3	< 0.3										
Total TPH	g.m-3	9.5	2.7	<0.2	<0.2	< 0.2	<0.2	< 0.4	< 0.4	< 0.4	< 0.4		15								
PAH																					
Acenaphthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Acenaphthylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004									
Benzo[a]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002									
Benzo[a]pyrene [BAP]	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[b]fluoranthene	g.m-3	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[g,h,i]perylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[k]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Chrysene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Dibenzo[a,h]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Fluoranthene	g.m-3	< 0.0001	0.0006	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	0.001									
Fluorene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Indeno[1,2,3-cd]pyrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001										
Naphthalene	g.m-3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.016									
Phenanthrene	g.m-3	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.002									
Pyrene	g.m-3	0.0019	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0002										

Notes:

(*1) Non-forecourt area manhole was a sewer/stormwater combined manhole. Samples were collected from the stormwater pipe avoiding the sewer line.

Key:

BOLD	Indicates that values exceeds ANZECC receiving fresh-water trigger value for 95% ecosystem protection
░	Indicates API Inlet exceeds control site lowest dissolved and total metal concentration
▓	Indicates API Outlet and NFA concentrations exceeds control site lowest dissolved and total metal concentration
Red	Dissolved metals reported as being at higher concentrations than total metals.
ID	Insufficent data

References:
1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand (1998) Minstry for the Environment (recommended TPH and TSS values).
3. Williamson et al (1991) Urban Runoff Data Book. National Institute of Water and Atmospheric Research
4. American Petroleum Institute Publication (API 1669), December 1994
5. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand.

Table 4-2: Surface Water Analytical Results for Site N

Sample Details and Analytical Results												Guidelines and Relevant Literature									
URS Sample Reference		SWG282	SWG283	SWG284	SWG285	SWG289	SWG290	SWG280	SWG281	SWG286	SWG287	ANZECC[1] Fresh Water 95% Level of Protection	MfE Environmental Guidelines for Water Discharges from Service Stations [2]	Data from Relevant Studies For Reference Only							
Laboratory Sample Reference		434879-1	434879-2	434879-3	434879-4	434879-5	434879-6	422002-1	422002-2	422002-3	422002-4			Urban Road Runoff NZ [3]	API 1669 [4]						
Date Sampled		9-Oct-06	9-Oct-06	9-Oct-06	9-Oct-06	9-Oct-06	9-Oct-06	12-Jun-06	12-Jun-06	12-Jun-06	12-Jun-06										
Time of Sampling		8.00pm	9.10pm	8.10pm	9.15pm	7.40pm	8.50pm	8.50am	9.50am	8.50am	10.05am										
Rainfall Information		**Field Observations:** Approximately 3-4mm over 3 hours **Rainfall data:** No rainfall recorded for 4 days prior to sampling. Approximately 3 mm of rainfall was recorded between 7.00 and 10.00pm (sampling duration) and 3mm mm over the 24 hour period.						**Rainfall Data:** No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.													
		Site N						**Contol Sites**													
Sampling Locations		**API Inlet(*1) First Flush**	**API Inlet Mid Storm**	**API Outlet (*2)First Flush**	**API Outlet Mid Storm**	**NFA First Flush**	**NFA Mid Storm**	**Control 1 First Flush**	**Control 1 Mid Storm**	**Control 2 First Flush**	**Control 2 Mid Storm**					Pananma Rd	Mobil Service Station	Pakuranga	Pacific Steel	Hayman Park	Unitec Sand Filter
Heavy Metals	**Units**																				
Dissolved Arsenic	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	0.013									
Total Arsenic	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.002				>0.01						
Dissolved Cadmium	g.m-3	< 0.00005	**0.00009**	**0.0002**	< 0.00005	**0.00038**	**0.00016**	0.00007	0.00006	< 0.00005	< 0.00005	0.0002									
Total Cadmium	g.m-3	0.00006	0.00011	0.00008	0.00008	0.00035	0.00042	< 0.00005	0.00008	0.00153	0.00006				>0.005						
Dissolved Chromium	g.m-3	0.0007	0.0007	**0.0013**	0.0009	0.0009	< 0.0005	0.001	0.0005	**0.0031**	**0.0015**	0.001									
Total Chromium	g.m-3	0.0024	0.0022	0.003	0.0018	0.0029	0.0077	0.0014	0.0027	0.017	0.0042				>0.005-0.011						
Dissolved Copper	g.m-3	0.006	**0.0062**	**0.0205**	0.009	**0.0193**	**0.0045**	**0.0129**	**0.0056**	**0.0698**	**0.0617**	0.0014		0.001							
Total Copper	g.m-3	0.02	0.017	0.0401	0.0157	0.0309	0.0327	0.0084	0.0202	0.197	0.0869			0.0009-0.0021	0.011-0.056	0.024-0.05	0.015-0.05	0.003-.050	0.01-2.42	0.02-0.07	0.002-0.077
Dissolved Nickel	g.m-3	< 0.0005	< 0.0005	0.0007	< 0.0005	0.001	< 0.0005	0.0007	< 0.0005	0.0006	< 0.0005	0.011									
Total Nickel	g.m-3	0.0019	0.0018	0.0028	0.0011	0.0025	0.0048	0.001	0.0018	0.0125	0.0012				>0.1						
Dissolved Lead	g.m-3	0.0003	0.0005	0.001	0.0006	0.0004	0.0004	0.001	0.0007	**0.0062**	**0.0052**	0.0034		0.00041							
Total Lead	g.m-3	0.0089	0.0081	0.012	0.0067	0.0119	0.0392	0.0068	0.0113	0.811	0.0258			0.0003-0.075	0.002-0.033	0.027-0.150	0.018-0.050	0.018-.050	0.017-1.660	0.021-1.51	0.005-0.094
Dissolved Zinc	g.m-3	0.007	**0.011**	**0.067**	**0.053**	**0.051**	**0.024**	**0.809**	**0.407**	0.102	**0.107**	0.008				0.03-0.129	0.01-0.150	0.028-0.321	0.005-.553	0.01-0.840	0.0080.022
Total Zinc	g.m-3	0.046	0.047	0.122	0.093	0.106	0.221	0.435	0.858	0.839	0.139			0.02-0.225	0.1-0.66	0.073-0.179	0.095-2.250	0.063-0.709	0.05-13.5	0.021-1.510	0.013-0.115
pH	pH Units	7.3	7.3	6.8	6.9	6.7	6.8	6.8	6.9	7.3	7.2										
Electrical Conductivity	mS/m	17.6	15.5	6.4	5	8.1	2.6	10.2	16.5	24.6	13										
Total Suspended Solids	g.m-3	43	34	35	25	69	62	11	20	21	21			50-470		35-286	8.0-26.0	2.0-95	1-1174	1-160	5-223
BTEX																					
Benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.95									
Toulene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003	ID									
Ethyl benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	ID									
o-Xylene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.35									
m & p-Xylene	g.m-3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.003	0.2									
Total Petroleum Hydrocarbons	g.m-3																				
C7-C9	g.m-3	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.05	< 0.05	< 0.05	< 0.05										
C10-C14	g.m-3	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.1										
C15-C36	g.m-3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 0.3	< 0.3										
Total TPH	g.m-3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.4	< 0.4	< 0.4	< 0.4		15								
PAH																					
Acenaphthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Acenaphthylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004									
Benzo[a]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002									
Benzo[a]pyrene [BAP]	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[b]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[g,h,i]perylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[k]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Chrysene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Dibenzo[a,h]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	0.001									
Fluorene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Indeno[1,2,3-cd]pyrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001										
Naphthalene	g.m-3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.016									
Phenanthrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.002									
Pyrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0002										

Notes:

(*1)	Sample collected from API inlet chamber (water was stagnant) when collected.
(*2)	Sample colllected from manhole which also has other non-forecourt area discharging to it. See report for further details.

Key:

BOLD	Indicates that values exceeds ANZECC receiving fresh-water trigger value for 95% ecosystem protection
▒	Indicates API Inlet exceeds control site lowest dissolved and total metal concentration
▓	Indicates API Outlet and NFA concentrations exceeds control site lowest dissolved and total metal concentration
Red	Dissolved metals reported as being at higher concentrations than total metals.
ID	Insufficent data

References:

1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand (1998) Minstry for the Environment (recommended TPH and TSS values).
3. Williamson et al (1991) Urban Runoff Data Book. National Institute of Water and Atmospheric Research
4. American Petroleum Institute Publication (API 1669), December 1994
5. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand.

Table 4-3: Surface Water Analytical Results for Site U

Sample Details and Analytical Results												**Guidelines and Relevant Literature**									
URS Sample Reference		SWK673	SWK674	SWK675	SWK676	SWK671	SWK672	SWG280	SWG281	SWG286	SWG287	ANZECC[1] Fresh Water 95% Level of Protection	MfE Environmental Guidelines for Water Discharges from Service Stations [2]	Data from Relevant Studies For Reference Only							
Laboratory Sample Reference		435439-2	435439-3	435439-4	435439-5	435439-6	435439-1	422002-1	422002-2	422002-3	422002-4			Urban Road Runoff NZ [3]	API 1669 [4]						
Date Sampled		16-Oct-06	16-Oct-06	16-Oct-06	16-Oct-06	16-Oct-06	16-Oct-06	12-Jun-06	12-Jun-06	12-Jun-06	12-Jun-06										
Time of Sampling		9.25am	10.00am	9.10am	10.10am	9.05am	9.50am	8.50am	9.50am	8.50am	10.05am										
Rainfall Information		**Field Observations:** Approximately 3-4mm over 3 hours **Rainfall data:** No rainfall recorded for 5 days prior to sampling. Approximately 4 mm of rainfall was recorded between 6.00am and 11.00am and 9.8mm over the 24 hour period. A few showers (<1-2mm) occurred prior to sample collect ion at 9.00am.						**Rainfall Data:** No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.													
Sampling Locations		**Site U**						**Contol Sites**													
		API Inlet First Flush	**API Inlet Mid Storm**	**API Outlet First Flush**	**API Outlet Mid Storm**	**NFA First Flush**	**NFA Mid Storm**	**Control 1 First Flush**	**Control 1 Mid Storm**	**Control 2 First Flush**	**Control 2 Mid Storm**					Pananma Rd	Mobil Service Station	Pakuranga	Pacific Steel	Hayman Park	Unitec Sand Filter
Heavy Metals	**Units**																				
Dissolved Arsenic	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	0.013									
Total Arsenic	g.m-3	0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.008	0.002				>0.01						
Dissolved Cadmium	g.m-3	0.00008	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00029	0.00007	0.00006	< 0.00005	< 0.00005	0.0002									
Total Cadmium	g.m-3	0.00029	0.00009	< 0.00005	< 0.00005	0.00008	0.00006	< 0.00005	0.00008	0.00153	0.00006				>0.005						
Dissolved Chromium	g.m-3	0.0006	< 0.0005	< 0.0005	< 0.0005	<0.0005	< 0.0005	0.001	0.0005	**0.0031**	**0.0015**	0.001									
Total Chromium	g.m-3	0.0036	0.0008	0.001	< 0.0005	0.0012	0.001	0.0014	0.0027	0.017	0.0042				>0.005-0.011						
Dissolved Copper	g.m-3	**0.0103**	**0.0023**	**0.0081**	**0.0017**	**0.0073**	**0.0082**	**0.0129**	**0.0056**	**0.0698**	**0.0617**	0.0014		0.001							
Total Copper	g.m-3	0.0282	0.0082	0.0105	0.0035	0.0157	0.0116	0.0084	0.0202	0.197	0.0869			0.0009-0.0021	0.011-0.056	0.024-0.05	0.015-0.05	0.003-.050	0.01-2.42	0.02-0.07	0.002-0.077
Dissolved Nickel	g.m-3	0.0007	< 0.0005	0.0006	< 0.0005	<0.0005	0.0007	0.0007	< 0.0005	0.0006	< 0.0005	0.011									
Total Nickel	g.m-3	0.003	0.0008	0.001	< 0.0005	0.0013	0.0008	0.001	0.0018	0.0125	0.0012				>0.1						
Dissolved Lead	g.m-3	0.0006	0.0001	0.0005	0.0001	0.0003	0.0005	0.001	0.0007	**0.0062**	**0.0052**	0.0034		0.00041							
Total Lead	g.m-3	0.0104	0.0036	0.0026	0.0012	0.0042	0.0037	0.0068	0.0113	0.811	0.0258			0.0003-0.075	0.002-0.033	0.027-0.150	0.018-0.050	0.018-.050	0.017-1.660	0.021-1.51	0.005-0.094
Dissolved Zinc	g.m-3	**0.064**	**0.029**	**0.047**	**0.017**	**0.59**	**0.627**	**0.809**	**0.407**	**0.102**	**0.107**	0.008				0.03-0.129	0.01-0.150	0.028-0.321	0.005-.553	0.01-0.840	0.0080.022
Total Zinc	g.m-3	0.234	0.1	0.102	0.039	0.455	0.783	0.435	0.858	0.839	0.139			0.02-0.225	0.1-0.66	0.073-0.179	0.095-2.250	0.063-0.709	0.05-13.5	0.021-1.510	0.013-0.115
pH	pH Units	7	7.2	7.1	7.2	7.2	7.1	6.8	6.9	7.3	7.2										
Electrical Conductivity	mS/m	14.6	6.2	23.1	7.7	20.6	14.6	10.2	16.5	24.6	13										
Total Suspended Solids	g.m-3	116	42	49	19	(*)	17	11	20	21	21			50-470		35-286	8.0-26.0	2.0-95	1-1174	1-160	5-223
BTEX																					
Benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.95									
Toulene	g.m-3	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003	ID									
Ethyl benzene	g.m-3	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	ID									
o-Xylene	g.m-3	0.002	0.01	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.35									
m & p-Xylene	g.m-3	< 0.002	0.019	< 0.002	< 0.002	0.003	< 0.002	< 0.002	< 0.002	0.003	0.003	0.2									
Total Petroleum Hydrocarbons	g.m-3																				
C7-C9	g.m-3	0.41	0.05	0.03	< 0.03	< 0.03	< 0.03	< 0.05	< 0.05	< 0.05	< 0.05										
C10-C14	g.m-3	36.5	0.34	0.06	< 0.05	< 0.05	1.27	< 0.1	< 0.1	< 0.1	< 0.1										
C15-C36	g.m-3	527	10.8	7.9	0.2	0.2	13.9	< 0.3	< 0.3	< 0.3	< 0.3										
Total TPH	g.m-3	***564***	11.2	8	0.2	0.2	***15.2***	< 0.4	< 0.4	< 0.4	< 0.4		15								
PAH																					
Acenaphthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Acenaphthylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Anthracene	g.m-3	**0.0005**	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004									
Benzo[a]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002									
Benzo[a]pyrene [BAP]	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[b]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[g,h,i]perylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[k]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Chrysene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Dibenzo[a,h]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Fluoranthene	g.m-3	< 0.0001	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	0.001									
Fluorene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Indeno[1,2,3-cd]pyrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001										
Naphthalene	g.m-3	0.0006	< 0.0005	< 0.0005	< 0.0005	0.001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.016									
Phenanthrene	g.m-3	**0.0048**	**0.0011**	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.002									
Pyrene	g.m-3	0.0291	0.0035	0.0007	0.0002	< 0.0001	0.0008	< 0.0001	< 0.0001	0.0003	0.0002										

Notes:

(*) Lab Error (see Hills Laboratory Letter, Appendix D)

Key:

BOLD	Indicates that values exceeds ANZECC receiving fresh-water trigger value for 95% ecosystem protection
░	Indicates API Inlet exceeds control site lowest dissolved and total metal concentration
▓	Indicates API Outlet and NFA concentrations exceeds control site lowest dissolved and total metal concentration
Red	Dissolved metals reported as being at higher concentrations than total metals.
ID	Insufficent data

References:

1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand (1998) Minstry for the Environment (recommended TPH and TSS values).
3. Williamson et al (1991) Urban Runoff Data Book. National Institute of Water and Atmospheric Research
4. American Petroleum Institute Publication (API 1669), December 1994
5. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand.

Table 4-4 : Surface Water Analytical Results for Site D

Sample Details and Analytical Results												**Guidelines and Relevant Literature**									
URS Sample Reference		SWD 637	SWD 638	SWD 639	SWD 640	SWD 641	SWD 642	SWG280	SWG281	SWG286	SWG287	ANZECC[1] Fresh Water 95% Level of Protection	MfE Environmental Guidelines for Water Discharges from Service Stations [2]	Data from Relevant Studies For Reference Only							
Laboratory Sample Reference		448841/5	448841/6	448841/1	448841/2	448841/3	4488441/4	422002-1	422002-2	422002-3	422002-4										
Date Sampled		12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Jun-06	12-Jun-06	12-Jun-06	12-Jun-06			Urban Road Runoff NZ [3]	API 1669 [4]						
Time of Sampling		5.00pm	7.00pm	5.10pm	7.10pm	5.20pm	7.20pm	8.50am	9.50am	8.50am	10.05am										
Rainfall Information		**Field Observations:** Approximately 2-3mm over 2 hours. **Rainfall data:** No rainfall recorded for 2 days prior to sampling. Approximately 3.6 mm of rainfall was recorded between 5.00pm and 8.00pm and 31mm over the 24 hour period.						**Rainfall Data:** No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.													
		Site D						**Contol Sites**													
Sampling Locations		**API Inlet First Flush**	**API Inlet Mid Storm**	**API Outlet First Flush**	**API Outlet Mid Storm**	**NFA First Flush**	**NFA Mid Storm**	**Control 1 First Flush**	**Control 1 Mid Storm**	**Control 2 First Flush**	**Control 2 Mid Storm**					Pananma Rd	Mobil Service Station	Pakuranga	Pacific Steel	Hayman Park	Unitec Sand Filter
Heavy Metals	**Units**																				
Dissolved Arsenic	g.m-3	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	0.013									
Total Arsenic	g.m-3	0.002	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.002				>0.01						
Dissolved Cadmium	g.m-3	0.00005	< 0.00005	< 0.00005	< 0.00005	0.00007	0.00005	0.00007	0.00006	< 0.00005	< 0.00005	0.0002									
Total Cadmium	g.m-3	0.00015	0.00014	< 0.00005	0.00006	0.00007	0.00012	< 0.00005	0.00008	0.00153	0.00006				>0.005						
Dissolved Chromium	g.m-3	0.0009	0.0011	< 0.0005	0.0005	0.0006	0.0005	0.001	0.0005	**0.0031**	**0.0015**	0.001									
Total Chromium	g.m-3	0.0057	0.0042	0.0007	0.0016	0.0009	0.0039	0.0014	0.0027	0.017	0.0042				>0.005-0.011						
Dissolved Copper	g.m-3	**0.0122**	0.014	**0.0079**	**0.0111**	**0.0122**	**0.0086**	**0.0129**	**0.0056**	**0.0698**	**0.0617**	0.0014		0.001							
Total Copper	g.m-3	0.0309	0.0373	0.0064	0.0342	0.0104	0.0253	0.0084	0.0202	0.197	0.0869			0.0009-0.0021	0.011-0.056	0.024-0.05	0.015-0.05	0.003-.050	0.01-2.42	0.02-0.07	0.002-0.077
Dissolved Nickel	g.m-3	0.0018	0.0017	0.0014	0.0017	0.0015	0.001	0.0007	< 0.0005	0.0006	< 0.0005	0.011									
Total Nickel	g.m-3	0.0044	0.0046	0.0021	0.0029	0.002	0.0031	0.001	0.0018	0.0125	0.0012				>0.1						
Dissolved Lead	g.m-3	0.0034	0.014	**0.0065**	**0.0078**	**0.0121**	0.0033	0.001	0.0007	**0.0062**	**0.0052**	0.0034		0.00041							
Total Lead	g.m-3	0.0249	0.0232	0.0049	0.0194	0.0059	0.0179	0.0068	0.0113	0.811	0.0258			0.0003-0.075	0.002-0.033	0.027-0.150	0.018-0.050	0.018-.050	0.017-1.660	0.021-1.51	0.005-0.094
Dissolved Zinc	g.m-3	**0.167**	**0.124**	**0.424**	**0.495**	**0.282**	**0.137**	**0.809**	**0.407**	**0.102**	**0.107**	0.008				0.03-0.129	0.01-0.150	0.028-0.321	0.005-.553	0.01-0.840	0.0080.022
Total Zinc	g.m-3	0.48	0.302	0.716	0.898	0.495	0.53	0.435	0.858	0.839	0.139			0.02-0.225	0.1-0.66	0.073-0.179	0.095-2.250	0.063-0.709	0.05-13.5	0.021-1.510	0.013-0.115
pH	pH Units	6.4	6.7	7.3	7.3	7.2	7	6.8	6.9	7.3	7.2										
Electrical Conductivity	mS/m	29.9	15.2	33.5	34.9	20.8	8.6	10.2	16.5	24.6	13										
Total Suspended Solids	g.m-3	167	93	16	20	34	52	11	20	21	21			50-470		35-286	8.0-26.0	2.0-95	1-1174	1-160	5-223
BTEX																					
Benzene	g.m-3	< 0.001	< 0.001	0.006	0.014	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.95									
Toulene	g.m-3	0.041	0.008	0.075	0.205	< 0.001	0.006	< 0.001	< 0.001	0.001	0.003	ID									
Ethyl benzene	g.m-3	< 0.001	< 0.001	0.008	0.018	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	ID									
o-Xylene	g.m-3	< 0.001	< 0.001	0.017	0.034	0.003	< 0.001	< 0.001	< 0.001	0.001	0.002	0.35									
m & p-Xylene	g.m-3	< 0.002	< 0.002	0.031	0.072	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.003	0.2									
Total Petroleum Hydrocarbons	g.m-3																				
C7-C9	g.m-3	0.1	< 0.03	< 0.03	< 0.03	0.47	< 0.03	< 0.05	< 0.05	< 0.05	< 0.05										
C10-C14	g.m-3	< 0.05	< 0.05	< 0.05	< 0.05	0.14	< 0.05	< 0.1	< 0.1	< 0.1	< 0.1										
C15-C36	g.m-3	< 0.1	< 0.1	4.9	2.2	3.4	2.9	< 0.3	< 0.3	< 0.3	< 0.3										
Total TPH	g.m-3	< 0.2	< 0.2	5	2.2	4	2.9	< 0.4	< 0.4	< 0.4	< 0.4		15								
PAH																					
Acenaphthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Acenaphthylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004									
Benzo[a]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002									
Benzo[a]pyrene [BAP]	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[b]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[g,h,i]perylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[k]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Chrysene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Dibenzo[a,h]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	0.001									
Fluorene	g.m-3	< 0.0001	< 0.0001	0.0003	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Indeno[1,2,3-cd]pyrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001										
Naphthalene	g.m-3	< 0.0005	< 0.0005	0.0018	0.0025	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.016									
Phenanthrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.002									
Pyrene	g.m-3	< 0.0001	< 0.0001	0.0017	0.001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0003	0.0002										

Key:

BOLD	Indicates that values exceeds ANZECC receiving fresh-water trigger value for 95% ecosystem protection
░	Indicates API Inlet exceeds control site lowest dissolved and total metal concentration
▓	Indicates API Outlet and NFA concentrations exceeds control site lowest dissolved and total metal concentration
Red	Dissolved metals reported as being at higher concentrations than total metals.
ID	Insufficent data

References:

1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand (1998) Minstry for the Environment (recommended TPH and TSS values).
3. Williamson et al (1991) Urban Runoff Data Book. National Institute of Water and Atmospheric Research
4. American Petroleum Institute Publication (API 1669), December 1994
5. MfE (1998) Environmental Guidelines for Water Discharges from Petroluem Industry Sites in New Zealand.

Table 4-5 : Surface Water Analytical Results for Site A

Sample Details and Analytical Results												**Guidelines and Relevant Literature**									
URS Sample Reference		SWL087	SWL088	SWL089	SWL090	SWL091	SWL092	SWG280	SWG281	SWG286	SWG287	ANZECC[1] Fresh Water 95% Level of Protection	MfE Environmental Guidelines for Water Discharges from Service Stations [2]	Data from Relevant Studies For Reference Only							
Laboratory Sample Reference		440410-1	440410-2	440410-3	440410-4	440410-5	440410-6	422002-1	422002-2	422002-3	422002-4			Urban Road Runoff NZ [3]	API 1669 [4]						
Date Sampled		30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	30-Nov-06	12-Jun-06	12-Jun-06	12-Jun-06	12-Jun-06										
Time of Sampling		10.05am	11.00am	10.20am	11.10am	9.50am	10.50am	8.50am	9.50am	8.50am	10.05am										
Rainfall Information		**Field Observations:** Approximately 5-6mm over a two hour period. **Rainfall data:** No rainfall recorded for 2 days prior to sampling. Approximately 8 mm of rainfall was recorded between 9.00am and 11.00am (sampling duration) and 12.6mm over the 24 hour period.						**Rainfall Data:** No rainfall recorded for 5 days prior to sampling. Approximately 15mm of rainfall was recorded between 8.33am -8.48am, with total of 66.8mm over the 24 hour period. Note however the rain-gauge at Auckland Airport only recorded 10.2 mm of rain during the 24 hour period.													
		Site A						**Contol Sites**													
Sampling Locations		**API Inlet First Flush**	**API Inlet Mid Storm**	**API Outlet First Flush**	**API Outlet Mid Storm**	**NFA First Flush**	**NFA Mid Storm**	**Control 1 First Flush**	**Control 1 Mid Storm**	**Control 2 First Flush**	**Control 2 Mid Storm**					Pananma Rd	Mobil Service Station	Pakuranga	Pacific Steel	Hayman Park	Unitec Sand Filter
Heavy Metals	**Units**																				
Dissolved Arsenic	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	0.013									
Total Arsenic	g.m-3	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.008	0.002				>0.01						
Dissolved Cadmium	g.m-3	0.00008	< 0.00005	0.00005	< 0.00005	< 0.00005	0.00006	0.00007	0.00006	< 0.00005	< 0.00005	0.0002									
Total Cadmium	g.m-3	0.0001	0.00007	0.00008	0.00006	0.00007	0.0001	< 0.00005	0.00008	0.00153	0.00006				>0.005						
Dissolved Chromium	g.m-3	0.0009	< 0.0005	< 0.0005	0.0005	< 0.0005	< 0.0005	0.001	0.0005	**0.0031**	**0.0015**	0.001									
Total Chromium	g.m-3	0.0024	< 0.0005	< 0.0005	0.0033	< 0.0005	0.0005	0.0014	0.0027	0.017	0.0042				>0.005-0.011						
Dissolved Copper	g.m-3	**0.0131**	**0.0025**	**0.0043**	**0.0023**	**0.0028**	**0.004**	**0.0129**	**0.0056**	**0.0698**	**0.0617**	0.0014		0.001							
Total Copper	g.m-3	0.0189	0.004	0.0056	0.0089	0.0729	0.0059	0.0084	0.0202	0.197	0.0869			0.0009-0.0021	0.011-0.056	0.024-0.05	0.015-0.05	0.003-.050	0.01-2.42	0.02-0.07	0.002-0.077
Dissolved Nickel	g.m-3	**0.0012**	0.0008	0.0009	< 0.0005	0.0007	0.0008	0.0007	< 0.0005	0.0006	< 0.0005	0.011									
Total Nickel	g.m-3	0.0018	0.0009	0.001	0.001	0.0009	0.0012	0.001	0.0018	0.0125	0.0012				>0.1						
Dissolved Lead	g.m-3	0.0019	0.0006	0.0009	0.0004	0.0006	0.0008	0.001	0.0007	**0.0062**	**0.0052**	0.0034		0.00041							
Total Lead	g.m-3	0.0113	0.0012	0.0013	0.0152	0.001	0.0016	0.0068	0.0113	0.811	0.0258			0.0003-0.075	0.002-0.033	0.027-0.150	0.018-0.050	0.018-.050	0.017-1.660	0.021-1.51	0.005-0.094
Dissolved Zinc	g.m-3	**0.151**	**0.409**	**0.586**	**0.023**	**0.397**	**0.527**	**0.809**	**0.407**	**0.102**	**0.107**	0.008				0.03-0.129	0.01-0.150	0.028-0.321	0.005-.553	0.01-0.840	0.0080.022
Total Zinc	g.m-3	0.168	0.606	0.663	0.093	0.552	0.649	0.435	0.858	0.839	0.139			0.02-0.225	0.1-0.66	0.073-0.179	0.095-2.250	0.063-0.709	0.05-13.5	0.021-1.510	0.013-0.115
pH	pH Units	6.3	7.5	7.3	6.9	7.4	7.2	6.8	6.9	7.3	7.2										
Electrical Conductivity	mS/m	11.6	21.1	14.4	2.2	20.8	14.5	10.2	16.5	24.6	13										
Total Suspended Solids	g.m-3	20	3	5	30	4	12	11	20	21	21			50-470		35-286	8.0-26.0	2.0-95	1-1174	1-160	5-223
BTEX																					
Benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.95									
Toulene	g.m-3	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003	ID									
Ethyl benzene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	ID									
o-Xylene	g.m-3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.35									
m & p-Xylene	g.m-3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.003	0.2									
Total Petroleum Hydrocarbons	g.m-3																				
C7-C9	g.m-3	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.05	< 0.05	< 0.05	< 0.05										
C10-C14	g.m-3	< 0.05	< 0.05	0.97	< 0.05	< 0.05	1.04	< 0.1	< 0.1	< 0.1	< 0.1										
C15-C36	g.m-3	< 0.1	0.3	10.8	< 0.1	0.3	12.7	< 0.3	< 0.3	< 0.3	< 0.3										
Total TPH	g.m-3	< 0.2	0.3	11.8	< 0.2	0.4	13.8	< 0.4	< 0.4	< 0.4	< 0.4		15								
PAH																					
Acenaphthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Acenaphthylene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0004									
Benzo[a]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0002									
Benzo[a]pyrene [BAP]	g.m-3	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[b]fluoranthene	g.m-3	0.0007	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[g,h,i]perylene	g.m-3	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001										
Benzo[k]fluoranthene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Chrysene	g.m-3	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Dibenzo[a,h]anthracene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Fluoranthene	g.m-3	0.0009	< 0.0001	< 0.0001	0.0006	< 0.0001	0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	0.001									
Fluorene	g.m-3	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001										
Indeno[1,2,3-cd]pyrene	g.m-3	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001										
Naphthalene	g.m-3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.016									
Phenanthrene	g.m-3	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	0.002									
Pyrene	g.m-3	0.0006	0.0004	0.0019	0.0003	0.0008	0.0039	< 0.0001	< 0.0001	0.0003	0.0002										

Key:

BOLD	Indicates that values exceeds ANZECC receiving fresh-water trigger value for 95% ecosystem protection
░	Indicates API Inlet exceeds control site lowest dissolved and total metal concentration
▓	Indicates API Outlet and NFA concentrations exceeds control site lowest dissolved and total metal concentration
Red	Dissolved metals reported as being at higher concentrations than total metals.
ID	Insufficent data

References:

1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. MfE (1998) Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand (1998) Minstry for the Environment (recommended TPH and TSS values).
3. Williamson et al (1991) Urban Runoff Data Book. National Institute of Water and Atmospheric Research
4. American Petroleum Institute Publication (API 1669), December 1994
5. MfE (1998) Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand.

Table 4-6: Sediment Analytical Results Compared to Sediment Quality Assessment Criteria

Sample Details and Analytical Results								**Guidelines and Relevant Literature**							
		Site N	**Site U**	**Site J**	**Site A**	**Site D**	Exposure Pathways Maintenance - Soil Ingestion and Dermal [4]	ANZECC[1] ISQG low	Data from Relevant Studies						
URS Sample Reference		SDG285	SWD 677	SWP 629	SDL 092	SWD 643									
Laboratory Sample Reference		434879-7	435436/1	440498/7	440410/7	448841/7									
Date Sampled		9-Oct-06	16-Oct-06	30-Nov-06	30-Nov-06	12-Mar-07									
Sample Location		Sediment Samples							Data from TP10 [2].					Data from Dunedin [3]	
		API Interceptor	API Interceptor	API Interceptor	API Interceptor	API Interceptor			Petrol Stations	Dairies	All day Parking lots	Streets	Residential Parking	Street dust	Sump Sediment
Heavy Metals	**Units**														
Total Arsenic	mg/kg	7	6	4	10	11	62	20							
Total Cadmium	mg/kg	0.4	0.5	0.3	0.2	0.2	183	1.5	35.6	17	13.2	13.6	13.5		
Total Chromium	mg/kg	99	30	188	43	37	> 10,000	80	350	233	258	291	323		
Total Copper	mg/kg	267	83	213	88	100	> 10,000	65	798	326	186	173	162	129 (145)	179 (145)
Total Nickel	mg/kg	157	21	135	77	35	838	21							
Total Lead	mg/kg	156	56	548	16	54.6	4610	50	1,183	677	309	544	180	289 (167)	262 (167)
Total Zinc	mg/kg	801	1,020	852	148	1400	> 10,000	200	6,785	4,025	1,580	1,800	878	528 (206)	424 (304)
Total Phosphorous	mg/kg	1,660	11,100	951	1,570	845			1,056	1,020	466	365	267		
Total Organic Carbon	g/100g	17.6	11.4	6.25	1.15	7.95			9.80	5.51	3.79	3.3	3.23		
Total Petroleum Hydrocarbons															
C7-C9	mg/kg	< 20	290	447	< 20	50	NA								
C10-C14	mg/kg	< 30	6,440	1,270	40	3,840	NA								
C15-C36	mg/kg	2,280	96,800	8,530	500	38,100	NA								
Total TPH	mg/kg	2,280	103,000	10,300	540	42,000			18,155	7,003	7,114	3,482	892		
PAH															
Acenaphthene	mg/kg	< 0.05	<0.09	< 0.05	< 0.06	< 0.1		16							
Acenaphthylene	mg/kg	< 0.05	<0.09	< 0.05	< 0.06	< 0.1		44							
Anthracene	mg/kg	< 0.05	<0.09	< 0.05	< 0.06	0.2		85							
Benzo[a]anthracene	mg/kg	0.12	0.42	0.46	0.51	< 0.1									
Benzo[a]pyrene [BAP]	mg/kg	0.3	0.33	0.28	0.53	< 0.1									
Benzo[b]fluoranthene	mg/kg	0.47	1.62	1.02	1.91	< 0.1									
Benzo[g,h,i]perylene	mg/kg	0.98	0.81	0.66	0.81	0.3									
Benzo[k]fluoranthene	mg/kg	0.21	0.69	0.22	0.78	< 0.1									
Chrysene	mg/kg	0.2	1.07	0.41	0.7	< 0.1									
Dibenzo[a,h]anthracene	mg/kg	< 0.05	<0.09	<0.05	< 0.06	< 0.1									
Fluoranthene	mg/kg	0.4	<0.09	0.74	2.13	0.7									
Fluorene	mg/kg	< 0.05	<0.09	<0.05	< 0.06	< 0.1		19							
Indeno[1,2,3-cd]pyrene	mg/kg	0.31	0.28	0.27	0.73	< 0.1									
Naphthalene	mg/kg	< 0.3	10.3	7.6	< 0.3	1.5	3,100	160							
Phenanthrene	mg/kg	0.18	12.3	<0.05	0.56	2.7		240							
Pyrene	mg/kg	0.77	31.1	3.32	1.75	9.8		665							
Benzo[a]pyrene [BAP] eq.	mg/kg	0.3941	0.5796	0.4613	0.8598	<0.1	25								

Notes: all concentrations are expressed on a dry weight basis

NA - indicates that contaminant not limiting as estimated health based criterion is signficantly higher than that likely to be encountered on site

References:

1. ANZECC and ARMCANZ 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand
2. ARC Technical Publication 10, 2003 (Table 10.1 page 10-4). These results show sediment quality found in oil/water separators relative to other land uses.
3. Brown & Peake 2005. Sources of heavy metals and PAHs in urban stormwater runoff (Data from Dunedine Studies)

Table 4-7 Range of Copper, Lead, Zinc, TSS and TPH in Service Station and Control Site Stormwater

Units: gm^3	API Inlet		API Outlet		NFA		Control sites		ANZECC Guidelines
	1st flush	Mid storm	1st flush	Mid storm	1st flush	Mid storm	1st flush	Mid Storm	
Dissolved Copper	0.0057-0.0131	0.0023-0.0145	0.0043-0.0205	0.0017-0.0111	0.0028-0.0193	0.004-0.0086	0.0129 – 0.0698	0.0056-0.0617	0.0008
Total Copper	0.0189-1.01	0.004-0.0889	0.0056-0.0401	0.0035-0.0342	0.0104-0.0729	0.0059 – 0.0327	0.0084-0.197	0.0202-0.0869	
Dissolved Lead	0.0003-0.0063	0.0001-0.014	0.0005-0.0065	0.0001-0.0078	0.0003-0.0121	0.0004-0.0033	0.001-0.0062	0.0007-0.0052	0.0008
Total Lead	0.0089-1.86	0.0012-0.148	0.0013-0.0131	0.0012-0.0194	0.001-0.0119	0.0016-0.0392	0.0068-0.811	0.0113-0.0258	
Dissolved Zinc	0.007-0.167	0.011-0.409	0.047-0.586	0.017-0.495	0.051-0.59	0.024-0.627	0.102-0.809	0.107-0.407	0.0008
Total Zinc	0.046-8.75	0.047-0.724	0.102-0.716	0.039-0.898	0.106-0.552	0.065-0.783	0.435-0.839	0.139-0.858	
Total Suspended Solids	20-4350	3-1070	5-49	12-30	4-69	8-62	11-21	20-21	
TPH	9.5-564	0.3-11.2	5-11.8	0.2-2.2	0.2-4	2.9-15.2	<0.4	<0.4	

4.4 Mass Load Data

A simple contaminant load calculation was undertaken using the API outlet and NFA monitoring data to estimate the total average annual contaminant load contribution from all service stations located in the Auckland Region. A similar calculation was undertaken for the two control sites monitored but using actual concentrations, as only one sample was collected from each control site.

In order to establish the estimated contaminant loads from all service stations in the Auckland Region and from the two control sites, the following assumptions were made:

- Average service station area: 0.22 hectares (based upon available industry data).
- There are currently in the order of 309 service stations in the Auckland Region (all brands, including independently operated sites) which equates to a total of approximately 68 hectares of land being occupied by service stations. The total approximate area of Auckland Region's mainland is approximately 451,800 hectares[3], with service stations occupying approximately 0.015% of this total area.
- Annual rainfall for the year (based on NIWA Data) for 2006 was 1,263mm.
- Control site 1 (Azda Plaza). Only one third of the total Azda Plaza car park area drains to the stormwater manhole sampled, equating to an area of approximately 1300m^2 (based on topographical information available for the Azda Plaza car park).
- Control site 2 (Auckland Museum Car park). Approximately 7900m^2 of the area around the Auckland Museum drains to the manhole from which stormwater samples were collected.

The number of service stations and average areas were provided by OIEWG members.

For comparison purposes, Table 4.8 and 4.9 presents the contaminant yields (i.e. the amount of contaminants produced per given source area in a given time (kga^{-1} ha^{-1})) calculated for service stations in the Auckland region and the two control sites. It should be noted that the mass loads/yields calculated from the OIEWG study are estimates and very conservative (i.e. likely to be higher than actual). The calculation of contaminant yield for each parameter is based on the average concentration found at each sample point across the five service stations. The contaminant yields calculated have been conservatively compared to available contaminant load information from the following ARC publications:

- ARC TP40104 – Sources and loads of metals in urban stormwater, June 2005. This technical report presents the mass loads and contaminant yields determined for three stormwater catchments in the Auckland area, namely Mission Bay (residential catchment), Auckland CBD (commercial catchment) and Mt Wellington (industrial catchment). It should be noted that this report does not specify whether predicted averages or actual averages from the monitoring data were used to determine the concentration yields.
- ARC Contaminant Load Model (ARC CLM, May 2006) – This spreadsheet model has been developed by ARC to calculate how much contaminants is produced in a given land area. Contaminant yields from this model have been used to provide some comparison for the OIEWG data. In particular, contaminant yields from model input categories: *paved surfaces other than roads* (i.e. commercial car parks and walkways); and *roads with traffic count of approximately 5000 -20,000 vehicles per day*. It should be noted that roof runoff in ARC model is a separate category. No information was available regarding how the yields were determined for the model.

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[3] Source: ARC Growth Strategy, ARC website. Total urban Auckland area is 53,000 hectares.

Table 4-8: Contaminant Yields for Service Stations in the Auckland Region and Control Sites - First Flush Scenario

	Service Stations		Control Sites		ARC TP04104 – June 2005			ARC Contaminant Load Model May 06	
Contaminant Yields (kga^{-1}ha^{-1})	API Outlet	NFA	Control Site 1	Control Site 2	Central Business District - Commercial (catchment area -30.1ha)	Mission Bay - Residential (catchment –area - 45.2 ha)	Mt Wellington - Industrial (catchment area - 34.0ha)	Commercial Paved Areas other than Roads or Roof (i.e. car parks, small driveways, walkways etc)	Roads – 5,000 to 20,000 vehicles/day (does not include roof runoff)
Copper	0.19	0.36	0.11	2.49	0.14	0.08	0.14	0.5	1.7
Lead	0.086	0.070	0.09	10.24	0.12	0.06	0.14	-	-
Zinc	4.53	4.34	5.49	10.60	1.63	0.57	5.2	0.5	5.4
TSS	303.12	359.96	138.93	265.23	310	620	252	1,000	1,500
TPH	63.15	12.12	-	-	-	-	-	-	26.8

Table 4-9: Contaminant Yields for Service Stations in the Auckland Region and Control Sites - Mid Storm Scenario

	Service Stations		Control Sites		ARC TP04104 – June 2005			ARC Contaminant Load Model May 06	
Contaminant Yields (kga^{-1}ha^{-1})	API Outlet	NFA	Control Site 1	Control Site 2	Central Business District - Commercial (catchment area -30.1ha)	Mission Bay - Residential (catchment –area - 45.2 ha)	Mt Wellington - Industrial (catchment area - 34.0ha)	Commercial Paved Areas other than Roads or Roof (i.e. car parks, small driveways, walkways etc)	Roads – 5,000 to 20,000 vehicles/day (does not include roof runoff)
Copper	0.17	0.21	0.26	1.10	0.14	0.08	0.14	0.5	1.7
Lead	0.115	0.166	0.14	0.33	0.12	0.06	0.14	-	-
Zinc	3.15	5.68	10.84	1.76	1.63	0.57	5.2	0.5	5.4
TSS	267.76	381.43	252.60	265.23	310	620	252	1,000	1,500
TPH	8.21	81.08	-	-	-	-	-	-	26.8

Notes for Table 4-8 and Table 4-9

1) Control Site 1: Azda Plaza car park site, approximately 1300m^2 of the total Azda Plaza car park discharges to the stormwater manhole monitored.

2) Control Site 2: car park around the Auckland Museum building, equating to approximately 7900m2 draining to stormwater manhole monitored.

References:

1) ARC TP04104. Sources and loads of metals in urban stormwater. ARC Technical Publication 04104, June 2005

Note that it is unclear whether contaminant yields are calculated using predicted averages or actual concentrations from study.

2) ARC Contaminant Load Model (CLM), May 2006 - Contaminant Yields

Note that the ARC CLM does not specify how the contaminant yields were calculated for the model.

Comparison of contaminant yields for all service stations in the Auckland Region with control sites and published data indicates the following:

Based on average first flush concentrations

- The estimated Cu and Pb yields from service stations in the Auckland Region (both API outlet and NFA) are within the range of Cu and Pb yields for the two control sites, and in the same order as the ranges presented in TP40104 and data representing commercial paved areas and roads in the ARC CLM (for Cu only).
- The estimated Zn yield from service stations in the Auckland Region (both API outlet and NFA) is less than the Zn yield calculated for the two control sites, and within the ranges presented in TP04104 and data representing road runoff in the ARC CLM.
- The estimated TSS yield from service stations in the Auckland Region (both API outlet and NFA) is greater (303 – 360kga^{-1} ha^{-1}) than the TSS yield for the two control sites (138 – 265kga^{-1} ha^{-1}) but within the ranges presented in the ARC TP04104 and significantly less than commercial paved areas other than roads or roof (1000kga^{-1} ha^{-1}) and roads (1500kga^{-1} ha^{-1}) in the ARC CLM model.

Based on average mid storm concentrations

- The estimated Cu yield from service stations in the Auckland Region (both API outlet and NFA) is less than the Cu yield for the two control sites, and less than commercial paved areas and roads in the ARC CLM.
- The estimated Pb and Zn yields from service stations in the Auckland Region (both API outlet and NFA) are comparable with Pb and Zn yields for the two control sites, and within the ranges presented in TP40104 and ARC CLM.
- The estimated TSS yield from service stations in the Auckland Region (both API outlet and NFA) is slightly greater (268 – 381 kga^{-1} ha^{-1}) than the TSS yield for the two control sites (252 -565 kga^{-1} ha^{-1}) but within the ranges presented in ARC TP04104 (252 – 620 kga^{-1} ha^{-1}), and significantly less than commercial paved areas other than roads or roof (1000kga^{-1} ha^{-1}) and roads (1500kga^{-1} ha^{-1}) in the ARC CLM model.

4.5 Other Matters

Table 4.10 provides a summary of Regional stormwater rules and/or standards for TSS management in the Regional plans which are applied by other Regional Councils throughout New Zealand[4]. The comments column provides a general overview of what the standards would mean for service station sites. The range of TSS concentrations measured in discharges from the non forecourt and forecourt areas of the five service station sites in this study are as follows:

- API outlet (5-49 gm^{-3})
- NFA (4 - 69 gm^{-3})

Table 4-10 Stormwater Rules/Standards for TSS

Council	Stormwater Rule /Standard for TSS	Comments
Northland Operative Regional Water and Soil Plan	Permitted stormwater 21.1.2 (e) (v) 100 gm^{-3} TSS	No treatment required if achieving the standard. Council does not control inputs to reticulated systems.
Auckland PARP: ALW	Treatment to achieve 75% reduction in TSS.	Treatment devices in accordance with ARC TP10 required in all circumstances.
Environment Waikato Proposed Regional Plan.	Rule 3.5.11.4 (Permitted into water). Required to meet TSS standards (in Rule 3.2.4.6) which stipulates that an increase in level by 10% or 100gm^{-3} or breach certain receiving water standards requires treatment.	Deemed to comply if discharge meets MfE Guideline. Environment Waikato does not regulate inputs to reticulated systems.
Environment BOP Proposed Regional Land and Water Plan	Rule 30 stormwater to surface. TSS standard either 150 gm^{-3}or more than 80gm^{-3} in the receiving environment.	EBOP does not regulate inputs to reticulated systems.
Taranaki Regional Freshwater Plan	Rule 23 Stormwater into land or water : TSS is 100gm^{-3}	Provisions do not distinguish between inputs to infrastructure as Council wishes to retain ability to control inappropriate inputs, however general practice is not to regulate for inputs into infrastructure.
Gisborne Regional Regional Discharges Plan	Rule 7.3.2. Stormwater no more than 25mg/l above receiving environment. Rule 7.3.2. A (for road construction and maintenance): 200 gm^{-3}or no more than 50 gm^{-3} above receiving environment standard.	Provisions unclear about inputs into reticulated systems, practice is more focused on end of pipe discharges.
Hawkes Bay Resource Management Plan	Rule 42: No permitted TSS standards. Excludes hazardous substance storage. Hazardous substances storage areas area controlled activity.	Council does not control inputs into infrastructure. Hazard substance storage areas are a controlled activity where directly discharging to water. Matters for control do not

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[4] Source: Burton Consultants Limited

Council	Stormwater Rule /Standard for TSS	Comments
		include treatment devices.
Horizons Land and Water Plan	Rule DSW 3. Notes change in visibility by more than 30% in receiving environment.	Not Council practice to control inputs into infrastructure. Industrial and trade premises with Hazardous substance areas need interceptor systems. Excludes Manawatu Catchment where any discharge from industrial and trade is a controlled activity and needs to meet the 30% visibility standard.
Greater Wellington Freshwater Plan	Rule 2 stormwater to surface water is permitted provided no conspicuous change in colour or visual clarity.	Rule 3 of Discharge to Land Plan permits discharges into infrastructure (includes no TSS standard). Both plans allow hazardous substance storage premises provided interceptor in place.
Tasman Tasman Resource Management plan	Rule 36.4.2 (permitted) and 36.4.3A (Controlled) No specific TSS standard.	Council does control inputs into infrastructure.
Nelson Freshwater	FWr 21. Stormwater permitted TSS 100 gm^{-3}.	Inputs controlled by bylaw (which includes refs to MfE Guidelines).
Marlborough Marlborough Sounds MP Wairau Awatere	No specific TSS standard although for discharges from water supply systems must meet 50 gm^{-3} for TSS in 1.11.1 (Wairau Plan)	Inputs not controlled in either plan.
West Coast Water Plan	Rule 12.5.1 No conspicuous change in visual clarity.	Discharge is from reticulated networks. Council does not control inputs into infrastructure.
ECAN Natural resources Plan	Rule 5 and 6. Includes 75% TSS treatment for new areas 500m^2 to 2 ha in a specific BP zone or unprotected areas of ground disturbance for more than 3 months or an area between 2 and 4 hectares elsewhere in the region.	Council does not control inputs into existing infrastructure. Focuses on extension of development. And effectively land development activities
Otago Water Plan	Rule 12.4. Permitted (from a reticulated system) no TSS standard, only visual clarity.	Council practice is not to seek inputs for inputs into infrastructure.
Southland	Permitted in Rule12 and 13 (no TSS standard) although have to meet WQ standards which includes various clarity standards.	Council does not control inputs into infrastructure systems.

The review of statutory rules and regulations conducted by Burton Consultants Limited shows that the concentrations of TSS measured in the API outlet and NFA samples for all five of the sites sampled would be permitted in almost all jurisdictions within New Zealand.

Section 5

Conclusions

The purpose of the study that forms the basis of this report was to investigate and assess the quality of stormwater and sediment at OIEWG company-operated service stations in Auckland Region. At each of five service stations, samples were taken to investigate the quality of:

- stormwater entering the American Petroleum Institute (API) separator;
- treated stormwater discharging from the API separator;
- stormwater discharging from non-forecourt areas of service station sites;
- stormwater discharging from typical public/commercial car parks in the Auckland area; and
- sediment retained in the API device.

Stormwater quality samples were also taken at two control sites.

A single round of stormwater and sediment sampling was conducted at each of the five service station sites and control sites between 12 June 2006 and 12 March 2007.

The following key findings were noted:

Water Quality

The water quality discharging from most of the five service stations monitored exceeded the ANZECC water quality standards for dissolved Zn and dissolved Cu. However, the monitoring results show that the water quality discharging from the API outlet (FF and MS) and NFA (FF and MS) is generally comparable and within the range discharging from the two control sites.

BTEX and PAH concentrations measured in the stormwater samples at all five service stations were either below the analytical laboratory detection limit and/or within the ANZECC water quality standard. The TPH concentrations measured in stormwater samples collected from most sites were below the MfE 1998 criterion of 15 gm^{-3}. A TPH concentration of 15.2 gm^{-3} was measured in the NFA MS sample at Site U. This result is considered to be anomalous, linked to the presence of drainage that is partially non-compliant with the MfE Guidelines.

The TSS concentrations measured in the samples collected from the API inlet and API outlet (both FF and MS) at all five service stations clearly demonstrate the efficiency of the API separator with respect to these contaminants. The TSS concentrations measured for API inlet samples (both FF and MS) were generally a magnitude higher than the TSS concentrations measured at the API outlet.

The TSS concentrations discharging from the API outlet (both FF and MS) at all five service stations were less than the MfE 1998 criterion of $100gm^{-3}$. Furthermore, the TSS concentrations measured in samples from all sites were also less than, or within the range for, TSS concentrations measured at the two control sites, and data representing urban road runoff and car parks in New Zealand.

The effectiveness of the API for TSS treatment was not only demonstrated by the TSS concentrations, but also by the heavy metal concentrations within sediment captured by the API (refer to API inlet results) compared with the concentration of metals exiting the API (API outlet sample). ARC TP10 indicates that API separators are not designed to remove TSS, therefore additional treatment devices would be required (i.e. sandfilters). However, the water and sediment quality data from the five service stations investigated suggests that APIs are effective in trapping TSS (including heavy metals) in the API chamber.

The TSS concentrations discharging from the NFA (both FF and MS) at all five service stations were less than the MfE 1998 criterion of $100gm^{-3}$ and within the range representing urban road runoff and car parks in New Zealand. The review of statutory rules and regulations also indicates that the level of TSS found in the API outlet and NFA samples would be permitted in almost all other jurisdictions within New Zealand.

Section 5 Conclusions

The water quality discharging into the API from most of the five service stations, when compared with the concentrations recorded discharging from NFA's, confirms that the 'high risk activity areas' (i.e. where stormwater containing potentially environmentally hazardous substances are generated) are in fact the forecourt areas of the service station which are serviced by an API at MfE compliant service stations. The sample results for API outlets show that the APIs are effective in reducing concentrations of contaminants to levels that are unlikely to have more than minor effects on the environment.

Sediment Quality

The sediment quality data for all five service station sites shows that all heavy metal and organic (PAH) concentrations were several times lower than those reported for service stations in the ARC TP10 publication (i.e. Table 10.1 which presents sediment quality data found in oil and water separators at U.S. petrol stations relative to other land uses).

Except for Sites U and D, the TPH concentrations measured were within the range presented for service stations in the ARC TP10 publication.

The TPH concentration in API sediments at Site U was higher than those reported for service stations in the ARC TP10 publication. Given that the samples were collected very near the end of the scheduled maintenance interval, the results are considered to reflect the late stage of the cleaning cycle. More importantly, the API outlet stormwater results demonstrate that the API interceptor is effective in containing TPH contaminated sediments.

The sediment sample at Site D was collected approximately one month after the API cleanout. Although the TPH concentration in sediment is elevated, the TPH concentration measured in the API outlet stormwater sample is within the 15 gm^{-3} criterion of MfE 1998, demonstrating the effectiveness of the API in capturing TPH-impacted sediment.

Therefore, regardless of the stage of the cleaning cycle, the API remains effective at capturing TPH contaminated sediments from the forecourt areas of service station sites.

Other Matters

1) Compliance with MfE Site Drainage Requirements

Based on as-built drawings and preliminary site walkovers, site drainage at all five service station sites, appeared to be compliant with Categories 1 to 4 of the MfE service station drainage criteria. However, during sampling and assessment of analysis results, it became apparent that arrangements at two service stations – Sites A and U – deviated to some extent from MfE guideline compliance. It is considered that these non-compliant elements were responsible for elevated stormwater TPH results from the NFAs at both sites.

5) API maintenance and cleaning

API maintenance/cleaning for each of the four OIEWG companies are conducted by Site Care, an independent contractor. The API separators are monitored and cleaned by Site Care following each of the oil company-specific management plans. In general, the API separators are monitored and cleaned every six months. Vacuum tankers are used to remove the sediment build up in the API separators.

6) Annual Estimated Mass Loads from service stations in the Auckland Region.

In general, the estimated metal yields (i.e. Cu, Pb and Zn) from service stations in the Auckland Region (for FF and MS scenario) are comparable with metal yields from the two control sites and yields presented in the ARC publications.

The estimated TSS yields from service stations in the Auckland Region (API outlet & NFA, and FF & MS) are slightly greater than the TSS yield for the two control sites but are within the ranges presented in ARC TP04104 (252 – 620 kga^{-1} ha^{-1}), and significantly less than commercial paved areas other than roads or roof (1000kga^{-1} ha^{-1}) and roads (1500kga^{-1} ha^{-1}) in the ARC CLM model.

Section 5 Conclusions

This report has been prepared by URS New Zealand Limited (URS) on behalf of the Oil Industry Environmental Working Group (OIEWG) and presents the findings of the stormwater and sediment quality monitoring conducted at five service stations (referred to as Site J, Site N, Site U, Site D, Site A) and two control sites (Azda Plaza, Auckland Museum car parks). URS understands that the OIEWG wishes to use the findings of this investigation to review the manner in which Auckland Regional Council (ARC) proposes to regulate service station sites in the Auckland region..

With reference to the Project Background set out in section 1.1 of this report, a number of observations can be made from the investigations carried out by URS. It should be noted that these observations are based on a limited number of samples and are applicable to service stations that are designed, constructed and operated in accordance with the relevant MfE Guideline.

- Physical segregation of forecourt and non-forecourt areas of service stations – Observations made during this investigation confirmed that to a large extent, there is good segregation between forecourt and non-forecourt areas of service stations. These observations were supported by clear differences in analytical quality data for stormwater samples taken from the two types of area, with contaminant loads being significantly higher at the inlet to separators serving forecourt areas than in discharges from non-forecourt areas.
- Quality of stormwater discharges from non-forecourt areas – Results of analysis show that contaminant concentrations - particularly TSS and TPH - in stormwater discharges from non-forecourt areas are similar to concentrations in stormwater discharged from public car parks. Sample results are also in line with the reported ranges contaminant concentrations in urban road runoff in New Zealand. These findings are consistent with observations regarding segregation of forecourt and non-forecourt areas, and with anecdotal evidence suggesting that non-forecourt areas are used predominantly for parking of vehicles rather than for activities with higher associated risk, such as servicing, oil changes etc.
- Capability of API Interceptors to Reduce Contaminant Loads – Analysis results for stormwater and sediment show very clearly that API interceptors installed and maintained in accordance with MfE Guidelines are capable of reducing significantly, concentrations of TSS, hydrocarbon and heavy metal contaminant concentrations in stormwater. Reductions have been found to levels that (i) meet the relevant MfE quality criteria,(ii) are in line with reported figures for urban road runoff, and (iii) in many cases, are lower than the relevant ANZECC guideline concentrations.

  Analysis of sediments from API interceptors indicates that the devices are capable of retaining suspended solids, metals and hydrocarbons to a much greater extent than indicated in ARC Technical Publication 10.

  Observations made during site visits confirmed that API interceptors are being maintained regularly and that this maintenance is critical to efficient retention of contaminants in the contained water and sediment.

From these observations, two key conclusions can be drawn:

Conclusion 1 – Non-forecourt areas of service stations are relatively ‘low risk’ in terms of stormwater contaminant generation, presenting no more risk to stormwater than typical public car parks or urban roads. Consequently, the oil industries focus on segregation of forecourt and non-forecourt areas, and on providing treatment only for discharges from forecourt areas, is appropriate.

Conclusion 2 - API interceptors that are designed, installed and maintained in accordance with MfE Guidelines provide appropriate treatment for forecourt stormwater runoff, reducing contaminant concentrations to levels that meet relevant criteria and are consistent with concentrations in public car parks and urban road runoff

Section 6 References

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Section 7

Limitations

URS New Zealand Limited (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Oil Industry Environmental Working Group and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in proposal dated 17 November 2005 (stormwater component) and 8 February 2006 (sediment sampling component).

The sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between November 2005 and February 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

The following specific project limitations are noted:

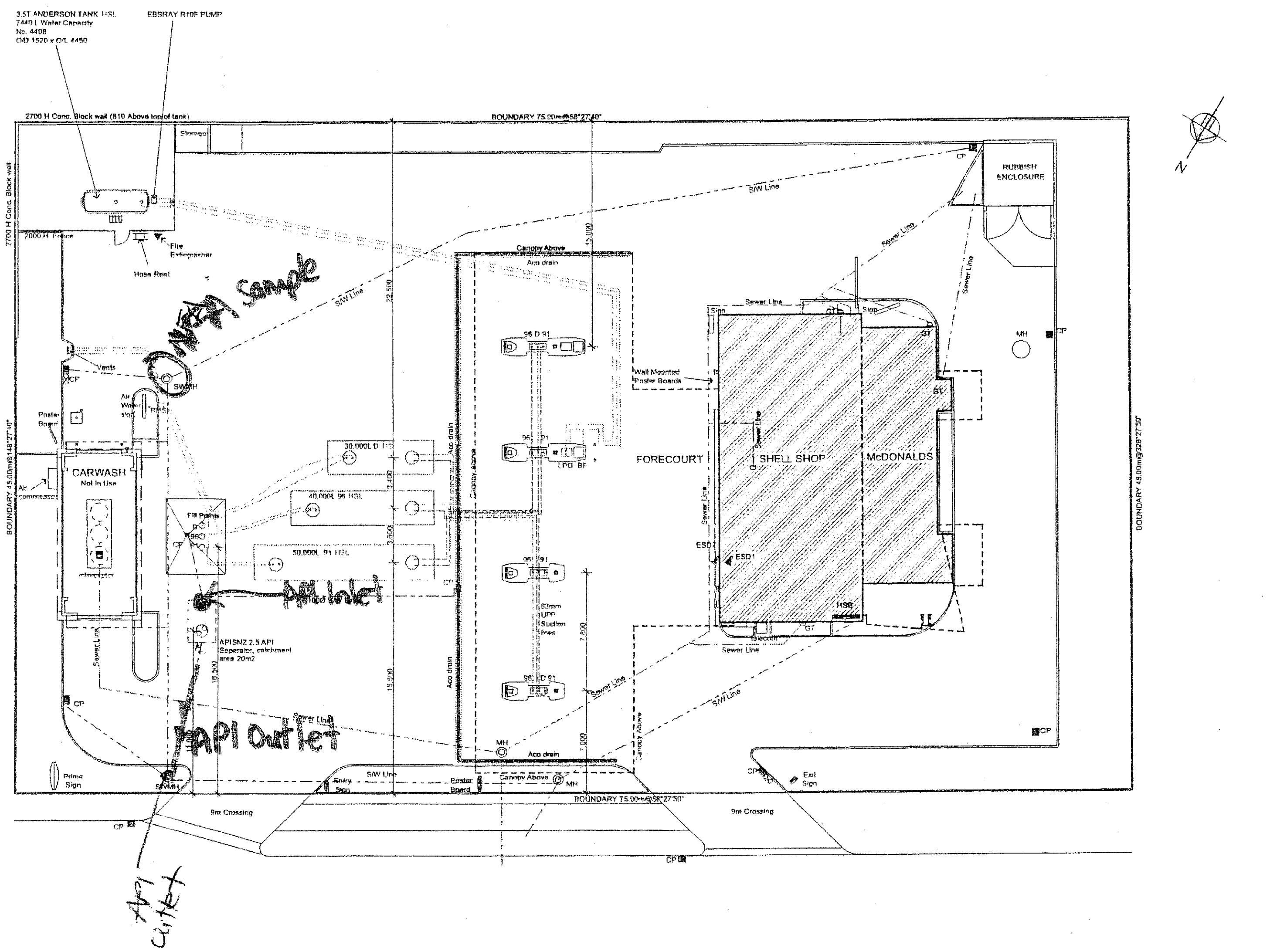
- Only one set of samples was collected from each service station and control sites - A greater number of samples at each site would enable further statistical analysis and understanding of sample variability to be determined.
- Control site and service station samples were collected on different days under different storm events which means that contaminant concentrations are likely to vary depending on the scale of storm event, therefore results are tentatively comparable.
- Control site drainage areas are significantly greater than the service station site non-forecourt drainage areas and total service station areas. Therefore, the mass load of contaminants draining from the control sites will be greater over the same rainfall period.

Appendix A

Stormwater and Sediment Sampling Protocol

Appendix B

As-buit Plans for Selected Sites



TANKAGE AND PIPING TABLE

TANK TYPE	TANK CAPACITY AND PRODUCT	DATE	TANK DEPTH	FILL	SPILL CONTAINER	OVERFILL VALVES	CATHODIC PROTECTION		ISO VALVE AT TANK	SAFE SUCTION	FILL LINES		SUCTION LINES		VENT LINES		PUMP SUMP
							INSTALLED	TYPE			MATERIAL	DATE	MATERIAL	DATE	MATERIAL	DATE	
Steel	50,000ltr 91	1992		Remote 03	Yes	Yes	Yes	Sacrificial Anode	Yes	Yes	UPP	2003	UPP	2003	UPP	2003	Yes
Steel	40,000ltr 91	1992		Remote 03	Yes	Yes	Yes	Sacrificial Anode	Yes	Yes	UPP	2003	UPP	2003	UPP	2003	Yes
Steel	30,000ltr 96	1992		Remote 03	Yes	Yes	Yes	Sacrificial Anode	Yes	Yes	UPP	2003	UPP	2003	UPP	2003	Yes

REFERENCE DRAWINGS

DWG NO	DRAWING TITLE
Z01	1_105144_05_Z_SHA_01
Z02	1_105144_05_Z_SHA_02

GENERAL NOTES

- Contractor shall verify all data on site prior to commencing any work.
- Do not reproduce any standard drawing before checking latest drawing revision with Shell H.O. engineering division.
- All underground plant shown assumed position only. Location should be determined on site.
- Boundaries unless specified with bearing and dimension are best approximation from current known information for HSNO puposes only.
- This drawing has been produced for the "Hazardous Substances & New Organisms Act 1996" and includes all relevant documents and supersedes drawing 1_105144_04_U_JCY_01, 1_105144_01_D_SNZ_01
- Site checked Don Robertson , 05/05/05

LEGEND:

Power & Comms
Air
Water
Ducts
Sewer
[illegible]
Suction Lines
Fill Lines
Vent Lines
LPG
CNG
MH = Manhole
CP = Catchpit
SV = Stop valve
BP = Backflow preventer
DP = Down pipe
GT = Gully trap
Terminal Vent
Emergency Stop
Monitoring Well
Main Switchboard
HSL = Hazardous Substance Location

A - 12/05/2005 - As Built For HSNO
Revisions

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PH (09) 309 9660
FX (09) 309 9661

SHELL NEW ZEALAND LTD
3 QUEENS WHARF, PO BOX 2091
WELLINGTON, NEW ZEALAND
TELEPHONE: 0800 474 355

drawn: J. Lee
date: March 2005
checked: M. Finlay
scale: 1:150 @ A1 1:300 @ A3

Site A

shell ref 1_105144_05_U_SHA_01
SHA Ref 04044
sheet U01
revision A

NOTES

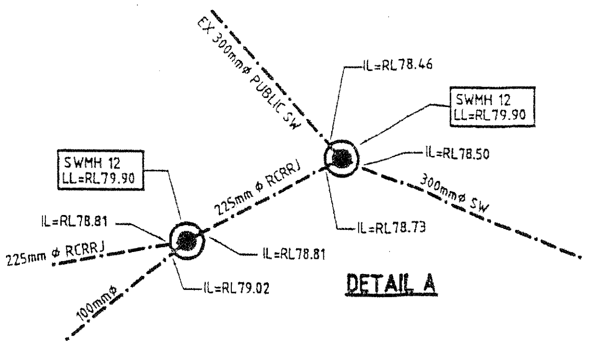
1. CO-ORDINATES ARE IN TERMS OF MT EDEN GEODETIC DATUM 1949 - 300,000mE 700,000mN. LEVELS ARE IN TERMS OF LINZ SURVEY DATUM.
2. REFER TO DWG NZL01-012050-C01 FOR SITE SERVICES PLAN.
3. REFER TO DWG NZL01-012050-C03 FOR GRADING PLAN.
4. REFER TO DWG NZL01-012050-C07 FOR DRAINAGE LONGSECTIONS.
5. REFER TO DRG-STD-NZL-C001 AND C002 FOR API SEPARATOR DETAILS
6. REFER TO DRG-STD-NZL-C009 FOR CESSPIT, PIPE AND MANHOLE DETAILS
7. ALL uPVC PIPES TO BE CLASS 'C'
8. ALL DISUSED PIPE CONNECTIONS HAVE BE SEALED OFF AT EXISTING MANHOLES.
9. NEW 1050Ø CONCRETE MANHOLE CHAMBER WITH HEAVY DUTY LID AND FRAME LID LEVEL TO MATCH FINISHED GROUND LEVEL INLET SOFFIT 75mm ABOVE OUTLET SOFFIT. OUTLET SOFFIT TO MATCH EXISTING WHERE APPLICABLE.
10. ALL 160Ø uPVC SANITARY SEWER PIPES ARE LAID AT A MINIMUM OF 1.0% GRADE.
11. ALL 110Ø uPP PIPES ARE LAID AT A MINIMUM OF 1.2% GRADE.
12. ALL 110Ø uPVC SW PIPES ARE LAID AT A MINIMUM OF 1.2% GRADE
13. ALL 160Ø uPVC SW PIPES ARE LAID AT A MINIMUM OF 1.0% GRADE.
14. ALL 225Ø uPVC SW PIPES ARE LAID AT A MINIMUM OF 1.0% GRADE.
15. ALL CESSPITS ARE 675x450 CONCRETE PRECAST UNITS WITH HEAVY DUTY FRAME AND GRATE. (REFER TO DWG-STD-NZL-009)
16. SAND FILTER IS APPROVED BY ARC AND COMPLIES WITH TP10 STANDARD. SIZE OF SAND FILTER CATCHMENT IS APPROX. 0.155ha EQUIVALENT TO 31.5m WQV. TWL=81.4mAD MAX. AVAILABLE HYDRAULIC HEAD=1.5m.
17. ALL PIPEWORK OVER 200ΦID ARE RCRRJ CLASS 2 PIPES.

SERVICES DISCLAIMER

EXISTNG SERVICES ARE BASED ON INFORMATION PROVIDED BY THE RESPECTIVE SERVICE PROVIDER AND ARE ASSUMED TO BE INDICATIVE ONLY. PRIOR TO ANY WORK COMMENCING ON SITE, THE CONTRACTOR IS TO VERIFY THE LOCATION OF ALL EXISTING SERVICES AND LIASE WITH THE ENGINEER ACCORDINGLY

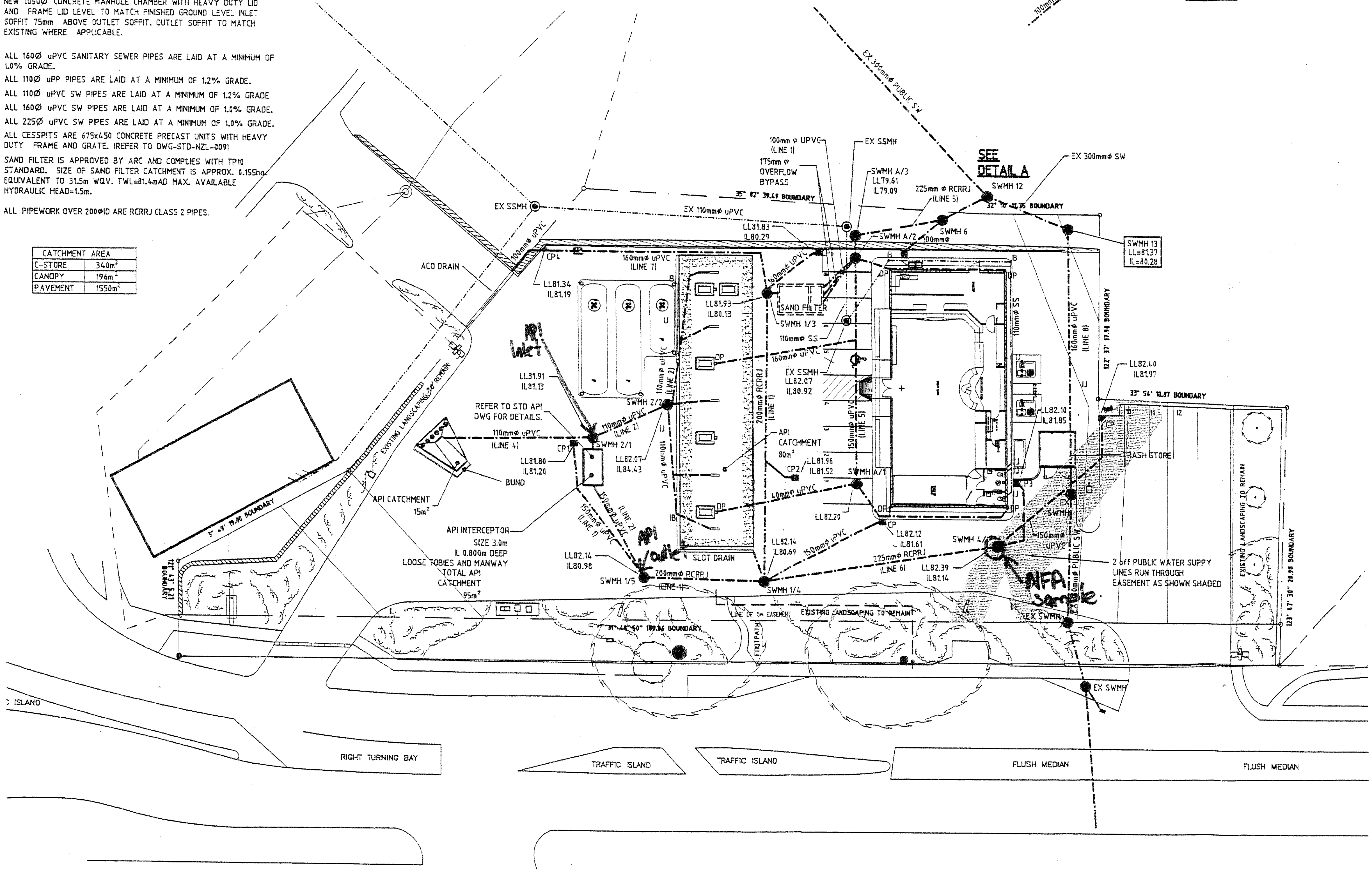
LEGEND

— · — · —	EX STORMWATER
— · — · —	EX PUBLIC STORMWATER
— · — · —	EX SANITARY SEWER
— · · — · · —	EX PUBLIC SANITARY SEWER
◉	MANHOLE
■	CESSPIT



DETAIL A

CATCHMENT AREA	
C-STORE	340m²
CANOPY	196m²
PAVEMENT	1550m²



NO	DATE	REMARKS	APP. BY
5	01.07.05	AS BUILT DRAWING	TJ
4	01.06.05	ISSUED FOR CONSTRUCTION	TJ
3	25.04.05	SAND FILTER MODS	TJ
2	14.04.05	ISSUED FOR CONSTRUCTION	TJ
1	04.04.05	ISSUED FOR CONSTRUCTION	TJ
0	01.04.05	ISSUED FOR CONSTRUCTION	TJ
A	18.03.05	ISSUED FOR RESOURCE CONSENT	TJ

Revision

Mobil Oil
New Zealand
Limited

Building Certifications :

"I HEREBY CERTIFY THAT THIS WORK HAS BEEN REVIEWED BY ME IN ACCORDANCE WITH SOUND ENGINEERING PRACTICE AND LOCAL REGULATORY REQUIREMENTS.

CONSULTANT SIGNATURE

SINCLAIR KNIGHT MERZ
SKM
SINCLAIR KNIGHT MERZ SDN. BHD. (503342-K)
SUITE E-15-02, LEVEL 15, BLOCK E,
PLAZA MONT' KIARA, NO. 2, JALAN KIARA,
MONT' KIARA, 50480 KUALA LUMPUR.
TEL : +603-6284 6688
FAX : +603-6204 6772

Country :
NEW ZEALAND

Site D

Site Address :

Building Type :
2900/2005

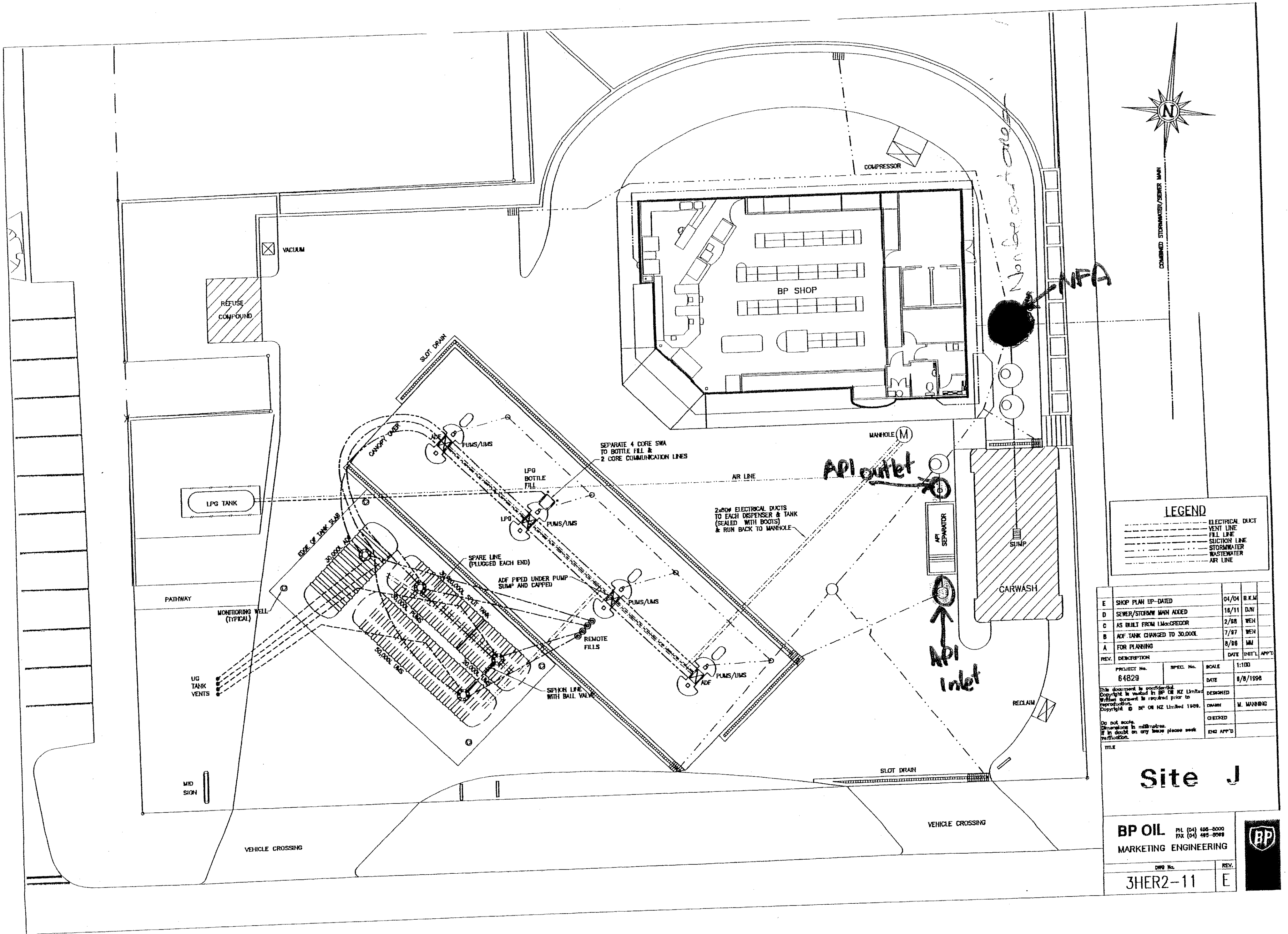
NORTH

Drawing Title :
DRAINAGE
LAYOUT PLAN

ISSUED FOR AS BUILT

SCALE	1:200(A1) 1:400(A3)
DRAWN BY	GARY HO
CHECKED BY	SIMON
DESIGNED BY	SIMON
DESIGN CHECKED BY	SIMON
CDO MANAGER	TJ

DRAWING NO. :	REV. NO.
DRG-DES-NZ01-002077-C16	5



LEGEND

- ELECTRICAL DUCT
- VENT LINE
- FILL LINE
- SUCTION LINE
- STORMWATER
- WASTEWATER
- AIR LINE

REV.	DESCRIPTION	DATE	INIT'L	APP'D
E	SHOP PLAN UP-DATED	04/04	B.K.M	
D	SEWER/STORMW MAIN ADDED	16/11	DJW	
C	AS BUILT FROM I.MacGREGOR	2/98	WEN	
B	ADF TANK CHANGED TO 30,000L	7/97	WEN	
A	FOR PLANNING	8/96	MM	

PROJECT No. 64829	SPEC. No.	SCALE	1:100
		DATE	8/8/1996
		DESIGNED	
		DRAWN	M. MANNING
		CHECKED	
		ENG APP'D	

Do not scale.
Dimensions in millimetres.
If in doubt on any issue please seek verification.

TITLE

Site J

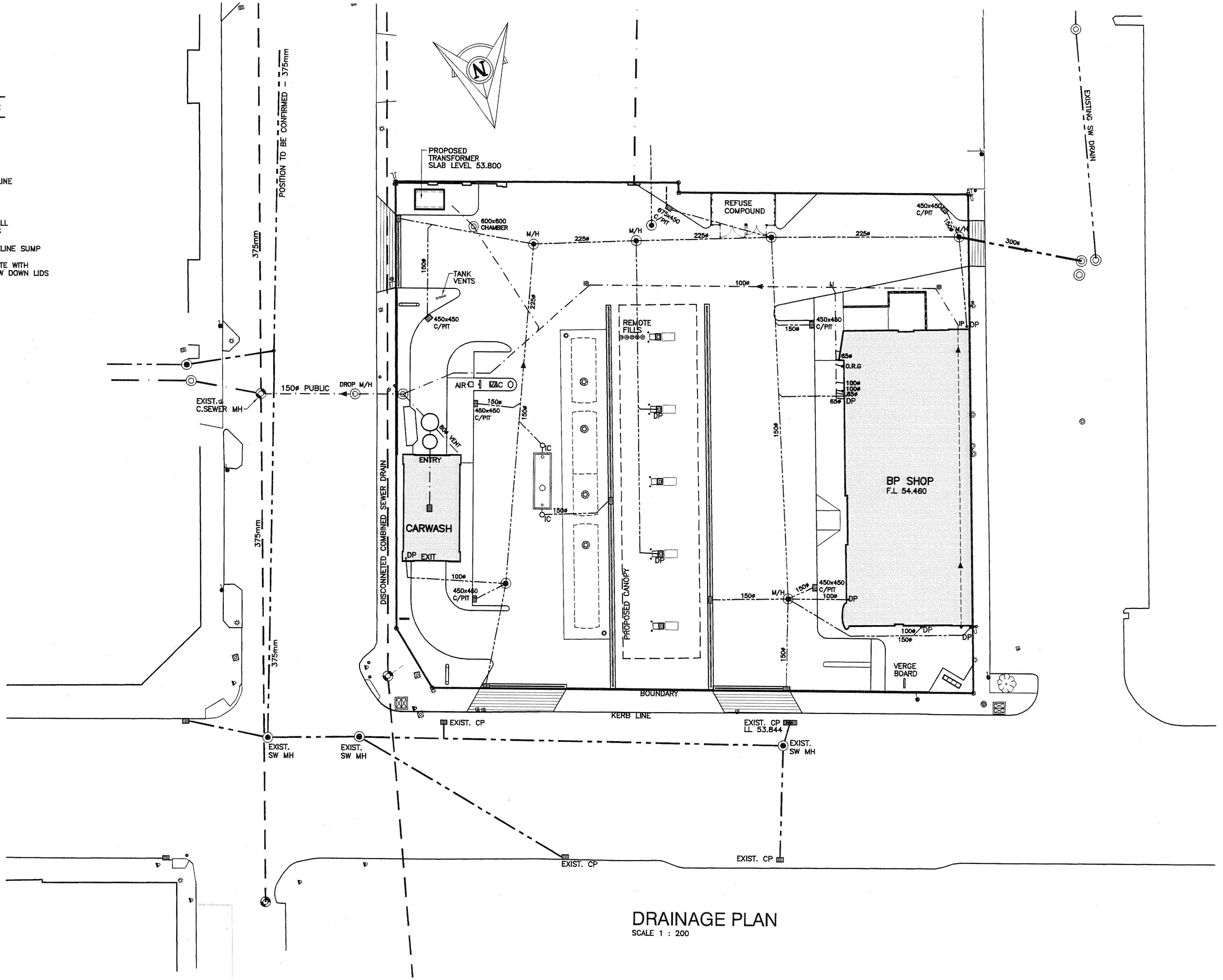
BP OIL PH. (04) 495-5000
FAX (04) 495-5099
MARKETING ENGINEERING

DWG No. 3HER2-11
REV. E

DRAINAGE LEGEND:

- EXISTING COMBINED SEWER
- EXISTING SANITARY SEWERLINE
- EXISTING FOUL DRAINS
- EXISTING STORMWATER SEWERLINE
- EXISTING STORMWATER DRAINS
- EXISTING 100mmø NOVA FLO SUBSOIL DRAINS LAID WITH FALL OF 1in180 MIN INTO CESSPITS
- ACO CHANNEL DRAINS WITH INLINE SUMP
- ○ IC INSPECTION CHAMBER COMPLETE WITH HEAVY DUTY CAST IRON SCREW DOWN LIDS
- MANHOLE – COMBINED SEWER
- ◎ MANHOLE – WASTEWATER
- ◉ MANHOLE – STORMWATER

LEVELS IN TERMS WITH DOSLI DATUM.
ORIGIN OF LEVELS IS SS M180
SO 50693, RL 54.055m



DRAINAGE PLAN

SCALE 1 : 200

5 0 5 10 15
SCALE 1:200

Rev:	Description:	Date:
A	AS BUILT DRAINAGE	24/05/01

BP Oil NZ Limited Ref No.:
3NM2-111-A

DO NOT SCALE
DIMENSIONS IN MILLIMETRES
IF IN DOUBT ON ANY ISSUE PLEASE SEEK VERIFICATION

Scale:	1:200 1:100
Date:	24/05/01
Designed:	M.T.KEOGH
Drawn:	L.N.MEIKLEJOHN
Checked:	
Plot Scale:	A1–1:1 A3–1:2

Project Title:
Site N

Drawing Title:

Drawing prepared by:
TECHNITRADES LIMITED
12 BEN LOMOND CRES.
PAKURANGA, AUCKLAND
PH/FAX (09) 576-7166

on behalf of:
BP OIL
MARKETING ENGINEERING
PO BOX 892, WGTN
PH. (04) 495-5000
FAX (04) 495-5599

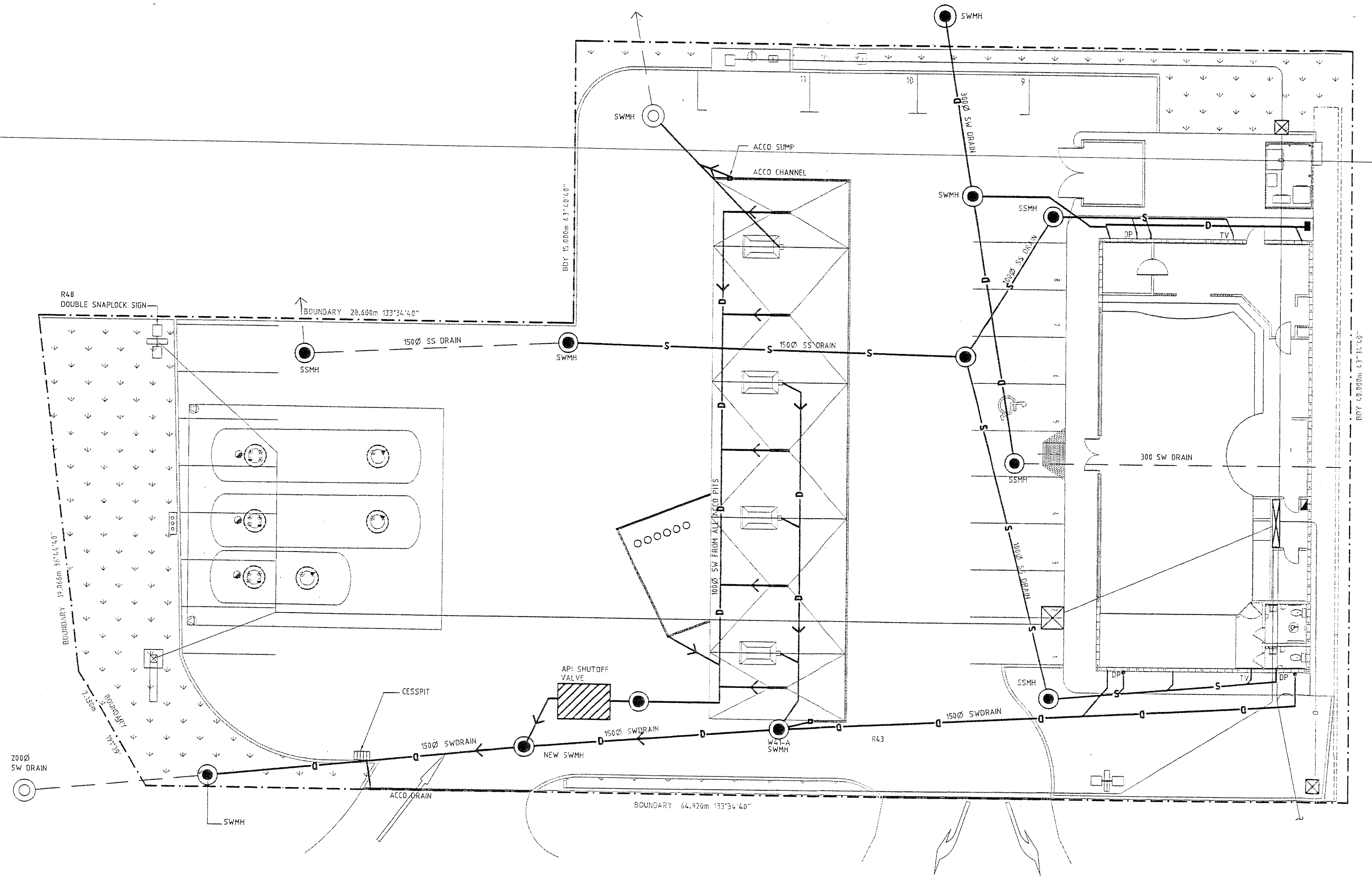
Technitrades Drawing No. :
1 OF 1 1819-Asb-Dr

Rev No. :
A

bp

LEGEND

— · — · —	BOUNDARY LINE
— — — —	STORMWATER TO REMAIN
— — — —	SANITARY SEWER TO REMAIN
——s——	SANITARY SEWER
——D——	STORMWATER
◉	MANHOLE (REFER NOTE 10)
■	CESSPIT
◠	GULLY TRAP
◎	MANHOLE



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NO	DATE	REMARKS	APP. BY
3	01.03.05	ISSUED ASBUILT	TJ
2	22.02.05	ISSUED ASBUILT	TJ
1	10.09.04	ISSUED FOR CONSTRUCTION	TJ
0	03.09.04	ISSUED FOR CONSTRUCTION	TJ
A	APRIL 04	ISSUED FOR BUILDING CONSENT	TJ

Revision

Mobil Oil
New Zealand
Limited

Building Certifications :

"I HEREBY CERTIFY THAT THIS WORK HAS BEEN REVIEWED BY ME IN ACCORDANCE WITH SOUND ENGINEERING PRACTICE AND LOCAL REGULATORY REQUIREMENTS.

CONSULTANT SIGNATURE

SINCLAIR KNIGHT MERZ
SKM

SUITE E-15-02, LEVEL 15, BLOCK E,
PLAZA MONT' KIARA, NO. 2, JALAN KIARA,
MONT' KIARA, 50480 KUALA LUMPUR.
TEL : +603-6204 6688
FAX : +603-6204 6772

Country :
NEW ZEALAND

Site R

Building Type :
2900/2004

NORTH

Drawing Title :
DRAINAGE PLAN

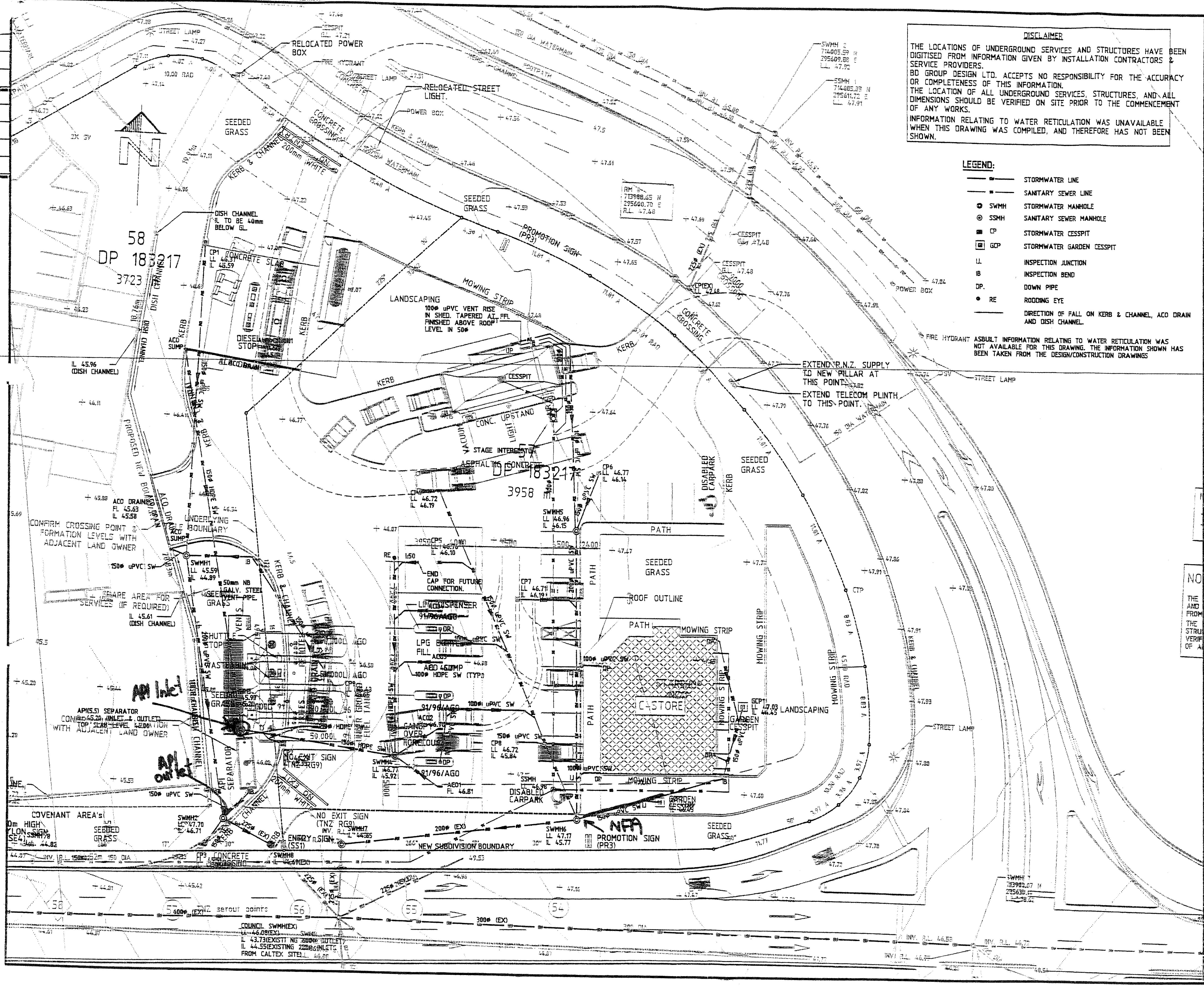
ISSUED FOR : AS BUILT

SCALE	1:250 (A3) & 1:125 (A1)
DRAWN BY	GARY HO
CHECKED BY	TLH
DESIGNED BY	TLH
DESIGN CHECKED BY	
CDO MANAGER	TJ

DRAWING NO. : DRG-DES-NZ01-002030-C05
REV. NO. 3

I:\PM00019 - XoM Asia Pacific\RM - Regional Program Mgnt\11 Site Information\11-03NZ- New Zealand\NZ2005 Royal Heights- D&R\CAD\asbuilt\DRG-DES-NZ01-002030-C05.dwg, 3/1/2005 4:06:18 PM, Jaws PDF Creator

SCALE WITH CAUTION
THIS DRAWING MAY HAVE DEFORMED DURING REPRODUCTION



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THE LOCATION OF ALL UNDERGROUND SERVICES, STRUCTURES, AND ALL DIMENSIONS SHOULD BE VERIFIED ON SITE PRIOR TO THE COMMENCEMENT OF ANY WORKS.
INFORMATION RELATING TO WATER RETICULATION WAS UNAVAILABLE WHEN THIS DRAWING WAS COMPILED, AND THEREFORE HAS NOT BEEN SHOWN.

LEGEND:

—SW—		STORMWATER LINE
—SS—		SANITARY SEWER LINE
●	SWMH	STORMWATER MANHOLE
⊙	SSMH	SANITARY SEWER MANHOLE
■	CP	STORMWATER CESSPIT
▣	GCP	STORMWATER GARDEN CESSPIT
IJ.		INSPECTION JUNCTION
IB		INSPECTION BEND
DP.		DOWN PIPE
•	RE	RODDING EYE
——		DIRECTION OF FALL ON KERB & CHANNEL, ACO DRAIN AND DISH CHANNEL.

ASBUILT INFORMATION RELATING TO WATER RETICULATION WAS NOT AVAILABLE FOR THIS DRAWING. THE INFORMATION SHOWN HAS BEEN TAKEN FROM THE DESIGN/CONSTRUCTION DRAWINGS

GENERAL NOTES

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2. CONTRACTOR SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS ON SITE.
3. ARCHITECTS TO BE NOTIFIED OF ANY VARIATION BETWEEN SITE DIMENSIONS AND THOSE ON PLANS.
4. THIS DRAWING IS THE PROPERTY OF CALTEX OIL (NZ) LIMITED AND MUST NOT BE USED, COPIED OR REPRODUCED IN WHOLE OR PART WITHOUT PRIOR WRITTEN PERMISSION.
5. THIS DRAWINGS TO BE READ IN CONJUCTION WITH ALL CONSULTANTS DRAWINGS AND SPECIFICATIONS.

REV.	BY	DATE	DESCRIPTION OF CHANGE	CHKD	APP.
A	N.G.B.	11/2001	ASBUILT DIMENSIONS		

REVISIONS

CALTEX

BD GROUP
DESIGN
LIMITED
23 Westminster Road
Mt. Eden, Auckland
Tel 64 09 638 7766
Fax 64 09 638 7766
dave@bdgroup.co.nz

APPROVALS	INITIALS	DATE
CWC		

CAD DRAWING-DO NOT REVISE BY HAND

Site U

ASBUILT SITE SERVICES LAYOUT PLAN

DRAWN N.G.B.	DATE 11/2001	DESIGNED	DATE
CHECKED	DATE	APPROVED	DATE
PLOT SCALE 1:1	DWG. SCALE 1:200 A1	CAD FILE No. 1508ABS02	
JOB No. 1508	DRAWING No. 1508ABS02		REV. A

Appendix C

Field Sheets

Appendix D

Laboratory Analytical Results

Auckland Wellington Christchurch

PATTLE DELAMORE PARTNERS LTD

Stormwater Treatment Devices Monitoring at Representative Z Service Stations in the Auckland Region

Z Energy Limited

***solutions** for your environment*

Stormwater Treatment Devices Monitoring at Representative Z Service Stations in the Auckland Region

Prepared for

Z Energy Limited

October 2013

PATTLE DELAMORE PARTNERS LTD
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235 Broadway, Newmarket, Auckland 1023
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Auckland Wellington Christchurch

solutions *for your environment*

Quality Control Sheet

TITLE	**Stormwater Treatment Devices Monitoring at Representative Z Service Stations in the Auckland Region**
CLIENT	Z Energy Limited
VERSION	Final
DATE	25 October 2013
JOB REFERENCE	A02579800
SOURCE FILE(S)	A02579800_R001

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE

Hayden Easton

Reviewed by

SIGNATURE

Roger Seyb

Approved by

Keith Delamore

Limitations:

This report has been prepared on the basis of information provided by Z Energy. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information. This report has been prepared by PDP on the specific instructions of Z Energy for the limited purposes described in the report. PDP accepts no liability to any other person for their use of or reliance on this report, and any such use or reliance will be solely at their own risk.

Sampling of water and sediment has been carried out under existing conditions at several service stations under synthetic rainfall conditions modelled using water sprinklers. The results obtained are based on these conditions and could change under different conditions in the treatment devices or under natural rainfall.

The laboratory test results provide an approximation of the concentration of petroleum hydrocarbon compounds and geochemical parameters and are subject to the inherent limitations of the laboratory techniques used for the tests.

PDP has sampled and tested only for those chemicals that are described in this report. The presence or absence of other chemicals at the site is not considered in this report.

Executive Summary

Z Energy service stations have a variety of stormwater treatment devices, ranging from American Petroleum Institute oil-water separators (API), to three and two stage oil-water interceptors. The principal purpose of these installed stormwater treatment devices is to treat stormwater discharges to minimise the potential discharge of contaminants to the environment. The purpose of this project was to determine the typical sediment and water quality performance achieved by these devices. Five Z Energy service stations and two high use commercial/recreational car parks (control sites) were used in this study.

The project methodology was carried out using methods that are in accordance with the Auckland Council's Proprietary Device Evaluation Protocol (Wong *et al*, 2012) and stormwater device technical specifications (Humes, 2006).

Sediment samples were obtained and analysed for the following parameters: heavy metals, polycyclic aromatic hydrocarbons, BTEX, and total hydrocarbons. Water quality samples were obtained and analysed for the following parameters: heavy metals, polycyclic aromatic hydrocarbons, BTEX, total suspended solids (TSS) and total hydrocarbons. In addition, water quality was also analysed with a handheld water quality meter for the following parameters: temperature, dissolved oxygen, pH, electrical conductivity, and oxygen reduction potential. The above analysed contaminant suite is considered appropriate given the vehicle related activities that occur at the Z service stations.

In general, for the sampling events carried out, water quality results identified that the stormwater treatment devices are achieving the effluent discharge requirements of water quality guidelines i.e. Auckland Regional Council Technical Publication 10 (ARC, 2003), and the Ministry for the Environment publication 'Guidelines for Water Discharges from Petroleum Industry Site in New Zealand' (MfE, 1998).

Sediment sampling was carried out in the primary catch pit to the stormwater network, or the primary chamber of the treatment device at each site. All rainfall events used in this project were synthetically generated. Rainfall was produced by applying water (sourced from a fire hydrant) via sprinkler across the sample drainage area. The rainfall intensity applied at each site depended upon the type and size of the device present. Water quality sampling involved the collection of first flush water and discharges at intervals of 10 and 30 minutes after the collection of the first flush sample.

A key driver of the quantity of sediment captured is the extent of landscaped areas adjacent to and within the service stations. Catch pits and oil water separators/interceptors are capturing high concentrations of these contaminants.

Contaminant concentrations obtained from within forecourt drainage areas, were commonly greater than non-forecourt drainage areas. Removal of accumulated sediments within catch pits/treatment devices should be based on the rate at which the potential contaminant load is produced within the site.

Oil water separators (API's) achieved a TSS removal performance of between 72% and 42% for the events sampled. The three stage oil water interceptor produced a TSS removal performance of 54% for the event sampled. All sites complied with MfE (1998) guidelines by achieving an average effluent discharge of 100 mg/L TSS for the duration of the design storm.

It is important to recognise that the actual TSS loads discharging into the devices were low. Similar studies on treatment devices such as Upflo filters show comparable performance at low sediment loads.

All stormwater discharges from the service stations that were assessed had TPH concentrations less than the required MfE (1998) discharge standard (15 mg/L).

The site effluent discharge concentrations of copper, zinc, and chromium in the water column often exceeded ANZECC (2000) 95% protection level triggers. Copper and zinc protection levels were commonly exceeded in both control car parks also. This result is expected due to the vehicular activities present at the sites. For the events monitored, dissolved heavy metal concentrations are greatest in non-forecourt areas.

In comparison to other similar studies (URS, 2008), mass loads obtained in this project were considered to be similar.

Table of Contents

Table of Figures

Table of Tables

Appendices

1.0 Introduction

Z Energy Limited (Z) has engaged Pattle Delamore Partners Limited (PDP) to obtain information to define the stormwater discharge quality from forecourt and non-forecourt areas of Z service stations.

Z service stations have a variety of stormwater treatment devices, ranging from American Petroleum Institute oil-water separators (API), to three and two stage oil-water interceptors. The principal purpose of these installed stormwater treatment devices is to minimise the discharge of separate phase hydrocarbons arising from fuel spillage on the forecourt. A secondary beneficial effect of the interceptors is the capture of sediment run-off from the forecourt areas. The devices are also required to meet water quality requirements set out in resource consents and regional plans. Typically this means meeting discharge quality criteria as described by Auckland Regional Council Technical Publication 10 (ARC, 2003), and the Ministry for the Environment publication ‘Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand’ (MfE, 1998).

1.1 Project Objectives

The objectives of this project are to understand:

- The design, operation, performance and achievable water quality discharge from the various types of stormwater treatment devices (oil-water separators/interceptors) located at Z service stations;
- The physical segregation of forecourt (areas that provide for the dispensing of petroleum products) and non-forecourt areas (areas that do not provide for the dispensing of petroleum product) of service stations;
- The activities that take place in non-forecourt areas of Z service stations;
- The quality of stormwater discharges from non-forecourt areas of service stations; and
- The quality of stormwater discharges from representative control drainage areas, so to allow comparative assessments to be made with Z service stations.

1.2 Project Scope of Works

In order to achieve the above project objectives, the following project scope of works were carried out:

- Identification of five Z service stations that are regarded as ‘typical’ in the Auckland region. In this context, ‘typical’ relates to the size of the service station, the traffic volume through the station, and the potential generation of stormwater and sediment contaminants.
- Collection of stormwater samples from the selected five service station sites, which demonstrate the quality of:
    - stormwater influent entering the stormwater treatment device;
    - treated stormwater effluent discharging from the stormwater treatment device; and

  - stormwater discharging from non-forecourt areas at each of the five service stations.
- Collection of stormwater samples from two control sites, where control sites represent typical public/commercial car parks.
- Collection of sediment samples from the primary treatment device chamber (either a pre-treatment catchpit, or the primary chamber of the stormwater treatment device) at each of the selected service stations to determine the quality of sediment retained within the footprint of Z service stations.
- Collection of sediment samples from non-forecourt areas at each of the five service stations.
- Collection of sediment samples from two control sites, where control sites represent typical public/commercial car parks.
- Assessments of each of the selected service station sites to determine, to the extent necessary, whether on site drainage systems comply with the 'Guidelines for Water Discharges from Petroleum Industry Site in New Zealand, Ministry for the Environment, 1998' (the MfE Guidelines).
- Calculation of the total approximate annual contaminant yield from the monitored Z service stations.
- Preparation of a report detailing the findings of the investigation.

1.3 Report Structure

The following report has been structured in the following key sections:

- Introduction; a brief summary of the project purpose.
- Relevant guidelines; an assessment of relevant local and national guidelines that are relevant to this project.
- Site selection; a discussion on the sites used in this project and the process as to how they were selected.
- Sampling methodology; a step by step discussion on the methodology used to obtain the relevant datasets.
- Results; detail on the results obtained during the project.
- Discussion; an analytical discussion on the results obtained, and what they imply.
- Conclusion; a summation of key project findings.

2.0 Consenting Framework and Relevant Guidelines

The following section provides a discussion on the consenting framework by which Z service stations (or any service station) are assessed. Also discussed, are the relevant guidelines to which Z service stations are required to comply, to meet the given consenting framework. Information is given regarding the individual standards and how these standards are to be monitored.

2.1 Consenting Framework

The consenting framework for stormwater discharges which Auckland service stations are required to achieve is a combination of industrial trade activity rules (Rules 5.5.14 to 5.5.19 of the Auckland Council Plan: Air, Land, and Water) and stormwater discharge rules (Rules 5.5.1 to 5.5.5 of the Auckland Council Plan: Air, Land, and Water and Chapter H (Natural Resources) Rules 4.8 of the proposed Auckland Unitary Plan). The relevant rules differ in relation to the differing activities that occur within the forecourt (an industrial trade activity area) and the non-forecourt (stormwater discharge area).

The differing rules associated with the various areas within a service station leads also to differing discharge standards. For the forecourt area (the industrial trade activity area) stormwater discharges are commonly required to meet the standards provided by MfE (1998). The non-forecourt area however, is commonly required to meet the discharge standard defined within Auckland Council Technical Publication 10.

Discussion of each of these documents, as well as other relevant documents that are also commonly referenced, is provided in the following sections.

2.2 Ministry for the Environment

The Ministry for the Environment publication ‘Guidelines for Water Discharges from Petroleum Industry Site in New Zealand’ (MfE, 1998) provides guidelines to assist petroleum industry site owners to ensure water discharges from their sites meet the water quality objectives in regional policy statements and plans.

The two key objectives that stormwater discharge effluent quality is required to achieve are:

- An average 100 mg/L Total Suspended Solids for the duration of the design storm.
- An average 15 mg/L Total Petroleum Hydrocarbons for the duration of the design storm.

2.3 Auckland Council

2.3.1 Technical Publication 10 (TP10)

Technical Publication 10 (TP10) is the Auckland Council’s guidance manual for the design of stormwater treatment devices within the Auckland region. Chapter 13 of TP10 provides specific guidance for the design and management of oil-water separators.

The key design criterion of TP10 for discharge quality from oil-water separators is the removal of oil and grease down to 15 mg/L using a 15 mm/hr rainfall intensity.

2.3.2 Proprietary Device Evaluation Protocol (PDEP)

The Proprietary Device Evaluation Protocol (PDEP) (Wong *et al.*, 2012) provides guidance to local and international proprietary device manufactures on how stormwater proprietary devices may become Auckland Council verified. A verified device may then be used by consent holders as a device that meets TP10 water quality objectives, i.e. by utilising a verified stormwater treatment device for an activity that requires consenting, the Auckland Council will have confidence/knowledge of the discharge quality that can be achieved.

Whilst Z are not seeking to achieve verification of the stormwater treatment devices that are present at their service stations, the PDEP however does provide discussion on the stormwater monitoring methodologies that may be used to assess the performance of proprietary devices, e.g. synthetic storm generation, manual grab sampling techniques, and laboratory analysis methods and these have been considered in this study.

2.4 Australia New Zealand Environment and Conservation Council (ANZECC)

The Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) provide discharge water quality trigger values for both freshwater and marine receiving environments. ANZECC (2000) also provides sediment quality guidelines.

For each receiving environment (be it freshwater or marine), ANZECC (2000) provides a range of different water quality trigger values for a level of protection that must be observed within the given receiving environment e.g. a 99% protection level is for a unmodified receiving environment with high conservation/ecological value, 95% or 90% protection is given for receiving environments with slightly to moderately disturbed systems where aquatic diversity may have been adversely affected, whilst a 80% protection level is provided for highly disturbed receiving environment of low ecological value. For the purposes of this project, monitoring results will be compared to the 95% level of protection, as well as the 80% level of protection. The former has also been selected to be consistent with similar service station assessments that have previously been carried out (URS, 2008)

Table 1 below presents the 95% and 80% level of protection trigger values (for freshwater receiving environments) for the parameters that were assessed in this project.

Table 1: ANZECC (2000) 95% and 80% Protection Level trigger values for Freshwater Receiving Environments

Parameter	Units	ANZECC (2000) 95% Protection trigger value	ANZECC (2000) 80% Protection trigger value
Naphthalene	g/m^3	0.016	0.085
Dissolved Arsenic	g/m^3	0.013	0.140
Dissolved Cadmium	g/m^3	0.0002	0.0008
Dissolved Chromium	g/m^3	0.001	0.040
Dissolved Copper	g/m^3	0.0014	0.0025
Dissolved Lead	g/m^3	0.0034	0.094
Dissolved Nickel	g/m^3	0.011	0.017
Dissolved Zinc	g/m^3	0.008	0.031
Benzene	g/m^3	0.95	2.00
m&p-Xylene	g/m^3	0.2	0.340
o-Xylene	g/m^3	0.35	0.640

It must be recognised that the standards provided in Table 1 are based on a discharge that has undergone reasonable mixing processes within the receiving environment. Due to the discharges being monitored directly at the influent and effluent of a stormwater treatment device or catch pit, comparison of results to the ANZECC (2000) must be considered as being conservative, i.e. the results could be higher and still meet ANZECC (2000) triggers at the receiving environment due to dilution and mixing effects.

The above trigger values presented in Table 1 are not regulatory standards. ANZECC (2000) notes that the interpretations of the trigger values are primarily for the initiation of management responses, i.e. they may trigger an investigation. ANZECC (2000) quotes the following:

'If a trigger value listed is exceeded at a site, further action results. The action can be:

- *Incorporation of additional information or further site-specific investigation to determine whether or not the chemical is posing a real risk to the environment. The investigation may determine the fraction of the chemical in the water that organisms can take up (the bioavailable fraction) to use for comparing with the trigger value. The investigation and/or regular monitoring may also result in refinement of the guideline figure to suit regional or local water quality parameters and other conditions. Such refinement would occur where exceedance of the trigger value was shown to have no adverse effects upon the ecosystem; alternatively*

- *Accept the trigger value without change as a guideline applying to that site and initiate management action or remediation.'*

Furthermore, ANZECC (2000) notes '*These trigger values should not be considered as blanket guidelines for national water quality, because ecosystem types vary so widely throughout Australia and New Zealand. Such variations, even on a smaller scale, can have marked effects on the bioavailability, transport and degradation of chemicals, and on their toxicity.'*

The above ANZECC (2000) statement implies that even if a trigger value is exceeded, it may not necessarily need a management approach, as the quality of the discharge needs to be placed in context with the receiving environment in which it is discharged.

Similar to water quality, ANZECC (2000) provides multiple sediment quality trigger values for differing levels of protection. Interim Sediment Quality Guideline-Low (ISQG-Low) and Interim Sediment Quality Guideline-High (ISQG-High) are based from the US National Oceanic and Atmospheric Administration (NOAA) listings, which ANZECC corresponds to the effects range-low and effects range-median, respectively (ANZECC, 2000). These guideline values are however, not appropriate for assessing the sediment quality from the Z service stations. Sediment collected from the Z service stations is from stormwater treatment devices, where a high proportion of the sediment load discharging from the site is expected to be retained, whereas the ISQG trigger values are based on sediment in the receiving environment where any untreated sediment load from the service station is likely to be a very small proportion of the total stream sediment load.

2.5 Auckland Regional Council Technical Publication 153

Auckland Regional Council Technical Publication 153 'Background Concentrations of Inorganic Elements in Soils from the Auckland Region' (ARC, 2001) presents ranges of background concentrations of trace elements in Auckland soils. Ranges are presented for non-volcanic and volcanic soils, where applicable.

The purpose of presenting this information is to identify if measured concentrations from the sample sites contain heavy metal concentrations that are attributable to the sediment sources that are tracked on to or derived from the area surrounding the service stations (i.e. landscaping).

Table 2 below presents the background concentrations of trace element in Auckland soils that are specific to this project.

Table 2: Background Ranges of Trace Elements in Auckland Soils (ARC, 2001)

Element (Total Recoverable)	Non-Volcanic Range	Volcanic Range
Arsenic	0.4-12	
Cadmium	<0.1-0.65	
Chromium	2-55	3-125
Copper	1-45	20-90
Lead	<1.5-65	
Nickel	0.9-35	4-320
Zinc	9-180	54-1160

Notes: 1. All values are presented as (mg/Kg).

2. Table only presents elements that are measured in this project.

All service stations monitored in this project (discussed in Section 3) are located on soils with a volcanic origin. The highest concentrations presented in Table 2 are therefore used as indicators for the service station contributions of heavy metals.

3.0 Site Selection

The five Z service stations selected for this project were:

- Z Browns Road; located in Wiri in an industrial/residential area.
- Z Highbrook; located in Highbrook in an industrial catchment.
- Z Hunters Corner; located in Papatoetoe in a commercial/residential area.
- Z Lakeside; located in Takapuna in a commercial/residential area.
- Z Sylvia Park; located south of Mt Wellington in an industrial area.

For the purposes of confidentiality, the two control sites used in this project are not named in this report. Both sites however, are described as ‘high use’ car parks relating to commercial/recreational activity (based on a qualitative assessment of relative use). Control Site A resides in a predominantly residential catchment, whilst Control Site B is based within a predominantly mixed use residential/commercial catchment. Further discussion on both sites is provided in Section 3.4.

To achieve the objectives of this project, the Z sites selected had to achieve a specific set of criteria:

- Be representative of the average stormwater treatment provided by Z service stations;
- Have drainage area characteristics that are common for Z service stations; and
- Have traffic volumes that are common for the majority of Z service stations.

Using the above criteria, sites were selected using a two stage process. Stage one involved a desktop review of all Auckland Z services station drainage plans to determine the characteristics of the stormwater network and associated stormwater treatment devices. Once a list of potential sites was identified, an on-site inspection was undertaken (stage two), to assess the ease of monitoring and the prospects of achieving successful monitoring outcomes.

3.1 Stormwater Treatment Devices

A range of stormwater treatment devices are present across Z service stations in the Auckland region. Devices range from:

- API oil-water separators (of various sizes);
- Three stage oil-water interceptors; and
- Two stage oil-water interceptors.

API oil-water separators are the most common and therefore in this project, have been given a greater priority in site selection.

For this project, the selected sites have the following stormwater treatment devices:

- Z Browns Road: Three Stage oil-water interceptor.
- Z Highbrook: Humes API oil-water separator (model 5500).
- Z Hunters Corner: Humes API oil-water separator (model 3000).
- Z Lakeside: Two Stage oil-water interceptor.
- Z Sylvia Park: Humes API oil-water separator (model 3500).

3.2 Design of the Monitored Stormwater Treatment Devices

The following section discusses the design of the various stormwater treatment devices monitored in this project.

3.2.1 Two Stage Interceptor

The two stage interceptor located at Z Lakeside is comprised of two cesspits in series.

The system has an estimated 0.2 m^3 of available detention, with an estimated 0.07 m^3 available for floatable hydrocarbon retention (i.e. the live storage volume). Note this site has been programmed for a drainage upgrade.

3.2.2 Three Stage Interceptor

The three stage interceptor is a series of three manhole systems comprising manhole risers, bases, lids, and covers. An estimated 3.1 m^3 of detention is provided by this interceptor, with an estimated 0.5 m^3 available for floatable hydrocarbon retention (live storage volume). As an additional component of the three stage interceptor, Z has installed a ball valve. The purpose of this valve is to allow for the disconnection of the stormwater discharge from the public stormwater network in the instance of a spill event occurring.

3.2.3 API Oil-Water Separators

The API oil-water separator provides separation of oil and water runoff from a range of land uses that involve hydrocarbon products. The API unit comes in a range of sizes to accommodate differing catchment areas. Depending on size, an API unit may have two to four independent chambers to manage runoff. These chambers are divided by a single grill and baffle(s) to allow oil droplets to float while stormwater can pass beneath. The grill is made from galvanised steel, whilst all other components are pre-cast concrete.

All API units also have an emergency shut-off valve to allow for the containment of any excessive accidental spills.

API units have been tested by various distributors within New Zealand (Humes and Hynds Environmental). Both distributors state that API units can achieve the requirements of ARC TP10 (2003) and MFE (1998) by being able to:

- Retain at least 2500 litres of petroleum spill; and
- Discharge less than 15 parts/million total petroleum hydrocarbons dissolved in the stormwater effluent.

MfE (1998) includes a simulated spill event where the API was filled with product and the effluent was sampled. This demonstrated that an API can achieve a discharge with less than 15 mg/L of TPH whilst retaining a large volume of product. In practice this is an overly conservative scenario. As such, a spill event can only occur during filling when a trained tanker driver will be present to turn off the API separator’s emergency shut off valve (preventing through-flow) and arrange an immediate pump out of the interceptor by a contractor. The study does however demonstrate that the API a robust device with respect to minimising off-site hydrocarbon discharges.

The other aspect of service station run-off that has come into focus is the potential for elevated levels of heavy metals in run-off. The API separator was not designed to address sediments but the retention times required to fulfil its primary purpose of hydrocarbon treatment result in a sediment control function.

Table 3 provides specific specification details for the various API monitored. Information is provided by Humes (Humes, 2006).

Table 3: API Specification Details (Humes, 2006)

Model Reference	**API3000**	**API3500**	**API4000**	**API4500**	**API5000**	**API5500**
Capacity for petroleum product (m^3)	3.0	3.63	4.25	4.88	5.5	6.13
Design Flow (m^3/hour)	2.45	2.95	3.45	3.95	4.35	4.80
ARC (2003) design criteria						
Design flow (m^3/hour)	1.75	2.10	2.40	2.75	3.05	3.40
Orifice size diameter (mm)	21	23	25	27	28	30
Catchment area (m^2)with 15 mm/hour rainfall event	117	140	160	183	203	227

3.3 Forecourt and Non-Forecourt Areas

Sampling was required in both the forecourt (within the refuelling bays) and non-forecourt areas (commonly the ingress or egress areas to the service station). When selecting the forecourt and non-forecourt areas for each monitored site, the following considerations were made:

- Whether the stormwater runoff would contain sufficient contaminant load to meet laboratory levels of detection when analysed, i.e. the drainage area had to be of sufficient size to allow a required minimum contaminant concentration to be mobilised.
- In contrast however, the area cannot be too large as it would change:
    - The intensity of rainfall applied across the drainage area, i.e. all stormwater treatment devices monitored are designed by flow rates, therefore the design rate at which rainfall is to be applied to a drainage area (to meet 100% performance of a device) does not alter. If therefore, the drainage area was too large, a lower rainfall intensity would have to be applied, which may limit the mobilisation of contaminants.

  - The operation of the service station. The project requires shutting down an area of the service station; if the drainage area is too large, this excluded area would affect the operation of the site.

It is recognised that by not applying simulated rainfall (discussed in Section 4.1) across the entire forecourt area that drains to the stormwater treatment device, this may not reflect the true potential contaminant load that may enter the device. This however, can be compensated for by the following;

- In a ‘normal’ situation, the entire forecourt drainage area does not provide stormwater runoff to the device, due to the drainage area being roofed via a canopy. Rainfall can only enter a forecourt via rainfall blown by the wind on to the forecourt, or by vehicle tracking.

In addition to the above considerations when selecting forecourt and non-forecourt drainage areas, the following assumptions were made:

- Within the forecourt drainage area at each site, the dispensers directly in front of the retail shop entrance were always included in the sampled drainage area. We assume that these dispensers are the ones most frequently used by patrons.
- The quantity of hydrocarbon staining within a forecourt provides a visual indication on the potential hydrocarbon load present within the drainage area. If a large area of hydrocarbon staining was observed, it was deemed appropriate that the sampled drainage area be reduced (as the load was anticipated to be sufficiently high to achieve the sampling objectives).

Using the above methodology to determine appropriate forecourt and non-forecourt sampling areas, we consider that the catchments selected are generally representative of each site.

3.3.1 Ministry for the Environment Classification

MfE (1998) provides guidance and specifications to allow for the classification of drainage areas within service stations. This classification was used to ensure that specific activities were carried out in selected Z service stations. The MfE (1998) guidance provides four categories, these are:

Category 1 - Drainage systems are dedicated to capture and dispose of stormwater from roof areas, paved open areas and unpaved areas.

Category 2 - Drainage systems are dedicated to capture and dispose of stormwater and product spills from beneath the canopy where vehicle fuelling takes place, and from the slab around the remote fill points.

Category 3 – Drainage systems on site are dedicated to the capture of wastes from car washes, toilets, ablutions and kitchens and similar wastes for disposal to sewers.

Category 4 - Drainage systems are dedicated to the capture of washings and waste from workshops.

Table 4 presents the categories that are present at each service station selected for this project.

Table 4: MfE Drainage Classification Present at Sample Sites (MfE, 1998)

Site	**Category 1**			**Category 2**			**Category 3**			**Category 4**			**Comments**
	Y	N	N/A	Y	N	N/A	Y	N	N/A	Y	N	N/A	
Z Browns Road	√			√			√					√	Car wash now decommissioned
Z Highbrook	√			√			√					√	Includes a truck refuelling station
Z Hunters Corner	√			√			√					√	
Z Lakeside	√			√			√					√	
Z Sylvia Park	√			√			√					√	

For the purposes of this project, and to ensure no cross contamination could occur from the individual drainage networks, all selected sites had separate drainage networks for categories 1 to 3.

3.4 Control Sites

Two control sites (two 'high use' uncovered car parks) were used in this project. The objective of the control sites was to determine what is the 'typical' stormwater quality discharged from sites with a similar traffic volume. These results can then be used for comparison purposes against a service station, but without vehicle refuelling activities present.

Whilst no traffic counts have been made, vehicles that enter these two car parks range from standard passenger vehicles, to commercial buses. The two car parks service recreational and commercial Auckland facilities that have approximately 850,000 and 950,000 visitors on an annual basis, respectively.

4.0 Monitoring Methodology

The following section describes the methodology used to assess the average performance of the stormwater treatment devices.

The methodology was developed in accordance with guidance presented in Wong *et al.* (2012), 'Proprietary Devices Evaluation Protocol (PDEP) for Stormwater Quality Treatment Devices', and technical specifications for the treatment devices (Humes, 2006).

The monitoring and sampling methodology was discussed with Auckland Council officers to allow opportunity for Council to provide input. Where feedback was provided (as discussed in section 4.6), this was incorporated into the sampling methodology.

4.1 Synthetic Rainfall

All rainfall events used in this project were synthetically generated. Rainfall was produced by applying water (sourced from a fire hydrant) across the sample drainage area via an array of up to eight sprinklers.

Sprinklers used in this project were selectively chosen to ensure that droplets were produced, rather than a mist. This was to ensure the characteristics of natural rainfall are achieved.

Each sample drainage area assessed (forecourt, non-forecourt, or control) had sprinklers arranged so an even distribution of rainfall was applied. Field notes were made describing the extent of the synthetic rainfall achieved during each assessment.

4.1.1 Rainfall Intensity and Flow Rate Calculations

Synthetic rainfall was applied across drainage areas at pre-determined flow rates. For each drainage area, flow rates and rainfall intensities were calculated using the following key principles:

1. For forecourt drainage areas that are treated by API oil-water separators, the peak design flow rate for the device (that drains the subject forecourt drainage area) was used, i.e. the applied rainfall intensity was determined from the maximum flow rate that the device can provide stormwater treatment for, before the emergency bypass structures are enabled.
2. For forecourt drainage areas that are treated by two or three stage interceptors, the rainfall intensity was determined by what was equivalent (in respect to drainage area) to the API model 5500 peak design flow rate. The key rationale for this methodology was to ensure that all sites could be compared, given that the maximum flow rate which an interceptor device can receive is much greater than an API separator i.e. the maximum design flow of an interceptor is defined by the effluent pipe (commonly a 150 mm dia. pipe) from the separator.
3. All rainfall intensities applied to control sites followed the same assumptions as above (principle 2).
4. For non-forecourt drainage areas, the same rainfall intensity as that applied to the site’s respective forecourt drainage area was used. This was to ensure a comparison between the two drainage areas could be carried out.

In regards to principle 1 above, the peak flow rate for each API oil-water separator model was sourced from the Humes website (www.humes.co.nz).

Table 5 below presents the drainage areas irrigated, the predetermined flow rates and their respective equivalent rainfall intensities that were applied to drainage areas with oil-water separators/interceptors.

Table 5: Flow Rates and Equivalent Rainfall Intensities applied to Sampled Drainage Areas

Site Reference	**Stormwater Treatment Device**	**Drainage Area (m^2)**	**Determined Flow Rate (L/s)**	**Equivalent Rainfall Intensity (mm/hour)**
Z Browns Road	Three Stage oil-water interceptor	131	1.3	40
Z Highbrook	API oil-water separator (model 5500)	99	1.36	49
Z Hunters Corner	API oil-water separator (model 3000)	62	0.69	40
Z Lakeside	Two Stage oil-water interceptor	118	1.5	34
Z Sylvia Park	API oil-water separator (model 3500)	115	0.8	26
Control Site A	Nil	155	1.3	31
Control Site B	Nil	152	1.3	32

Device information sourced from the Humes website includes design drainage areas for respective design rainfall intensities. To ensure and verify that the above proposed rainfall intensities/flow rates (as provided in Table 4) are consistent with the API's devices design specifications, an assessment of the pre-determined flow rates and equivalent rainfall intensities was carried out. Graphical information that illustrates this assessment is provided in Appendix B.

Results from this assessment indicate that the determined flow rates are consistent with design specifications provided by Humes.

4.1.2 Applying Determined Flow Rate

To ensure that the determined flow rates are correctly applied to the respective drainage areas, flow rates were calibrated in the field using two methods:

1. Using the flow meter included with the fire hydrant standpipe; and
2. By carrying out volumetric assessments.

For the volumetric assessments, the following procedures were carried out:

- Water discharged from sprinklers was placed within a 20 L container;
- The time to fill the 20 L container was measured;
- The flow rate was then either adjusted or further sprinklers were included/removed (if required), with the above steps repeated to achieve the desired flow rate.

4.2 Site Maintenance Pre Sampling

During site reconnaissance (prior to sampling) PDP staff observed, for most service station sites, stormwater drainage (commonly catch pits or ACO drains) to the treatment devices was impaired by organic matter. In most instances, the organic matter was vegetation from nearby landscaped areas. This would limit the stormwater entering the stormwater treatment device. Site maintenance was therefore necessary to ensure the project objectives were achieved. Organic matter within the stormwater treatment devices and stormwater catch pits was not removed.

The accumulation of sediment in these stormwater devices indicates that they reduce sediment run-off from the sites. The methodology does not allow an assessment of the primary sedimentation occurring in these systems as the sampling of device influent occurs after the ACO drains.

Once site maintenance was carried out, all water quality assessments were carried out as soon as practicably possible.

4.3 Sediment Sampling Methodology

The following section describes the sediment sampling methodology.

All sediment sampling was carried out prior to any maintenance actions (as described in Section 4.2 above) were undertaken.

4.3.1 Sample Locations

Sediment samples were collected at the following locations:

- For forecourt drainage areas, sediment samples were obtained from either the first catch pit (pre-treatment catch pit) in the stormwater reticulation that collects water from the forecourt, or if no pre-treatment catch pit was present, the sample was collected from the primary chamber of the stormwater treatment device.
- For non-forecourt and control site drainage areas, the sediment sample was obtained from the stormwater catch pit that drains the subject sample drainage area.

4.3.2 Sample Collection

All samples were collected using manual grab methods i.e. via a collection container attached to mighty grippers. All sampling equipment was washed with Decon 90 detergent between sites to ensure no cross contamination could occur.

All sediment samples collected were placed on ice and stored in chilly bins to minimise the possibility of samples undergoing thermal and/or photo degradation. Sediment samples were then couriered to Hills Laboratories (IANZ Accredited) for analysis within 24 hours of collection. All sediment samples were analysed at screen levels of detection.

4.3.3 Contaminants of Concern

Sediment samples were assessed for the following suite of contaminants, which are considered to be typical of the metal and petroleum compounds found on vehicular pathways:

- Total Petroleum Hydrocarbons (TPH);
- Benzene, toluene, ethyl benzene, xylene (BTEX)
- Polycyclic Aromatic Hydrocarbons (PAH);
- Total heavy metals, consisting of:
    - Arsenic;
    - Cadmium;
    - Chromium;
    - Copper;
    - Lead;
    - Nickel; and
    - Zinc.
- pH.

In addition to the above suite of contaminants, sediment grain size was assessed. All sediment grain size analysis was conducted using the University of Waikato's MALVERN Mastersizer 2000 particle size analyser (a laser particle size analyser that measures the diffraction of the laser beams to detect the range of particle sizes present). This instrument is specifically designed for measuring sediment grain sizes between 0.02 - 2000 μm.

4.4 Water Quality Sampling Methodology

The following section describes the methodology used to obtain water quality data. The methodology was carried out using methods that are in accordance with the Auckland Councils Proprietary Device Evaluation Protocol (Wong *et al*, 2012) and stormwater device technical specifications (Humes, 2006).

4.4.1 Sample Locations

Samples were collected at the following locations:

- For forecourt drainage areas, influent water quality samples were collected from either the first catch pit (pre-treatment catch pit) in the stormwater reticulation that collects water from the forecourt, or if no pre-treatment catch pit was present, the sample was collected from the influent pipe that discharges to the primary chamber of the stormwater treatment device.

- Effluent water quality samples were collected at the location where effluent water (from the stormwater treatment device) discharged to the stormwater reticulation network. In all sample sites monitored, this was directly adjacent to the stormwater treatment device.
- For non-forecourt and control site drainage areas, water quality samples were obtained from the stormwater catch pit that drains the subject sample drainage area.

All sample locations described above, are illustrated in figures provided in Appendix A.

4.4.2 Sample Collection

Whilst the characteristics of the synthetic storm event may vary from site to site, the stormwater sampling methodology is consistent for each site monitored. Key water quality sampling attributes used in this project were:

- Water quality sampling was only conducted if at least three days dry antecedent weather conditions had occurred.
- A total of eight stormwater samples were collected from each service station, comprising:
    - One ‘first flush’ stormwater sample collected from initial stormwater discharge into the stormwater treatment device.
    - One ‘mid flow’ stormwater sample at the stormwater treatment device, collected approximately 30 minutes after the first flush sample was obtained (dependent on the size of the stormwater treatment device chambers).
    - One ‘first flush’ stormwater sample collected from initial stormwater discharge as it exits (effluent) the stormwater treatment device.
    - One ‘mid flow’ stormwater sample from discharge exiting the stormwater treatment device. This is collected approximately 30 minutes after the first flush effluent sample was obtained.
    - One ‘first flush’ stormwater sample collected from initial stormwater discharge into the catch pit from the ‘non-forecourt’ drainage area.
    - One ‘mid flow’ stormwater sample at the catch pit draining the ‘non-forecourt’ drainage area, collected approximately 30 minutes after the first flush sample was obtained.
    - One sample of the fire hydrant water used to create the synthetic storm. This sample is used to test the presence of contaminants before passing across the test areas.
- All stormwater/water samples were collected using manual grab sampling methods. A sampling pole (mighty gripper) was used (when required) to reduce risk to staff.
- All sampling equipment was washed with Decon 90 detergent between sites to ensure no cross contamination could occur.

- All samples were placed within ice filled chilly bins to ensure samples did not undergo photo and thermal degradation.
- Field notes and photographs were taken during the collection of samples at all sites.

4.4.3 Contaminants of Concern

All water quality samples collected were laboratory analysed for the following contaminants, which are considered to be typical of the metal and petroleum compounds found on vehicular pathways:

- Total Petroleum Hydrocarbons (TPH);
- Benzene, toluene, ethyl benzene, xylene (BTEX);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Total heavy metals, consisting of:
    - Arsenic;
    - Cadmium;
    - Chromium;
    - Copper;
    - Lead;
    - Nickel; and
    - Zinc.
- Dissolved heavy metals (consisting of the same metal suite as total heavy metals);
- Total Suspended Solids;
- pH; and
- Electrical conductivity.

Where relevant, water quality samples were analysed at screen levels of detection.

In addition to the above contaminants, field measurements were collected using a handheld water quality sensor (Professional Plus YSI Multiparameter Handheld with Quatro Probe or a Horiba Multiparameter Water Quality U-50 series) for the following parameter suite:

- Dissolved oxygen (% Saturation);
- Temperature (˚C);
- Oxygen reduction potential (mV); and
- Turbidity (NTU)

4.5 Sample Collection Timing

Sediment and water quality sampling at each Z service station was undertaken on differing days. Sediment sampling occurred prior to the site maintenance discussed in Section 4.2 and was completed during the period 15 January 2013 to 21 January 2013. The collection of sediment and water quality samples from Control Sites A and B was undertaken on 28 February 2013. Water quality sampling at the Z service stations was carried out once site maintenance (as discussed in Section 4.2) for all service stations was completed. This occurred during the period 13 March 2013 and 26 March 2013.

4.5.1 Antecedent Rainfall Conditions

Table 6 below presents the date in which water quality samples were obtained, and the respective period of dry antecedent weather conditions prior to sampling.

Table 6: Antecedent Weather Conditions prior to sampling

Site	Date Sampled	Days of Dry Antecedent Weather
Z Browns Road	14/03/2013	10[1]
Z Highbrook	13/03/2013	9[1]
	26/03/2013	6[1]
Z Hunters Corner	14/03/2013	10[1]
Z Lakeside	26/03/2013	6[2]
Z Sylvia Park	13/03/2013	10[1]
Control Site A	28/02/2013	12[1]
Control Site B	28/02/2013	12[1]

Notes: 1. *Rainfall data obtained from automatic rainfall station located at Auckland International Airport.*
2. *Rainfall data obtained from automatic rainfall station located Rosedale Treatment Ponds, Oteha.*

4.6 Additional Sample Collection

In consultation with the Auckland Council, it was agreed by PDP and Z that an additional water quality sampling round was to be conducted at one service station. PDP selected Z Highbrook for the additional sampling assessment. The primary purpose of replicating a sample round was to provide quality assurance of data obtained, i.e. to check result repeatability.

During the period in which water quality samples were collected, it was also agreed by PDP and Z that additional water quality samples were to be obtained. This additional sampling was carried out to ensure that the rate at which contaminants were being discharged from the drainage area was being sufficiently determined (i.e. to ensure that the peak discharge of contaminants was being sampled).

In addition to the sampling methodology described in Section 4.4.2, the following was also carried out for Z Lakeside, and the replicated assessment at Z Highbrook:

- One ‘mid flow’ stormwater sample at the stormwater treatment device, collected approximately 10 minutes after the first flush sample was obtained (dependent on the size of the stormwater treatment device chambers).

- One ‘mid flow’ stormwater sample from the discharge exiting the stormwater treatment device. This was collected approximately 10 minutes after the first flush effluent sample was obtained.
- One ‘mid flow’ stormwater sample at the catch pit draining the ‘non-forecourt’ drainage area, collected approximately 10 minutes after the first flush sample was obtained.
- Time interval turbidity measurements (via the handheld water quality meter). These measurements were obtained to confirm the rate which contaminants were being discharged from these sites, and to verify the correct sample collection timing was carried out, i.e. were the first flush samples achieving maximum contaminant concentrations.

5.0 Results

The following section presents the results obtained during this project. Field observations made during the collection of samples, and the results of sediment and water quality sampling are provided.

5.1 Field Observations

The following section summarises the field observations made whilst PDP staff obtained samples at all sites.

5.1.1 Z Browns Road

Sediment sampling was carried out on 16 January 2013. The forecourt area sediment sample was collected from the primary chamber of the stormwater treatment device. The sediment grain size obtained was much larger than the sediment obtained from other sites sampled. Sediment comprised mostly of gravels and sands (i.e. 5 mm to 2 mm diameter).

The non-forecourt sediment sample was collected from the catch pit located in the northern corner of the site. This sample was rich in organic matter (leaves and sticks).

The water quality sampling was undertaken on 14 March 2013. The forecourt area was sampled first.

The slot drains on the northern edge of the forecourt were observed to contain organic material and sediment. Four sprinklers were used to simulate the rain event. Stormwater runoff took a long time to travel from the slot drain to the stormwater treatment device’s influent sampling location. Stormwater runoff had a slight hydrocarbon odour and was dark in colour. The effluent discharge from the stormwater treatment device was relatively clear during the first flush and the 30 minute sample.

First flush discharge waters from the non-forecourt area had very low clarity and were black in colour. Samples had a strong hydrocarbon odour and an oil sheen was observed on the surface of the water flowing into the catch pit. By the mid-stream sample the stormwater runoff was observed to be much clearer.

5.1.2 Z Highbrook

Sediment sampling was carried out on 15 January 2013. The forecourt area sediment sample was collected from the primary chamber of the stormwater treatment device. Very little sediment was present within the chamber. Sediment collected had a very strong hydrocarbon odour, and water collected with the sediment sample had an oil sheen.

The non-forecourt sediment sample was collected from the catch pit located adjacent to the primary entrance (eastern entrance). This sample was rich in organic matter (leaves and sticks).

Water quality sampling was undertaken at Z Highbrook on 13 March 2013. A second sampling round was conducted on 26 March 2013. In both sampling rounds, the non-forecourt area was sampled prior to the forecourt area.

The location of the non-forecourt area was to the east of the station forecourt. The synthetic rain event was created using four sprinklers. The surface gradient of the area meant the water flowed into the catch pit to the western side of the entrance from Highbrook Drive. The initial first flush was sediment laden and black in colour. The colour of the stormwater runoff became clear however after a few minutes.

Similarly, the forecourt area was sampled in the same location for both sampling rounds (between pumps 2, 3, 4 and 5). The forecourt stormwater runoff drained into catch pits located in the middle of each of the two bays (between pumps 2 and 3, 4 and 5). These catch pits were observed to have oily emulsions floating on their water surface. The influent water to the stormwater treatment device was sampled from a man hole on the eastern side of the site. On both sampling rounds, the effluent from the stormwater treatment device was noted to have a hydrocarbon odour.

5.1.3 Z Hunters Corner

Sediment sampling was carried out on 15 January 2013. The forecourt area sediment sample was collected from the primary chamber of the stormwater treatment device.

Sediment from the non-forecourt area was obtained at the catch pit that provides drainage to the main access route to the refuelling bays.

At both the forecourt and non-forecourt sediment sampling locations, an approximate 2 cm thick layer of sediment was present within the catch pit and API oil-water separator.

Water quality sampling was undertaken on 14 March 2013. The non-forecourt area was sampled prior to the forecourt area at this site.

The synthetic rainstorm for the non-forecourt area was created using six sprinklers to increase the coverage of water.

The non-forecourt first flush of runoff to the catch pit was laden with sediment and was black in colour. Hydrocarbon odour and some sheen were observed. This odour and sheen were not present within a few minutes, and by 30 minutes the water samples obtained were clear and had minimal odour.

The forecourt area of the site has sumps in the middle of each pump bay, and the concrete is graded so water flows into a respective sump. Sumps were inspected prior to commencement of the sampling, and it was observed that a petroleum layer was present (~10 cm in thickness).

The refuelling bay between pumps 2 and 3 had been selected prior to arrival at the site. However, this location had to be altered, due to an obstacle. A sampling drainage area to the pump bay between pumps 4 and 5 was selected instead. Four sprinklers were used to irrigate the forecourt drainage area.

The first flush of water was less sediment-laden than other sites assessed, but samples still had a dark colour. The first flush of water from the API effluent was very foamy and had a detergent odour. This foaming was observed for approximately 20 minutes in the effluent discharge. After 30 minutes, effluent water from the API oil-water separator was clear, although the water quality sample obtained still foamed when poured into the sample vessels (as a result of these observations, Z have re-emphasised to all staff at the petrol station that windscreen wash is not to be discharged to the stormwater drainage system).

5.1.4 Z Lakeside

The sediment sampling was undertaken 21 January 2013. The forecourt area sediment sample was collected from the primary chamber of the stormwater treatment device. A very small amount of sediment (~ 1 cm thick) was present in the base of the chamber.

The sediment sample from the non-forecourt area was taken from the catch pit on the eastern edge of the retail shop, next to a landscaped garden. There was a limited amount of sediment (~ 3-4 cm thick) in the catch pit and the sediment appeared to be organic rich comprising mostly of leaves and sticks.

The water quality sampling was undertaken on 26 March 2013. The forecourt area was sampled prior to the non-forecourt area.

The forecourt area was sampled using four sprinklers. One sprinkler was located to the west of Pump 1, the remaining three between Pumps 2 and 3. Runoff flowed towards the slot drains across the entrance and exit on Taharoto Road. The influent sample was collected in the southern slot drain which accounted for approximately 70% of the flow, the additional 30% of flow went to the northern slot drain. The forecourt influent water sample collected five minutes after the first flush water sample appeared dark in colour. This discoloration was not observed after 30 minutes. The forecourt effluent water sample collected 5 minutes after the first flush water sample was pink in colour and foamed when sampled. By 30 minutes, stormwater runoff was relatively clear and the amount of foaming had reduced when the samples were taken.

The non-forecourt area was sampled using four sprinklers. The non-forecourt water sample collected 5 minutes after the first flush water sample was black in colour. After 30 minutes, the non-forecourt discharge colour was clear. No hydrocarbon odours were noted.

5.1.5 Z Sylvia Park

Sediment sampling was undertaken on 15 January 2013. Sediment for the forecourt drainage area was collected from the ACO drain. The sample was very organic rich and had a very strong hydrocarbon odour.

The non-forecourt sediment sample was collected from the catch pit that is adjacent to the main eastern entrance. As well as draining the main entrance to the service station, this catch pit also provides drainage for a car park area. Sediment within this catch pit was high in leaf litter content.

The water quality sampling occurred on 13 March 2013. The non-forecourt area was sampled prior to the forecourt area.

The non-forecourt area was sampled using four sprinklers, the initial flush of water was full of sediment and black in colour (this was likely due to the high organic content within the sediment), this cleared up by the 30 minute sample.

The influent slot drains to the north of the forecourt contained sediment and organic material. The initial flush of stormwater was heavily sediment laden. The effluent first flush from the API was however clear, but after approximately 2 minutes it turned black. Organic matter was also observed flowing out of the device after 5 minutes. By 10 minutes the discharge appeared to clear and by 30 minutes both the influent and effluent samples appeared clear, but a slight hydrocarbon odour was still present.

5.1.6 Control Site A

Sediment sampling and water quality sampling were conducted in respective order on the same day (28 February 2013).

During the process of obtaining the correct flow rate for fire hydrant water, an orange discharge occurred (likely to be iron oxides within the water supply pipe network). Because of this, fire hydrant water was irrigated over an adjacent grass area (not within the experimental drainage area) for a period of five minutes to ensure all traces of the orange discharge had been flushed.

During the irrigation of the car park, no issues were encountered or observations made that warrant comment.

5.1.7 Control Site B

Sediment sampling and water quality sampling were conducted in respective order on the same day (28 February 2013).

During the irrigation of the car park, no issues were encountered or observations made that warrant comment.

5.2 Sediment Results

Laboratory reports and analytical reports for sediment samples obtained are discussed in the following sections.

5.2.1 Sediment Quality

Appendix C contains the laboratory reports. Table 7 presents a summary of the sediment quality results obtained.

Upon receipt of sediment quality results, a review of data was carried out. This review identified a number of sampled parameters with elevated concentrations (particularly PAH and TPH).

Sites and parameters regarded as having elevated concentrations of PAH and TPH were:

- Z Browns Road Forecourt; Polycyclic Aromatic Hydrocarbons (Total PAH 139.5 mg/Kg)
- Z Browns Road Non-Forecourt; Polycyclic Aromatic Hydrocarbons (Total PAH 1123 mg/Kg)
- Z Highbrook Forecourt; Total Petroleum Hydrocarbons (250,000 mg/Kg)
- Z Sylvia Park Forecourt; Total Petroleum Hydrocarbons (197,000 mg/Kg)

TPH concentrations from Z Hunters Corner forecourt were also elevated. This sample location was not reassessed to confirm the result however, as it was consistent with results obtained by URS (2008).

In order to determine the reliability of the PAH and TPH results obtained, duplicate samples were collected and reanalysed. Table 8 presents results obtained from duplicate samples.

All service stations monitored had one or more heavy metal concentration that exceeded an ARC TP 153 referenced values for background concentrations of heavy metals within Auckland soils. This indicates that activities carried out on Z service stations have potential to contribute heavy metal load to the stormwater network. The highest concentrations were observed at Z Highbrook and Z Sylvia Park. Z Lakeside had heavy metal concentrations with only minor exceedances of ARC TP 153 values.

It is important to note that the results obtained from sediment samples demonstrate the nature of the contaminant within the treatment device, i.e. the measured concentrations are not being discharged from the service station. The concentrations of contaminants being discharged from the service station are provided by effluent water quality results discussed in section 5.3.

Table 7: Sediment Quality Results

		Z Service Station										**Control Sites**		**Guideline**
		Z Browns Road		**Z Highbrook**		**Z Hunters Corner**		**Z Lakeside**		**Z Sylvia Park**		**Control Site A**	**Control Site B**	**ARC TP 153**
Sample Location		**Forecourt**	**Non forecourt**	**Forecourt**	**Non forecourt**	**Forecourt**	**Non forecourt**	**Forecourt**	**Non forecourt**	**Forecourt**	**Non forecourt**	**Stormwater catch pit**	**Stormwater catch pit**	
Sample Field Reference no		BRN SS01	BRN SS02	HBK SS01	HBK SS02	HCR SS01	HCR SS02	LAK SS01	LAK SS02	SLV SS02	SLV SS01	BGC SS01	AMC SS01	
Sample Date		16/01/2013	16/01/2013	15/01/2013	15/01/2013	15/01/2013	15/01/2013	21/01/2013	21/01/2013	15/01/2013	15/01/2013	28/02/2013	28/02/2013	
Sample Parameter	**Units**													
Dry Matter	g/100g as rcvd	49	25	28	42	37	28	68	32	33	39	21	20	
Total Recoverable Phosphorus	mg/kg	1,260	1,040	1,430	1,170	1,730	960	1,000	660	1,270	1,430	2,100	1,560	
pH	pH Units	7.2	6.2	6.3	6.9	8.5	6.5	7.4	7.1	5.7	6.2	-	-	
Total Organic Carbon	g/100g	4.5	24	32	4.5	10.7	12.6	3.0	32	26	14.5	13.5	22	
Acenaphthene	mg/kg	<0.9	<2	<0.9	<0.10	0.66	<0.16	<0.07	<0.15	<0.8	<0.07	<0.11	<0.12	
Acenaphthylene	mg/kg	<0.9	<2	<0.9	<0.10	<0.13	<0.16	<0.07	<0.15	<0.8	<0.07	<0.11	<0.12	
Anthracene	mg/kg	0.9	7	<0.9	<0.10	0.91	<0.16	<0.07	<0.15	<0.8	<0.07	<0.11	<0.12	
Benzo[a]anthracene	mg/kg	6.9	55	<0.9	0.28	0.71	<0.16	0.11	<0.15	<0.8	0.10	0.13	<0.12	
Benzo[a]pyrene (BAP)	mg/kg	12.4	91	<0.9	0.30	0.50	<0.16	0.10	<0.15	<0.8	0.14	0.12	<0.12	
Benzo[b+j]fluoranthene	mg/kg	20	151	0.9	0.44	1.17	0.24	0.15	<0.15	2.1	0.24	0.23	<0.12	
Benzo[g,h,i]perylene	mg/kg	13.8	89	1.0	0.61	1.54	0.46	0.28	0.18	1.8	0.48	0.17	<0.12	
Benzo[k]fluoranthene	mg/kg	8.6	66	<0.9	0.16	0.23	<0.16	<0.07	<0.15	<0.8	0.07	<0.11	<0.12	
Chrysene	mg/kg	14.2	109	<0.9	0.32	0.95	<0.16	0.10	<0.15	<0.8	0.15	0.17	<0.12	
Dibenzo[a,h]anthracene	mg/kg	2.4	17	<0.9	<0.10	<0.13	<0.16	<0.07	<0.15	<0.8	<0.07	<0.11	<0.12	
Fluoranthene	mg/kg	19.9	198	1.6	0.77	2.6	0.26	0.25	0.19	1.2	0.25	0.38	<0.12	
Fluorene	mg/kg	<0.9	2	<0.9	<0.10	2.8	<0.16	<0.07	<0.15	<0.8	<0.07	<0.11	<0.12	
Indeno(1,2,3-c,d)pyrene	mg/kg	15.1	102	<0.9	0.20	0.35	<0.16	0.08	<0.15	0.9	0.10	<0.11	<0.12	
Naphthalene	mg/kg	<5	<10	<5	<0.5	17.0	3.1	<0.4	<0.8	<4	<0.4	<0.6	<0.6	
Phenanthrene	mg/kg	6.0	70	3.8	0.40	7.4	0.22	0.22	<0.15	<0.8	0.17	0.35	<0.12	
Pyrene	mg/kg	16.7	159	46	1.41	10.8	0.59	0.55	0.28	29	0.71	0.37	<0.12	
Total Recoverable Arsenic	mg/kg	4	13	6	4	13	4	6	<4	16	7	6	4	12
Total Recoverable Cadmium	mg/kg	0.22	0.70	1.30	0.77	0.40	0.73	0.23	<0.19	1.00	0.66	1.21	0.65	0.65
Total Recoverable Chromium	mg/kg	36	150	58	41	68	47	43	16	110	90	94	22	125
Total Recoverable Copper	mg/kg	74	181	109	63	135	141	94	63	230	159	96	69	90
Total Recoverable Lead	mg/kg	68	400	109	48	70	138	40	65	165	124	44	60	65
Total Recoverable Nickel	mg/kg	85	60	38	48	67	63	69	24	49	74	33	22	320
Total Recoverable Zinc	mg/kg	980	1,270	2,700	980	2,200	750	1,200	510	3,700	1,420	380	440	1160
BTEX in Soil														
Benzene	mg/kg	<0.11	<0.4	<0.4	<0.13	2.8	<0.4	<0.07	<0.18	<0.17	1.16	<0.5	<0.5	
Toluene	mg/kg	1.50	3.8	<0.4	1.88	55	7.2	2.8	0.27	<0.3	33	39	8.5	
Ethylbenzene	mg/kg	0.68	<0.4	0.6	<0.13	12.4	<0.4	<0.07	<0.18	<0.3	1.59	0.9	<0.5	
m&p-Xylene	mg/kg	2.4	<0.8	2.5	<0.3	67	<0.7	<0.13	<0.4	<0.4	6.5	<0.9	<1.0	
o-Xylene	mg/kg	1.08	<0.4	1.6	<0.13	29	<0.4	0.09	<0.18	<0.17	2.8	<0.5	<0.5	
C7 - C9	mg/kg	<30	<60	51	<30	1,680	179	<10	53	29	67	820	<40	
C10 - C14	mg/kg	52	<120	27,000	<60	9,800	370	26	158	13,300	65	240	<80	
C15 - C36	mg/kg	1,340	4,400	220,000	4,400	73,000	3,100	1,040	1,070	184,000	2,300	3,400	1,420	
Total hydrocarbons (C7 - C36)	mg/kg	1,400	4,400	250,000	4,400	84,000	3,600	1,060	1,290	197,000	2,400	4,500	1,420	

Notes:
1. *'-'denotes that this parameter was not sampled for.*
2. *All measurements (except pH) are expressed on a dry weight basis.*
3. *Highlighted values indicate heavy metal concentrations that exceed background ranges of trace elements in Auckland soils (ARC, 2001).*

Table 8: Sediment Quality Results for Retested Sites

		Z Service Station			
		Z Browns Road		**Z Highbrook**	**Z Sylvia Park**
Sample Location		**Forecourt**	**Non forecourt**	**Forecourt**	**Forecourt**
Sample Field Reference no		BRN SS01a	BRN SS02	HBK SS01a	SLV SS02a
Sample Date		05/02/2013	05/02/2013	05/02/2013	05/02/2013
Sample Parameter	**Units**				
Dry Matter	g/100 g as rcvd	38	26	30	54
Polycyclic Aromatic Hydrocarbons Screening in Soil					
Acenaphthene	mg/kg	0.16	0.89	-	-
Acenaphthylene	mg/kg	0.23	0.74	-	-
Anthracene	mg/kg	0.99	3.9	-	-
Benzo[a]anthracene	mg/kg	9.8	55	-	-
Benzo[a]pyrene (BAP)	mg/kg	14.9	63	-	-
Benzo[b+j]fluoranthene	mg/kg	22	93	-	-
Benzo[g,h,i]perylene	mg/kg	18.0	79	-	-
Benzo[k]fluoranthene	mg/kg	9.8	46	-	-
Chrysene	mg/kg	12.7	71	-	-
Dibenzo[a,h]anthracene	mg/kg	1.83	9.0	-	-
Fluoranthene	mg/kg	27	157	-	-
Fluorene	mg/kg	0.42	1.6	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg	18.6	65	-	-
Naphthalene	mg/kg	<0.7	<0.9	-	-
Phenanthrene	mg/kg	8.1	56	-	-
Pyrene	mg/kg	24	132	-	-
Total Petroleum Hydrocarbons in Soil					
C7 - C9	mg/kg	-	-	720	<30
C10 - C14	mg/kg	-	-	29,000	790
C15 - C36	mg/kg	-	-	280,000	26,000
Total hydrocarbons (C7 - C36)	mg/kg	-	-	310,000	27,000

Notes: 1. '-'denotes that this parameter was not sampled for.

The TPH results obtained for Z Highbrook and Z Sylvia Park suggest that the sediment sample obtained has a high proportion of petroleum residual attached to the sediment.

5.2.2 Sediment Grain Size Distribution Analysis

The quantity of sediment sample obtained at each sample location varied considerably. In general, non-forecourt drainage areas generated a greater quantity of sediment primarily due to landscaped areas being present within their drainage areas.

The grain size distribution of the sediment samples obtained was also dependent upon the drainage area type. Non-forecourt drainage areas commonly had a larger range of sediment particles present i.e. sediment both greater and less than 2.0 mm (a mix of sands and gravels), whilst forecourt drainage areas had sediment particles commonly less than 2.0 mm (sands and silts). Again, this is likely due to contributions of variable grain size provided by surrounding landscaped areas.

Table 9 below provides the % comparison of sediment grain sizes that are greater and less than 2.0 mm dia.

Table 9: % Comparison of Sediment Grain Sizes Greater and Less than 2.0 mm dia.

Site	Sample Location	%> 2.0 mm	%< 2.0 mm
Z Browns Road	Forecourt	92.4[1]	7.6
	Non-Forecourt	94.3[1]	5.7
Z Highbrook	Forecourt	0	100
	Non-Forecourt	51.2	48.8
Z Hunters Corner	Forecourt	0	100
	Non-Forecourt	38.3	61.7
Z Lakeside	Forecourt	30.8[1]	69.2
	Non-Forecourt	61.5	38.5
Z Sylvia Park	Forecourt	64.4[1]	35.6
	Non-Forecourt	4.3	95.7

Notes: 1. *The high proportion of sediment grain size > 2.0 mm is likely due to the stormwater treatment device and ACO drains being located within, and adjacent to, a landscaped area, respectively.*

2. *Capture of course sediments in ACO drains upstream of the sample location may also account for the generally low level of coarse material in the API's .*

Malvern Mastersizer 2000 analysis was undertaken on the sediment proportion that is less than 2.0 mm dia. Results obtained from the Malvern Mastersizer 2000 are presented in Appendix D. Grain size classification of this sediment proportion is provided in Table 10.

Table 10: Grain size classification of sediment proportion <2.0 mm dia

Site	Site Location	Grain Size Classification
Z Browns Road	Forecourt	Medium SAND with some silt
	Non-Forecourt	Well graded silty SAND
Z Highbrook	Forecourt	SILT with some fine sand and with minor clay
	Non-Forecourt	Coarse SAND with some fine sand
Z Hunters Corner	Forecourt	Well graded sandy SILT
	Non-Forecourt	Coarse SAND with some fine sand and with minor silt
Z Lakeside	Forecourt	Medium SAND with some Coarse sand
	Non-Forecourt	Medium coarse SAND
Z Sylvia Park	Forecourt	Coarse SAND with some fine sand
	Non-Forecourt	Well graded silty SAND

Notes: 1. *Interpretation of grain size description obtained from New Zealand Geotechnical Society Inc. (2005)*

5.3 Water Quality Results

Laboratory reports for water quality samples are provided in Appendix C and a summary of these results are presented in the following sections. Tables 11-16 present a summary of water quality information obtained for each service station assessed.

ANZECC (2000) 95% protection level trigger values and water quality data obtained from the two control sites are also included for comparison purposes.

Figures 1-6 provide graphs to present a comparison of the specific data obtained for the Z service stations at various monitoring locations and times.

Graphs are provided for the following:

- Total zinc - Forecourt.
- Total zinc - Non-forecourt.
- Total copper - Forecourt.
- Total copper - Non-forecourt.
- Total suspended solids - Forecourt.
- Total suspended solids - Non-forecourt.

Table 11: Z Browns Road Water Quality Results

		Z Service Station							**Control Site**					
		Z Browns Road							**Control Site A**		**Control Site B**		**Guideline Trigger**	
Sample Location		**Three Stage Interceptor**				**Catch pit**			**Catch pit**		**Catch pit**			
		Forecourt Influent First Flush (0 min)	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid flow (30 min)**	**Non-forecourt First Flush (0 min)**	**Non-Forecourt Mid Flow (30 min)**	**Fire Hydrant Water**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**BRN SW 004**	**BRN SW 006**	**BRN SW 005**	**BRN SW 007**	**BRN SW 001**	**BRN SW 002**	**BRN SW 003**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		0400	0430	0406	0436	0508	0538	0352	2130	2200	2315	2345		
Sample Parameter	**Units**													
Temperature	˚C	22.6	19.6	21.6	20.2	16.9	17.2	20.1	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	109.3	108.7	40.5	44.2	122.3	120.6	94.4	80.3	79.0	72.7	75.1		
Oxygen Reduction Potential	mV	260.1	215.8	240.6	219.3	219.5	218.5	257.9	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	117.6	18.4	15.0	16.1	31.5	16.3	15.4	51.4	17.2	33	14.6		
pH	pH Units	6.8	7.7	7.0	7.1	6.6	7.4	8.0	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	48	< 3	22	6	540	9	< 3	320	25	380	7	100^3	
Polycyclic Aromatic Hydrocarbons Screening in Water														
Acenaphthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	0.1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b+j]fluoranthene	mg/m^3	0.17	< 0.10	< 0.10	< 0.10	0.3	0.21	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	0.21	< 0.10	< 0.10	< 0.10	0.22	0.17	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	0.19	0.16	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	0.6	0.54	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	0.22	< 0.10	< 0.10	< 0.10	0.33	0.23	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16^1	85^2
Phenanthrene	mg/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	< 0.2	< 0.2	< 0.2	< 0.2	0.3	0.3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn														
Total Recoverable Arsenic	g/m^3	0.0016	0.0012	< 0.0011	< 0.0011	0.0029	0.0012	< 0.0011	0.002	< 0.0011	0.0028	0.0012	0.013^1	0.140^2
Total Recoverable Cadmium	g/m^3	0.000114	< 0.000053	< 0.000053	< 0.000053	0.00021	< 0.000053	< 0.000053	0.00065	0.000073	0.00044	< 0.000053	0.0002^1	0.0008^2
Total Recoverable Chromium	g/m^3	0.002	< 0.00053	0.00062	< 0.00053	0.0057	0.00078	< 0.00053	0.0065	0.00076	0.0056	< 0.00053	0.001^1	0.040^2
Total Recoverable Copper	g/m^3	0.0172	0.0029	0.00186	0.003	0.037	0.0024	0.008	0.07	0.0032	0.064	0.002	0.0014^1	0.0025^2
Total Recoverable Lead	g/m^3	0.005	0.00043	0.00031	0.0004	0.024	0.00124	0.0019	0.0163	0.00139	0.024	0.00104	0.0034^1	0.0094^2
Total Recoverable Nickel	g/m^3	0.00197	< 0.00053	< 0.00053	0.00068	0.005	< 0.00053	< 0.00053	0.0068	< 0.00053	0.0062	< 0.00053	0.011^1	0.017^2
Total Recoverable Zinc	g/m^3	0.57	0.069	0.0147	0.034	0.7	0.056	0.0029	0.55	0.039	0.67	0.023	0.008^1	0.031^2
Dissolved Arsenic	g/m^3	< 0.0010	0.0011	< 0.0010	< 0.0010	0.0014	0.0012	0.0011	0.0013	< 0.0010	0.0018	0.001	0.013^1	0.140^2
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00013	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002^1	0.0008^2
Dissolved Chromium	g/m^3	0.0007	< 0.0005	< 0.0005	< 0.0005	0.0009	< 0.0005	0.0007	0.0016	< 0.0005	0.0011	< 0.0005	0.001^1	0.040^2
Dissolved Copper	g/m^3	0.0094	0.0023	0.0008	0.0016	0.02	0.0014	0.0011	0.042	0.002	0.035	0.0013	0.0014^1	0.0025^2
Dissolved Lead	g/m^3	0.00035	0.00013	< 0.00010	0.0002	0.00112	0.0002	0.00059	0.00113	0.00017	0.0034	0.0002	0.0034^1	0.0094^2
Dissolved Nickel	g/m^3	0.0009	< 0.0005	< 0.0005	< 0.0005	0.0015	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011^1	0.017^2
Dissolved Zinc	g/m^3	0.165	0.051	0.0051	0.0151	0.48	0.044	0.0014	0.37	0.032	0.35	0.0174	0.008^1	0.031^2
BTEX in Water by Headspace														
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95^1	2.0^2
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2^1	0.34^2
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35^1	0.64^2
Total Petroleum Hydrocarbons in Water														
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15^3	

Notes:
1. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
2. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
3. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
4. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

Table 12: Z Highbrook Water Quality Results 13 March 2012

		Z Service Station							**Control Site**					
		Z Highbrook							**Control Site A**		**Control Site B**		**Guideline Trigger**	
Sample Location		**API Oil-Water Separator (Model 5500)**				**Catch Pit**		**Fire Hydrant Water**	**Catch Pit**		**Catch Pit**			
		Forecourt Influent First Flush (0 min)	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid flow (30 min)**	**Non-forecourt First Flush (0 min)**	**Non-Forecourt Mid Flow (30 min)**		**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**HBK SW 004**	**HBK SW 006**	**HBK SW 005**	**HBK SW 007**	**HBK SW 001**	**HBK SW 002**	**HBK SW 003**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		2318	2348	2321	2351	2220	2250	2210	2130	2200	2315	2345		
Sample Parameter	**Units**													
Temperature	°C	21.9	19.3	24.6	22.3	21.8	20.5	19.5	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	54.2	100.3	31.6	32.1	90.0	80.3	107.7	80.3	79.0	72.7	75.1		
Oxygen Reduction Potential	mV	132.6	79.3	256.4	10.8	233.4	438.1	313	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	51.6	17.8	35.4	32.8	33.2	16	15.7	51.4	17.2	33	14.6		
pH	pH Units	7.0	7.8	7.3	6.9	7.0	7.4	8	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	310	5	163	15	970	15	< 3	320	25	380	7	100[3]	
Polycyclic Aromatic Hydrocarbons Screening in Water														
Acenaphthene	mg/m^3	< 0.7	0.17	< 0.10	0.14	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b+j]fluoranthene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	1.7	0.13	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	2.5	0.5	< 0.2	0.6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	< 0.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 4	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16[1]	85[2]
Phenanthrene	mg/m^3	4.6	0.5	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	5.2	3.3	0.6	1.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn														
Total Recoverable Arsenic	g/m^3	0.0013	< 0.0011	< 0.0011	< 0.0011	0.0025	< 0.0011	< 0.0011	0.002	< 0.0011	0.0028	0.0012	0.013[4]	0.140[2]
Total Recoverable Cadmium	g/m^3	0.000113	< 0.000053	0.000081	0.000090	0.00061	< 0.000053	< 0.000053	0.00065	0.000073	0.00044	< 0.000053	0.0002[4]	0.0008[2]
Total Recoverable Chromium	g/m^3	0.0031	0.00055	0.00106	0.00075	0.0082	0.00082	0.00063	0.0065	0.00076	0.0056	< 0.00053	0.001[4]	0.040[2]
Total Recoverable Copper	g/m^3	0.0199	0.0036	0.0040	0.0052	0.048	0.0021	0.0087	0.07	0.0032	0.064	0.002	0.0014[4]	0.0025[2]
Total Recoverable Lead	g/m^3	0.0188	0.0028	0.0027	0.0023	0.033	0.0013	0.00076	0.0163	0.00139	0.024	0.00104	0.0034[4]	0.0094[2]
Total Recoverable Nickel	g/m^3	0.0055	0.00070	0.0052	0.0048	0.0080	< 0.00083	< 0.00053	0.0068	< 0.00053	0.0062	< 0.00053	0.011[4]	0.017[2]
Total Recoverable Zinc	g/m^3	0.24	0.062	0.78	0.34	1.29	0.059	0.01	0.55	0.039	0.67	0.023	0.008[4]	0.031[2]
Dissolved Arsenic	g/m^3	< 0.0010	0.0010	< 0.0010	< 0.0010	0.0012	< 0.0010	0.0011	0.0013	< 0.0010	0.0018	0.001	0.013[1]	0.140[2]
Dissolved Cadmium	g/m^3	0.00005	< 0.00005	< 0.00005	< 0.00005	0.00035	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002[1]	0.0008[2]
Dissolved Chromium	g/m^3	0.0009	< 0.0005	0.0007	0.0007	0.0016	< 0.0005	0.0006	0.0016	< 0.0005	0.0011	< 0.0005	0.001[1]	0.040[2]
Dissolved Copper	g/m^3	0.0054	0.0024	0.0014	0.0023	0.021	0.0011	0.0025	0.042	0.002	0.035	0.0013	0.0014[1]	0.0025[2]
Dissolved Lead	g/m^3	0.00058	0.00033	0.00044	0.00041	0.00193	0.0001	0.0002	0.00113	0.00017	0.0034	0.0002	0.0034[1]	0.0094[2]
Dissolved Nickel	g/m^3	0.0036	< 0.0005	0.0035	0.0033	0.0031	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011[1]	0.017[2]
Dissolved Zinc	g/m^3	0.054	0.040	0.35	0.166	0.62	0.045	0.0073	0.37	0.032	0.35	0.0174	0.008[1]	0.031[2]
BTEX in Water by Headspace														
Benzene	g/m^3	0.0042	< 0.0010	0.0015	0.079	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95[1]	2.0[2]
Toluene	g/m^3	0.50	< 0.0010	0.0083	1.44	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	0.0018	< 0.0010	0.0028	0.126	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	0.021	< 0.002	< 0.002	0.81	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2[1]	0.34[2]
o-Xylene	g/m^3	0.0154	< 0.0010	0.0115	0.46	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35[1]	0.64[2]
Total Petroleum Hydrocarbons in Water														
C7 - C9	g/m^3	1.5	< 0.10	0.18	2.9	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
C10 - C14	g/m^3	240	2.5	< 0.2	0.8	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	3,400	41	1.7	5.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	3,700	44	1.9	9.0	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15[3]	

Notes:
1. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
2. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
3. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
4. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

Table 13: Z Hunters Corner Water Quality Results

		Z Service Station							**Control Site**					
		Z Hunters Corner							**Control Site A**		**Control Site B**		**Guideline Trigger**	
		API Oil-Water Separator (Model 3000)				**Catch Pit**		**Fire Hydrant Water**	**Catch Pit**		**Catch Pit**			
Sample Location		**Forecourt Influent First Flush (0 min)**	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid flow (30 min)**	**Non-forecourt First Flush (0 min)**	**Non-Forecourt Mid Flow (30 min)**		**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**HCR SW 004**	**HCR SW 006**	**HCR SW 005**	**HCR SW 007**	**HCR SW 001**	**HCR SW 002**	**HCR SW 003**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	14/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		0206	0236	0210	0240	0122	0152	0118	2130	2200	2315	2345		
Sample Parameter	**Units**													
Temperature	°C	19.2	18.7	22.4	21.2	21.6	19.7	20.6	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	111.2	120.8	44.4	44.9	102.9	103.7	101.8	80.3	79.0	72.7	75.1		
Oxygen Reduction Potential	mV	252.8	260.2	149.2	30.0	1779	259.9	265.3	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	20.6	16.5	25.3	26.2	26.1	15.9	15.6	51.4	17.2	33	14.6		
pH	pH Units	7.6	7.8	7.3	7.0	6.7	7.4	7.8	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	76	<3	21	18	330	5	< 3	320	25	380	7	100[3]	
Acenaphthene	mg/m^3	< 0.10	< 0.10	< 0.10	0.29	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	< 0.2	< 0.2	< 0.2	0.8	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 0.5	< 0.5	< 0.5	15.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16[1]	85[2]
Phenanthrene	mg/m^3	< 0.4	< 0.4	< 0.4	0.6	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	0.3	< 0.2	0.3	0.7	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn														
Total Recoverable Arsenic	g/m^3	0.0015	0.0013	0.0037	0.0022	0.0016	< 0.0011	0.0011	0.002	< 0.0011	0.0028	0.0012	0.013[4]	0.140[2]
Total Recoverable Cadmium	g/m^3	< 0.000053	< 0.000053	< 0.000053	< 0.000053	0.000096	< 0.000053	< 0.000053	0.00065	0.000073	0.00044	< 0.000053	0.0002[4]	0.0008[2]
Total Recoverable Chromium	g/m^3	0.00129	< 0.00053	0.00108	0.00146	0.0035	0.00056	0.00062	0.0065	0.00076	0.0056	< 0.00053	0.001[4]	0.040[2]
Total Recoverable Copper	g/m^3	0.0098	0.00152	0.0079	0.0095	0.03	0.0022	0.011	0.07	0.0032	0.064	0.002	0.0014[4]	0.0025[2]
Total Recoverable Lead	g/m^3	0.0047	0.00043	0.00166	0.0021	0.0114	0.00067	0.0036	0.0163	0.00139	0.024	0.00104	0.0034[4]	0.0094[2]
Total Recoverable Nickel	g/m^3	0.00118	< 0.00053	0.0046	0.0023	0.0032	< 0.00053	< 0.00053	0.0068	< 0.00053	0.0062	< 0.00053	0.011[4]	0.017[2]
Total Recoverable Zinc	g/m^3	0.114	0.0125	0.3	0.2	0.49	0.04	0.078	0.55	0.039	0.67	0.023	0.008[4]	0.031[2]
Dissolved Arsenic	g/m^3	< 0.0010	0.001	0.0029	0.002	0.0013	0.001	0.0011	0.0013	< 0.0010	0.0018	0.001	0.013[1]	0.140[2]
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00005	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002[1]	0.0008[2]
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	0.0012	0.0011	0.0007	< 0.0005	< 0.0005	0.0016	< 0.0005	0.0011	< 0.0005	0.001[1]	0.040[2]
Dissolved Copper	g/m^3	0.0025	0.0008	0.0056	0.0061	0.0151	0.0013	0.0011	0.042	0.002	0.035	0.0013	0.0014[1]	0.0025[2]
Dissolved Lead	g/m^3	0.0001	< 0.00010	0.00105	0.00147	0.00057	< 0.00010	0.00018	0.00113	0.00017	0.0034	0.0002	0.0034[1]	0.0094[2]
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	0.0038	0.002	0.0014	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011[1]	0.017[2]
Dissolved Zinc	g/m^3	0.0144	0.0052	0.22	0.15	0.3	0.031	0.053	0.37	0.032	0.35	0.0174	0.008[1]	0.031[2]
BTEX in Water by Headspace														
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.100	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95[1]	2.0[2]
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.93	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.065	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	0.66	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2[1]	0.34[2]
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.33	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35[1]	0.64[2]
Total Petroleum Hydrocarbons in Water														
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	2.2	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	1.6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	1.1	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	4.9	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15[3]	

Notes:
1. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
2. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
3. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
4. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

Table 14: Z Lakeside Water Quality Results

		Z Service Station										**Control Site**				**Guideline Trigger**	
		Z Lakeside										**Control Site A**		**Control Site B**			
		Two Stage Oil-Water Interceptor						**Catch Pit**				**Catch Pit**		**Catch Pit**			
Sample Location		**Forecourt Influent First Flush (0 min)**	**Forecourt Influent Mid Flow (10 min)**	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid flow (10 min)**	**Forecourt Effluent Mid flow (30 min)**	**Non-forecourt First Flush**	**Non-Forecourt Mid Flow (10 min)**	**Non-Forecourt Mid Flow (30 min)**	**Fire Hydrant Water**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**LAK SW 004**	**LAK SW 008**	**LAK SW 006**	**LAK SW 005**	**LAK SW 009**	**LAK SW 007**	**LAK SW 001**	**LAK SW 010**	**LAK SW 002**	**LAK SW 003**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		0141	0151	0211	0143	0153	0213	0255	0305	0325	0130	2130	2200	2315	2345		
Sample Parameter	**Units**																
Temperature	˚C	18.06	18.19	17.83	19.06	18.19	17.95	19.00	18.75	18.17	19.74	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	103.1	79.9	100.9	80.7	102.6	74.2	101.3	75.8	76.9	112.6	80.3[3]	79.0[3]	72.7[3]	75.1[3]		
Oxygen Reduction Potential	mV	260	245	427	7	200	393	442	516	619	425	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	17.7	-	16.7	17.2	-	17	18.2	-	16.7	15.7	51.4	17.2	33	14.6		
pH	pH Units	7.9	7.86	7.9	7.1	6.9	7.2	8.0	7.91	8.0	7.9	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	9	5	3	15	18	9	49	17	18	3	320	25	380	7	100[6]	
Polycyclic Aromatic Hydrocarbons Screening in Water																	
Acenaphthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	< 0.2	-	< 0.2	< 0.2	-	< 0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 0.5	-	< 0.5	< 0.5	-	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16[4]	85[5]
Phenanthrene	mg/m^3	< 0.4	-	< 0.4	< 0.4	-	< 0.4	< 0.4	-	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	0.3	-	< 0.2	0.4	-	0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn																	
Total Recoverable Arsenic	g/m^3	< 0.0011	-	< 0.0011	0.0017	-	0.0012	< 0.0011	-	< 0.0011	< 0.0011	0.002	< 0.0011	0.0028	0.0012	0.013[4]	0.140[5]
Total Recoverable Cadmium	g/m^3	< 0.000053	-	< 0.000053	< 0.000053	-	< 0.000053	< 0.000053	-	< 0.000053	< 0.000053	0.00065	0.000073	0.00044	< 0.000053	0.0002[4]	0.0008[5]
Total Recoverable Chromium	g/m^3	0.00118	-	0.00066	0.0021	-	0.00056	0.00177	-	0.00117	0.00081	0.0065	0.00076	0.0056	< 0.00053	0.001[4]	0.040[5]
Total Recoverable Copper	g/m^3	0.0042	-	0.00131	0.0126	-	0.003	0.0086	-	0.00137	0.0173	0.07	0.0032	0.064	0.002	0.0014[4]	0.0025[5]
Total Recoverable Lead	g/m^3	0.00109	-	0.00025	0.0023	-	0.00067	0.0032	-	0.00069	0.00192	0.0163	0.00139	0.024	0.00104	0.0034[4]	0.0094[5]
Total Recoverable Nickel	g/m^3	< 0.00053	-	< 0.00053	0.00138	-	< 0.00053	0.00105	-	< 0.00053	< 0.00053	0.0068	< 0.00053	0.0062	< 0.00053	0.011[4]	0.017[5]
Total Recoverable Zinc	g/m^3	0.039	-	0.014	0.72	-	0.055	0.087	-	0.0188	0.0124	0.55	0.039	0.67	0.023	0.008[4]	0.031[5]
Dissolved Arsenic	g/m^3	< 0.0010	-	< 0.0010	0.0013	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	0.0013	< 0.0010	0.0018	0.001	0.013[4]	0.140[5]
Dissolved Cadmium	g/m^3	< 0.00005	-	< 0.00005	< 0.00005	-	< 0.00005	< 0.00005	-	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002[4]	0.0008[5]
Dissolved Chromium	g/m^3	0.0007	-	< 0.0005	0.0014	-	< 0.0005	0.0007	-	0.0006	0.0008	0.0016	< 0.0005	0.0011	< 0.0005	0.001[4]	0.040[5]
Dissolved Copper	g/m^3	0.0026	-	0.001	0.008	-	0.0018	0.0018	-	0.0006	0.0017	0.042	0.002	0.035	0.0013	0.0014[4]	0.0025[5]
Dissolved Lead	g/m^3	0.0002	-	< 0.00010	0.00094	-	0.00013	0.00012	-	< 0.00010	0.00023	0.00113	0.00017	0.0034	0.0002	0.0034[4]	0.0094[5]
Dissolved Nickel	g/m^3	< 0.0005	-	< 0.0005	0.0011	-	< 0.0005	< 0.0005	-	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011[4]	0.017[5]
Dissolved Zinc	g/m^3	0.0147	-	0.0076	0.55	-	0.039	0.0135	-	0.0065	0.0033	0.37	0.032	0.35	0.0174	0.008[4]	0.031[5]
BTEX in Water by Headspace																	
Benzene	g/m^3	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95[4]	2.0[5]
Toluene	g/m^3	< 0.0010	-	< 0.0010	0.0052	-	0.001	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	< 0.002	-	< 0.002	0.002	-	< 0.002	< 0.002	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2[4]	0.34[5]
o-Xylene	g/m^3	< 0.0010	-	< 0.0010	0.0014	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35[4]	0.64[5]
Total Petroleum Hydrocarbons in Water																	
C7 - C9	g/m^3	< 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		
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	0.6	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	2.6	0.9	< 0.4	2.7	2.3	0.6	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	2.6	0.9	< 0.7	3.3	2.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15[6]	

Notes:

1. *Note additional water quality samples were collected at 10 minutes after first flush sample were collected. These additional water quality samples were obtained at all monitoring locations (except the fire hydrant). Water quality parameters collected were TSS and TPH only.*
2. *Note a Horiba multi parameter water quality sensor was used to obtain field measurements at Z Lakeside.*
3. *'-' denotes that this parameter was not sampled.*
4. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
5. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
6. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
7. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

Table 15: Z Sylvia Park Water Quality Results

		Z Service Station							Control Site				Guideline Trigger	
		Z Sylvia Park							Control Site A		Control Site B			
		API Oil-Water Separator (Model 3500)				Catch Pit			Catch Pit		Catch Pit			
Sample Location		**Forecourt Influent First Flush (0 min)**	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid Flow (30 min)**	**Non-forecourt First Flush (0 min)**	**Non-Forecourt Mid Flow (30 min)**	**Fire Hydrant Water**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**SYL SW 004**	**SYL SW 006**	**SYL SW 005**	**SYL SW 007**	**SYL SW 001**	**SYL SW 002**	**SYL SW 003**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	13/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		0210	0240	0220	0250	1224	1254	1215	2130	2200	2315	2345		
Sample Parameter	**Units**													
Temperature	˚C	20.8	19.4	23.1	20.9	18.7	17.8	19.9	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	92.0	95.8	34.7	48.0	84.8	81.0	73.9	80.3	79.0	72.7	75.1		
Oxygen Reduction Potential	mV	258.0	245.7	252.9	128.2	215.4	291.8	292.3	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	25.4	18.3	17.5	16.0	31.7	15.8	15.7	51.4	17.2	33	14.6		
pH	pH Units	7.3	8.0	7.6	8.9	6.8	7.2	7.7	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	92	4	51	8	850	6	< 3	320	25	380	7	100[3]	
Polycyclic Aromatic Hydrocarbons Screening in Water														
Acenaphthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b+j]fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16[1]	85[2]
Phenanthrene	mg/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	0.6	0.5	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn														
Total Recoverable Arsenic	g/m^3	0.0019	< 0.0011	0.0043	0.0015	0.0024	< 0.0011	< 0.0011	0.002	< 0.0011	0.0028	0.0012	0.013[4]	0.140[2]
Total Recoverable Cadmium	g/m^3	0.000122	< 0.000053	0.00012	< 0.000053	0.00028	< 0.000053	0.000063	0.00065	0.000073	0.00044	< 0.000053	0.0002[4]	0.0008[2]
Total Recoverable Chromium	g/m^3	0.0039	0.00072	0.0186	0.00087	0.0059	0.00064	< 0.00053	0.0065	0.00076	0.0056	< 0.00053	0.001[4]	0.040[2]
Total Recoverable Copper	g/m^3	0.034	0.0061	0.036	0.0032	0.056	0.002	0.0024	0.07	0.0032	0.064	0.002	0.0014[4]	0.0025[2]
Total Recoverable Lead	g/m^3	0.0109	0.001	0.059	0.0012	0.0176	0.00125	0.0023	0.0163	0.00139	0.024	0.00104	0.0034[4]	0.0094[2]
Total Recoverable Nickel	g/m^3	0.0046	0.00059	0.0186	< 0.00053	0.0085	< 0.00053	0.00058	0.0068	< 0.00053	0.0062	< 0.00053	0.011[4]	0.017[2]
Total Recoverable Zinc	g/m^3	0.26	0.055	1.78	0.152	0.73	0.047	0.005	0.55	0.039	0.67	0.023	0.008[4]	0.031[2]
Dissolved Arsenic	g/m^3	0.0013	0.0012	< 0.0010	0.0012	0.0012	< 0.0010	< 0.0010	0.0013	< 0.0010	0.0018	0.001	0.013[1]	0.140[2]
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00015	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002[1]	0.0008[2]
Dissolved Chromium	g/m^3	0.0009	< 0.0005	< 0.0005	< 0.0005	0.0008	< 0.0005	< 0.0005	0.0016	< 0.0005	0.0011	< 0.0005	0.001[1]	0.040[2]
Dissolved Copper	g/m^3	0.0146	0.0046	0.0006	0.0013	0.03	0.0011	0.0007	0.042	0.002	0.035	0.0013	0.0014[1]	0.0025[2]
Dissolved Lead	g/m^3	0.0006	0.00014	0.00013	0.00021	0.00092	0.00043	0.00024	0.00113	0.00017	0.0034	0.0002	0.0034[1]	0.0094[2]
Dissolved Nickel	g/m^3	0.0019	< 0.0005	0.0006	< 0.0005	0.004	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011[1]	0.017[2]
Dissolved Zinc	g/m^3	0.076	0.0193	0.197	0.057	0.41	0.036	< 0.0010	0.37	0.032	0.35	0.0174	0.008[1]	0.031[2]
BTEX in Water by Headspace														
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95[1]	2.0[2]
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0048	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2[1]	0.34[2]
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35[1]	0.64[2]
Total Petroleum Hydrocarbons in Water														
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	< 0.4	2.5	< 0.4	0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	2.5	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15[3]	

Notes:
1. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
2. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
3. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
4. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

Table 16: Z Highbrook Water Quality Results 26 March 2012

		Z Service Station										Control Site				Guideline Trigger	
		Z Highbrook										Control Site A		Control Site B			
		API Oil-Water Separator (Model 5500)						Catch Pit				Catch Pit		Catch Pit			
Sample Location		**Forecourt Influent First Flush (0 min)**	**Forecourt Influent Mid Flow (10 min)**	**Forecourt Influent Mid Flow (30 min)**	**Forecourt Effluent First Flush (0 min)**	**Forecourt Effluent Mid flow (10 min)**	**Forecourt Effluent Mid flow (30 min)**	**Non-forecourt First Flush (0 min)**	**Non-Forecourt Mid Flow (10 min)**	**Non-Forecourt Mid Flow (30 min)**	**Fire Hydrant Water**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**Effluent First Flush (0 min)**	**Effluent Mid Flow (30 min)**	**ANZECC (2000) 95% trigger and MfE (1998)**	**ANZECC (2000) 80% trigger**
Sample Field Reference no		**HBK SW 004a**	**HBK SW 009a**	**HBK SW 006a**	**HBK SW 005a**	**HBK SW 010a**	**HBK SW 007a**	**HBK SW 001a**	**HBK SW 008a**	**HBK SW 002a**	**HBK SW 003a**	**ABG SW01**	**ABG SW02**	**AMU SW01**	**AMU SW02**		
Sample Date		26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	26/03/2013	28/02/2013	28/02/2013	28/02/2013	28/02/2013		
Sample Time		2314	2324	2344	2316	2326	2346	2213	2223	2243	2200	2130	2200	2315	2345		
Sample Parameter	**Units**																
Temperature	˚C	20.13	$-^{3}$	19.44	22.26	$-^{3}$	21.11	20.29	19.7	19.06	21.16	20.6	19.0	20.6	19.4		
Dissolved Oxygen	% Sat	61.6	$-^{3}$	70.3	34.9	$-^{3}$	42.5	102.5	101.8	101.5	128.4	80.3^{3}	79.0^{3}	72.7^{3}	75.1^{3}		
Oxygen Reduction Potential	mV	17	$-^{3}$	156	34	$-^{3}$	21	418	466	601	326	258.6	358.6	309.8	399.1		
Electrical Conductivity	mS/m	36.6	-	20.1	18.5	-	22.6	16.4	-	15.7	15.6	51.4	17.2	33	14.6		
pH	pH Units	7.2	-	7.5	7.2	-	7.0	7.5	-	7.7	8.2	4.6	7.3	6.2	7.2		
Total Suspended Solids	g/m^3	18	10	7	8	7	10	30	20	10	<3	320	25	380	7	100^{6}	
Polycyclic Aromatic Hydrocarbons Screening in Water																	
Acenaphthene	mg/m^3	< 0.10	-	< 0.00010	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Anthracene	mg/m^3	< 0.10	-	0.12	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]anthracene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene (BAP)	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[g,h,i]perylene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[k]fluoranthene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Chrysene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Dibenzo[a,h]anthracene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	mg/m^3	< 0.10	-	0.11	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	mg/m^3	< 0.2	-	< 0.2	< 0.2	-	< 0.2	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Indeno(1,2,3-c,d)pyrene	mg/m^3	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	-	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
Naphthalene	mg/m^3	< 0.05	-	< 0.5	< 0.5	-	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	16^{4}	85^{5}
Phenanthrene	mg/m^3	< 0.4	-	< 0.4	< 0.4	-	< 0.4	< 0.4	-	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Pyrene	mg/m^3	1.8	-	2.5	0.9	-	0.0015	< 0.2	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn																	
Total Recoverable Arsenic	g/m^3	0.0012	-	< 0.0011	< 0.0011	-	< 0.0011	0.0011	-	< 0.0011	< 0.0011	0.002	< 0.0011	0.0028	0.0012	0.013^{4}	0.140^{5}
Total Recoverable Cadmium	g/m^3	0.000105	-	< 0.000053	< 0.000053	-	< 0.000053	0.000154	-	< 0.000053	< 0.000053	0.00065	0.000073	0.00044	< 0.000053	0.0002^{4}	0.0008^{5}
Total Recoverable Chromium	g/m^3	0.00179	-	0.00055	0.00177	-	0.0021	0.00182	-	0.00093	0.033	0.0065	0.00076	0.0056	< 0.00053	0.001^{4}	0.040^{5}
Total Recoverable Copper	g/m^3	0.012	-	0.003	0.0041	-	0.006	0.0057	-	0.00087	0.0027	0.07	0.0032	0.064	0.002	0.0014^{4}	0.0025^{5}
Total Recoverable Lead	g/m^3	0.0048	-	0.00177	0.00085	-	0.00174	0.0056	-	0.00089	0.00033	0.0163	0.00139	0.024	0.00104	0.0034^{4}	0.0094^{5}
Total Recoverable Nickel	g/m^3	0.00183	-	< 0.00053	0.0028	-	0.003	0.00129	-	< 0.00053	0.0027	0.0068	< 0.00053	0.0062	< 0.00053	0.011^{4}	0.017^{5}
Total Recoverable Zinc	g/m^3	0.11	-	0.035	0.35	-	0.21	0.21	-	0.035	0.0033	0.55	0.039	0.67	0.023	0.008^{4}	0.031^{5}
Dissolved Arsenic	g/m^3	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	-	< 0.0010	< 0.0010	0.0013	< 0.0010	0.0018	0.001	0.013^{4}	0.140^{5}
Dissolved Cadmium	g/m^3	0.00005	-	< 0.00005	< 0.00005	-	< 0.00005	0.00008	-	< 0.00005	< 0.00005	0.00042	0.00006	0.00022	< 0.00005	0.0002^{4}	0.0008^{5}
Dissolved Chromium	g/m^3	0.0008	-	< 0.0005	0.0012	-	0.0015	< 0.0005	-	0.0005	0.0006	0.0016	< 0.0005	0.0011	< 0.0005	0.001^{4}	0.040^{5}
Dissolved Copper	g/m^3	0.005	-	0.0013	0.0026	-	0.0031	0.0022	-	0.0006	0.0006	0.042	0.002	0.035	0.0013	0.0014^{4}	0.0025^{5}
Dissolved Lead	g/m^3	0.0005	-	0.00022	0.0005	-	0.00058	0.00016	-	< 0.00010	0.00013	0.00113	0.00017	0.0034	0.0002	0.0034^{4}	0.0094^{5}
Dissolved Nickel	g/m^3	0.0013	-	< 0.0005	0.0022	-	0.0024	< 0.0005	-	< 0.0005	< 0.0005	0.0034	< 0.0005	0.0034	< 0.0005	0.011^{4}	0.017^{5}
Dissolved Zinc	g/m^3	0.04	-	0.0198	0.25	-	0.122	0.086	-	0.02	0.0031	0.37	0.032	0.35	0.0174	0.008^{4}	0.031^{5}
BTEX in Water by Headspace																	
Benzene	g/m^3	< 0.0010	-	< 0.0010	< 0.0010	-	0.006	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.95^{4}	2.0^{5}
Toluene	g/m^3	0.007	-	< 0.0010	0.0035	-	0.124	< 0.0010	-	0.003	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
Ethylbenzene	g/m^3	0.001	-	< 0.0010	0.0018	-	0.0138	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010		
m&p-Xylene	g/m^3	0.004	-	< 0.002	0.012	-	0.189	< 0.002	-	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.2^{4}	0.34^{5}
o-Xylene	g/m^3	0.0025	-	< 0.0010	0.0052	-	0.119	< 0.0010	-	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.35^{4}	0.64^{5}
Total Petroleum Hydrocarbons in Water																	
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	0.26	0.43	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10		
C10 - C14	g/m^3	3.8	1.4	1.3	< 0.2	0.2	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2		
C15 - C36	g/m^3	72	30	32	1.5	2	4.1	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4		
Total hydrocarbons (C7 - C36)	g/m^3	76	31	33	1.5	2.5	5	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	15^{6}	

Notes:

1. *Note additional water quality samples were collected at 10 minutes after first flush sample were collected. These additional water quality samples were obtained at all monitoring locations (except the fire hydrant). Water quality parameters collected were TSS and TPH only.*
2. *Note a Horiba multi parameter water quality sensor was used to obtain field measurements at Z Lakeside.*
3. *'-' denotes that this parameter was not sampled.*
4. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 95% level of protection.*
5. *ANZECC (2000) Australian and New Zealand guidelines for fresh and marine water quality. Freshwater 80% level of protection.*
6. *MfE (1998) Environmental guidelines for water discharges from petroleum industry sites in New Zealand.*
7. *Highlighted values indicate exceedances against a referenced guideline. Red cells donate exceedance of 80% and 95% ANZECC (2001) triggers, Yellow cells donate exceedance in 95% ANZECC (2001) trigger only. Orange cells donate exceedance in MfE (1998) values.*

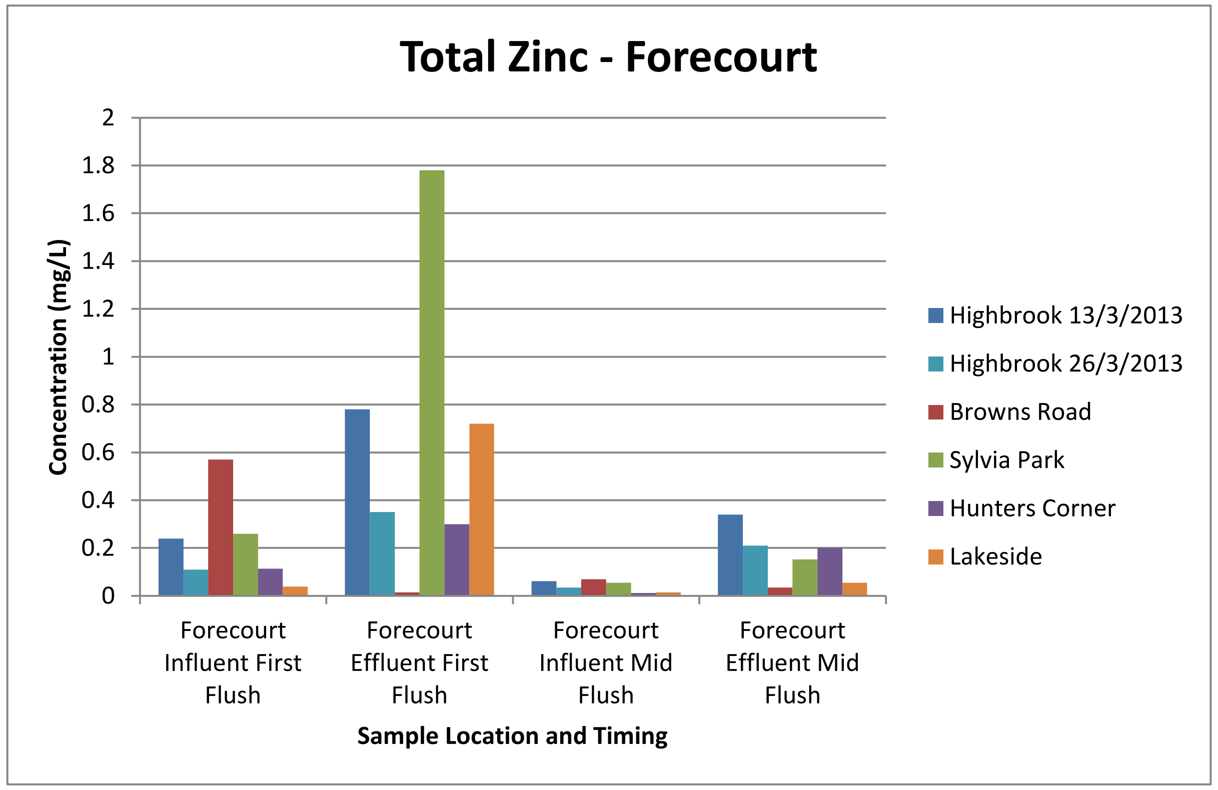

Figure 1: Water Quality Results of Total Zinc from Z Forecourts

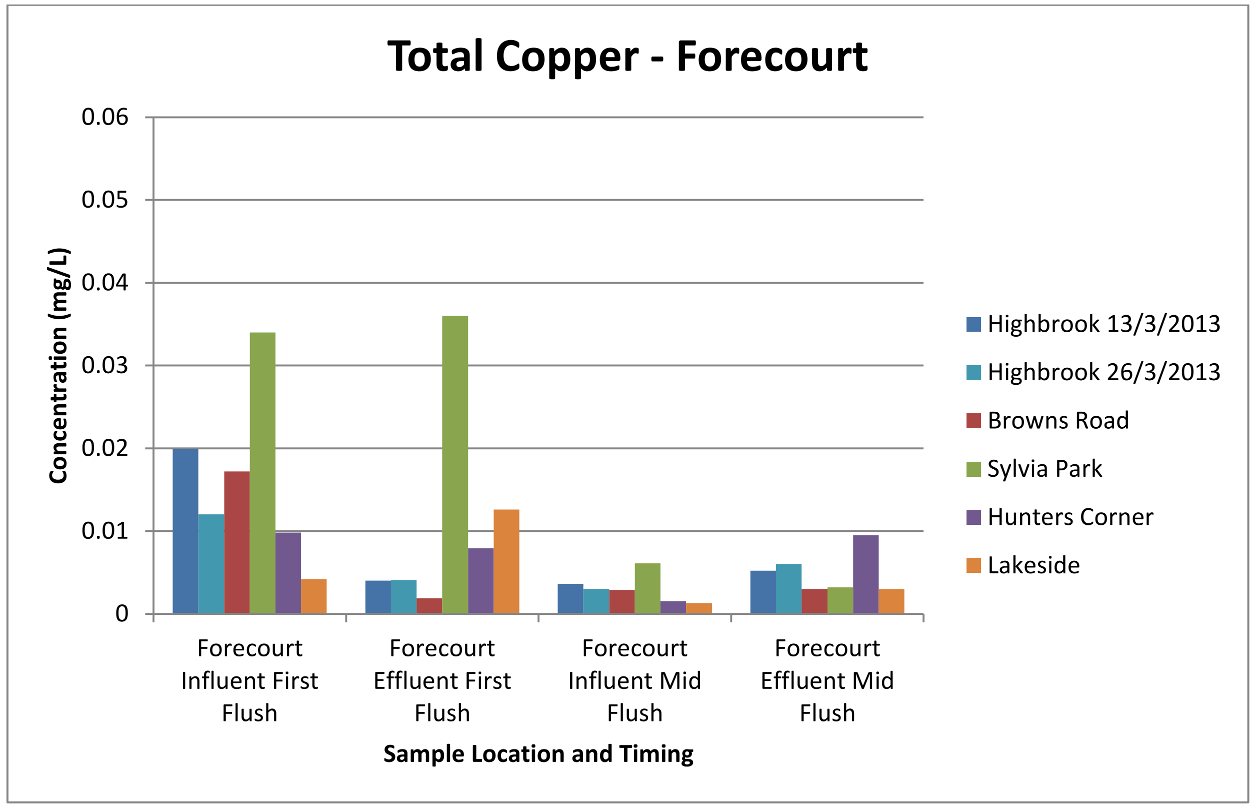

Figure 3: Water Quality Results of Total Copper from Z Forecourts

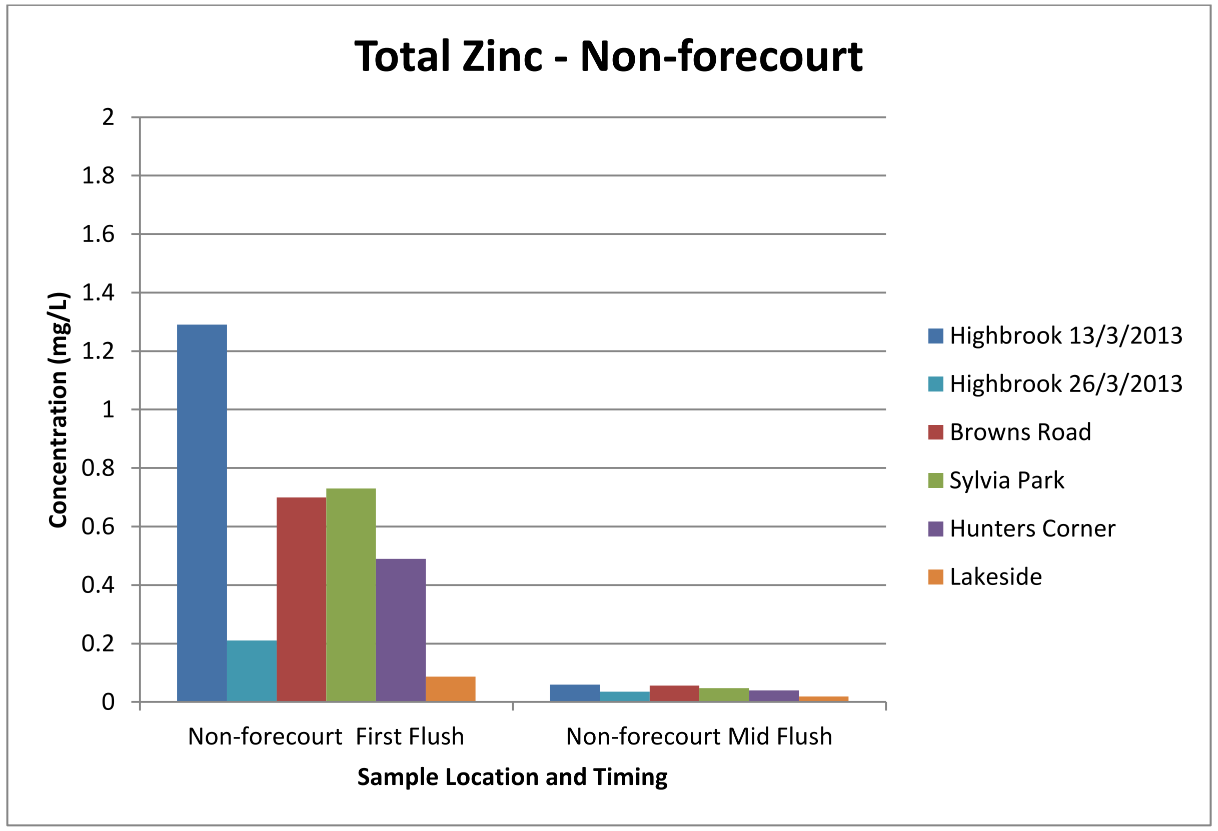

Figure 2: Water Quality Results of Total Zinc from Z Non-Forecourts

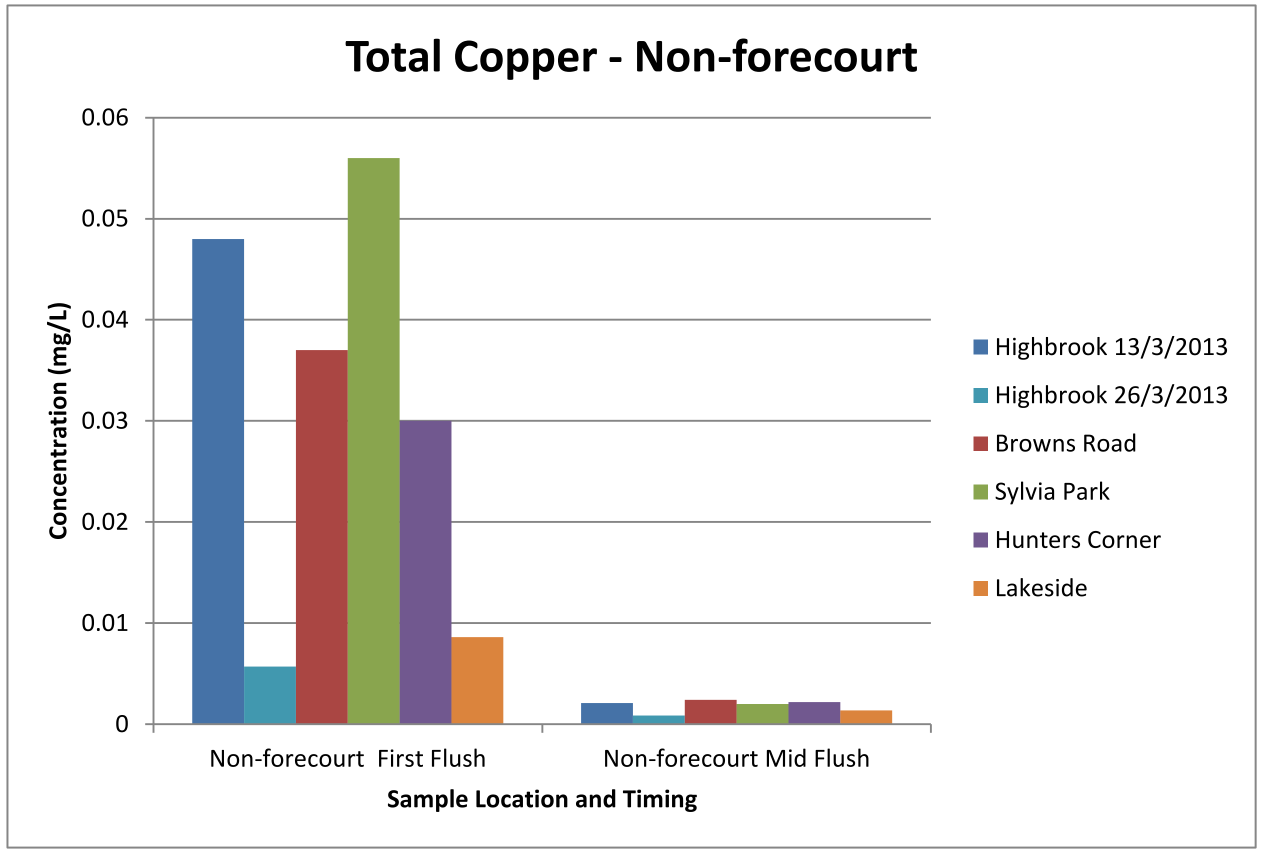

Figure 4: Water Quality Results of Total Copper from Z Non-Forecourts

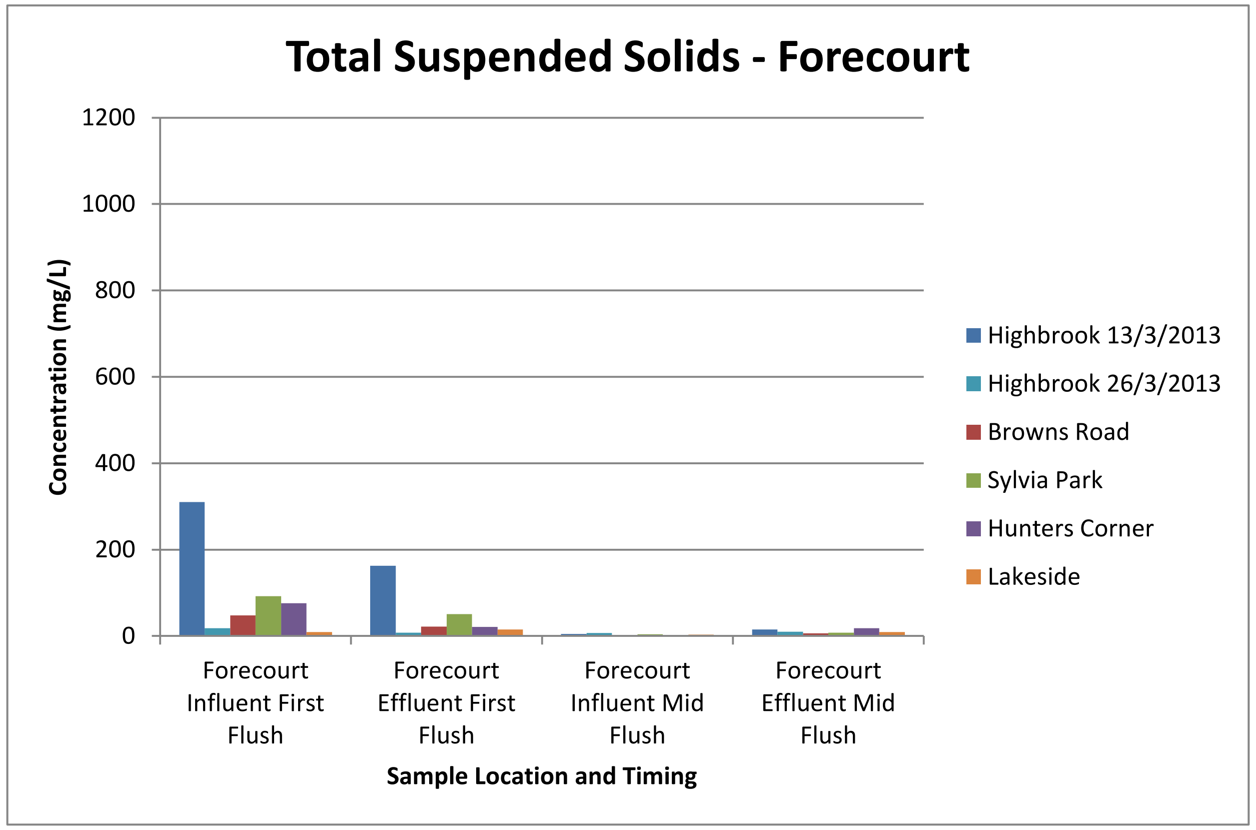

Figure 5: Water Quality Results of Total Suspended Solids from Z Forecourts

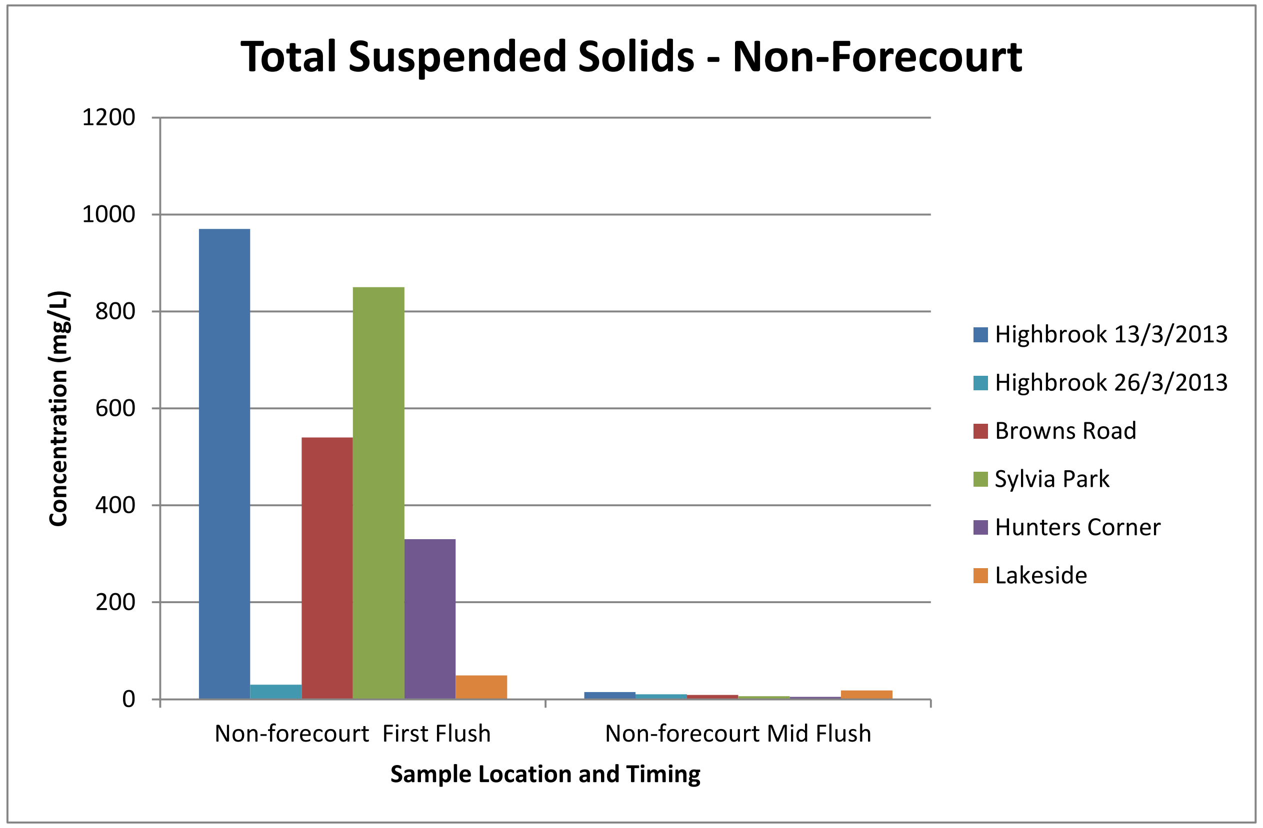

Figure 6: Water Quality Results of Total Suspended Solids from Z Non-Forecourts

5.3.1 First Flush Assessment

To ascertain whether the above sampling captured the first flush (or peak flux of the contamination discharged from the drainage area), turbidity measurements were obtained during water quality sampling at Z Lakeside and Z Highbrook on 26 March 2013. Turbidity measurements were selected as a surrogate parameter to assess for the first flush across all contaminants.

Figures 7 and 8 below illustrate turbidity results obtained for Z Lakeside and Z Highbrook, respectively. For both of these sites, the first flush occurred immediately with the first waters discharged from the site, i.e. there was no increase in contaminant load over time.

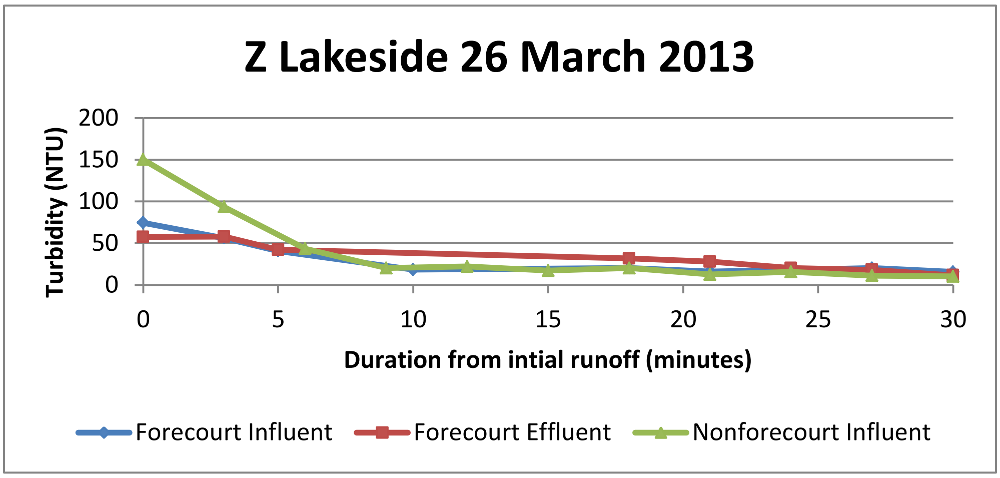

Figure 7: Z Lakeside Turbidity Results

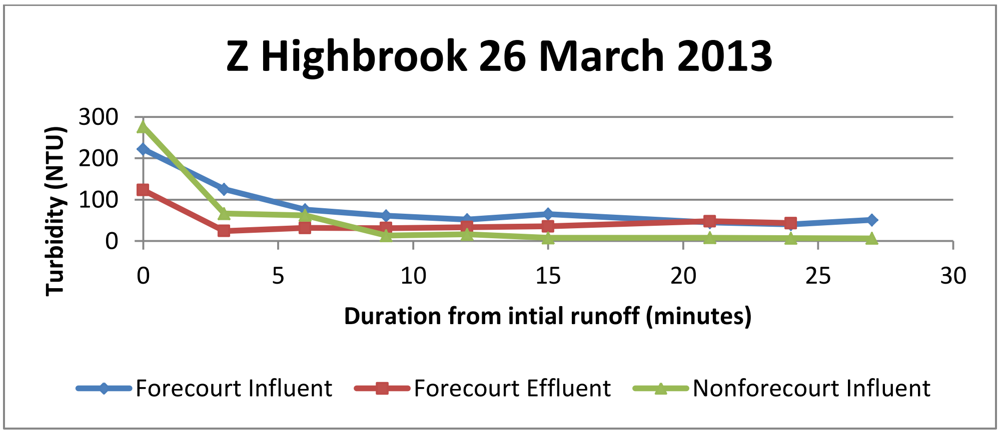

Figure 8: Z Highbrook Turbidity Results

Based on the information presented in Figures 7 and 8, the majority of the contaminant load is discharged within the first five minutes of the stormwater runoff occurring. It is assumed that this result is typical for all contaminants and for all sites assessed in this project, due to the similar drainage area characteristics for all sites, i.e. the timing in which peak stormwater discharges from the monitored drainage areas are anticipated to be similar. This verifies that the grab samples collected as soon as stormwater entered into the monitoring location (be it the stormwater treatment device or the catch pit) represent the first flush and therefore the peak contaminant concentrations.

5.4 Mass Load Assessment

A simple contaminant load calculation was undertaken using forecourt effluent data (the discharge from the oil-water separator/interceptor) and the non-forecourt data (untreated discharge to the catch pit) to estimate the average annual contaminant load contribution from all drainage areas assessed in this project, i.e. the amount of contaminants produced per given source area in a given time (Kg/annum/hectare).

The assessment was carried out in two stages:

- Stage one was used to calculate the average contaminant load contributions from first flush and mid flow data. This assessment defines the ranges of possible contaminant mass load that could be (based on the obtained data) discharged from the forecourt and non-forecourt drainage areas.
- Stage two involved calculating the annual average contaminant load contribution from the forecourt and non-forecourt drainage areas.

The stage one methodology used to determine the mass loads from first flush and mid flow, involved the multiplication of the measured contaminant concentration and the annual stormwater flow discharged from the sampled catchment area. This resultant was then divided by the drainage area that was monitored.

In order to establish the estimated annual contaminant loads from the drainage areas, the Auckland Airport 2012 annual precipitation value of 1,063 mm was used (NIWA, 2013).

The annual stormwater flow was calculated using the Rational Method (i.e. stormwater discharge = Runoff co-efficient x rainfall x drainage area). For the purposes of this project, a runoff co-efficient of 0.95 was used to represent that not all rainfall events produce a stormwater discharge, i.e. 5% of the annual rainfall does not produce sufficient rainfall to produce a stormwater discharge. This runoff co-efficient is representative for an impervious surface e.g. concrete or asphalt (Horner *et al.* 1994).

For the purposes of comparing the obtained results with published data, all results are reported in units of Kg/annum/hectare.

For comparison purposes, contaminant yield assessments were carried out for both first flush and the mid flow (30 minutes) data. Tables 17 and 18 present first flush and the mid flow results, respectively. For purposes of comparison of data, a similar assessment was carried out for the two control sites.

The contaminant yields calculated have been compared to available contaminant load information from the following publications:

- URS (2008) - This report presented contaminant yield results obtained from the monitoring of actual storm events across five Auckland service stations (not exclusive to Z service stations). The values presented are the average contaminant yields obtained from all five service stations assessed.
- Kennedy and Sutherland (2008) – This technical report presents the mass loads and contaminant yields determined for three stormwater catchments in the Auckland area, namely Mission Bay (residential catchment), Auckland CBD (commercial catchment) and Mt Wellington (industrial catchment).

The stage two methodology was used to determine the ‘best estimate’ of annual contaminant load contribution from the forecourt and non-forecourt drainage areas.

Based on the turbidity data collected to determine the characteristics of the first flush event (refer to figures 7 and 8), the median load would occur within the first five minutes of the stormwater discharge.

At an average 1 L/s irrigation flow rate across the Z Service Stations, and an average irrigation area of 100 m^2, the applied synthetic rainfall for 5 minutes is 300 L per 100 m^2, or 3 mm of rainfall, would be discharged at the first flush concentration. For rainfall depths greater than 3 mm, contaminant concentrations would then be discharged at the mid flow contaminant concentration.

Median first flush and mid flow concentrations for the forecourt and non-forecourt drainage areas were used in this assessment.

20 years of rainfall record (obtained from the Auckland International Airport) were used to estimate the average annual depth from rainfall events 3 mm or less, plus the first 3 mm of rainfall for larger events. The ratio of this to the total annual rainfall was then used to prorate the first flush to mid flow concentration data.

Table 19 presents annual contaminant mass loads for forecourt and non-forecourt drainage areas. For comparative purposes, Table 19 also includes data obtained from Kennedy and Sutherland (2008) for residential, commercial and industrial land uses.

Table 17: Average Contaminant Mass Load for Z Service Stations Assessed -First Flush Scenario

Parameter	Z Service Stations		Control Sites		URS (2009)		Kennedy and Sutherland (2008)		
	Forecourt Effluent	Non-Forecourt Effluent	Control Site A Effluent	Controls Site B Effluent	Forecourt Effluent	Non-Forecourt Effluent	Central Business District	Residential	Industrial
Total Copper	0.112	0.258	0.729	0.667	0.19	0.36	0.14	0.08	0.14
Total Lead	0.112	0.103	0.170	0.250	0.086	0.07	0.12	0.06	0.14
Total Zinc	6.64	5.21	5.73	6.98	4.53	4.34	1.63	0.57	5.2
Total Suspended Solids	472.43	4660.46	3333.57	3958.61	303.12	359.96	310	620	252
Total Petroleum Hydrocarbons	14.85	7.07	<7.29	<7.29	63.15	12.12	-	-	-

Notes:

1. *All results are expressed as Kg/annum/hectare*
2. *'-' denotes that this parameter has not been calculated.*
3. *Service station forecourt area for sites used in this study ranged between 280 m² and 350 m². Service station non-forecourt area for sites used in this study ranged between1,100 m² and 1,700 m² (based on GIS assessment).*

Table 18: Average Contaminant Mass Load for Z Service Stations Assessed -Mid Flow Scenario

Parameter	Z Service Stations		Control Sites		URS (2009)		Kennedy and Sutherland (2008)		
	Forecourt Effluent	Non-Forecourt Effluent	Control Site A Effluent	Controls Site B Effluent	Forecourt Effluent	Non-Forecourt Effluent	Central Business District	Residential	Industrial
Total Copper	0.050	0.018	0.033	0.021	0.17	0.21	0.14	0.08	0.14
Total Lead	0.014	0.010	0.014	0.011	0.115	0.166	0.12	0.06	0.14
Total Zinc	1.67	0.43	0.41	0.24	3.15	5.68	1.63	0.57	5.2
Total Suspended Solids	111.08	106.03	260.44	72.92	267.76	381.43	310	620	252
Total Petroleum Hydrocarbons	35.345	7.069	<7.292	<7.292	8.21	81.08	-	-	-

Notes:

1. *All results are expressed as Kg/annum/hectare*
2. *'-' denotes that this parameter has not been calculated.*
3. *URS (2009) mid flow results were collected approximately one hour after the first flush sample.*
4. *This studies mid flow samples were collected 30 minutes after the first flush sample.*

Table 19: Average Annual Contaminant Mass Load for Z Service Stations Assessed - Drainage Area Type

Parameter	**Drainage Area Type**				
	Z Energy		**Kennedy and Sutherland (2008)**		
	Forecourt Effluent	**Non-Forecourt Effluent**	**Central Business District**	**Residential**	**Industrial**
Total Copper	0.05	0.06	0.14	0.08	0.14
Total Lead	0.02	0.03	0.12	0.06	0.14
Total Zinc	2.4	1.2	1.63	0.57	5.2
Total Suspended Solids	119	653	310	620	252
Total Petroleum Hydrocarbons	28	8	-	-	-

Notes: 1. All results are expressed as Kg/annum/hectare
2. '-' denotes that this parameter has not been calculated.

6.0 Discussion

6.1 Sediment Quality

The following section discusses the sediment quality results obtained. Comments below are specific to contaminants that have specific values that are significantly different when compared to other sediment quality data obtained in this project or results obtained by URS (2008).

6.1.1 pH

From the sediment quality results obtained, the pH varied considerably across the service stations assessed (ranging from 5.7-8.5 pH units).

A relationship of pH and total organic carbon can be formed, i.e. when total organic carbon concentrations are elevated, pH concentrations are usually reduced. This implies that organic matter (such as leaf litter) is a key component for determining the sediment pH, due to a reducing environment resulting from organic degradation.

This correlation however, is not consistent with the Hunters Corner forecourt result where values of 8.5 pH units and 10.7 g/100g of total organic carbon were obtained. It is therefore assumed that a second source may have caused the pH increase. This would be consistent with the presence of detergent in the sediment.

6.1.2 Polycyclic Aromatic Hydrocarbons

In general, based on the sample results obtained, PAH compounds bind well to sediment particles when present. PAH compounds bound to sediment, clearly accumulate within the stormwater oil-water interceptors/separators and sumps. This is specifically demonstrated by the elevated sediment concentrations of PAH at Z Browns Road and Z Sylvia Park while water quality results obtained had very low PAH concentrations.

6.1.3 Heavy Metals

Elevated concentrations of heavy metals were obtained at all Z service stations and control sites. All service stations had heavy metal concentrations that were greater than background concentrations within Auckland soils. Meaning that the activities undertaken at the service stations were contributing heavy metal load. This result is consistent with other studies and reports that have monitored vehicle related land uses (Moores *et al*, 2009a, Moores *et al*, 2009b, Kennedy and Sutherland, 2008, URS, 2008).

Key heavy metal sources that may have generated the observed contaminants are:

- Vehicular movements leading to tyre wear, brake lining wear;
- Vehicle emissions, from vehicle movement and vehicle starting; and
- Vehicle oils losses.

High concentrations of zinc at Highbrook and Hunters Corner may be attributed to the silts and clays present at these sites. This is due to the greater capacity for smaller sediment particles to adsorb contaminants. In comparison, due to a larger grain size distribution being present at Browns Road, the concentrations of zinc were considerably less.

Sylvia Park had the greatest concentration of heavy metals present in sediments. A possible explanation for this is the additional transport related activities that occur at this site in comparison to all other sites (e.g. the Repco and NZ Courier depots).

As previously discussed, Z Silvia Park now has a Hynds Environmental Upflow Filter installed to further treat stormwater prior to discharge from the site to the public stormwater reticulation network.

6.1.4 BTEX Compounds

BTEX compounds are volatile and degrade readily in the presence of oxygen. This is the likely reason why the majority of sites assessed had little to no BTEX compounds present in the sediment samples obtained. The only site that had BTEX concentrations different to other samples obtained in this project was the Z Hunters Corner forecourt sample. Whilst it cannot be confirmed, a possible explanation for this result may be from a recent spill event (in the past day) where BTEX compounds may not have had sufficient time to allow volatilisation to occur. This theory is in alignment with visual observations made at Z Hunters Corner (Section 5.1.3).

6.1.5 Total Petroleum Hydrocarbons

The TPH results obtained varied across all sites assessed. TPH concentrations were commonly greatest in sediment that is discharged from forecourts into the treatment devices. TPH concentrations were also lowest at sites where trucks are not common (e.g. Z Lakeside and Z Browns Road (whilst being in a predominantly industrial catchment, few trucks use Z Browns Road, due to Z Roscommon Road (sited approximately 2 km north) having a dedicated truck stop refuelling facility)). This statement is verified by the TPH chromatograms obtained during water quality sampling for samples from Z Highbrook, Z Hunters Corner, and Z Sylvia Park, which indicate that the predominant sources of TPH are derived from high carbon chain compounds e.g., diesels, oils and lubricants, or degraded petrol.

Comparing non-forecourt sediment and water quality TPH samples, TPH concentrations were, in the majority, only measureable in the sediment particulate datasets for the sample events measured. This suggests that the majority of TPH concentrations derived within the non-forecourt area readily attach to sediment particles. Catch pits will therefore remove the coarse fraction of sediment and associated TPH load.

Very elevated concentrations of TPH were measured at Z Highbrook and Z Sylvia Park forecourts (250,000 mg/Kg and 197,000 mg/Kg, respectively).

To confirm these results, a second sediment sample was collected at both service stations on 5 February 2013. The result of the second sample at Z Sylvia Park provided a TPH concentration that was significantly reduced compared to the first result obtained (27,000 mg/Kg). Possible explanations for this significant difference between the results may be;

- A possible hydrocarbon globule was analysed in first sample.
- Any contaminated sediments that were retained within the treatment device/catch pit, were flushed by a storm event that occurred between the two sampling dates (21 mm of rainfall occurred on 4 February 2013[1])

TPH results obtained at the Z Highbrook forecourt were consistently elevated (the second sample had a TPH measure of 310,000 mg/Kg). A possible reason for the elevated TPH results may be the uncovered truck stop located at Z Highbrook. This area may be exposed to a greater potential for leaking oils and lubricants from trucks and for diesel losses during filling. It is noted that petrol spills are relatively rapidly evaporated whereas diesel, being less volatile) tends to leave a residue of heavy end hydrocarbons on the ground. Visual evidence of oil staining on the truck stop area provides some indication of this.

Comparison of the sediment quality TPH results to water quality TPH results (discussed in Section 6.2.7) indicates that the TPH discharges are binding well to sediments associated with the discharge, rather than remaining mobile in the influent and effluent waters

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[1] Data recorded at the Auckland International Airport. Data obtained from the NZ Climate Database.

discharged from site. This clearly reflects the low solubility of diesel and oil range hydrocarbons.

6.2 Water Quality

The following section discusses the water quality results obtained. The comments below are specific to contaminants that have measured exceedances (compared with ANZECC (2000) 95% and 80% protection trigger values), or contaminants that have specific values that are significantly different when compared to other data obtained in this project. This information provides insight into whether the stormwater treatment device located at Z service stations are able to treat the various contaminants measured in this study and how the contaminant loads compare to other types of land-use.

It is important to note that water quality results obtained are for a single storm event at a given time. The following discussion is therefore based only on the data obtained during this project. Data obtained does not represent the long-term performance that may be achieved from the stormwater treatment devices located at Z service stations. By testing across several sites, general conclusions are inferred about contaminant loading and treatment device performance.

6.2.1 pH

Similar to the pH measurements obtained from sediment quality monitoring, the water quality pH measurements obtained also showed a significant variability across the service stations and control sites.

Water quality pH results from services stations varied from 6.6 to 8.9 pH units.

The pH of the discharge water should be within the range 5.0–9.0, assuming that the buffering capacity of the water is low near the extremes of the pH limits (ANZECC, 2000).

No specific trend between forecourt and non-forecourt drainage areas could be identified. This implies that the potential sources for pH modification are either sourced in both areas, or more likely, can be easily tracked/transported by vehicular movements or wind. As discussed in Section 6.1.1, detergent may be a source of elevated pH within the forecourt discharges.

The value of 8.9 pH units obtained at Sylvia Park forecourt effluent mid-flow, may be explained by the installation of an Upflow filter™[2] during February. To install this treatment device, concrete would have had to been cut and removed. It is assumed that residual concrete dust from this installation could have caused the elevated pH measurement obtained.

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[2] A stormwater treatment proprietary product.

6.2.2 Dissolved Oxygen and Oxygen Reduction Potential

Dissolved oxygen concentrations and oxygen reduction potential measurements were significantly less in forecourt effluent samples than compared to forecourt influent samples. A possible explanation for this is due to the influence of water residing within the stormwater treatment devices during the dry antecedent weather conditions. Whilst no measurements were obtained, it is assumed that biological oxygen demanding (BOD) substances and chemical oxygen demanding (COD) substances would be present within the stormwater treatment devices and the stagnant water within the devices would have dissolved oxygen concentrations reduced by the BOD and COD substances. As an example, organic matter present within the stormwater treatment devices may undergo biological degradation and cause a depletion of dissolved oxygen concentrations.

The forecourt effluent dissolved oxygen concentration sample at Z Lakeside was however elevated (80.7% saturation). Oxygen reduction potential was however, very low (7 mV), meaning that the water has chemical properties that may allow dissolved oxygen concentrations to become reduced. A possible explanation for this is the reduced live storage within this device and increased turbulence (i.e. the two stage interceptor has lesser volume of stagnant water retained within the device than compared to all other treatment devices), as discussed in Section 3.2.1.

6.2.3 Total Suspended Solids

High sediment loads were commonly correlated to service stations that had landscaped areas. Sediment is likely to have been transferred to the forecourt and non-forecourt areas by either being wind-blown or tracked by vehicles throughout the service station.

As expected, TSS concentrations were greatest in first flush samples. TSS concentrations then reduce over time, typically within the first 5 minutes of discharge.

Table 20 below presents the sediment removal performance achieved by the installed stormwater treatment devices for the events monitored.

Table 20: % TSS Removal Achieved by Installed Stormwater Treatment Devices

Site	Sample Location	% TSS removal[1]
Z Browns Road	Three Stage Interceptor	54
Z Highbrook	5.0 API oil water separator	47[2]
		55[3]
Z Hunters Corner	3.0 API oil water separator	72
Z Lakeside	Two Stage Interceptor	-66
Z Sylvia Park	3.5 API oil water separator	44

Notes:
1. *Assessment is based on comparative values recorded from first flush samples.*
2. *Sample date 13 March 2013*
3. *Sample date 26 March 2013*

The value obtained for the two stage interceptor (Z Lakeside) indicates an export of sediment from the device. This result is considered to be due to the reduced live storage of the device and increased turbulence within the treatment device itself and that this result is an outlier and should not be considered as a 'typical' result that can be achieved from stormwater treatment devices located on Z service stations. If the measurement from Z Lakeside is removed from the dataset, the average TSS removed by the stormwater treatment devices, during the events sampled, was 54%. It is noted that the Z Lakeside site is scheduled for a drainage upgrade (the existing drainage is a relic from the previous service station operator and does not meet Z standards).

The results obtained are consistent with other TSS monitoring results for devices with low TSS influent concentrations.

Moores *et al.* (2012) assessed the contaminant removal efficiencies of a range of proprietary stormwater treatment devices from car park runoff, including:

- Hynds Up-Flow Filters;
- Stormwater 360 Stormfilters; and
- Humes Filternators.

All stormwater treatment devices used in the Moores *et al*. (2012) study, use filtration processes to treat stormwater. The oil-water interceptors/separators treatment devices monitored in this project, however, use sedimentation processes. Key differences between these two stormwater treatment processes are:

- Filtration devices enable the stormwater to pass through a filter media, e.g. zeolite, perlite; and
- Sedimentation devices require a detention of the stormwater to allow for the settlement of entrained contaminants to occur.

Based on the differing processes, it is expected that filtration devices should provide a greater performance in removing TSS from stormwater. This conclusion is consistent with results presented in the USEPA BMP database[3], where a filtration device should achieve an average 83% reduction in TSS[4], while a sedimentation type device should achieve an average 47% reduction in TSS[5].

However, results obtained from the Moores *et al* (2012) study, found that the majority of TSS removal efficiencies for these devices (for the storm events assessed) were not able to achieve 75% TSS removal, even though all of these stormwater treatment devices are Auckland Council accredited to achieve this performance standard. Table 21 presents the per cent TSS removal achieved for the above stormwater treatment devices during the Moores *et al.* (2012) study.

Table 21: % TSS Removal Achieved by Other Stormwater Treatment Devices during the Moores *et al.*(2012) Study.

Stormwater Treatment Device	% TSS removal
Up-Flow Filter	15[1]
Stormfilter	24
Filternator	68[2]

Notes:

1. *Moores et al. (2012) attributes the low % TSS removal due to the fine sediment grainsize that was present, and the overall low sediment load in the influent sample.*
2. *Events sampled for the Filternator had a significantly less flow rate than other devices. The sample event used to assess the Filternator only had a peak influent flow rate of 2.2 L/s, whilst the Up-Flow Filter and the Stormfilter had peak influent flow rates of 31.0 L/s and 32.4 L/s, respectively.*

The results obtained by Moores *et al.* (2012) demonstrate the variability that can occur in stormwater treatment devices when removing TSS from stormwater discharges from car parks.

Moores *et al.* (2012) attributes the reduced TSS removal performance to a low TSS concentration in the influent. During the Moores *et al.* (2012) study, typical influent TSS concentrations ranged from 14 to 150 mg/L. These TSS influent results are similar to those obtained in this study.

Therefore due to the variability of TSS removal performance that may occur in stormwater treatment devices when they are located within land uses with high proportions of impermeable surfaces (e.g. service stations and car parks), the results obtained in this study are consistent with data reported in the USEPA BMP database for other sedimentation type devices. It is considered that the oil-water separators/interceptors monitored in this project (except the two stage interceptor) were performing appropriately.

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[3] United States Environmental Protection Agency Best Management Practice Database.

[4] Based on ‘media filter’ treatment.

[5] Based on ‘manufactured device’ treatment.

6.2.4 Polycyclic Aromatic Hydrocarbons

For the water quality samples obtained in this project, PAH concentrations were commonly below laboratory detection limits for most water quality samples discharged from Z service stations and control sites. For any PAH compounds that were detected, these were less than ANZECC (2000) 95% protection trigger values. This reported result is consistent with other studies (URS, 2008).

As discussed in Section 6.1.2, of the PAH data collected, the majority of PAH load is associated with sediment. This suggests that for the sampling conducted in this study, PAH compounds that are derived within service stations, are commonly bound to sediment particles, which are then able to be captured and retained within sedimentation type stormwater treatment devices.

6.2.5 Heavy Metals

During the sampled events, all sites assessed (services stations and control sites) had elevated heavy metal concentrations. Zinc, copper, and chromium were common parameters that exceeded ANZECC (2000) 95% protection level triggers. From comparison to ANZECC (2000) 80% protection level triggers, exceedances are only common for zinc and copper. In the majority, the quantity of exceedances for zinc and copper are the same (compared between ANZECC (2000) 95% and 80% protection level triggers), however the 80% protection level is commonly not exceeded in the effluent discharge.

As discussed in Section 6.1.3, key sources that are likely to contribute such concentrations, are:

- Vehicular movements leading to tyre wear (zinc), brake lining wear (copper);
- Vehicle emissions, from vehicle movement and vehicle starting; and
- Vehicle oils losses.

Roof areas of service stations are commonly piped directly to the stormwater reticulation network, i.e. no discharge of roof runoff occurs across forecourt or non-forecourt areas. For all the Z service stations assessed, all roof runoff was piped directly to the stormwater reticulation network.

In general, the forecourt drainage areas had lower heavy metal concentrations than the non-forecourt drainage areas. This may be due to an increase in sources available in the non-forecourt drainage areas, such as; atmospheric deposition from additional surrounding sources or the activities that take place in the two drainage areas differ. The vehicular movement is of particular difference. In the non-forecourt drainage areas, tyre wear and brake lining wear are likely to be greater. Due to the difference in vehicle speeds (and therefore vehicle braking requirements) and more turning movements as vehicles pull into the forecourt. Non-forecourt areas are commonly asphalted, whilst forecourt areas are concreted. Due to the greater roughness of asphalt (compared to concrete), it is assumed that tyre wear may be greater than compared to the smoother concrete surfaces located on forecourts.

A higher dissolved fraction of heavy metals was obtained in the non-forecourt areas than compared to the forecourt areas. This result may be attributed to the sediment grain sizes present in each drainage area. Forecourt sediments were predominantly of smaller grain size than non-forecourt sediments (silts versus sands respectively). This may be attributed to the finer sediment particles having being already washed away by previous rainfall events in non-forecourt drainage areas.

In forecourt drainage areas, the effluent heavy metal concentrations are commonly greater than influent heavy metal concentrations. This may be due to the exportation of fine grained sediment from the stormwater treatment device. It is assumed that coarse grained sediment is retained within the devices based on the sediment particle size distributions obtained from within the primary chambers of the stormwater treatment devices.

In some instances, total and dissolved metal concentrations (particularly zinc) in the forecourt effluent flow were greater than the influent flow. This is illustrated in figures 1 and 3. Possible explanations for this may be attributed to:

- The galvanised grill within the API oil-water separators. Stagnant water within the API oil-water separator during the inter event dry period can increase dissolved zinc concentrations as it is in continual contact with a source of zinc;
- Entrainment of previous accumulated fine particles during the monitored events. Fine particles that were discharged into the stormwater treatment devices from a previous storm event may have become remobilised as the next storm events first flush waters pass through the device.

This study has identified that in comparison to the effluent heavy metal loads obtained from forecourt drainage areas with the control sites (car parks), forecourts typically had lower effluent concentrations. Non-forecourt drainage areas typically had similar heavy metal effluent concentrations to the control sites.

The results obtained in this project are consistent with the majority of other studies considered. The results obtained by URS (2008) and during this study both showed elevated effluent concentrations of zinc and copper in particular. URS (2008) also concluded however, that the treated effluent concentrations obtained from the API's and non-forecourt drainage areas monitored, were generally comparable to the control sites (high use car parks) monitored. The results of this study also found that forecourt and non-forecourt drainage areas were comparable to the control sites monitored.

6.2.6 BTEX Compounds

As previously discussed in Section 6.1.4, BTEX compounds are volatile and readily degrade in the presence of oxygen. As anticipated then, for the events sampled, BTEX discharges were, in the majority, compliant with ANZECC (2000) 95% protection trigger values. The only site that did have exceedances was Z Highbrook.

6.2.7 Total Petroleum Hydrocarbons

All TPH discharges from the Z services stations assessed were compliant with MfE guidelines (MfE, 1998) during the events sampled. This result is consistent with results achieved by URS (2008).

Significant TPH removal was recorded at Z Highbrook on 13 March 2013. A possible reason for this result may be associated with a comparable high TSS concentration also observed. This implies that the TPH present at Z Highbrook readily bonds to the sediment. Therefore, if the sediment is effectively removed by the stormwater treatment device, the TPH concentration will also be effectively removed.

In general, and as expected, TPH concentrations were greatest in forecourt areas. Samples collected from non-forecourt drainage areas commonly had TPH concentrations below laboratory levels of detection. As such, from the sample events measured, stormwater catch pits will retain the proportion of TPH attached to coarser sediment particles.

6.2.8 Mass Load Assessment

Contaminant loads discharged during the effluent first flush were consistent with values reported by URS (2009). Effluent mid flow results however, had poor correlations with URS (2009) data. Whilst it is not clear the reason for this, a possible explanation could be due to variable rainfall intensities that were observed when URS sampled. URS used actual rainfall events of lower intensity to obtain their data, whereas this study used synthetic rainfall that was applied at a constant intensity. If the rainfall intensity were to change over time (increase or decrease), the characteristics of the peak discharge may be different, i.e. the peak discharge concentration may occur for a longer or shorter duration.

Mass loads discharged from non-forecourt drainage areas are aligned to results obtained from the control sites. This is a key result which indicates that the loading rates discharged from the non-forecourt drainage areas and high use car parks are similar.

Best estimates of annual effluent contaminant mass loads in comparison to other land use categories, best align to an industrial land use. This result is expected given that the similarity in activities carried out at industrial sites and service stations (compared to activities carried out in commercial and residential areas).

7.0 Conclusion

Key conclusions from the sediment monitoring are:

- The quantity of sediment captured within catch pits/treatment devices is variable across the sites assessed. A key driver of the quantity of sediment captured is the extent of landscaped areas adjacent to and within the service stations, i.e. landscaped areas are the key source of sediment at sites assessed.

- Catch pits and oil-water separators/interceptors are capturing significant amounts of contaminants loads that are bound to the sediment, particularly heavy end petroleum products.
- Treatment devices managing forecourts areas are, in the majority, retaining higher TPH load in comparison to non-forecourt drainage areas (ranging from a 4 to 100 fold difference), whilst non-forecourt drainage areas produce a higher heavy metal load in comparison to forecourt areas (approximately a 2-3 fold difference).
- Comparison of the sediment quality PAH and TPH results to water quality PAH and TPH results (discussed in Sections 6.1.2 and 6.2.7) indicates that the PAH and the heavy end petroleum fraction are binding well to sediments associated with the discharge, rather than remaining mobile in the influent and effluent waters discharged from site.

For the water quality monitoring events sampled, the following key conclusions were achieved:

- Effluent dissolved oxygen concentrations from the oil-water separators/interceptors may be strongly affected by residual waters contained within the devices from previous storm events. A reduced live storage volume (and therefore increased turbulence) within the two stage interceptor located at Z Lakeside produced an elevated dissolved oxygen result. However this reduced live storage, also caused a reduced contaminant removal performance for other contaminants during the event sampled, i.e. TSS removal.
- Oil-water separators (API's) achieved a TSS removal performance between 42 and 72% for the events sampled. The triple oil-water interceptor (located at Z Browns Road) achieved a TSS removal performance of 54%. This result is consistent with other stormwater treatment devices that operate using sedimentation processes.
- Due to increased turbulence within the two stage interceptor (Z Lakeside) the effluent TSS concentration was higher in the discharge for the event sampled. This site was selected as the drainage system was inherited and is due to be upgraded.
- Forecourt stormwater is characterised by a first flush with elevated levels of TPH and TSS. BTEX and heavy metal concentrations are correspondingly elevated. By mid flow however, the concentration of contaminants within the forecourt had typically reduced by 50 to 90%.
- Heavy metal concentrations for copper, zinc, and chromium from forecourt and non-forecourt drainage areas often exceeded ANZECC (2000) 95% protection level triggers. Some ANZECC (2000) 80% protection level triggers were also exceeded. This result is consistent with other studies of service stations and sites which have low speed vehicle movement (URS, 2008, Moores *et al*, 2012). Copper and zinc trigger levels were also commonly exceeded in effluent

discharges from both control car parks. This result is expected due to the vehicular activities present at the sites.

- During the events monitored dissolved heavy metal loads were greatest in non-forecourt areas. The reason for this is unknown/unclear.
- During the events monitored, effluent BTEX concentrations at Z Highbrook were elevated. For the majority of sites monitored however, BTEX concentrations were below laboratory levels of detection. This is because BTEX compounds are volatile and are readily degradable in the presence of oxygen.
- All TPH effluent concentrations from the service stations assessed were well within the MfE (1998) discharge standard (15 mg/L).
- Effluent first flush mass loads obtained in this project are similar to other monitoring studies (URS, (2008)) carried out previously. However the first flush results are not representative of contaminant load through the duration of a rainfall event as concentrations decline rapidly.
- Mass loads discharged from non-forecourt drainage areas were not significantly different to the results obtained from the control sites.

8.0 References

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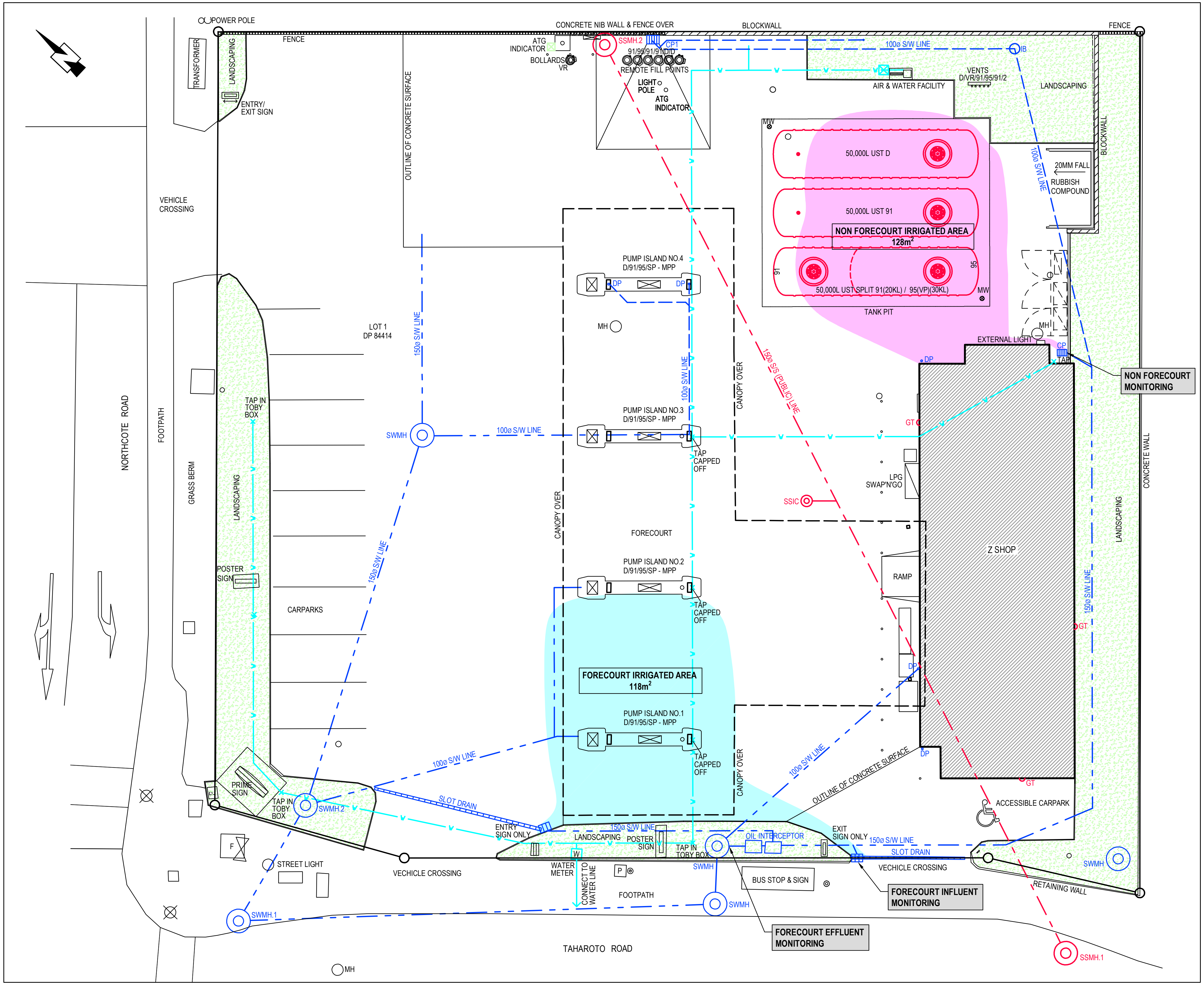
Appendix A

Site Maps

STORMWATER AND SEDIMENT MONITORING, Z LAKESIDE, 33 TAHAROTO ROAD, TAKAPUNA – Z ENERGY LTD



LEGEND

INVESTIGATION WORKS

🟦	IRRIGATED AREA - FORECOURT
🟪	IRRIGATED AREA - NON FORECOURT

SERVICES

— - —	SEWER LINE
— - —	STORMWATER LINE
—v—	WATER MAIN
▭	SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE

NOTES:

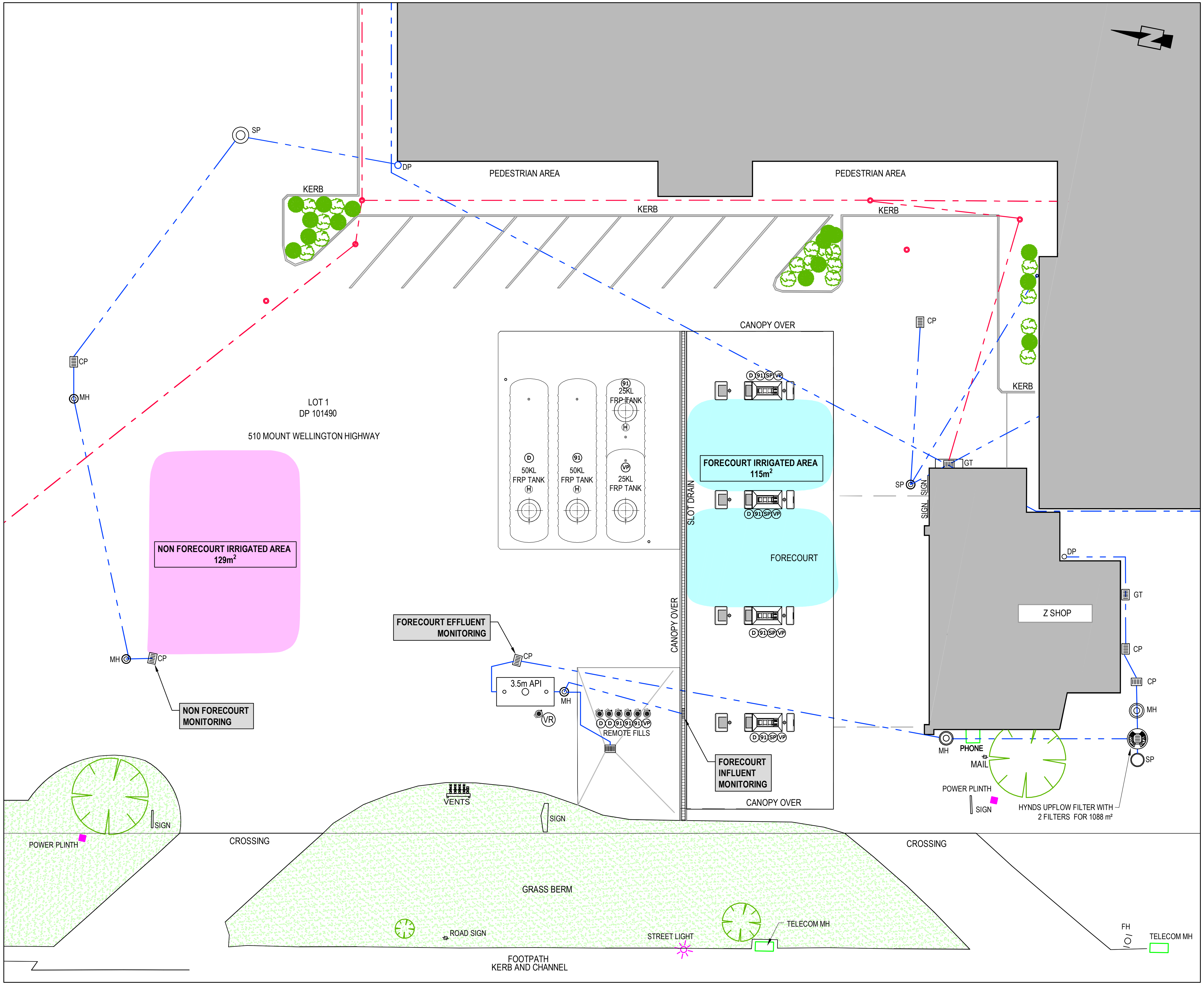
1. BASE DRAWING Z REF : 1_100061_12_A_SHA_12, REV A, SUPPLIED BY SHA ARCHITECTURE LTD.,DATED 20/06/12.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 2 4 6 8 10m

SCALE 1:200 (A3)

FIGURE A1 : SITE PLAN - LAKESIDE

STORMWATER AND SEDIMENT MONITORING, Z SILVIA PARK, 510 MT WELLINGTON HIGHWAY – Z ENERGY LTD



LEGEND

INVESTIGATION WORKS

🟦	IRRIGATED AREA - FORECOURT
🟪	IRRIGATED AREA - NON FORECOURT

SERVICES

— - —	SEWER LINE
— - —	STORMWATER LINE
▨	SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE
SP	SOAKPIT

NOTES:

1. BASE DRAWING No : 09026-008-1, ISSUE A, SUPPLIED BY ECL DESIGN SERVICES.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 5 10m

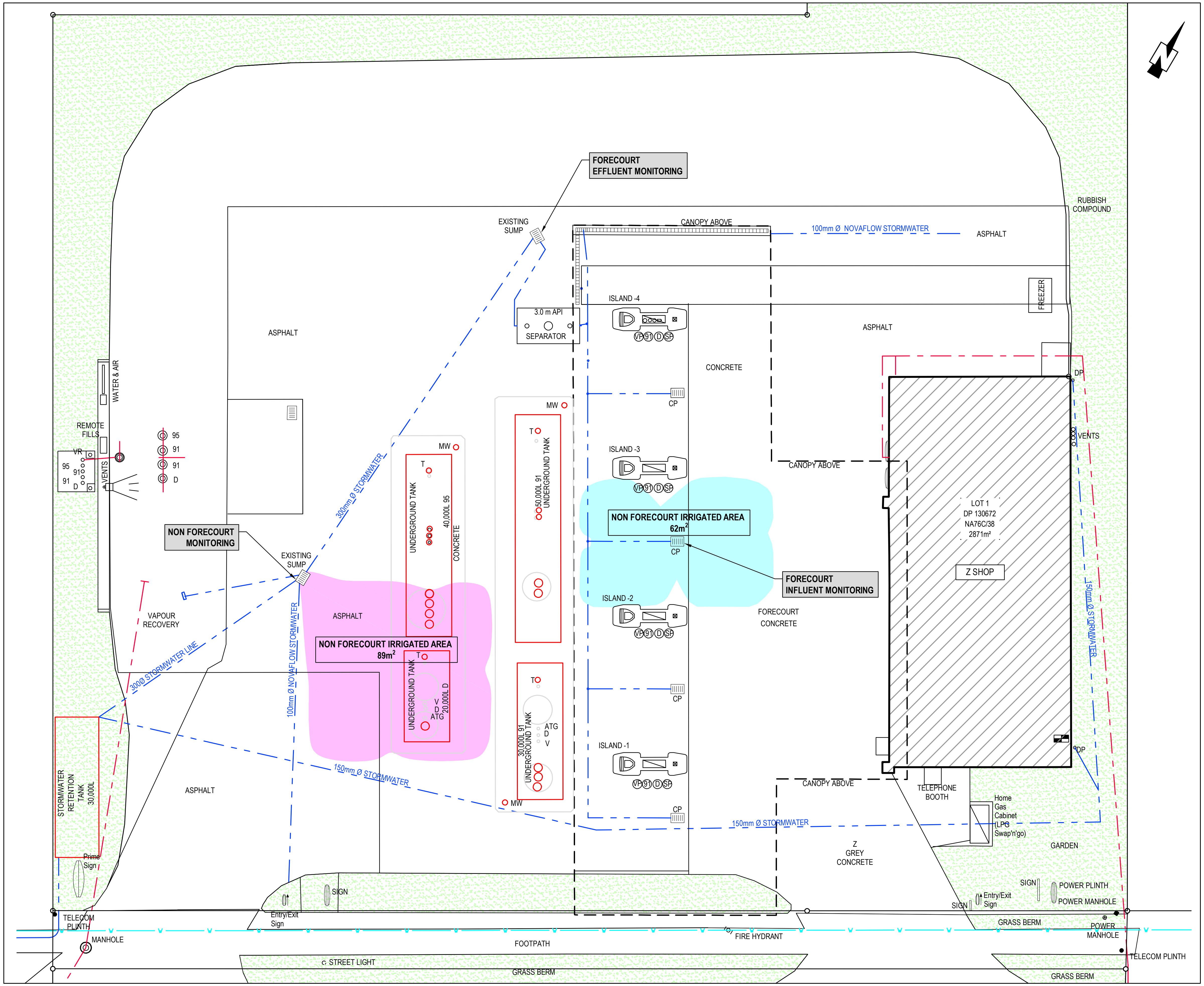
SCALE 1:250 (A3)

FIGURE A2 : SITE PLAN - SILVIA PARK

PATTLE DELAMORE PARTNERS LTD

A02579800D002_SilviaPark.dwg Oct-13 FINAL

STORMWATER AND SEDIMENT MONITORING, Z HUNTERS CORNER, 72–76 EAST TAMAKI ROAD – Z ENERGY LTD



LEGEND

INVESTIGATION WORKS

🟦	IRRIGATED AREA - FORECOURT
🟪	IRRIGATED AREA - NON FORECOURT

SERVICES

— - —	SEWER LINE
— - —	STORMWATER LINE
— v —	WATER MAIN
▥	SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE
SP	SOAKPIT

NOTES:

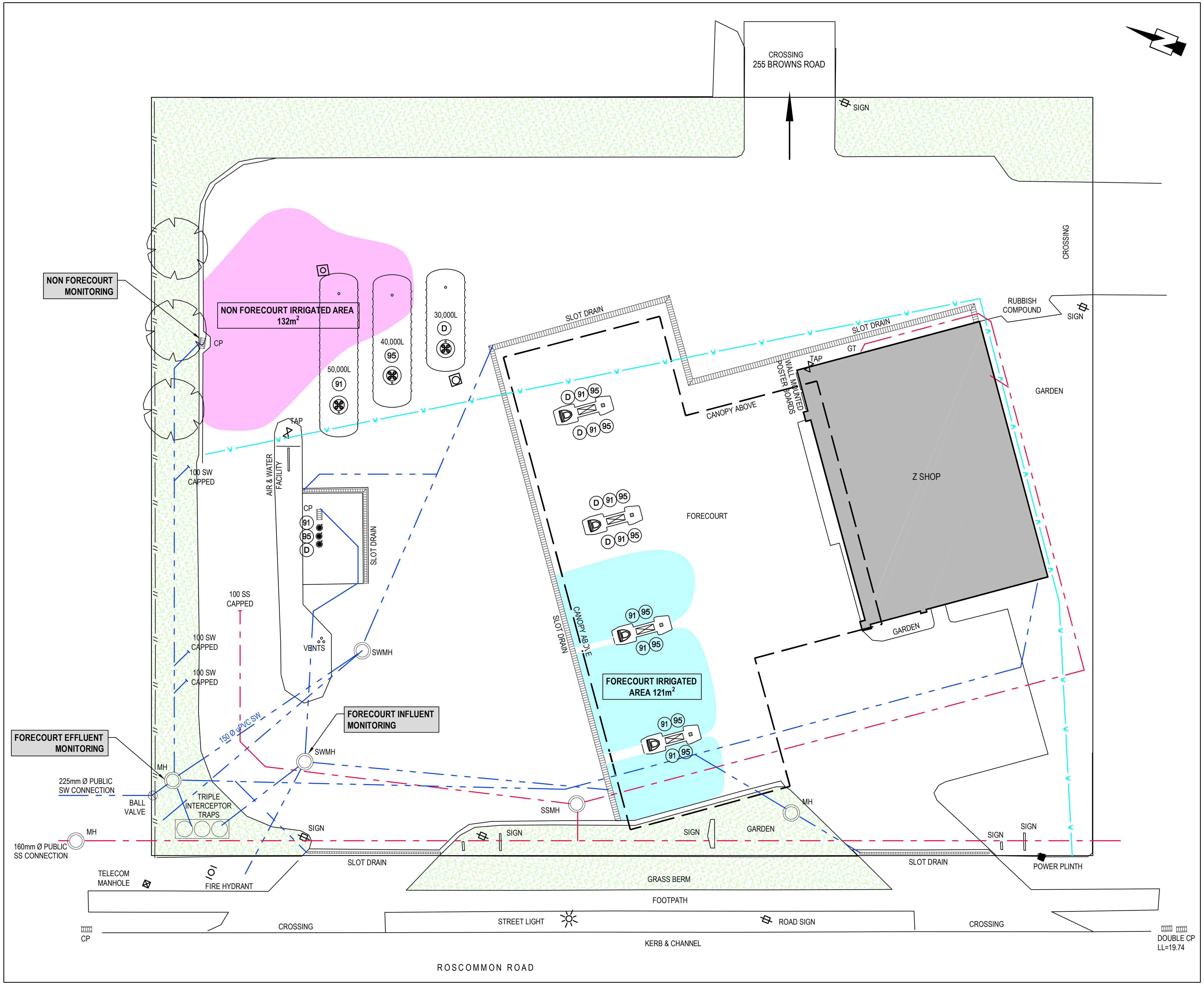
1. BASE DRAWING Z REF : 1_100632_12_U_SHA_01, REV F, SUPPLIED BY SHA ARCHITECTURE LTD.,DATED 30/08/12.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 2 4 6 8 10m

SCALE 1:200 (A3)

FIGURE A3 : SITE PLAN - HUNTERS CORNER

STORMWATER AND SEDIMENT MONITORING, Z BROWNS ROAD, 255 BROWNS ROAD, MANUKAU CITY – Z ENERGY LTD



LEGEND

INVESTIGATION WORKS

🟦	IRRIGATED AREA - FORECOURT
🟪	IRRIGATED AREA - NON FORECOURT

SERVICES

— · —	SEWER LINE
— —	STORMWATER LINE
—v—	WATER MAIN
▭	SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE
SP	SOAKPIT

NOTES:

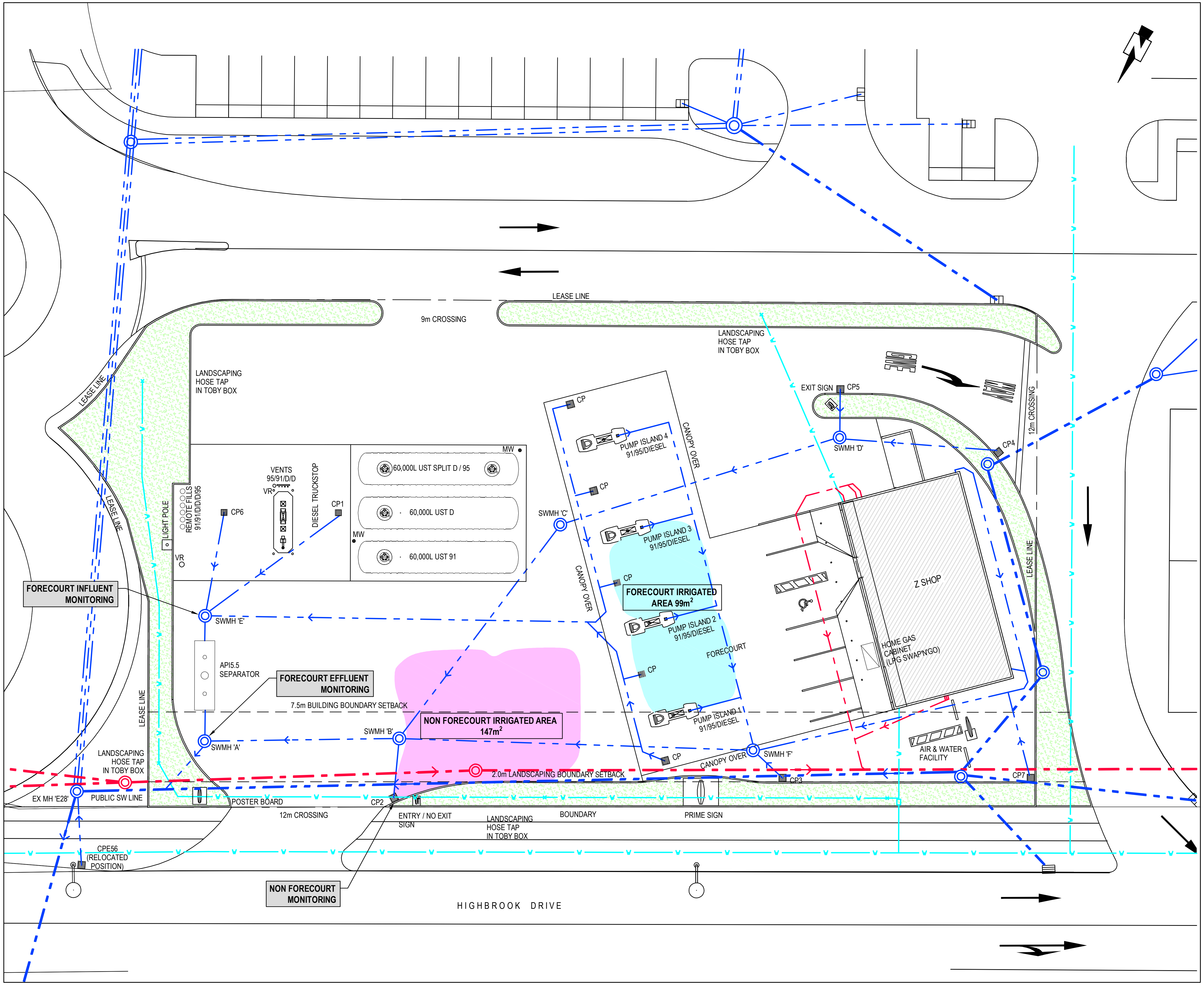
1. BASE DRAWING No : 08066-008, ISSUE A, SUPPLIED BY ECL DESIGN SERVICES.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 5 10m

SCALE 1:250 (A3)

FIGURE A4 : SITE PLAN - BROWNS ROAD

STORMWATER AND SEDIMENT MONITORING, Z HIGHBROOK, 60 HIGHBROOK DRIVE EAST, MANUKAU – Z ENERGY LTD



LEGEND

INVESTIGATION WORKS

🟦 IRRIGATED AREA - FORECOURT

🟪 IRRIGATED AREA - NON FORECOURT

SERVICES

SEWER LINE

STORMWATER LINE

WATER MAIN

SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE
SP	SOAKPIT

OTHER

XXX

NOTES:

1. BASE DRAWING Z REF : 1_221955_10_U_SHA_01, REV D, SUPPLIED BY SHA ARCHITECTURE LTD, DATED 20/06/12.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 5 10 15m

SCALE 1:300 (A3)

FIGURE A5 : SITE PLAN - HIGHBROOK 13.03.13

STORMWATER AND SEDIMENT MONITORING, Z HIGHBROOK, 60 HIGHBROOK DRIVE EAST, MANUKAU – Z ENERGY LTD

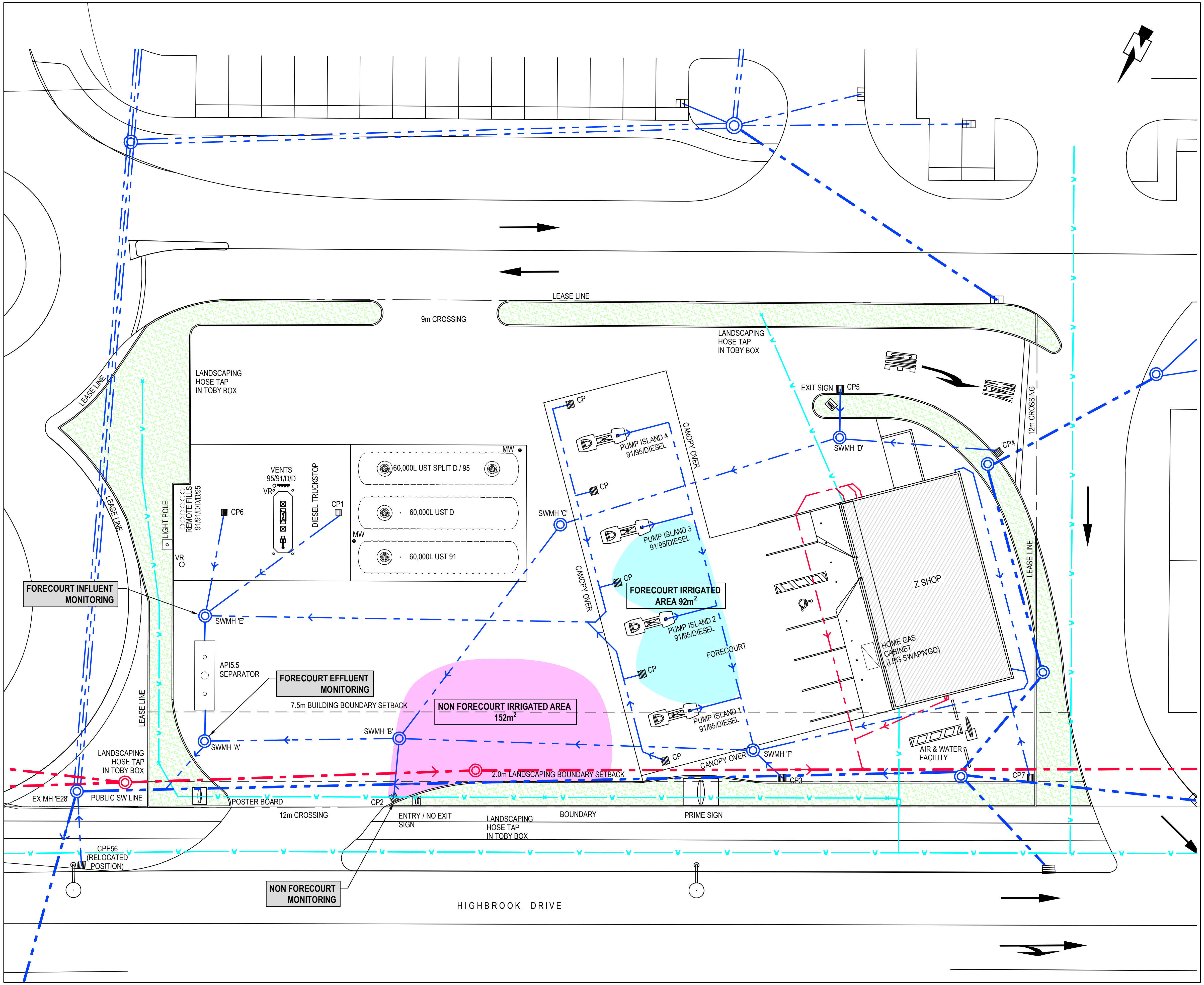


FIGURE A6 : SITE PLAN - HIGHBROOK 26.03.13

LEGEND

INVESTIGATION WORKS

🟦	IRRIGATED AREA - FORECOURT
🟪	IRRIGATED AREA - NON FORECOURT

SERVICES

— - —	SEWER LINE
— - —	STORMWATER LINE
—— v ——	WATER MAIN
▭▭▭	SLOT DRAIN

ABBREVIATIONS

CP	CATCHPIT
DP	DOWN PIPE
GT	GULLY TRAP
MH	MANHOLE
SP	SOAKPIT

NOTES:

1. BASE DRAWING Z REF : 1_221955_10_U_SHA_01 , REV D, SUPPLIED BY SHA ARCHITECTURE LTD.,DATED 20/06/12.
2. THE ACCURACY OF THE SERVICES AND THEIR LOCATIONS SHOWN ON THIS PLAN IS UNKNOWN. THE INFORMATION IS FOR ILLUSTRATION OF THE PLAN ONLY, AND SHOULD NOT BE USED FOR ANY OTHER PURPOSES.

0 5 10 15m

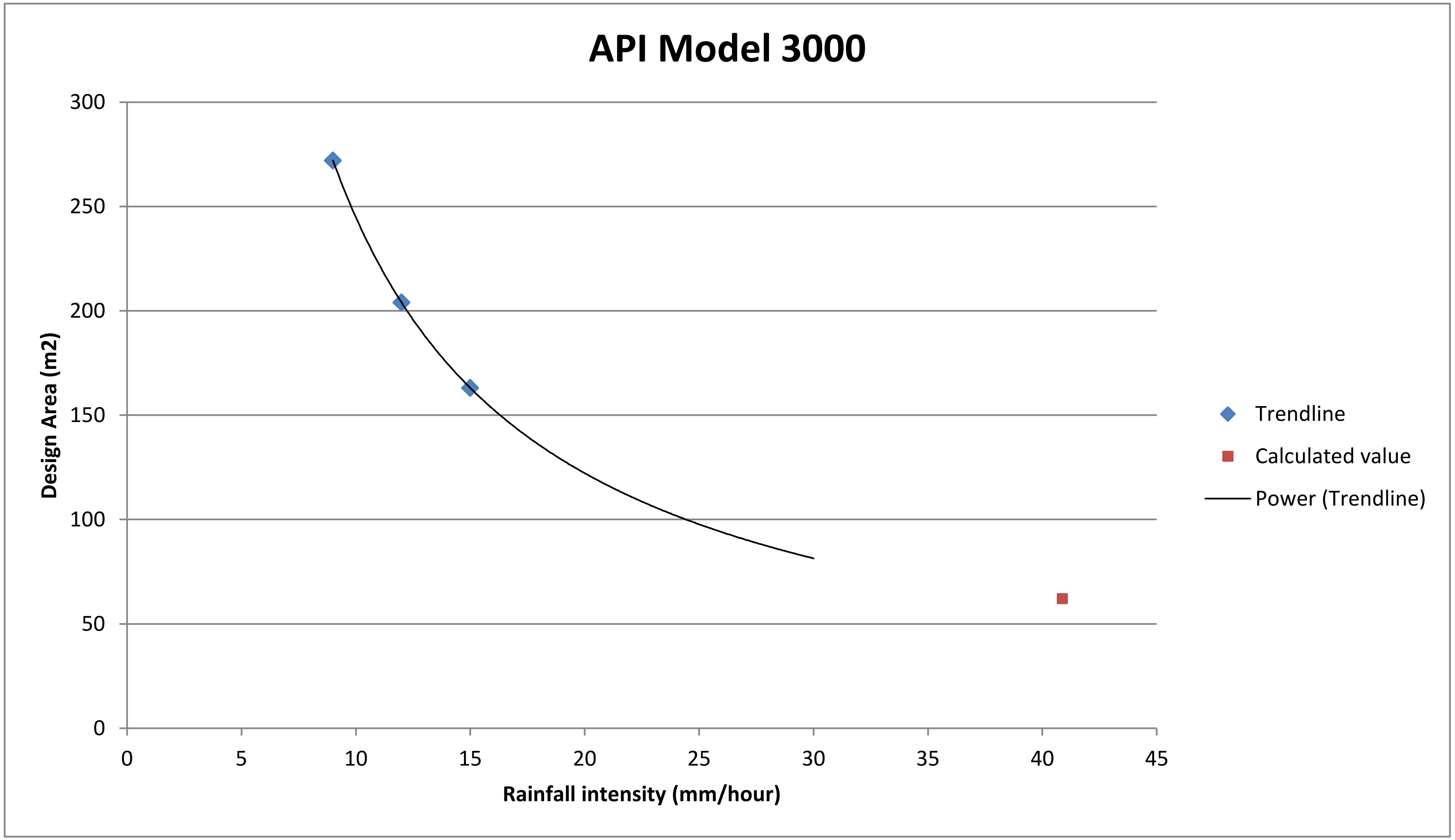
SCALE 1:300 (A3)

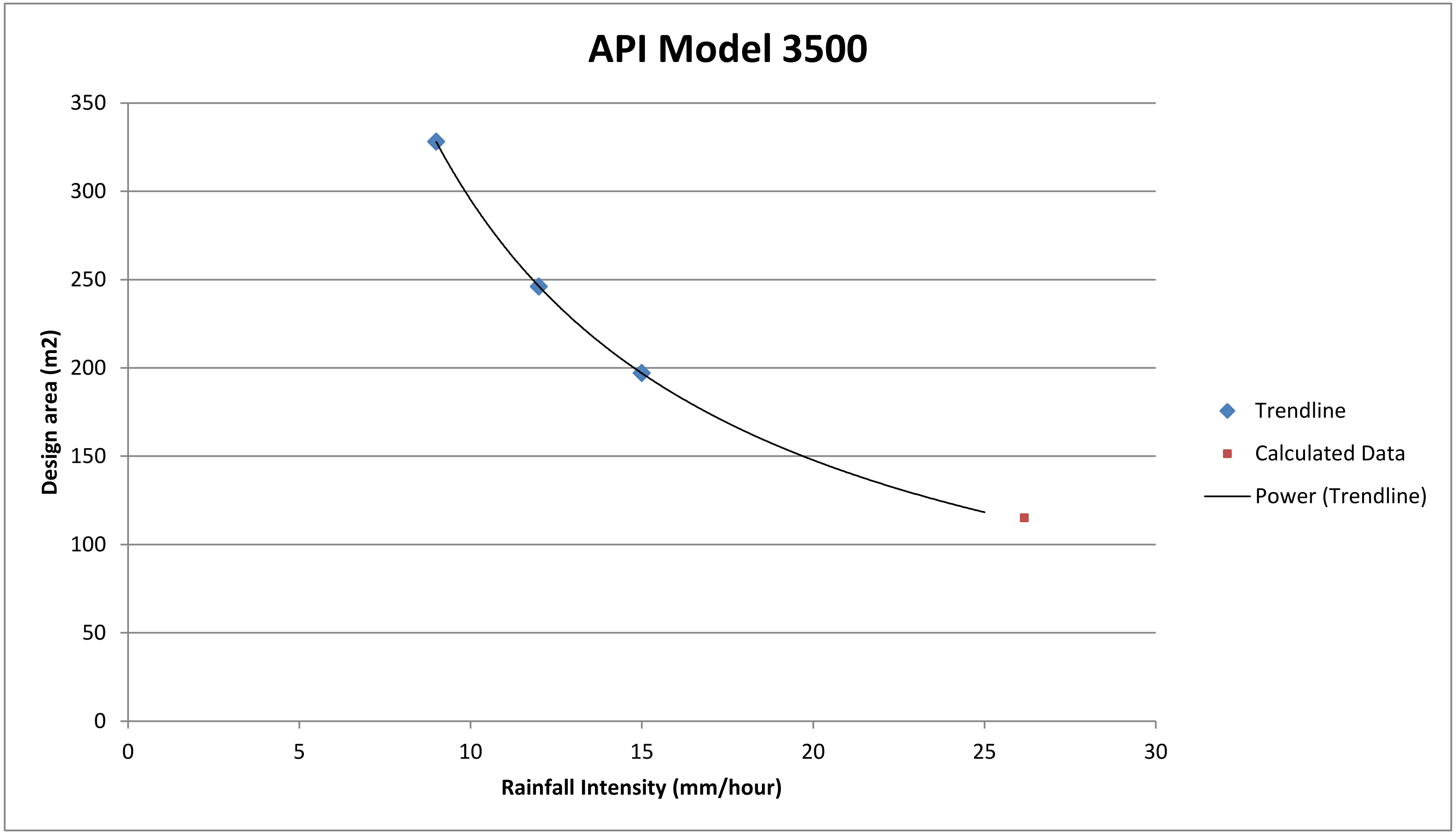
PATTLE DELAMORE PARTNERS LTD

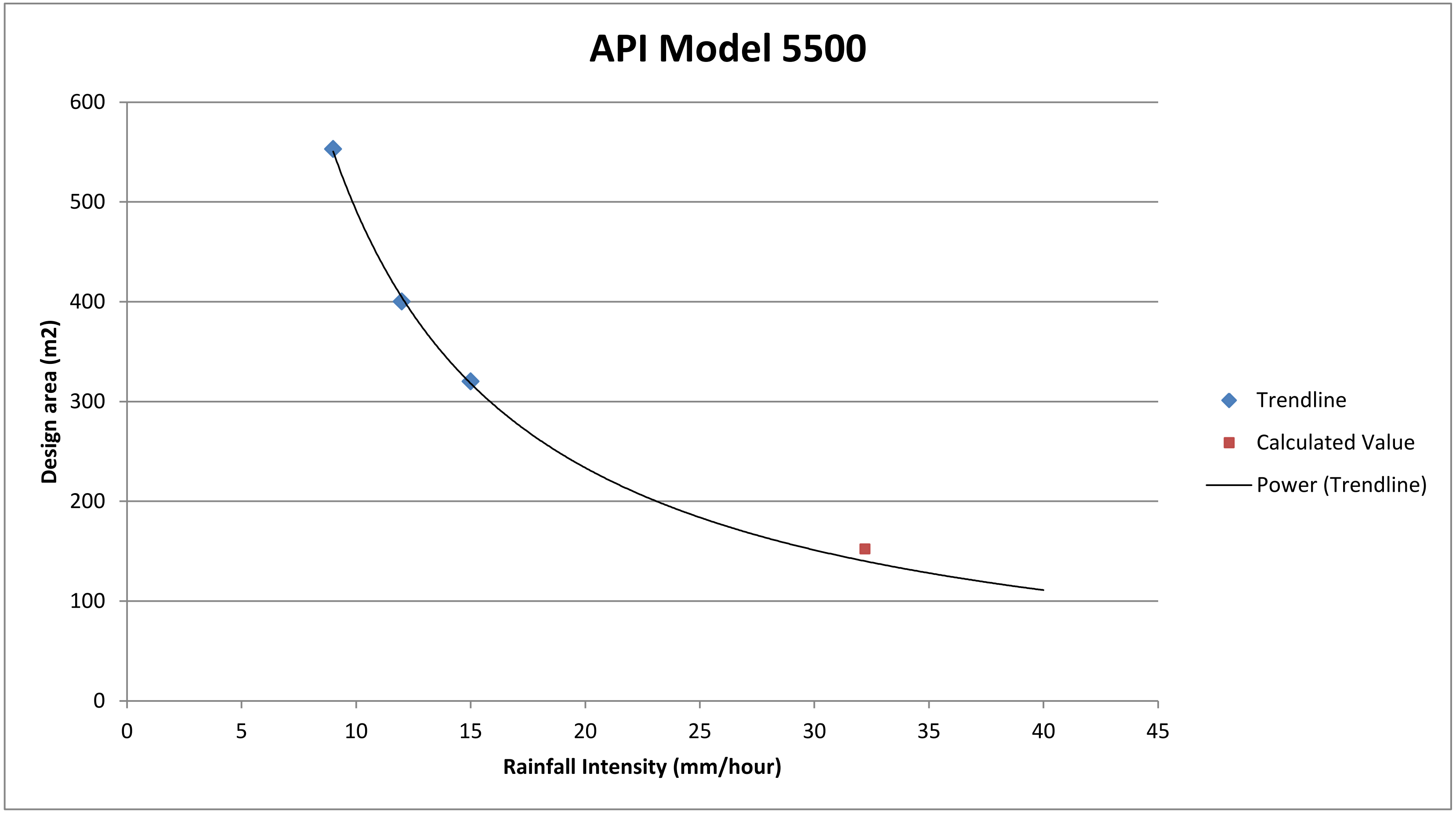
A02579800D005_Highbrook.dwg Oct-13 FINAL

Appendix B

Flow Rate/Rainfall Intensity Verification


API Model 3000
Design Area (m2)
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
Rainfall intensity (mm/hour)
Trendline
Calculated value
Power (Trendline)


API Model 3500
Design area (m2)
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
Rainfall Intensity (mm/hour)
◆ Trendline
■ Calculated Data
Power (Trendline)


API Model 5500
Design area (m2)
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
Rainfall Intensity (mm/hour)
Trendline
Calculated Value
Power (Trendline)

Appendix C

Laboratory Reports

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1089736 SPv1
Contact:	H Easton	**Date Registered:**	16-Jan-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	31-Jan-2013
	PO Box 9528	**Quote No:**	51293
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Chris Foote

Sample Type: Sediment

Sample Name:		SLV SS01 15-Jan-2013	SLV SS02 15-Jan-2013	HBK SS01 15-Jan-2013	HBK SS02 15-Jan-2013	HCR SS01 15-Jan-2013
Lab Number:		1089736.1	1089736.2	1089736.3	1089736.4	1089736.5
Individual Tests						
Dry Matter	g/100g as rcvd	39	33	28	42	37
Total Recoverable Phosphorus	mg/kg dry wt	1,430	1,270	1,430	1,170	1,730
pH*	pH Units	6.2	5.7	6.3	6.9	8.5
Total Organic Carbon*	g/100g dry wt	14.5	26	32	4.5	10.7
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	7	16	6	4	13
Total Recoverable Cadmium	mg/kg dry wt	0.66	1.00	1.30	0.77	0.40
Total Recoverable Chromium	mg/kg dry wt	90	110	58	41	68
Total Recoverable Copper	mg/kg dry wt	159	230	109	63	135
Total Recoverable Lead	mg/kg dry wt	124	165	109	48	70
Total Recoverable Nickel	mg/kg dry wt	74	49	38	48	67
Total Recoverable Zinc	mg/kg dry wt	1,420	3,700	2,700	980	2,200
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	1.16	< 0.17	< 0.4	< 0.13	2.8
Toluene	mg/kg dry wt	33	< 0.3	< 0.4	1.88	55
Ethylbenzene	mg/kg dry wt	1.59	< 0.3	0.6	< 0.13	12.4
m&p-Xylene	mg/kg dry wt	6.5	< 0.4	2.5	< 0.3	67
o-Xylene	mg/kg dry wt	2.8	< 0.17	1.6	< 0.13	29
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.07	< 0.8	< 0.9	< 0.10	0.66
Acenaphthylene	mg/kg dry wt	< 0.07	< 0.8	< 0.9	< 0.10	< 0.13
Anthracene	mg/kg dry wt	< 0.07	< 0.8	< 0.9	< 0.10	0.91
Benzo[a]anthracene	mg/kg dry wt	0.10	< 0.8	< 0.9	0.28	0.71
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.14	< 0.8	< 0.9	0.30	0.50
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.24	2.1	0.9	0.44	1.17
Benzo[g,h,i]perylene	mg/kg dry wt	0.48	1.8	1.0	0.61	1.54
Benzo[k]fluoranthene	mg/kg dry wt	0.07	< 0.8	< 0.9	0.16	0.23
Chrysene	mg/kg dry wt	0.15	< 0.8	< 0.9	0.32	0.95
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.07	< 0.8	< 0.9	< 0.10	< 0.13
Fluoranthene	mg/kg dry wt	0.25	1.2	1.6	0.77	2.6
Fluorene	mg/kg dry wt	< 0.07	< 0.8	< 0.9	< 0.10	2.8
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	0.10	0.9	< 0.9	0.20	0.35
Naphthalene	mg/kg dry wt	< 0.4	< 4	< 5	< 0.5	17.0
Phenanthrene	mg/kg dry wt	0.17	< 0.8	3.8	0.40	7.4
Pyrene	mg/kg dry wt	0.71	29	46	1.41	10.8
Total Petroleum Hydrocarbons in Soil						

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment

Sample Name:		SLV SS01 15-Jan-2013	SLV SS02 15-Jan-2013	HBK SS01 15-Jan-2013	HBK SS02 15-Jan-2013	HCR SS01 15-Jan-2013
Lab Number:		1089736.1	1089736.2	1089736.3	1089736.4	1089736.5
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	67	29	51	< 30	1,680
C10 - C14	mg/kg dry wt	65	13,300	27,000	< 60	9,800
C15 - C36	mg/kg dry wt	2,300	184,000	220,000	4,400	73,000
Total hydrocarbons (C7 - C36)	mg/kg dry wt	2,400	197,000	250,000	4,400	84,000

Sample Name:		HCR SS02 15-Jan-2013				
Lab Number:		1089736.6				
Individual Tests						
Dry Matter	g/100g as rcvd	28	-	-	-	-
Total Recoverable Phosphorus	mg/kg dry wt	960	-	-	-	-
pH*	pH Units	6.5	-	-	-	-
Total Organic Carbon*	g/100g dry wt	12.6	-	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	4	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.73	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	47	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	141	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	138	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	63	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	750	-	-	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.4	-	-	-	-
Toluene	mg/kg dry wt	7.2	-	-	-	-
Ethylbenzene	mg/kg dry wt	< 0.4	-	-	-	-
m&p-Xylene	mg/kg dry wt	< 0.7	-	-	-	-
o-Xylene	mg/kg dry wt	< 0.4	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.16	-	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.16	-	-	-	-
Anthracene	mg/kg dry wt	< 0.16	-	-	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.16	-	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.16	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.24	-	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.46	-	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.16	-	-	-	-
Chrysene	mg/kg dry wt	< 0.16	-	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.16	-	-	-	-
Fluoranthene	mg/kg dry wt	0.26	-	-	-	-
Fluorene	mg/kg dry wt	< 0.16	-	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.16	-	-	-	-
Naphthalene	mg/kg dry wt	3.1	-	-	-	-
Phenanthrene	mg/kg dry wt	0.22	-	-	-	-
Pyrene	mg/kg dry wt	0.59	-	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	179	-	-	-	-
C10 - C14	mg/kg dry wt	370	-	-	-	-
C15 - C36	mg/kg dry wt	3,100	-	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	3,600	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.3 - Particle Size Report - 1089736

Appendix No.4 - Particle Size Report - 1089736

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-6
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	1-6
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-6
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-6
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-6
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-6
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-6
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-6
pH*	1:2 (v/v) soil : water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-6
Total Organic Carbon*	Acid pretreatment to remove carbonates if present, neutralisation, Elementar Combustion Analyser.	0.05 g/100g dry wt	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

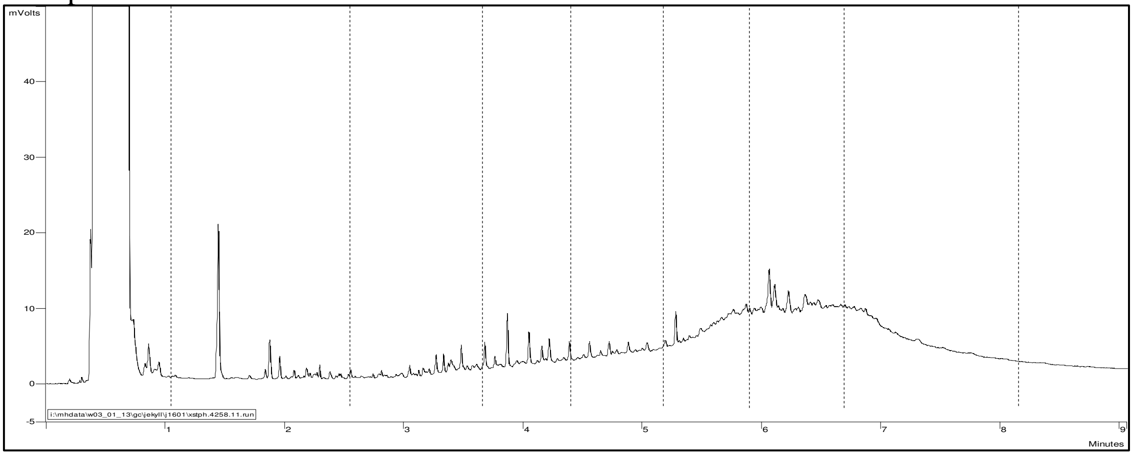
This report must not be reproduced, except in full, without the written consent of the signatory.

Carole Rodger-Carroll

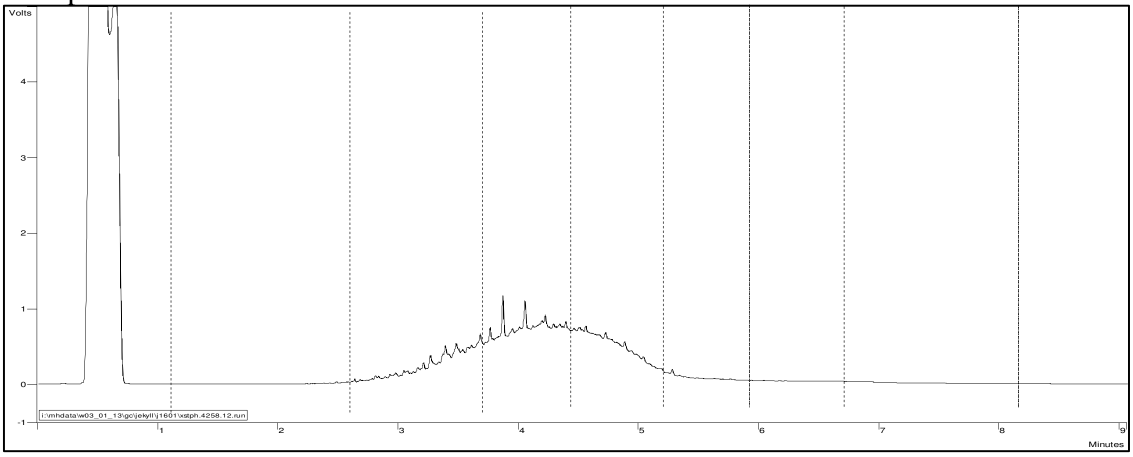
Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

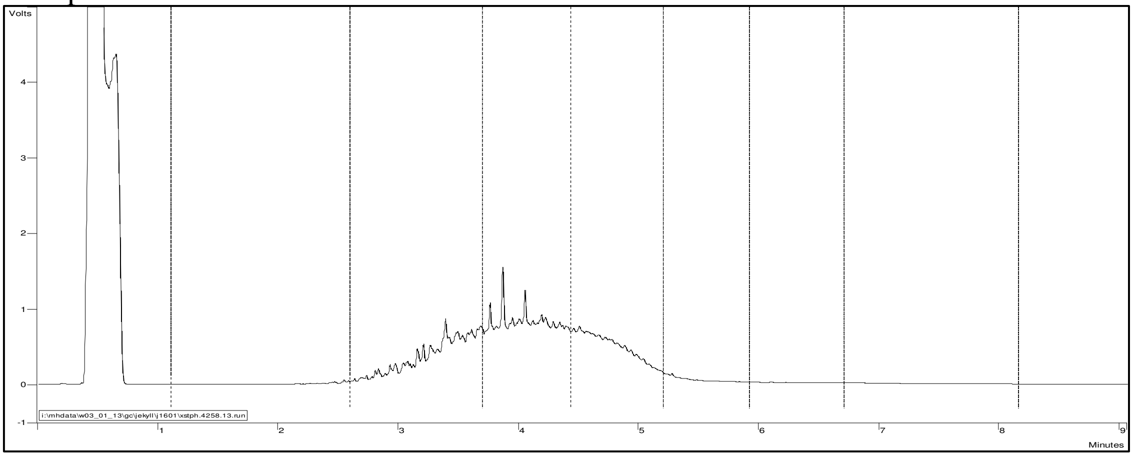
Sample : 1089736.1

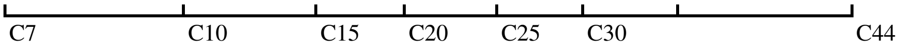


Sample : 1089736.2



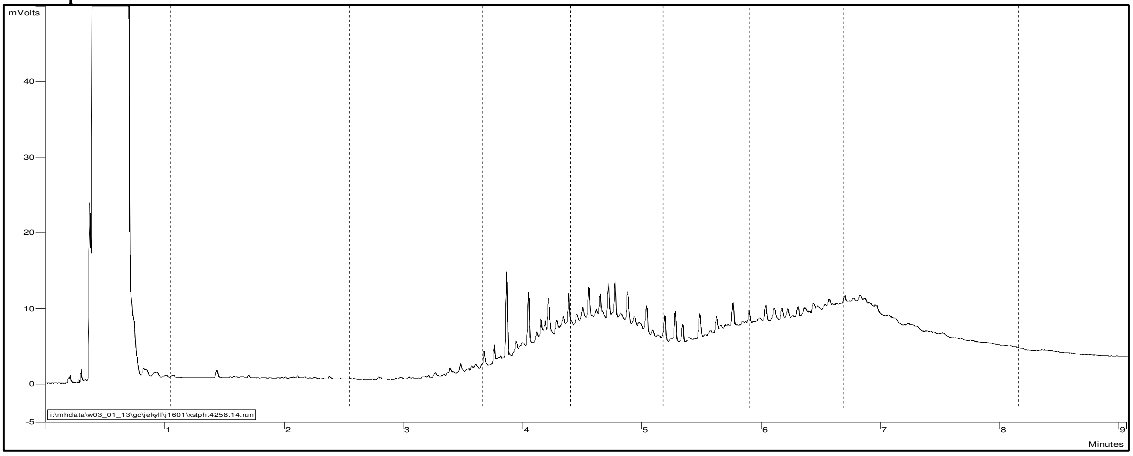
Sample : 1089736.3



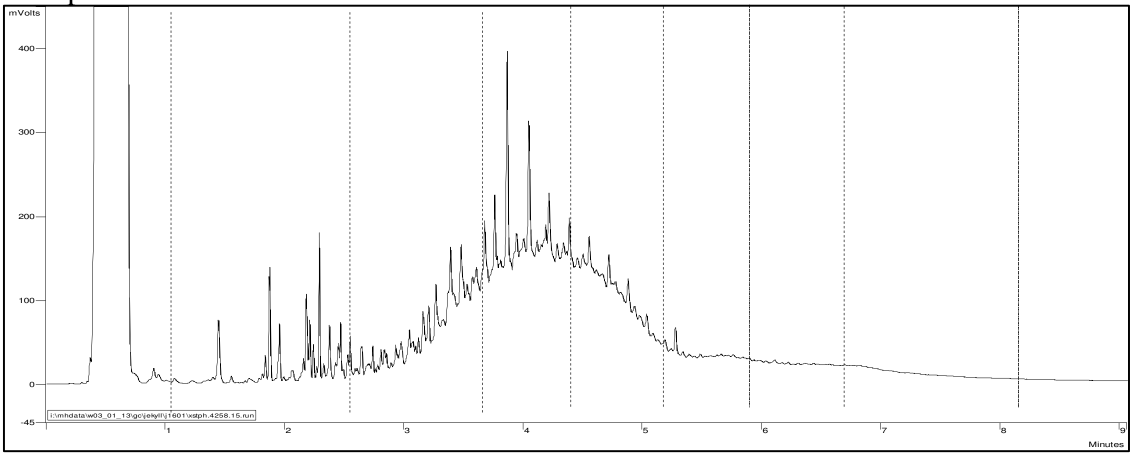


Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

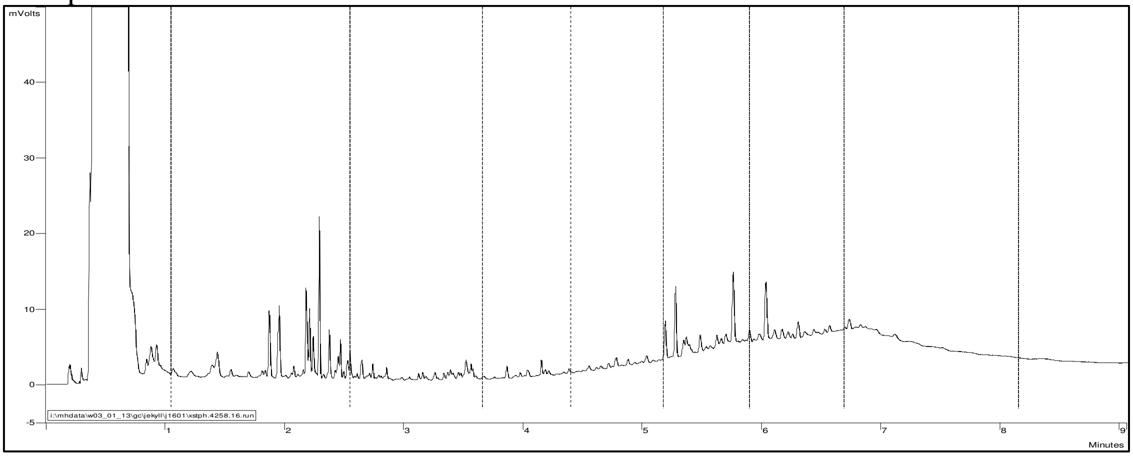
Sample : 1089736.4

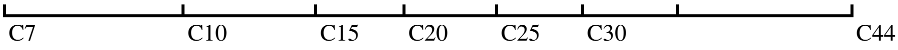


Sample : 1089736.5



Sample : 1089736.6





Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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Hamilton 3240, New Zealand

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Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1090879 SPv1
Contact:	Chris Foote	**Date Registered:**	18-Jan-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	01-Feb-2013
	PO Box 9528	**Quote No:**	51293
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	H Easton

Sample Type: Sediment

Sample Name:		BRN SS01 16-Jan-2013	BRN SS02 16-Jan-2013			
Lab Number:		1090879.1	1090879.2			
Individual Tests						
Dry Matter	g/100g as rcvd	49	25	-	-	-
Total Recoverable Phosphorus	mg/kg dry wt	1,260	1,040	-	-	-
pH*	pH Units	7.2	6.2	-	-	-
Total Organic Carbon*	g/100g dry wt	4.5	24	-	-	-
Acenaphthene	mg/kg dry wt	< 0.9	< 2	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.9	< 2	-	-	-
Anthracene	mg/kg dry wt	0.9	7	-	-	-
Benzo[a]anthracene	mg/kg dry wt	6.9	55	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	12.4	91	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	20	151	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	13.8	89	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	8.6	66	-	-	-
Chrysene	mg/kg dry wt	14.2	109	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	2.4	17	-	-	-
Fluoranthene	mg/kg dry wt	19.9	198	-	-	-
Fluorene	mg/kg dry wt	< 0.9	2	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	15.1	102	-	-	-
Naphthalene	mg/kg dry wt	< 5	< 10	-	-	-
Phenanthrene	mg/kg dry wt	6.0	70	-	-	-
Pyrene	mg/kg dry wt	16.7	159	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	4	13	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.22	0.70	-	-	-
Total Recoverable Chromium	mg/kg dry wt	36	150	-	-	-
Total Recoverable Copper	mg/kg dry wt	74	181	-	-	-
Total Recoverable Lead	mg/kg dry wt	68	400	-	-	-
Total Recoverable Nickel	mg/kg dry wt	85	60	-	-	-
Total Recoverable Zinc	mg/kg dry wt	980	1,270	-	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.11	< 0.4	-	-	-
Toluene	mg/kg dry wt	1.50	3.8	-	-	-
Ethylbenzene	mg/kg dry wt	0.68	< 0.4	-	-	-
m&p-Xylene	mg/kg dry wt	2.4	< 0.8	-	-	-
o-Xylene	mg/kg dry wt	1.08	< 0.4	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 30	< 60	-	-	-

Sample Type: Sediment

Sample Name:		BRN SS01 16-Jan-2013	BRN SS02 16-Jan-2013			
Lab Number:		1090879.1	1090879.2			
Total Petroleum Hydrocarbons in Soil						
C10 - C14	mg/kg dry wt	52	< 120	-	-	-
C15 - C36	mg/kg dry wt	1,340	4,400	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	1,400	4,400	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Particle Size Report - BRN SS01 & BRN SS02 - 1090879.1 & .2

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-2
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	1-2
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-2
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-2
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-2
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-2
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-2
pH*	1:2 (v/v) soil : water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-2
Total Organic Carbon*	Acid pretreatment to remove carbonates if present, neutralisation, Elementar Combustion Analyser.	0.05 g/100g dry wt	1-2
Acenaphthene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Acenaphthylene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Anthracene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Benzo[a]anthracene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Benzo[a]pyrene (BAP)	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Benzo[b]fluoranthene + Benzo[j] fluoranthene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Benzo[g,h,i]perylene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Benzo[k]fluoranthene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Chrysene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Dibenzo[a,h]anthracene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Fluoranthene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Fluorene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Indeno(1,2,3-c,d)pyrene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Naphthalene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.05 mg/kg dry wt	1-2

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Phenanthrene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2
Pyrene	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis. Modified US EPA 8270.	0.010 mg/kg dry wt	1-2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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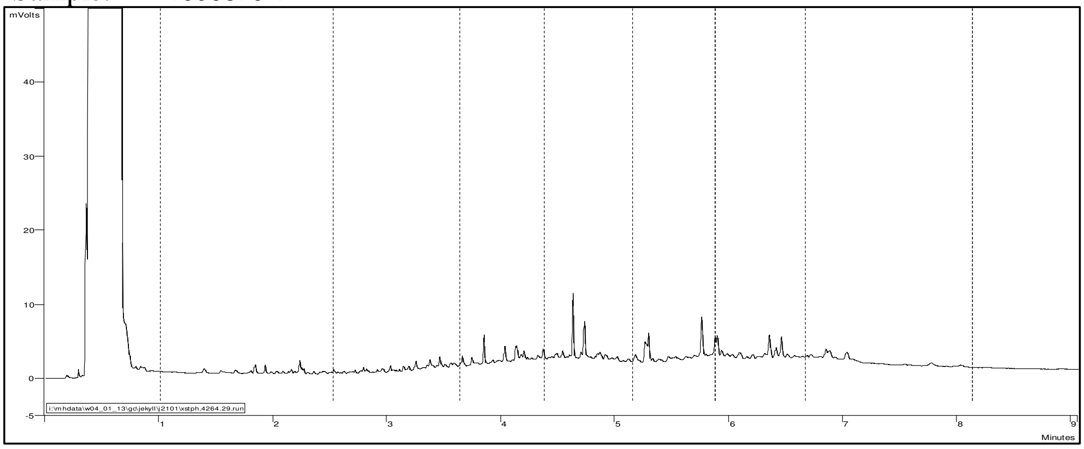
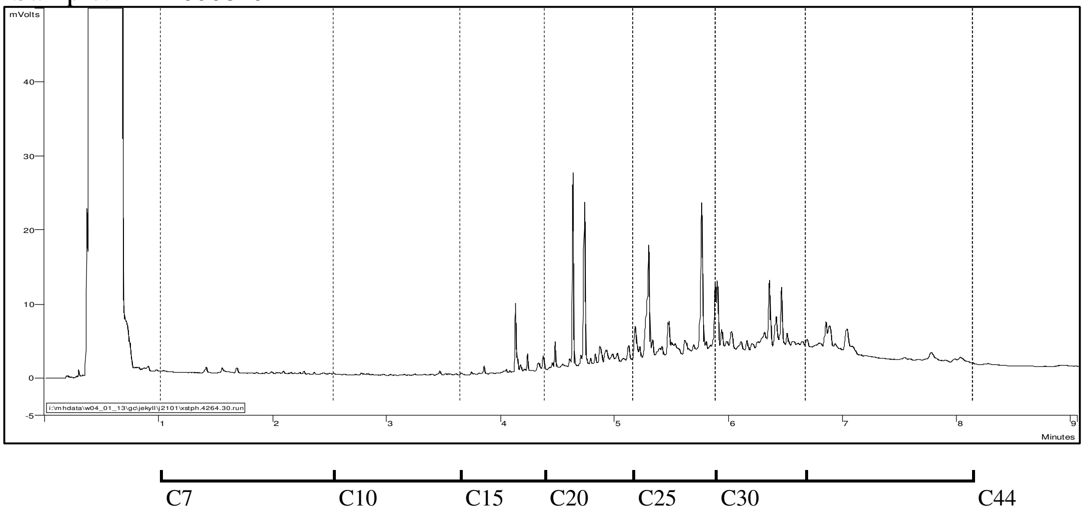
Martin Cowell - BSc (Chem)
Client Services Manager - Environmental Division

Sample: 1090879.1



Sample: 1090879.2



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ANALYSIS REPORT

				SPv1
Client:	Pattle Delamore Partners Ltd	**Lab No:**	1091690	
Contact:	Chris Foote	**Date Registered:**	22-Jan-2013	
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	07-Feb-2013	
	PO Box 9528	**Quote No:**	51293	
	Newmarket	**Order No:**		
	AUCKLAND 1149	**Client Reference:**	A02579800	
		Submitted By:	Paul Churchill	

Sample Type: Sediment

Sample Name:		TBC SS 001 21-Jan-2013	LAK SS 001 21-Jan-2013 10:00 am	LAK SS 002 21-Jan-2013 10:15 am		
Lab Number:		1091690.1	1091690.2	1091690.3		
Individual Tests						
Dry Matter	g/100g as rcvd	82	68	32	-	-
Total Recoverable Phosphorus	mg/kg dry wt	1,430	1,000	660	-	-
pH*	pH Units	7.1	7.4	7.1	-	-
Total Organic Carbon*	g/100g dry wt	3.0	3.0	32 #1	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	4	6	< 4	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.11	0.23	< 0.19	-	-
Total Recoverable Chromium	mg/kg dry wt	41	43	16	-	-
Total Recoverable Copper	mg/kg dry wt	71	94	63	-	-
Total Recoverable Lead	mg/kg dry wt	86	40	65	-	-
Total Recoverable Nickel	mg/kg dry wt	103	69	24	-	-
Total Recoverable Zinc	mg/kg dry wt	240	1,200	510	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.05	< 0.07	< 0.18	-	-
Toluene	mg/kg dry wt	< 0.05	2.8	0.27	-	-
Ethylbenzene	mg/kg dry wt	< 0.05	< 0.07	< 0.18	-	-
m&p-Xylene	mg/kg dry wt	< 0.10	< 0.13	< 0.4	-	-
o-Xylene	mg/kg dry wt	< 0.05	0.09	< 0.18	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Acenaphthylene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Anthracene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.06	0.11	< 0.15	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.06	0.10	< 0.15	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.06	0.15	< 0.15	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.10	0.28	0.18	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Chrysene	mg/kg dry wt	< 0.06	0.10	< 0.15	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Fluoranthene	mg/kg dry wt	0.09	0.25	0.19	-	-
Fluorene	mg/kg dry wt	< 0.06	< 0.07	< 0.15	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.06	0.08	< 0.15	-	-
Naphthalene	mg/kg dry wt	< 0.3	< 0.4	< 0.8	-	-
Phenanthrene	mg/kg dry wt	< 0.06	0.22	< 0.15	-	-
Pyrene	mg/kg dry wt	0.11	0.55	0.28	-	-
Total Petroleum Hydrocarbons in Soil						

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment

Sample Name:		TBC SS 001 21-Jan-2013	LAK SS 001 21-Jan-2013 10:00 am	LAK SS 002 21-Jan-2013 10:15 am		
Lab Number:		1091690.1	1091690.2	1091690.3		
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 9	< 10	53	-	-
C10 - C14	mg/kg dry wt	< 20	26	158	-	-
C15 - C36	mg/kg dry wt	1,100	1,040	1,070	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	1,100	1,060	1,290	-	-

Analyst's Comments

[#1] It should be noted that the matrix of the sample caused peak distortion for the total organic carbon analysis.The sample was analysed in duplicate and the result reported is the average of both samples, with the entirety of the distorted peak included.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Particle Size Report

Appendix No.3 - Sieve Analysis Report

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-3
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	1-3
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-3
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-3
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-3
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-3
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-3
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-3
pH*	1:2 (v/v) soil : water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-3
Total Organic Carbon*	Acid pretreatment to remove carbonates if present, neutralisation, Elementar Combustion Analyser.	0.05 g/100g dry wt	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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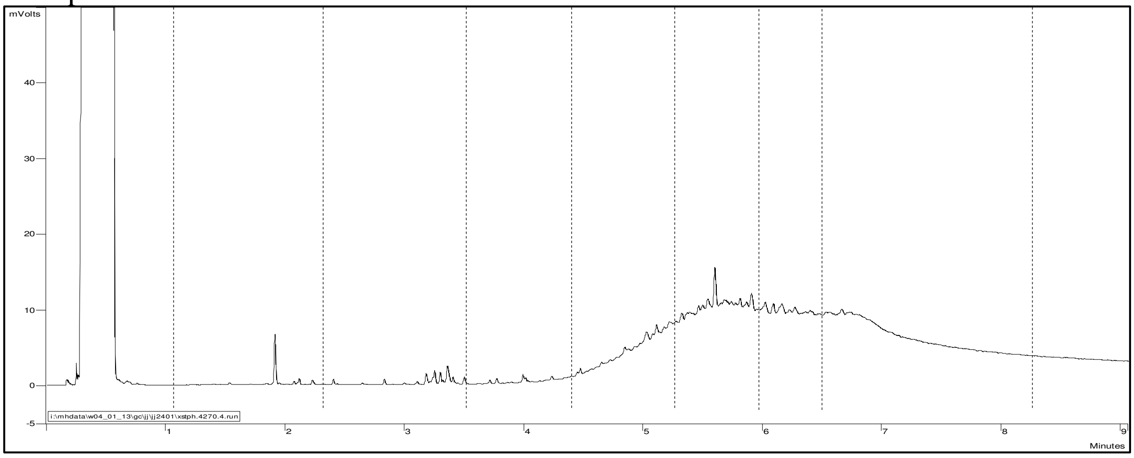
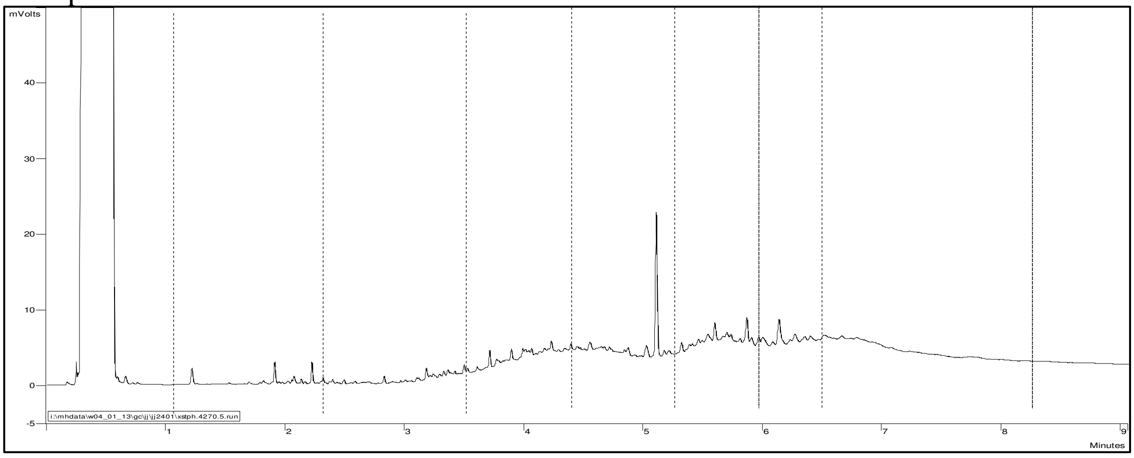
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

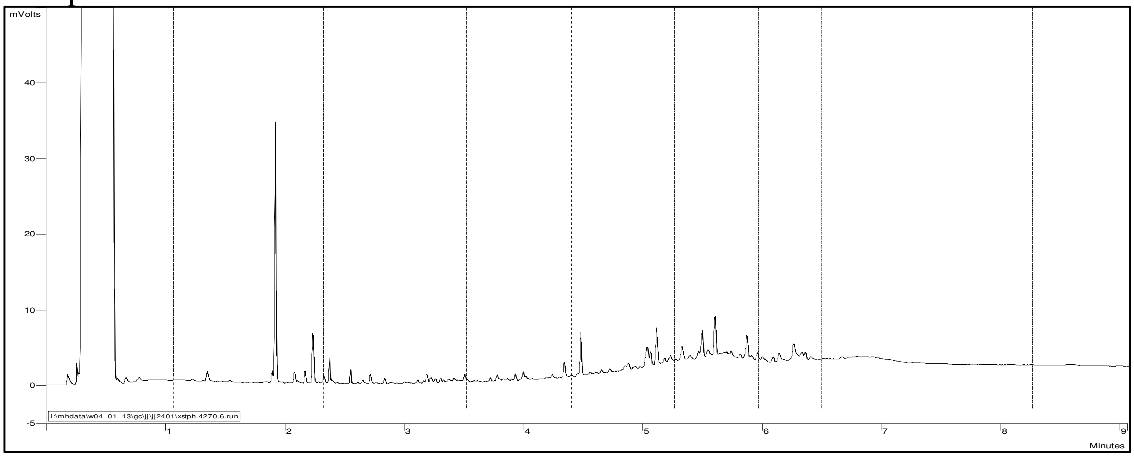
Sample : 1091690.1

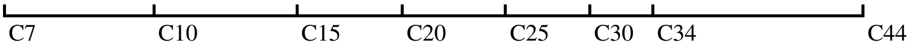


Sample : 1091690.2



Sample : 1091690.3





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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1096998 SPv2
Contact:	H Easton	**Date Registered:**	06-Feb-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	14-Feb-2013
	PO Box 9528	**Quote No:**	51293
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Chris Foote

Sample Type: Sediment

Sample Name:		BRN SS01a 05-Feb-2013	BRN SS02a 05-Feb-2013	SLVSS02a 05-Feb-2013	HBKSS01a 05-Feb-2013	
Lab Number:		1096998.1	1096998.2	1096998.3	1096998.4	
Individual Tests						
Dry Matter	g/100g as rcvd	38	26	54	30	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	0.16	0.89	-	-	-
Acenaphthylene	mg/kg dry wt	0.23	0.74	-	-	-
Anthracene	mg/kg dry wt	0.99	3.9	-	-	-
Benzo[a]anthracene	mg/kg dry wt	9.8	55	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	14.9	63	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	22	93	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	18.0	79	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	9.8	46	-	-	-
Chrysene	mg/kg dry wt	12.7	71	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	1.83	9.0	-	-	-
Fluoranthene	mg/kg dry wt	27	157	-	-	-
Fluorene	mg/kg dry wt	0.42	1.60	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	18.6	65	-	-	-
Naphthalene	mg/kg dry wt	< 0.7	< 0.9	-	-	-
Phenanthrene	mg/kg dry wt	8.1	56	-	-	-
Pyrene	mg/kg dry wt	24	132	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	-	-	< 30	720	-
C10 - C14	mg/kg dry wt	-	-	790	29,000	-
C15 - C36	mg/kg dry wt	-	-	26,000	280,000	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	-	-	27,000	310,000	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Polycyclic Aromatic Hydrocarbons Screening in Soil	Sonication extraction, Dilution or SPE cleanup (if required), GC-MS SIM analysis (modified US EPA 8270). Tested on as received sample.	-	1-2
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	3-4

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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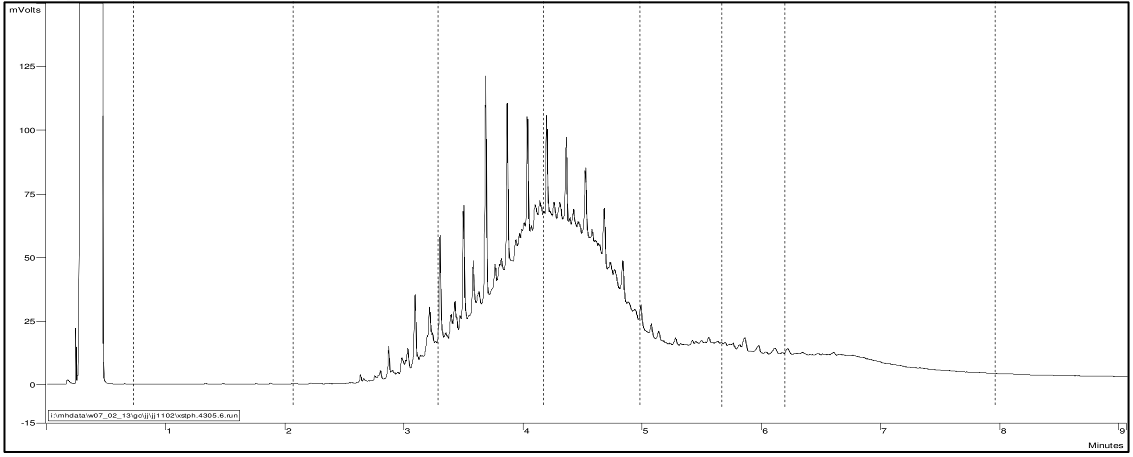
Peter Robinson

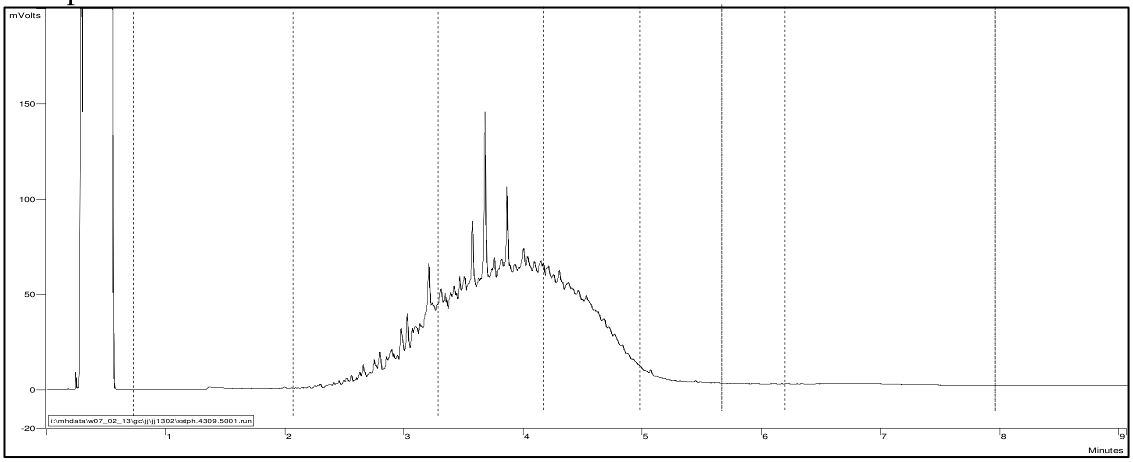
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

Sample : 1096998.3



Sample : 1096998.4



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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1106358 SPv3
Contact:	Chris Foote	**Date Registered:**	01-Mar-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	21-Mar-2013
	PO Box 9528	**Quote No:**	51293
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	H Easton

Amended Report

This report replaces an earlier report issued on the 15 Mar 2013 at 10:33 am
Following a request from the client, pH has been added to samples 1 and 2.

Sample Type: Sediment

Sample Name:		AMU SS01 28-Feb-2013	ABG SS01 28-Feb-2013			
Lab Number:		1106358.1	1106358.2			
Individual Tests						
Dry Matter	g/100g as rcvd	21	20	-	-	-
Total Recoverable Phosphorus	mg/kg dry wt	2,100	1,560	-	-	-
pH*	pH Units	6.7	7.4	-	-	-
Total Organic Carbon*	g/100g dry wt	13.5	22	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	6	4	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	1.21	0.65	-	-	-
Total Recoverable Chromium	mg/kg dry wt	94	22	-	-	-
Total Recoverable Copper	mg/kg dry wt	96	69	-	-	-
Total Recoverable Lead	mg/kg dry wt	44	60	-	-	-
Total Recoverable Nickel	mg/kg dry wt	33	22	-	-	-
Total Recoverable Zinc	mg/kg dry wt	380	440	-	-	-
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.5	< 0.5	-	-	-
Toluene	mg/kg dry wt	39	8.5	-	-	-
Ethylbenzene	mg/kg dry wt	0.9	< 0.5	-	-	-
m&p-Xylene	mg/kg dry wt	< 0.9	< 1.0	-	-	-
o-Xylene	mg/kg dry wt	< 0.5	< 0.5	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Acenaphthylene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Anthracene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Benzo[a]anthracene	mg/kg dry wt	0.13	< 0.12	-	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	0.12	< 0.12	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	0.23	< 0.12	-	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	0.17	< 0.12	-	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Chrysene	mg/kg dry wt	0.17	< 0.12	-	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Fluoranthene	mg/kg dry wt	0.38	< 0.12	-	-	-
Fluorene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.11	< 0.12	-	-	-
Naphthalene	mg/kg dry wt	< 0.6	< 0.6	-	-	-
Phenanthrene	mg/kg dry wt	0.35	< 0.12	-	-	-

Sample Type: Sediment

Sample Name:		AMU SS01 28-Feb-2013	ABG SS01 28-Feb-2013			
Lab Number:		1106358.1	1106358.2			
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Pyrene	mg/kg dry wt	0.37	< 0.12	-	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	820	< 40	-	-	-
C10 - C14	mg/kg dry wt	240	< 80	-	-	-
C15 - C36	mg/kg dry wt	3,400	1,420	-	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	4,500	1,420	-	-	-

Sample Type: Aqueous

Sample Name:		AMU SW01 28-Feb-2013	AMU SW02 28-Feb-2013	AMU SW03 28-Feb-2013	ABG SW01 28-Feb-2013	ABG SW02 28-Feb-2013
Lab Number:		1106358.3	1106358.4	1106358.5	1106358.6	1106358.7
Individual Tests						
pH	pH Units	6.2	7.2	7.7	4.6	7.3
Electrical Conductivity (EC)	mS/m	33.0	14.6	14.5	51.4	17.2
Total Suspended Solids	g/m^3	380	7	< 3	320	25
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0013	< 0.0010	< 0.0010	0.0018	0.0010
Dissolved Cadmium	g/m^3	0.00042	0.00006	< 0.00005	0.00022	< 0.00005
Dissolved Chromium	g/m^3	0.0016	< 0.0005	< 0.0005	0.0011	< 0.0005
Dissolved Copper	g/m^3	0.042	0.0020	0.0032	0.035	0.0013
Dissolved Lead	g/m^3	0.00113	0.00017	0.00167	0.0034	0.00020
Dissolved Nickel	g/m^3	0.0034	< 0.0005	< 0.0005	0.0034	< 0.0005
Dissolved Zinc	g/m^3	0.37	0.032	0.0041	0.35	0.0174
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0020	< 0.0011	< 0.0011	0.0028	0.0012
Total Cadmium	g/m^3	0.00065	0.000073	< 0.000053	0.00044	< 0.000053
Total Chromium	g/m^3	0.0065	0.00076	< 0.00053	0.0056	< 0.00053
Total Copper	g/m^3	0.070	0.0032	0.0162	0.064	0.0020
Total Lead	g/m^3	0.0163	0.00139	0.0039	0.024	0.00104
Total Nickel	g/m^3	0.0068	< 0.00053	< 0.00053	0.0062	< 0.00053
Total Zinc	g/m^3	0.55	0.039	0.0043	0.67	0.023
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002

Sample Type: Aqueous

Sample Name: **Lab Number:**		AMU SW01 28-Feb-2013 1106358.3	AMU SW02 28-Feb-2013 1106358.4	AMU SW03 28-Feb-2013 1106358.5	ABG SW01 28-Feb-2013 1106358.6	ABG SW02 28-Feb-2013 1106358.7
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Sample Name: **Lab Number:**		ABG SW03 28-Feb-2013 1106358.8	AMU-A 28-Feb-2013 1106358.9			
Individual Tests						
pH	pH Units	7.7	7.8	-	-	-
Electrical Conductivity (EC)	mS/m	16.9	14.5	-	-	-
Total Suspended Solids	g/m^3	< 3	< 3	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0011	< 0.0010	-	-	-
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	-	-	-
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	-	-	-
Dissolved Copper	g/m^3	0.0009	0.0031	-	-	-
Dissolved Lead	g/m^3	0.00112	0.00159	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	-	-	-
Dissolved Zinc	g/m^3	0.0051	0.0041 [#1]	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0012	< 0.0011	-	-	-
Total Cadmium	g/m^3	< 0.000053	< 0.000053	-	-	-
Total Chromium	g/m^3	< 0.00053	< 0.00053	-	-	-
Total Copper	g/m^3	0.00125	0.0153	-	-	-
Total Lead	g/m^3	0.00184	0.0041	-	-	-
Total Nickel	g/m^3	< 0.00053	< 0.00053	-	-	-
Total Zinc	g/m^3	0.0060	0.0040 [#1]	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	-	-	-
Toluene	g/m^3	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m^3	< 0.002	< 0.002	-	-	-
o-Xylene	g/m^3	< 0.0010	< 0.0010	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	-	-	-
Anthracene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Chrysene	g/m^3	< 0.00010	< 0.00010	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	-	-	-
Fluoranthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Fluorene	g/m^3	< 0.0002	< 0.0002	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	-	-	-
Naphthalene	g/m^3	< 0.0005	< 0.0005	-	-	-
Phenanthrene	g/m^3	< 0.0004	< 0.0004	-	-	-
Pyrene	g/m^3	< 0.0002	< 0.0002	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	-	-	-
C10 - C14	g/m^3	< 0.2	< 0.2	-	-	-
C15 - C36	g/m^3	< 0.4	< 0.4	-	-	-

Sample Type: Aqueous

Sample Name: Lab Number:	ABG SW03 28-Feb-2013 1106358.8	AMU-A 28-Feb-2013 1106358.9			
Total Petroleum Hydrocarbons in Water					
Total hydrocarbons (C7 - C36) g/m^3	< 0.7	< 0.7	-	-	-

Analyst's Comments

Supplement to test report issued 14/3/2013

[#1] It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-2
Soil Prep Dry & Sieve for Agriculture	Air dried at 35°C and sieved, <2mm fraction.	-	1-2
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-2
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-2
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550. (Free water removed before analysis).	0.10 g/100g as rcvd	1-2
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-2
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-2
pH*	1:2 (v/v) soil : water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-2
Total Organic Carbon*	Acid pretreatment to remove carbonates if present, neutralisation, Elementar Combustion Analyser.	0.05 g/100g dry wt	1-2

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	3-9
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	3-9
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	3-9
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	3-9
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	3-9
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	3-9
pH	pH meter. APHA 4500-H$^+$ B 21st ed. 2005.	0.1 pH Units	3-9
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	3-9
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	3-9

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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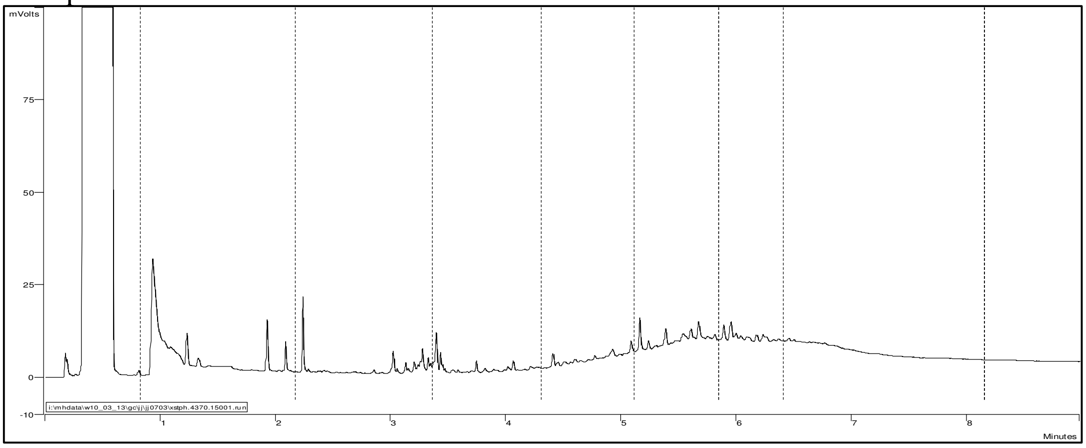
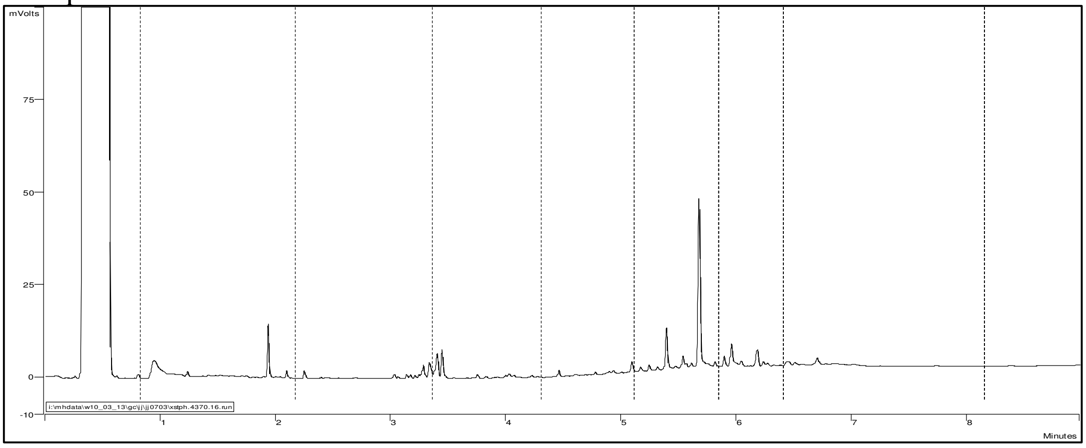
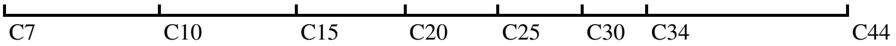
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample: 1106358.1

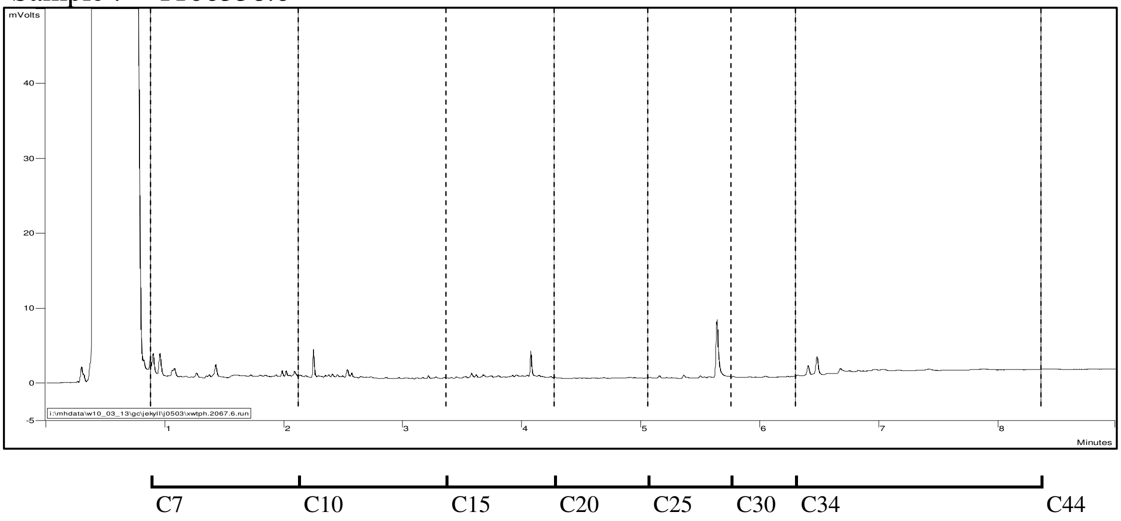


Sample: 1106358.2





Sample : 1106358.6



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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1111033 SPv1
Contact:	H Easton C/- Pattle Delamore Partners Ltd PO Box 9528 Newmarket AUCKLAND 1149	**Date Registered:**	14-Mar-2013
		Date Reported:	20-Mar-2013
		Quote No:	51293
		Order No:	
		Client Reference:	A02579800
		Submitted By:	Chris Foote

Sample Type: Aqueous

	Sample Name:	SYL SW 001	SYL SW 002	SYL SW 003	SYL SW 004	SYL SW 005
	Lab Number:	1111033.1	1111033.2	1111033.3	1111033.4	1111033.5
Individual Tests						
pH	pH Units	6.8	7.2	7.7	7.3	7.6
Electrical Conductivity (EC)	mS/m	31.7	15.8	15.7	25.4	17.5
Total Suspended Solids	g/m^3	850	6	< 3	92	51
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0012	< 0.0010	< 0.0010	0.0013	< 0.0010
Dissolved Cadmium	g/m^3	0.00015	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0008	< 0.0005	< 0.0005	0.0009	< 0.0005
Dissolved Copper	g/m^3	0.030	0.0011	0.0007	0.0146	0.0006
Dissolved Lead	g/m^3	0.00092	0.00043	0.00024	0.00060	0.00013
Dissolved Nickel	g/m^3	0.0040	< 0.0005	< 0.0005	0.0019	0.0006
Dissolved Zinc	g/m^3	0.41	0.036	< 0.0010	0.076	0.197
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0024	< 0.0011	< 0.0011	0.0019	0.0043
Total Cadmium	g/m^3	0.00028	< 0.000053	0.000063	0.000122	0.000120
Total Chromium	g/m^3	0.0059	0.00064	< 0.00053	0.0039	0.0186
Total Copper	g/m^3	0.056	0.0020	0.0024	0.034	0.036
Total Lead	g/m^3	0.0176	0.00125	0.0023	0.0109	0.059
Total Nickel	g/m^3	0.0085	< 0.00053	0.00058	0.0046	0.0186
Total Zinc	g/m^3	0.73	0.047	0.0050	0.26	1.78
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010

Sample Type: Aqueous						
Sample Name:		SYL SW 001	SYL SW 002	SYL SW 003	SYL SW 004	SYL SW 005
Lab Number:		1111033.1	1111033.2	1111033.3	1111033.4	1111033.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.0006	< 0.0002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	2.9	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	2.9	< 0.7

Sample Name:		SYL SW 006 13-Mar-2013	SYL SW 007 13-Mar-2013	SYL SW A 13-Mar-2013		
Lab Number:		1111033.6	1111033.7	1111033.8		
Individual Tests						
pH	pH Units	8.0	8.9	8.4	-	-
Electrical Conductivity (EC)	mS/m	18.3	16.0	16.3	-	-
Total Suspended Solids	g/m^3	4	8	9	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0012	0.0012	0.0012	-	-
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	-	-
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	< 0.0005	-	-
Dissolved Copper	g/m^3	0.0046	0.0013	0.0012	-	-
Dissolved Lead	g/m^3	0.00014	0.00021	0.00020	-	-
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	-	-
Dissolved Zinc	g/m^3	0.0193	0.057	0.059	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	0.0015	0.0013	-	-
Total Cadmium	g/m^3	< 0.000053	< 0.000053	< 0.000053	-	-
Total Chromium	g/m^3	0.00072	0.00087	0.00088	-	-
Total Copper	g/m^3	0.0061	0.0032	0.0030	-	-
Total Lead	g/m^3	0.00100	0.00120	0.00115	-	-
Total Nickel	g/m^3	0.00059	< 0.00053	0.00062	-	-
Total Zinc	g/m^3	0.055	0.152	0.155	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	-	-
Toluene	g/m^3	< 0.0010	0.0048	0.0049	-	-
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	-	-
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	-	-
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	-	-

Sample Type: Aqueous

Sample Name:		SYL SW 006 13-Mar-2013	SYL SW 007 13-Mar-2013	SYL SW A 13-Mar-2013		
Lab Number:		1111033.6	1111033.7	1111033.8		
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Phenanthrene	g/m³	< 0.0004	< 0.0004	< 0.0004	-	-
Pyrene	g/m³	0.0005	< 0.0002	0.0002	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	< 0.10	< 0.10	< 0.10	-	-
C10 - C14	g/m³	< 0.2	< 0.2	< 0.2	-	-
C15 - C36	g/m³	2.5	0.4	< 0.4	-	-
Total hydrocarbons (C7 - C36)	g/m³	2.5	< 0.7	< 0.7	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-8
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-8
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-8
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-8
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-8
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-8
pH	pH meter. APHA 4500-H$^+$ B 21st ed. 2005.	0.1 pH Units	1-8
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-8
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m³	1-8

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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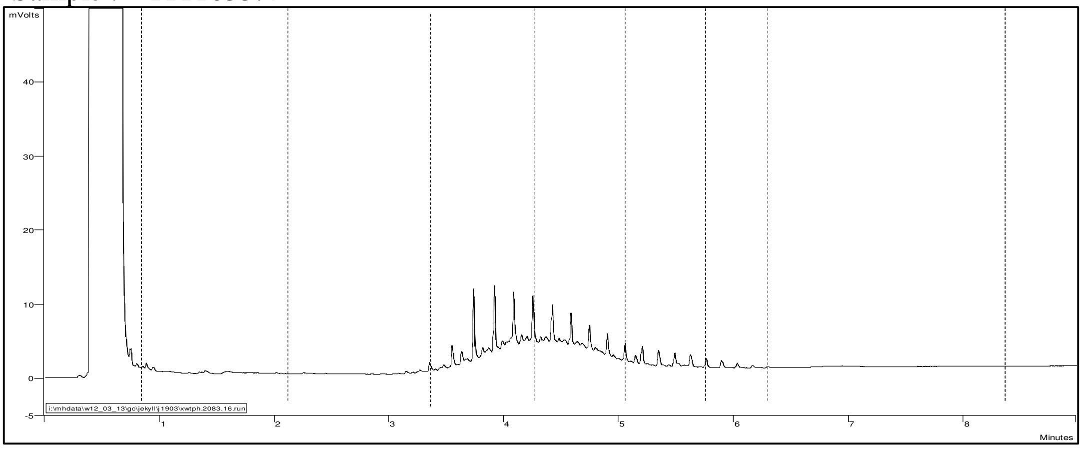
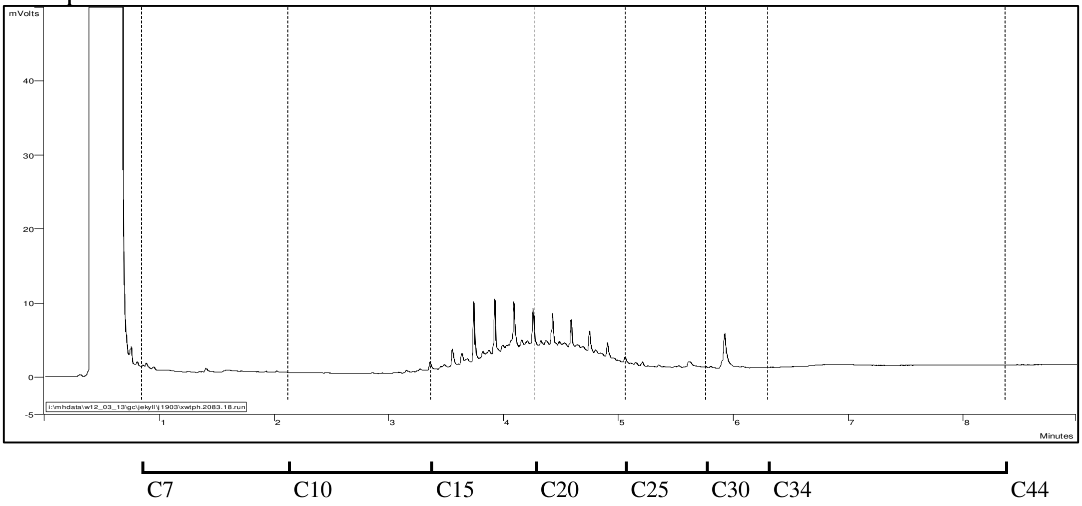
Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

Sample : 1111033.4



Sample : 1111033.6



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ANALYSIS REPORT

Client: Pattle Delamore Partners Ltd
Contact: H Easton
C/- Pattle Delamore Partners Ltd
PO Box 9528
Newmarket
AUCKLAND 1149

Lab No: 1111585 SPv1
Date Registered: 15-Mar-2013
Date Reported: 25-Mar-2013
Quote No: 53670
Order No:
Client Reference: A02579800
Submitted By: Chris Foote

Sample Type: Aqueous

Sample Name:		HBK SW 001	HBK SW 002	HBK SW 003	HBK SW 004	HBK SW 005
Lab Number:		1111585.1	1111585.2	1111585.3	1111585.4	1111585.5
Individual Tests						
pH	pH Units	7.0	7.4	8.0	7.0	7.3
Electrical Conductivity (EC)	mS/m	33.2	16.0	15.7	51.6	35.4
Total Suspended Solids	g/m^3	970	15	< 3	310	163
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0012	< 0.0010	0.0011	< 0.0010	< 0.0010
Dissolved Cadmium	g/m^3	0.00035	< 0.00005	< 0.00005	0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0016	< 0.0005	0.0006	0.0009	0.0007
Dissolved Copper	g/m^3	0.021	0.0011	0.0025	0.0054	0.0014
Dissolved Lead	g/m^3	0.00196	0.00010	0.00020	0.00058	0.00044
Dissolved Nickel	g/m^3	0.0031	< 0.0005	< 0.0005	0.0036	0.0035
Dissolved Zinc	g/m^3	0.62	0.045	0.0073	0.054	0.34
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0025	< 0.0011	< 0.0011	0.0013	< 0.0011
Total Cadmium	g/m^3	0.00061	< 0.000053	< 0.000053	0.000113	0.000081
Total Chromium	g/m^3	0.0082	0.00082	0.00063	0.0031	0.00106
Total Copper	g/m^3	0.048	0.0021	0.0087	0.0199	0.0040
Total Lead	g/m^3	0.033	0.00130	0.00076	0.0188	0.0027
Total Nickel	g/m^3	0.0080	< 0.00053	< 0.00053	0.0055	0.0052
Total Zinc	g/m^3	1.29	0.059	0.0100	0.24	0.78
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0042	0.0015
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.050	0.0083
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0018	0.0028
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	0.021	< 0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0154	0.0115
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	0.0017	< 0.00010

Sample Type: Aqueous

Sample Name:		HBK SW 001	HBK SW 002	HBK SW 003	HBK SW 004	HBK SW 005
Lab Number:		1111585.1	1111585.2	1111585.3	1111585.4	1111585.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.0025	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.0007	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.004	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	0.0046	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.052	0.0006
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	1.5	0.18
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	240	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	3,400	1.7
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	3,700	1.9

Sample Name:		HBK SW 006	HBK SW 007	HBK SW A		
Lab Number:		1111585.6	1111585.7	1111585.8		
Individual Tests						
pH	pH Units	7.8	6.9	7.0	-	-
Electrical Conductivity (EC)	mS/m	17.8	32.8	33.0	-	-
Total Suspended Solids	g/m^3	5	15	12	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0010	< 0.0010	< 0.0010	-	-
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	-	-
Dissolved Chromium	g/m^3	< 0.0005	0.0007	0.0007	-	-
Dissolved Copper	g/m^3	0.0024	0.0023	0.0023	-	-
Dissolved Lead	g/m^3	0.00033	0.00041	0.00047	-	-
Dissolved Nickel	g/m^3	< 0.0005	0.0033	0.0032	-	-
Dissolved Zinc	g/m^3	0.040	0.166	0.169	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	< 0.0011	< 0.0011	-	-
Total Cadmium	g/m^3	< 0.000053	0.000090	0.000063	-	-
Total Chromium	g/m^3	0.00055	0.00075	0.00118	-	-
Total Copper	g/m^3	0.0036	0.0052	0.0057	-	-
Total Lead	g/m^3	0.0028	0.0023	0.0023	-	-
Total Nickel	g/m^3	0.00070	0.0048	0.0050	-	-
Total Zinc	g/m^3	0.062	0.34	0.34	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	0.079	0.070	-	-
Toluene	g/m^3	< 0.0010	1.44	1.24	-	-
Ethylbenzene	g/m^3	< 0.0010	0.126	0.0067	-	-
m&p-Xylene	g/m^3	< 0.002	0.81	0.69	-	-
o-Xylene	g/m^3	< 0.0010	0.46	0.43	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	0.00017	0.00014	0.00013	-	-
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Fluoranthene	g/m^3	0.00013	< 0.00010	< 0.00010	-	-
Fluorene	g/m^3	0.0005	0.0006	0.0005	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	-	-
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	-	-

Sample Type: Aqueous

Sample Name:		HBK SW 006	HBK SW 007	HBK SW A		
Lab Number:		1111585.6	1111585.7	1111585.8		
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Phenanthrene	g/m^3	0.0005	< 0.0004	< 0.0004	-	-
Pyrene	g/m^3	0.0033	0.0012	0.0013	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	2.9	2.6	-	-
C10 - C14	g/m^3	2.5	0.8	0.7	-	-
C15 - C36	g/m^3	41	5.4	5.3	-	-
Total hydrocarbons (C7 - C36)	g/m^3	44	9.0	8.6	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-8
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-8
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-8
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-8
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-8
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-8
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-8
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-8
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-8

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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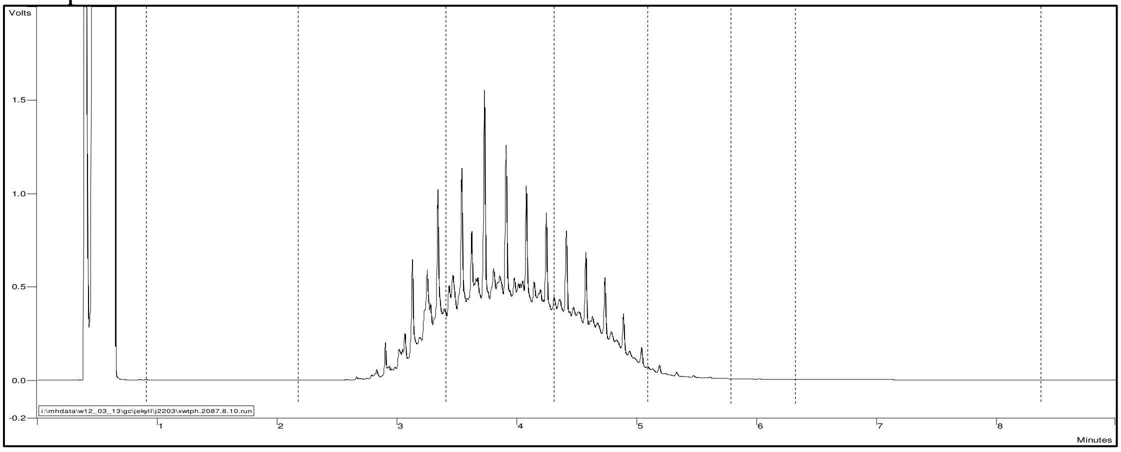
Carole Rodgers-Carroll

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

Sample : 1111585.4



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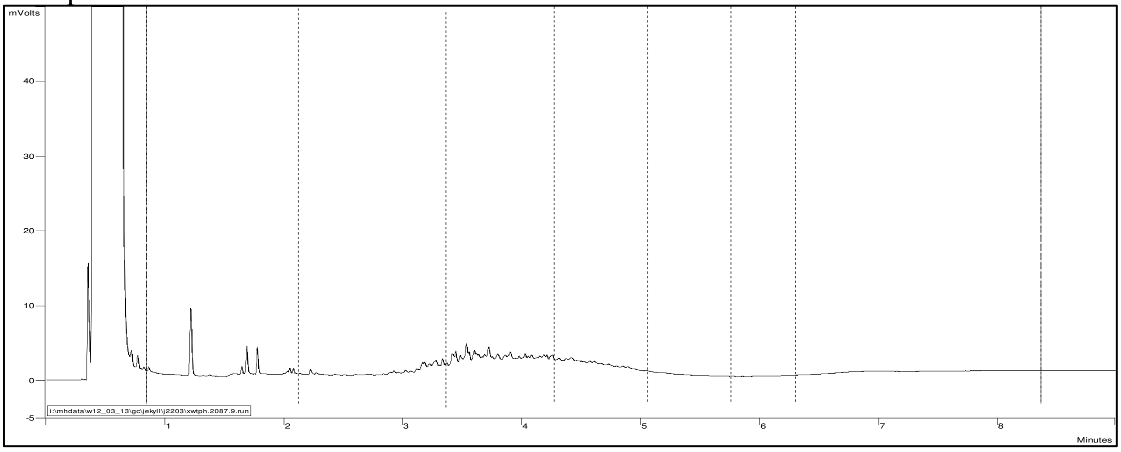
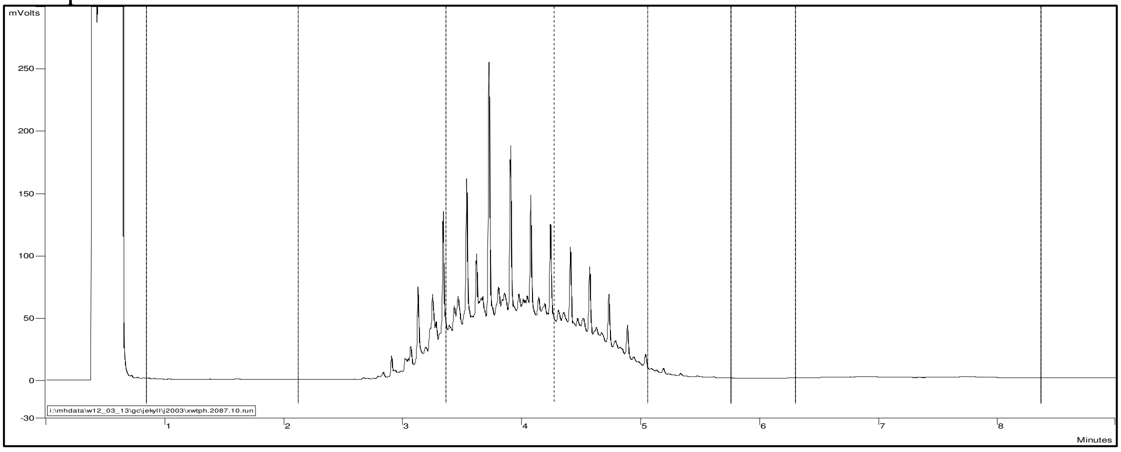
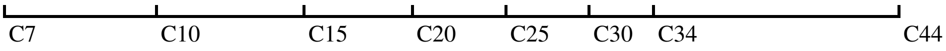


Sample : 1111585.6





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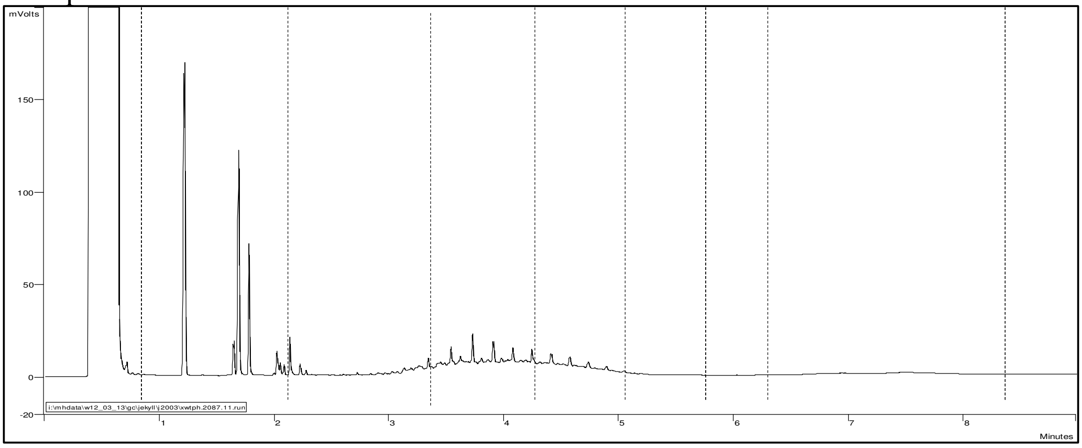
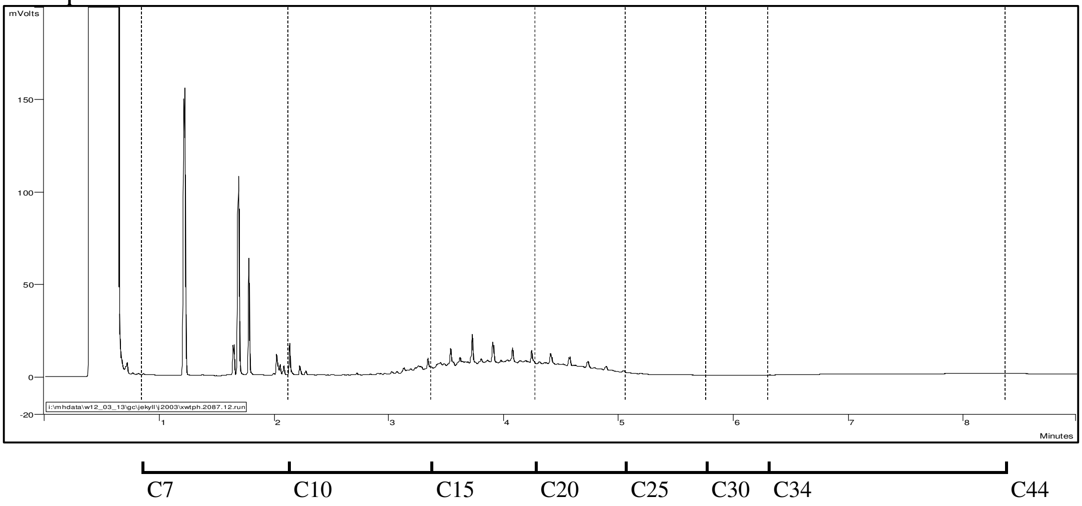


Sample : 1111585.8



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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1111669 SPv1
Contact:	Chris Foote	**Date Registered:**	15-Mar-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	22-Mar-2013
	PO Box 9528	**Quote No:**	53670
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Chris Foote

Sample Type: Aqueous

Sample Name:		BRN SW01 14-Mar-2013	BRN SW02 14-Mar-2013	BRN SW03 14-Mar-2013	BRN SW04 14-Mar-2013	BRN SW05 14-Mar-2013
Lab Number:		1111669.1	1111669.2	1111669.3	1111669.4	1111669.5
Individual Tests						
pH	pH Units	6.6	7.4	8.0	6.8	7.0
Electrical Conductivity (EC)	mS/m	31.5	16.3	15.4	117.6	15.0
Total Suspended Solids	g/m^3	540	9	< 3	48	22
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0014	0.0012	0.0011	< 0.0010	< 0.0010
Dissolved Cadmium	g/m^3	0.00013	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0009	< 0.0005	0.0007 [#1]	0.0007	< 0.0005
Dissolved Copper	g/m^3	0.020	0.0014	0.0011	0.0094	0.0008
Dissolved Lead	g/m^3	0.00112	0.00020	0.00059	0.00035	< 0.00010
Dissolved Nickel	g/m^3	0.0015	< 0.0005	< 0.0005	0.0009	< 0.0005
Dissolved Zinc	g/m^3	0.48	0.044	0.0014	0.165	0.0051
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0029	0.0012	< 0.0011	0.0016	< 0.0011
Total Cadmium	g/m^3	0.00021	< 0.000053	< 0.000053	0.000114	< 0.000053
Total Chromium	g/m^3	0.0057	0.00078	< 0.00053 [#1]	0.0020	0.00062
Total Copper	g/m^3	0.037	0.0024	0.0080	0.0172	0.00186
Total Lead	g/m^3	0.024	0.00124	0.00190	0.0050	0.00031
Total Nickel	g/m^3	0.0050	< 0.00053	< 0.00053	0.00197	< 0.00053
Total Zinc	g/m^3	0.70	0.056	0.0029	0.57	0.0147
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	0.00030	0.00021	< 0.00010	0.00017	< 0.00010
Benzo[g,h,i]perylene	g/m^3	0.00022	0.00017	< 0.00010	0.00021	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	0.00019	0.00016	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010

Sample Type: Aqueous

Sample Name: Lab Number:		BRN SW01 14-Mar-2013 1111669.1	BRN SW02 14-Mar-2013 1111669.2	BRN SW03 14-Mar-2013 1111669.3	BRN SW04 14-Mar-2013 1111669.4	BRN SW05 14-Mar-2013 1111669.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluoranthene	g/m^3	0.00060	0.00054	< 0.00010	< 0.00010	< 0.00010
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	0.00033	0.00023	< 0.00010	0.00022	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	0.0003	0.0003	< 0.0002	< 0.0002	< 0.0002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Sample Name: Lab Number:		BRN SW06 14-Mar-2013 1111669.6	BRN SW07 14-Mar-2013 1111669.7	HCR SW01 14-Mar-2013 1111669.8	HCR SW02 14-Mar-2013 1111669.9	HCR SW03 14-Mar-2013 1111669.10
Individual Tests						
pH	pH Units	7.7	7.1	6.7	7.4	7.8
Electrical Conductivity (EC)	mS/m	18.4	16.1	26.1	15.9	15.6
Total Suspended Solids	g/m^3	< 3	6	330	5	< 3
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	0.0011	< 0.0010	0.0013	0.0011 [#1]	0.0011
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	< 0.0005	< 0.0005	0.0007	< 0.0005	< 0.0005
Dissolved Copper	g/m^3	0.0023	0.0016	0.0151	0.0013	0.0011
Dissolved Lead	g/m^3	0.00013	0.00020	0.00057	< 0.00010	0.00018
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	0.0014	< 0.0005	< 0.0005
Dissolved Zinc	g/m^3	0.051	0.0151	0.30	0.031	0.053
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0012	< 0.0011	0.0016	< 0.0011 [#1]	0.0011
Total Cadmium	g/m^3	< 0.000053	< 0.000053	0.000096	< 0.000053	< 0.000053
Total Chromium	g/m^3	< 0.00053	< 0.00053	0.0035	0.00056	0.00062
Total Copper	g/m^3	0.0029	0.0030	0.030	0.0022	0.0110
Total Lead	g/m^3	0.00043	0.00040	0.0114	0.00067	0.0036
Total Nickel	g/m^3	< 0.00053	0.00068	0.0032	< 0.00053	< 0.00053
Total Zinc	g/m^3	0.069	0.034	0.49	0.040	0.078
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010

Sample Type: Aqueous

Sample Name: **Lab Number:**		BRN SW06 14-Mar-2013 1111669.6	BRN SW07 14-Mar-2013 1111669.7	HCR SW01 14-Mar-2013 1111669.8	HCR SW02 14-Mar-2013 1111669.9	HCR SW03 14-Mar-2013 1111669.10
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	0.5	< 0.4	< 0.4
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

Sample Name: **Lab Number:**		HCR SW04 14-Mar-2013 1111669.11	HCR SW05 14-Mar-2013 1111669.12	HCR SW06 14-Mar-2013 1111669.13	HCR SW07 14-Mar-2013 1111669.14	
Individual Tests						
pH	pH Units	7.6	7.3	7.8	7.0	-
Electrical Conductivity (EC)	mS/m	20.6	25.3	16.5	26.2	-
Total Suspended Solids	g/m^3	76	21	< 3	18	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	0.0029	0.0010	0.0020	-
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	-
Dissolved Chromium	g/m^3	< 0.0005	0.0012 [#1]	< 0.0005	0.0011	-
Dissolved Copper	g/m^3	0.0025	0.0056	0.0008	0.0061	-
Dissolved Lead	g/m^3	0.00010	0.00105	< 0.00010	0.00147	-
Dissolved Nickel	g/m^3	< 0.0005	0.0038	< 0.0005	0.0020	-
Dissolved Zinc	g/m^3	0.0144	0.22	0.0052	0.150	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0015	0.0037	0.0013	0.0022	-
Total Cadmium	g/m^3	< 0.000053	< 0.000053	< 0.000053	< 0.000053	-
Total Chromium	g/m^3	0.00129	0.00108 [#1]	< 0.00053	0.00146	-
Total Copper	g/m^3	0.0098	0.0079	0.00152	0.0095	-
Total Lead	g/m^3	0.0047	0.00166	0.00043	0.0021	-
Total Nickel	g/m^3	0.00118	0.0046	< 0.00053	0.0023	-
Total Zinc	g/m^3	0.114	0.30	0.0125	0.20	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.100	-
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.93	-
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.065	-
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	0.66	-
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.33	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	0.00029	-
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.0008	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	-
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	0.0152	-
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	0.0006	-
Pyrene	g/m^3	0.0003	0.0003	< 0.0002	0.0007	-

Sample Type: Aqueous

Sample Name:		HCR SW04 14-Mar-2013	HCR SW05 14-Mar-2013	HCR SW06 14-Mar-2013	HCR SW07 14-Mar-2013	
Lab Number:		1111669.11	1111669.12	1111669.13	1111669.14	
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	2.2	-
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	1.6	-
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	1.1	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	4.9	-

Analyst's Comments

[#1] It has been noted that the result for the dissolved fraction was greater than that for the total fraction, but within analytical variation of the methods.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms
Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-14
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-14
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-14
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-14
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-14
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-14
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-14
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-14
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-14

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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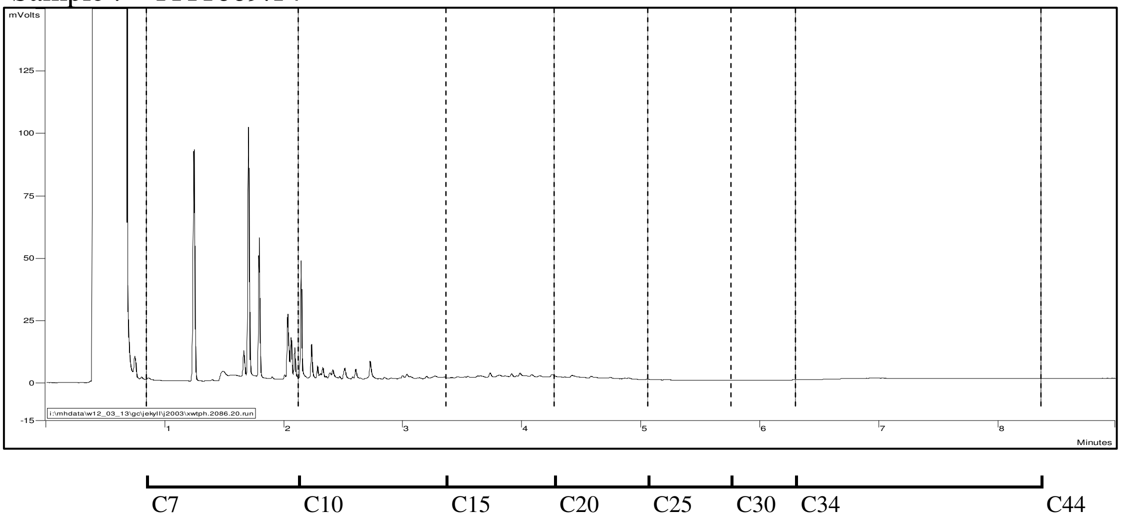
Carole Rodger-Caroll

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Sample : 1111669.14



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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1116799 SPv1
Contact:	H Easton	**Date Registered:**	28-Mar-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	08-Apr-2013
	PO Box 9528	**Quote No:**	53670
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Paul Churchill

Sample Type: Aqueous

Sample Name:		HBK SW 006a 26-Mar-2013	HBK SW 007a 26-Mar-2013	HBK SW 008a 26-Mar-2013	HBK SW 009a 26-Mar-2013	HBK SW 010a 26-Mar-2013
Lab Number:		1116799.1	1116799.2	1116799.3	1116799.4	1116799.5
Individual Tests						
pH	pH Units	7.5	7.0	-	-	-
Electrical Conductivity (EC)	mS/m	20.1	22.6	-	-	-
Total Suspended Solids	g/m^3	7	10	20	10	7
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	-	-	-
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	-	-	-
Dissolved Chromium	g/m^3	< 0.0005	0.0015	-	-	-
Dissolved Copper	g/m^3	0.0013	0.0031	-	-	-
Dissolved Lead	g/m^3	0.00022	0.00058	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	0.0024	-	-	-
Dissolved Zinc	g/m^3	0.0198	0.122	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	< 0.0011	-	-	-
Total Cadmium	g/m^3	< 0.000053	< 0.000053	-	-	-
Total Chromium	g/m^3	0.00055	0.0021	-	-	-
Total Copper	g/m^3	0.0030	0.0060	-	-	-
Total Lead	g/m^3	0.00177	0.00174	-	-	-
Total Nickel	g/m^3	< 0.00053	0.0030	-	-	-
Total Zinc	g/m^3	0.035	0.21	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	0.0060	-	-	-
Toluene	g/m^3	< 0.0010	0.124	-	-	-
Ethylbenzene	g/m^3	< 0.0010	0.0138	-	-	-
m&p-Xylene	g/m^3	< 0.002	0.189	-	-	-
o-Xylene	g/m^3	< 0.0010	0.119	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	-	-	-
Anthracene	g/m^3	0.00012	< 0.00010	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	-	-	-
Chrysene	g/m^3	< 0.00010	< 0.00010	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	-	-	-

Sample Type: Aqueous

Sample Name:		HBK SW 006a 26-Mar-2013	HBK SW 007a 26-Mar-2013	HBK SW 008a 26-Mar-2013	HBK SW 009a 26-Mar-2013	HBK SW 010a 26-Mar-2013
Lab Number:		1116799.1	1116799.2	1116799.3	1116799.4	1116799.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluoranthene	g/m^3	0.00011	< 0.00010	-	-	-
Fluorene	g/m^3	< 0.0002	< 0.0002	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	-	-	-
Naphthalene	g/m^3	< 0.0005	< 0.0005	-	-	-
Phenanthrene	g/m^3	< 0.0004	< 0.0004	-	-	-
Pyrene	g/m^3	0.0025	0.0015	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	0.43	< 0.10	< 0.10	0.26
C10 - C14	g/m^3	1.3	0.4	< 0.2	1.4	0.2
C15 - C36	g/m^3	32	4.1	< 0.4	30	2.0
Total hydrocarbons (C7 - C36)	g/m^3	33	5.0	< 0.7	31	2.5

Sample Name:		HBK SW Aa 26-Mar-2013				
Lab Number:		1116799.6				
Individual Tests						
pH	pH Units	6.9	-	-	-	-
Electrical Conductivity (EC)	mS/m	22.6	-	-	-	-
Total Suspended Solids	g/m^3	9	-	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	-	-	-	-
Dissolved Cadmium	g/m^3	< 0.00005	-	-	-	-
Dissolved Chromium	g/m^3	0.0015	-	-	-	-
Dissolved Copper	g/m^3	0.0035	-	-	-	-
Dissolved Lead	g/m^3	0.00059	-	-	-	-
Dissolved Nickel	g/m^3	0.0023	-	-	-	-
Dissolved Zinc	g/m^3	0.129	-	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	-	-	-	-
Total Cadmium	g/m^3	< 0.000053	-	-	-	-
Total Chromium	g/m^3	0.00140	-	-	-	-
Total Copper	g/m^3	0.0053	-	-	-	-
Total Lead	g/m^3	0.00167	-	-	-	-
Total Nickel	g/m^3	0.0026	-	-	-	-
Total Zinc	g/m^3	0.20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	0.0063	-	-	-	-
Toluene	g/m^3	0.130	-	-	-	-
Ethylbenzene	g/m^3	0.0150	-	-	-	-
m&p-Xylene	g/m^3	0.20	-	-	-	-
o-Xylene	g/m^3	0.127	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	-	-	-	-
Acenaphthylene	g/m^3	< 0.00010	-	-	-	-
Anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	-	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	-	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	-	-	-	-
Chrysene	g/m^3	< 0.00010	-	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	-	-	-	-
Fluoranthene	g/m^3	< 0.00010	-	-	-	-
Fluorene	g/m^3	< 0.0002	-	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	-	-	-	-

Sample Type: Aqueous						
Sample Name:		HBK SW Aa 26-Mar-2013				
Lab Number:		1116799.6				
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Naphthalene	g/m^3	< 0.0005	-	-	-	-
Phenanthrene	g/m^3	< 0.0004	-	-	-	-
Pyrene	g/m^3	0.0015	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	0.45	-	-	-	-
C10 - C14	g/m^3	0.4	-	-	-	-
C15 - C36	g/m^3	4.7	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	5.6	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-2, 6
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-2, 6
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-2, 6
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-2, 6
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-6
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-2, 6
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-2, 6
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-2, 6
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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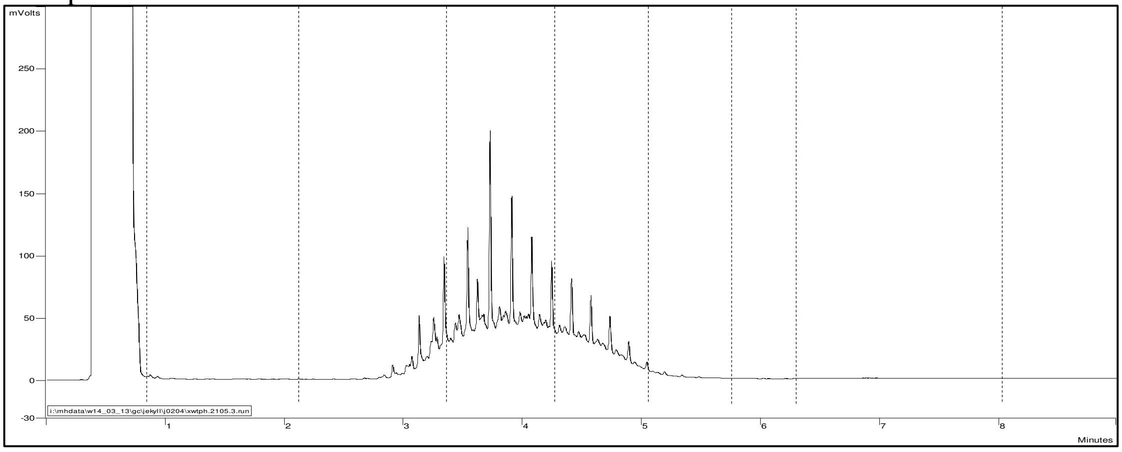
Client Services Manager - Environmental Division

Sample : 1116799.1



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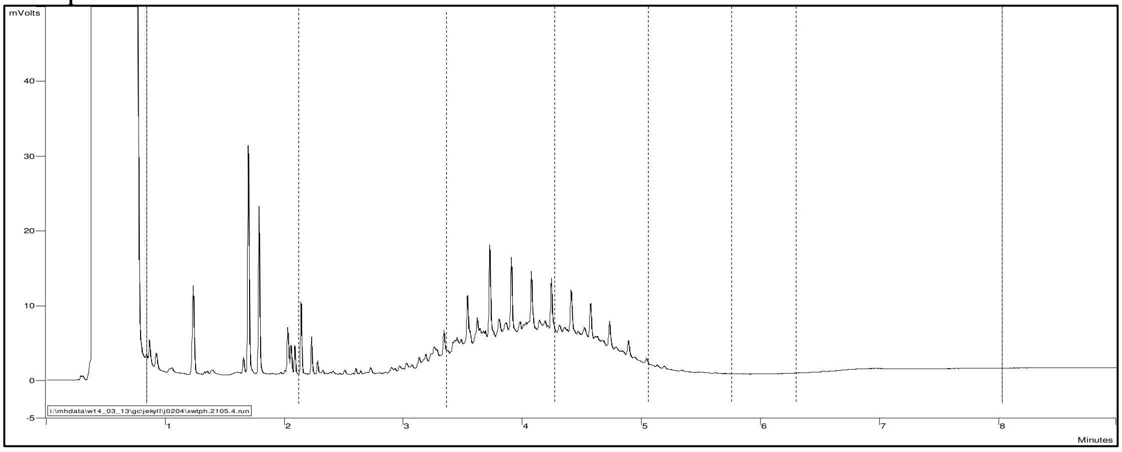
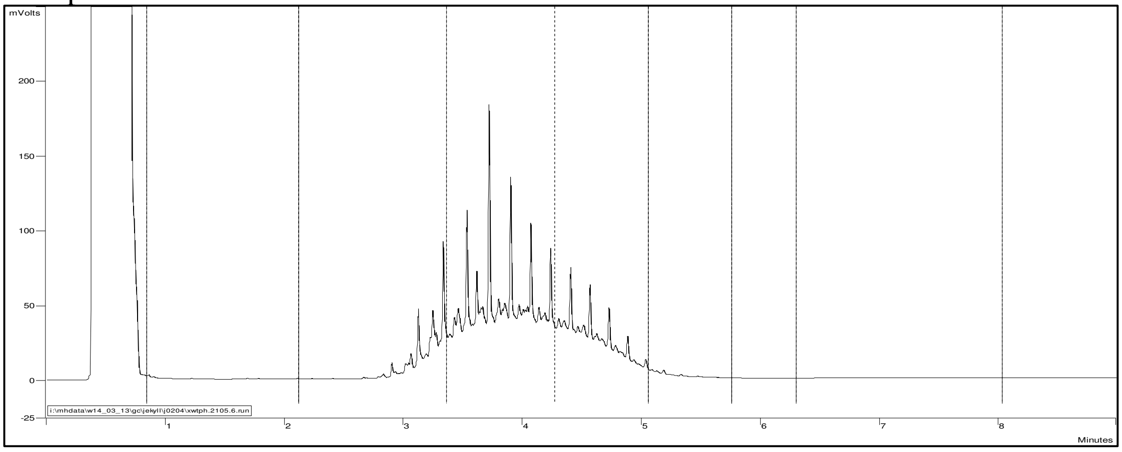
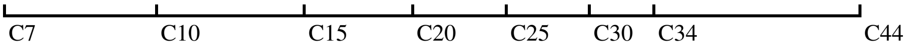


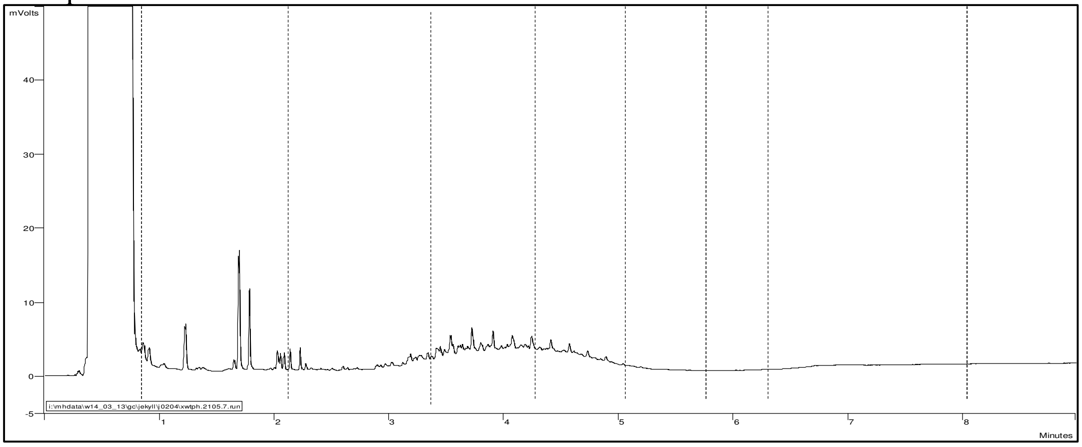
Sample : 1116799.4





Appendix No.2 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

Sample : 1116799.5



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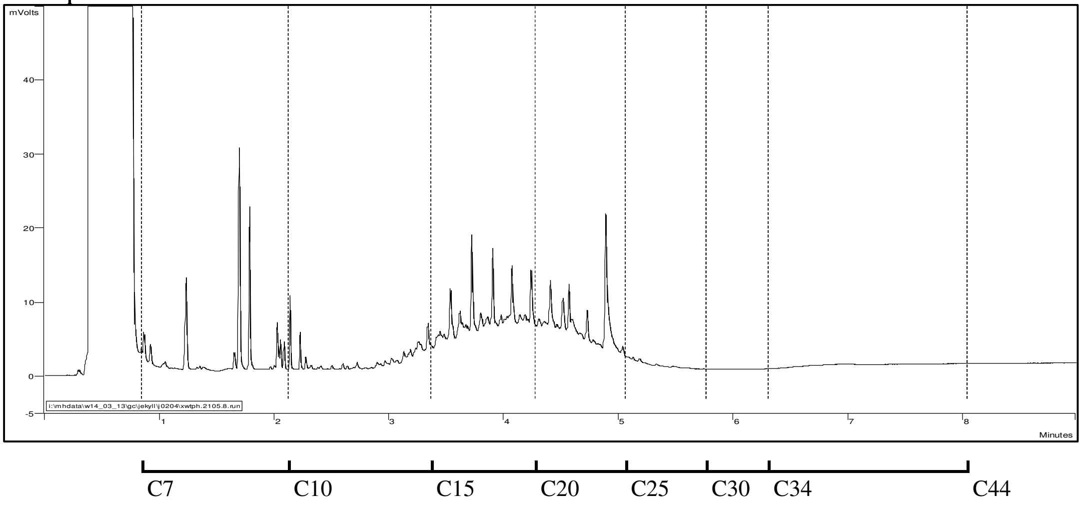

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ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1116808 SPv1
Contact:	H Easton	**Date Registered:**	28-Mar-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	08-Apr-2013
	PO Box 9528	**Quote No:**	53670
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Paul Churchill

Sample Type: Aqueous

Sample Name:		LAK SW 007 27-Mar-2013	LAK SW 008 27-Mar-2013	LAK SW 009 27-Mar-2013	LAK SW 010 27-Mar-2013	
Lab Number:		1116808.1	1116808.2	1116808.3	1116808.4	
Individual Tests						
pH	pH Units	7.2	-	-	-	-
Electrical Conductivity (EC)	mS/m	17.0	-	-	-	-
Total Suspended Solids	g/m^3	9	5	18	17	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	-	-	-	-
Dissolved Cadmium	g/m^3	< 0.00005	-	-	-	-
Dissolved Chromium	g/m^3	< 0.0005	-	-	-	-
Dissolved Copper	g/m^3	0.0018	-	-	-	-
Dissolved Lead	g/m^3	0.00013	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Zinc	g/m^3	0.039	-	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0012	-	-	-	-
Total Cadmium	g/m^3	< 0.000053	-	-	-	-
Total Chromium	g/m^3	0.00056	-	-	-	-
Total Copper	g/m^3	0.0030	-	-	-	-
Total Lead	g/m^3	0.00067	-	-	-	-
Total Nickel	g/m^3	< 0.00053	-	-	-	-
Total Zinc	g/m^3	0.055	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	-	-	-	-
Acenaphthylene	g/m^3	< 0.00010	-	-	-	-
Anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	-	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	-	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	-	-	-	-
Chrysene	g/m^3	< 0.00010	-	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	-	-	-	-

Sample Type: Aqueous

Sample Name:		LAK SW 007 27-Mar-2013	LAK SW 008 27-Mar-2013	LAK SW 009 27-Mar-2013	LAK SW 010 27-Mar-2013	
Lab Number:		1116808.1	1116808.2	1116808.3	1116808.4	
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluoranthene	g/m^3	< 0.00010	-	-	-	-
Fluorene	g/m^3	< 0.0002	-	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	-	-	-	-
Naphthalene	g/m^3	< 0.0005	-	-	-	-
Phenanthrene	g/m^3	< 0.0004	-	-	-	-
Pyrene	g/m^3	0.0002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	-
C10 - C14	g/m^3	< 0.2	< 0.2	0.4	< 0.2	-
C15 - C36	g/m^3	0.6	0.9	2.3	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	0.9	2.7	< 0.7	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-4
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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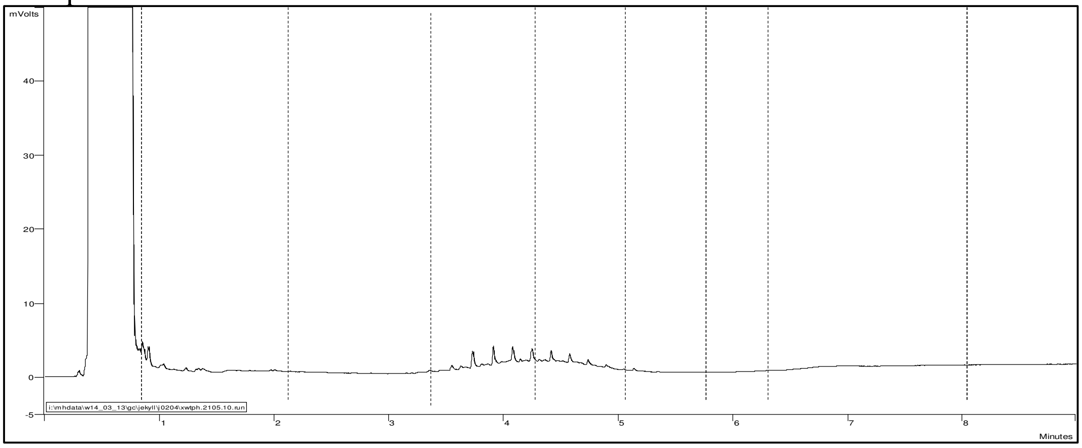
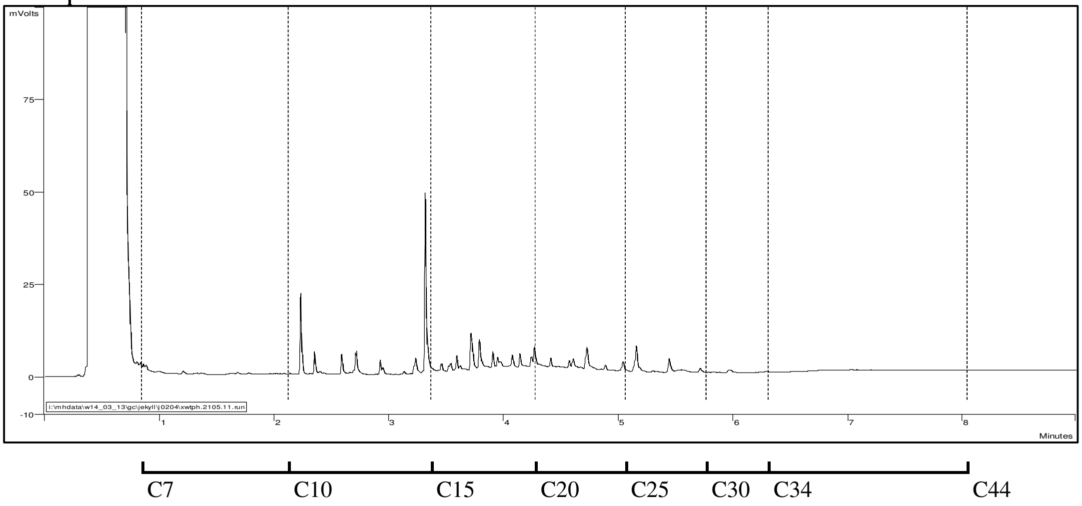
Client Services Manager - Environmental Division

Sample : 1116808.2



Sample : 1116808.3



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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1116817 SPv1
Contact:	H Easton	**Date Registered:**	28-Mar-2013
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	08-Apr-2013
	PO Box 9528	**Quote No:**	53670
	Newmarket	**Order No:**	
	AUCKLAND 1149	**Client Reference:**	A02579800
		Submitted By:	Paul Churchill

Sample Type: Aqueous

	Sample Name:	LAK SW 001	LAK SW 002	LAK SW 003	LAK SW 004	LAK SW 005
	Lab Number:	1116817.1	1116817.2	1116817.3	1116817.4	1116817.5
Individual Tests						
pH	pH Units	8.0	8.0	7.9	7.9	7.1
Electrical Conductivity (EC)	mS/m	18.2	16.7	15.7	17.7	17.2
Total Suspended Solids	g/m^3	49	18	3	9	15
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0013
Dissolved Cadmium	g/m^3	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Dissolved Chromium	g/m^3	0.0007	0.0006	0.0008	0.0007	0.0014
Dissolved Copper	g/m^3	0.0018	0.0006	0.0017	0.0026	0.0080
Dissolved Lead	g/m^3	0.00012	< 0.00010	0.00023	0.00020	0.00094
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0011
Dissolved Zinc	g/m^3	0.0135	0.0065	0.0033	0.0147	0.55
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0017
Total Cadmium	g/m^3	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	g/m^3	0.00177	0.00117	0.00081	0.00118	0.0021
Total Copper	g/m^3	0.0086	0.00137	0.0173	0.0042	0.0126
Total Lead	g/m^3	0.0032	0.00069	0.00192	0.00109	0.0023
Total Nickel	g/m^3	0.00105	< 0.00053	< 0.00053	< 0.00053	0.00138
Total Zinc	g/m^3	0.087	0.0188	0.0124	0.039	0.72
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0052
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	< 0.002	0.002
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0014
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010

Sample Type: Aqueous

	Sample Name:	LAK SW 001	LAK SW 002	LAK SW 003	LAK SW 004	LAK SW 005
	Lab Number:	1116817.1	1116817.2	1116817.3	1116817.4	1116817.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.0003	0.0004
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	< 0.2	0.6
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	2.6	2.7
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	2.6	3.3

	Sample Name:	LAK SW 006				
	Lab Number:	1116817.6				
Individual Tests						
pH	pH Units	7.9	-	-	-	-
Electrical Conductivity (EC)	mS/m	16.7	-	-	-	-
Total Suspended Solids	g/m^3	3	-	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	-	-	-	-
Dissolved Cadmium	g/m^3	< 0.00005	-	-	-	-
Dissolved Chromium	g/m^3	< 0.0005	-	-	-	-
Dissolved Copper	g/m^3	0.0010	-	-	-	-
Dissolved Lead	g/m^3	< 0.00010	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Zinc	g/m^3	0.0076	-	-	-	-
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	-	-	-	-
Total Cadmium	g/m^3	< 0.000053	-	-	-	-
Total Chromium	g/m^3	0.00066	-	-	-	-
Total Copper	g/m^3	0.00131	-	-	-	-
Total Lead	g/m^3	0.00025	-	-	-	-
Total Nickel	g/m^3	< 0.00053	-	-	-	-
Total Zinc	g/m^3	0.0140	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	-	-	-	-
Acenaphthylene	g/m^3	< 0.00010	-	-	-	-
Anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	-	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	-	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	-	-	-	-
Chrysene	g/m^3	< 0.00010	-	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	-	-	-	-
Fluoranthene	g/m^3	< 0.00010	-	-	-	-
Fluorene	g/m^3	< 0.0002	-	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	-	-	-	-
Naphthalene	g/m^3	< 0.0005	-	-	-	-

Sample Type: Aqueous

Sample Name:		LAK SW 006				
Lab Number:		1116817.6				
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Phenanthrene	g/m^3	< 0.0004	-	-	-	-
Pyrene	g/m^3	< 0.0002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	-	-	-	-
C10 - C14	g/m^3	< 0.2	-	-	-	-
C15 - C36	g/m^3	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	-	-	-	-

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-6
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-6
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-6
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-6
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-6
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-6
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-6
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-6
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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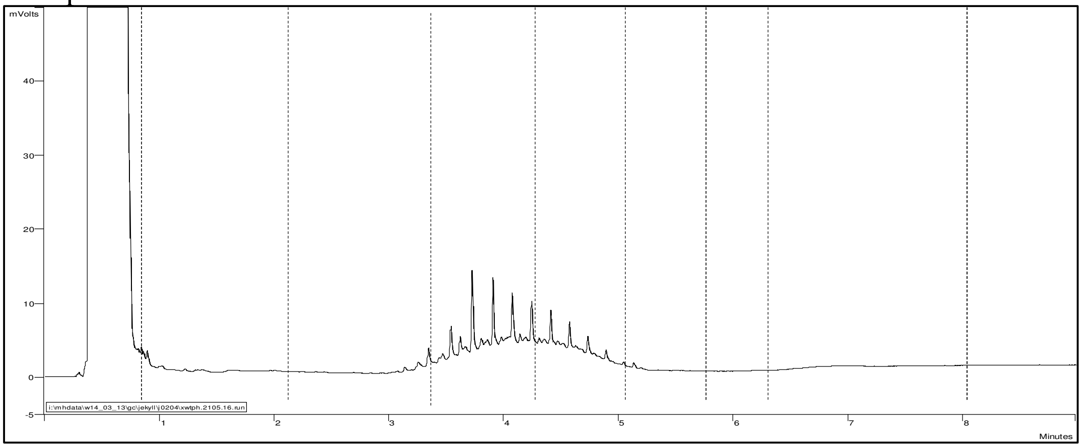
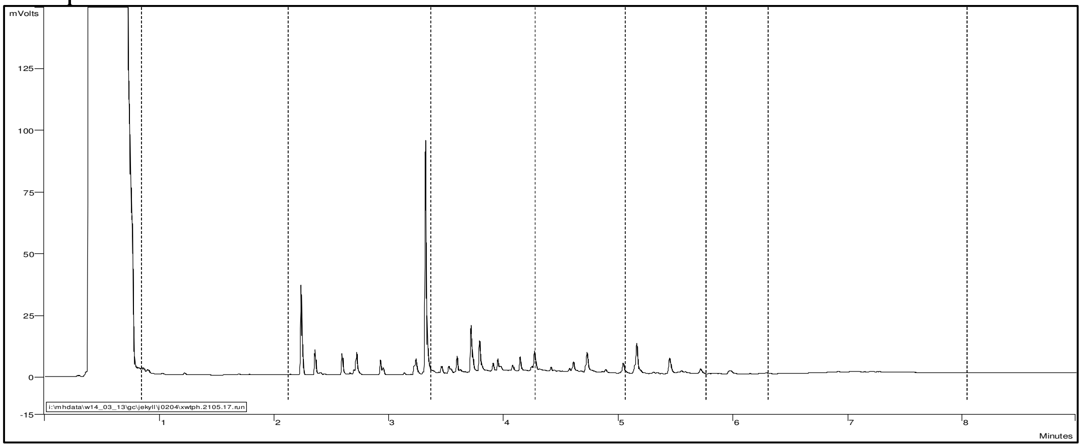
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

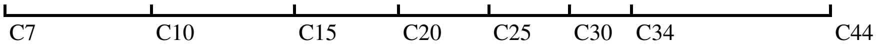
Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms - Page 1 of 1

Sample : 1116817.4



Sample : 1116817.5





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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Pattle Delamore Partners Ltd	**Lab No:**	1116854	SPv1
Contact:	H Easton	**Date Registered:**	28-Mar-2013	
	C/- Pattle Delamore Partners Ltd	**Date Reported:**	08-Apr-2013	
	PO Box 9528	**Quote No:**	53670	
	Newmarket	**Order No:**		
	AUCKLAND 1149	**Client Reference:**	A02579800	
		Submitted By:	Paul Churchill	

Sample Type: Aqueous

Sample Name:		HBK SW 001a	HBK SW 002a	HBK SW 003a	HBK SW 004a	HBK SW 005a
Lab Number:		1116854.1	1116854.2	1116854.3	1116854.4	1116854.5
Individual Tests						
pH	pH Units	7.5	7.7	8.2	7.2	7.2
Electrical Conductivity (EC)	mS/m	16.4	15.7	15.6	36.6	18.5
Total Suspended Solids	g/m^3	30	10	< 3	18	8
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Dissolved Cadmium	g/m^3	0.00008	< 0.00005	< 0.00005	0.00005	< 0.00005
Dissolved Chromium	g/m^3	< 0.0005	0.0005	0.0006	0.0008	0.0012
Dissolved Copper	g/m^3	0.0022	0.0006	0.0006	0.0050	0.0026
Dissolved Lead	g/m^3	0.00016	< 0.00010	0.00013	0.00050	0.00050
Dissolved Nickel	g/m^3	< 0.0005	< 0.0005	< 0.0005	0.0013	0.0022
Dissolved Zinc	g/m^3	0.086	0.020	0.0031	0.040	0.25
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	0.0011	< 0.0011	< 0.0011	0.0012	< 0.0011
Total Cadmium	g/m^3	0.000154	< 0.000053	< 0.000053	0.000105	< 0.000053
Total Chromium	g/m^3	0.00182	0.00093	0.033	0.00179	0.00177
Total Copper	g/m^3	0.0057	0.00087	0.0027	0.0120	0.0041
Total Lead	g/m^3	0.0056	0.00089	0.00033	0.0048	0.00085
Total Nickel	g/m^3	0.00129	< 0.00053	0.0027	0.00183	0.0028
Total Zinc	g/m^3	0.21	0.035	0.0033	0.110	0.35
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m^3	< 0.0010	0.0030	< 0.0010	0.0070	0.0035
Ethylbenzene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0010	0.0018
m&p-Xylene	g/m^3	< 0.002	< 0.002	< 0.002	0.004	0.012
o-Xylene	g/m^3	< 0.0010	< 0.0010	< 0.0010	0.0025	0.0052
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Acenaphthylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[g,h,i]perylene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Benzo[k]fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Chrysene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Fluoranthene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010

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new zealand accredited laboratory

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Aqueous

Sample Name:		HBK SW 001a	HBK SW 002a	HBK SW 003a	HBK SW 004a	HBK SW 005a
Lab Number:		1116854.1	1116854.2	1116854.3	1116854.4	1116854.5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Fluorene	g/m^3	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
Naphthalene	g/m^3	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Phenanthrene	g/m^3	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Pyrene	g/m^3	< 0.0002	< 0.0002	< 0.0002	0.0018	0.0009
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14	g/m^3	< 0.2	< 0.2	< 0.2	3.8	< 0.2
C15 - C36	g/m^3	< 0.4	< 0.4	< 0.4	72	1.5
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 0.7	< 0.7	76	1.5

Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	-	1-5
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	-	1-5
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1-5
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis	-	1-5
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1-5
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	1-5
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	1-5
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21st ed. 2005.	0.1 mS/m	1-5
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	1-5

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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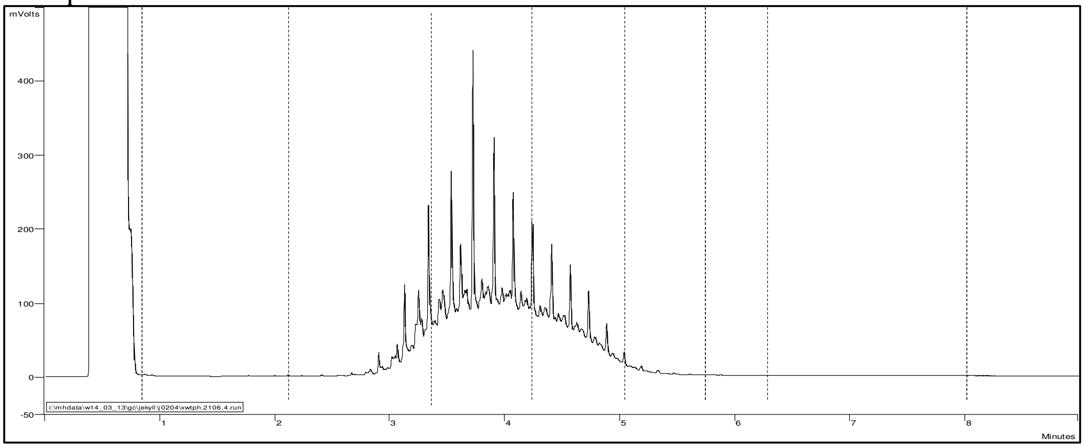
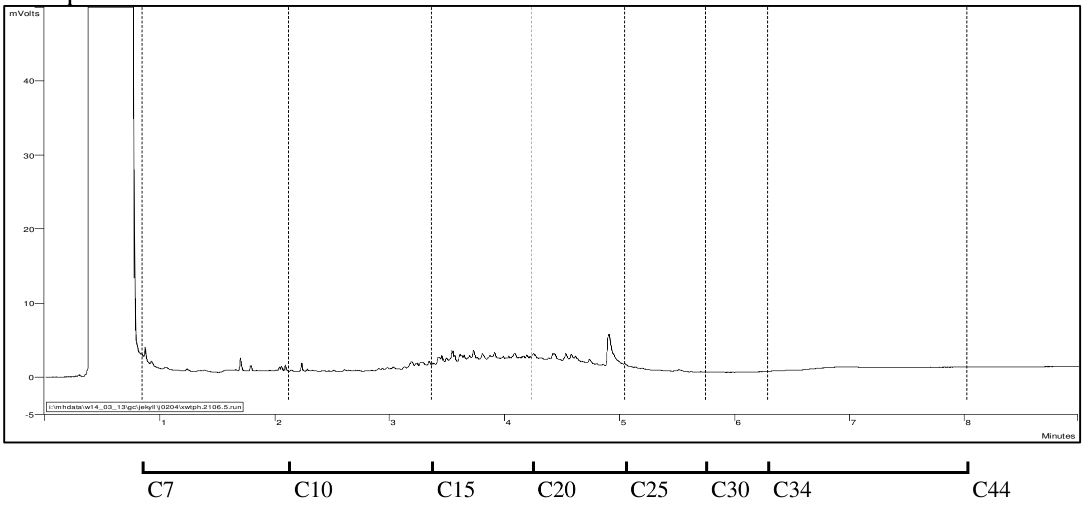
Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Sample : 1116854.4



Sample : 1116854.5



Appendix D

Malvern Mastersizer 2000 Reports

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Te Whare Wānanga o Waikato

The University of Waikato
Private Bag 3105
Hamilton, New Zealand

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
BROWNS ROAD FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013008/1

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Edited

Measured:
Wednesday, 30 January 2013 11:44:10 a.m.

Analysed:
Wednesday, 30 January 2013 11:44:12 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.503 %

Sensitivity:
Enhanced

Obscuration:
17.83 %

Result Emulation:
Off

Concentration:
0.0846 %Vol

Specific Surface Area:
0.214 m²/g

Span :
3.404

Surface Weighted Mean D[3,2]:
28.004 um

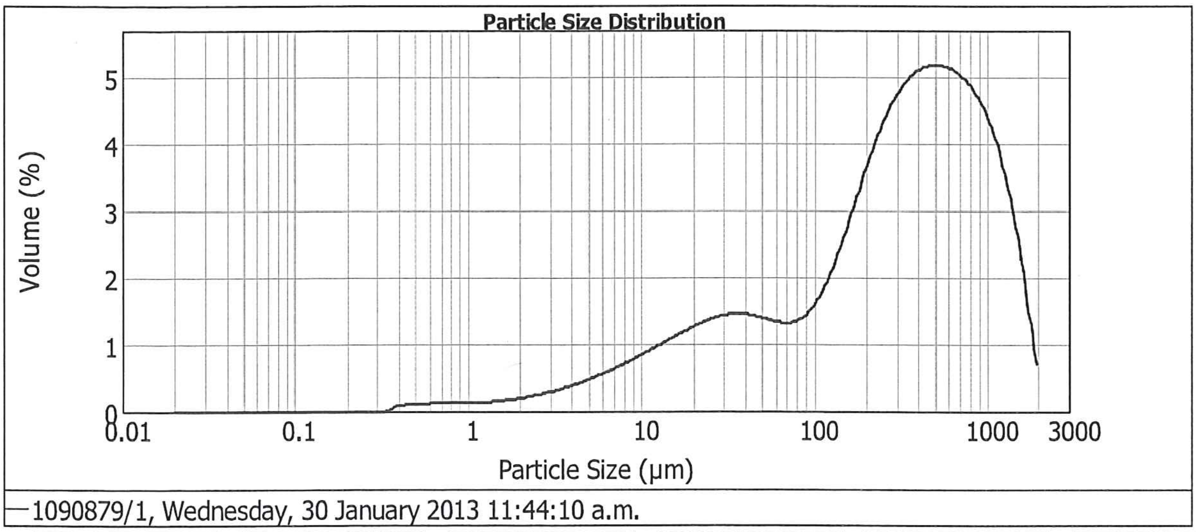
Uniformity:
1.04

Vol. Weighted Mean D[4,3]:
450.043 um

Result units:
Volume

Standard Deviation
433.979 um

d(0.1): **17.756** **um** **d(0.5):** **319.874** **um** **d(0.9):** **1106.743** **um**



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.71	37.000	16.52	105.000	26.06	300.000	48.00	840.000	81.90
0.060	0.00	2.000	1.39	44.000	18.16	125.000	28.16	350.000	52.88	1000.000	87.17
0.120	0.00	3.900	2.59	53.000	19.86	149.000	30.81	420.000	58.90	1190.000	91.89
0.240	0.00	7.800	4.95	63.000	21.38	177.000	34.06	500.000	64.77	1410.000	95.71
0.490	0.18	15.600	9.03	74.000	22.77	210.000	37.97	590.000	70.35	1680.000	98.57
0.700	0.44	31.000	14.85	88.000	24.30	250.000	42.60	710.000	76.50	2000.000	100.00

Operator notes:

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MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
BROWNS ROAD NON-FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013008/2

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Edited

Measured:
Wednesday, 30 January 2013 11:49:00 a.m.

Analysed:
Wednesday, 30 January 2013 11:49:02 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.148 %

Sensitivity:
Enhanced

Obscuration:
17.86 %

Result Emulation:
Off

Concentration:
0.0868 %Vol

Specific Surface Area:
0.198 m²/g

Span :
5.875

Surface Weighted Mean D[3,2]:
30.334 um

Uniformity:
1.74

Vol. Weighted Mean D[4,3]:
314.022 um

Result units:
Volume

Standard Deviation
384.93 um

d(0.1): 16.229 um **d(0.5):** 148.911 um **d(0.9):** 891.046 um

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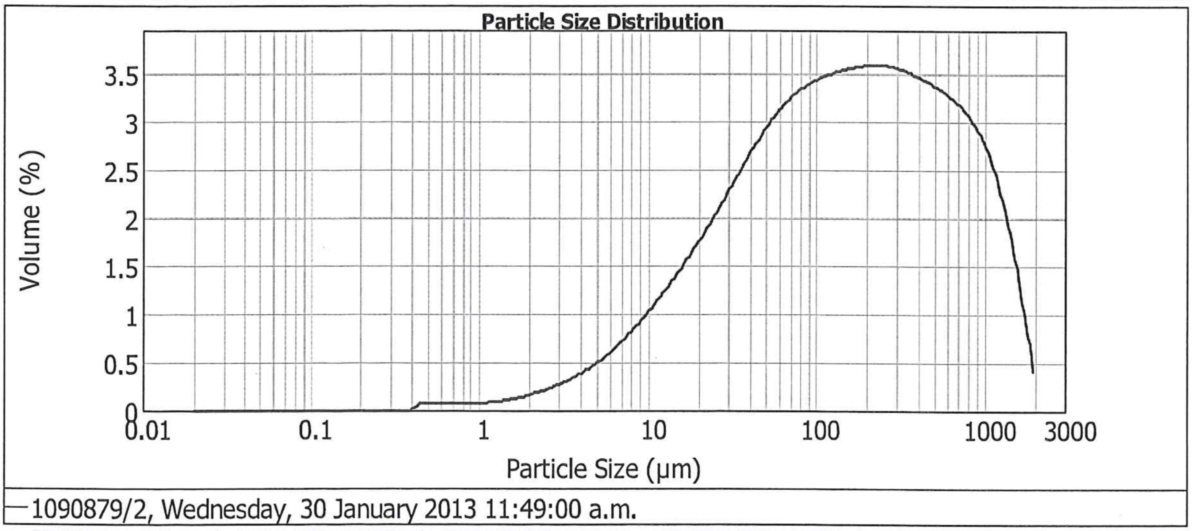

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.41	37.000	20.87	105.000	42.00	300.000	66.36	840.000	88.85
0.060	0.00	2.000	0.90	44.000	23.90	125.000	45.97	350.000	69.92	1000.000	92.15
0.120	0.00	3.900	2.01	53.000	27.41	149.000	50.01	420.000	74.06	1190.000	95.08
0.240	0.00	7.800	4.56	63.000	30.89	177.000	54.02	500.000	77.94	1410.000	97.42
0.490	0.07	15.600	9.62	74.000	34.28	210.000	58.02	590.000	81.54	1680.000	99.15
0.700	0.24	31.000	18.05	88.000	38.06	250.000	62.11	710.000	85.45	2000.000	100.00

Operator notes:

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MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
HIGHBROOK FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013009/3

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Edited

Measured:
Wednesday, 30 January 2013 4:02:33 p.m.

Analysed:
Wednesday, 30 January 2013 4:02:35 p.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.790 %

Sensitivity:
Enhanced

Obscuration:
16.77 %

Result Emulation:
Off

Concentration:
0.0193 %Vol

Specific Surface Area:
0.891 m²/g

Span :
4.718

Surface Weighted Mean D[3,2]:
6.731 um

Uniformity:
1.64

Vol. Weighted Mean D[4,3]:
50.692 um

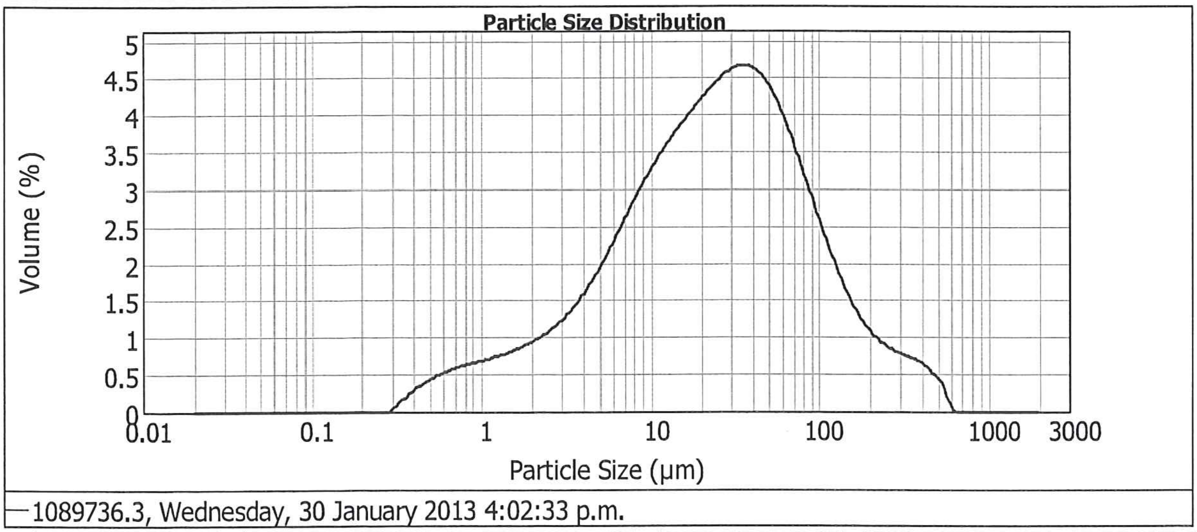
Result units:
Volume

Standard Deviation
76.487 um

d(0.1): 3.033 um

d(0.5): 24.714 um

d(0.9): 119.630 um



Size (μm)	Vol Under %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.78
0.700	1.98

Size (μm)	Vol Under %
0.980	3.38
2.000	7.07
3.900	12.27
7.800	21.97
15.600	37.39
31.000	56.75

Size (μm)	Vol Under %
37.000	62.13
44.000	67.38
53.000	72.79
63.000	77.45
74.000	81.34
88.000	84.98

Size (μm)	Vol Under %
105.000	88.08
125.000	90.58
149.000	92.60
177.000	94.17
210.000	95.43
250.000	96.50

Size (μm)	Vol Under %
300.000	97.48
350.000	98.24
420.000	99.05
500.000	99.66
590.000	100.00
710.000	100.00

Size (μm)	Vol Under %
840.000	100.00
1000.000	100.00
1190.000	100.00
1410.000	100.00
1680.000	100.00
2000.000	100.00

Operator notes:

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MASTERSIZER 2000

Result Analysis Report

Sample Name:
HIGHBROOK NON-FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013009/4

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Thursday, 31 January 2013 9:40:54 a.m.

Analysed:
Thursday, 31 January 2013 9:40:56 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.609 %

Sensitivity:
Enhanced

Obscuration:
19.84 %

Result Emulation:
Off

Concentration:
0.2174 %Vol

Specific Surface Area:
0.0836 m²/g

Span :
3.473

Surface Weighted Mean D[3,2]:
71.748 um

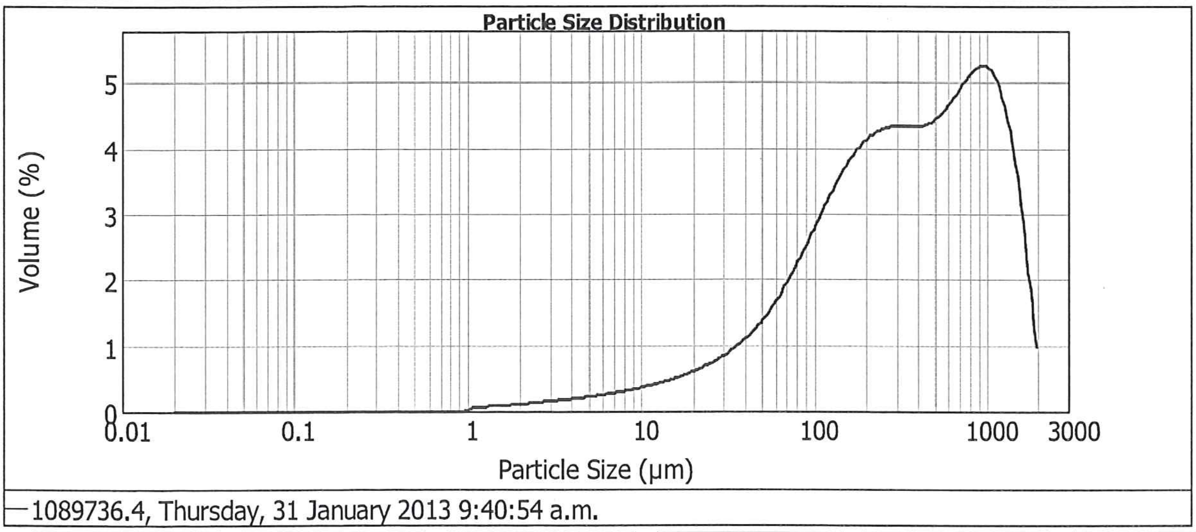
Uniformity:
1.07

Vol. Weighted Mean D[4,3]:
505.229 um

Result units:
Volume

Standard Deviation
464.111 um

d(0.1): 49.083 um **d(0.5):** 339.462 um **d(0.9):** 1228.127 um



Size (μm)	Vol Under %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00
2.000	0.34
3.900	0.97
7.800	2.05
15.600	3.81
31.000	6.77
37.000	7.85
44.000	9.10
53.000	10.70
63.000	12.49
74.000	14.49
88.000	17.05
105.000	20.14
125.000	23.67
149.000	27.67
177.000	31.98
210.000	36.53
250.000	41.36
300.000	46.50
350.000	50.86
420.000	56.02
500.000	60.99
590.000	65.87
710.000	71.62
840.000	77.18
1000.000	83.16
1190.000	89.00
1410.000	94.04
1680.000	97.98
2000.000	100.00

Operator notes:

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MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
HUNTERS CORNER FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013009/5

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Edited

Measured:
Wednesday, 30 January 2013 4:07:53 p.m.

Analysed:
Wednesday, 30 January 2013 4:07:55 p.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.691 %

Sensitivity:
Enhanced

Obscuration:
19.42 %

Result Emulation:
Off

Concentration:
0.0171 %Vol

Specific Surface Area:
1.2 m²/g

Span :
7.817

Surface Weighted Mean D[3,2]:
5.004 um

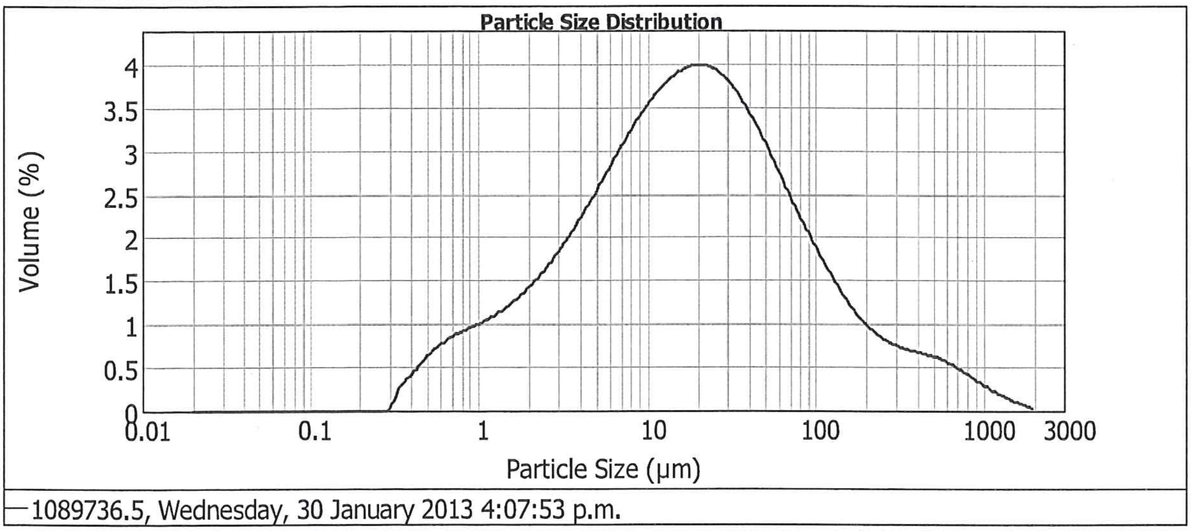
Uniformity:
3.29

Vol. Weighted Mean D[4,3]:
65.147 um

Result units:
Volume

Standard Deviation
156.259 um

d(0.1): 1.913 um **d(0.5): 17.723 um** **d(0.9): 140.454 um**



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	4.92	37.000	68.64	105.000	86.99	300.000	94.93	840.000	98.98
0.060	0.00	2.000	10.41	44.000	72.54	125.000	88.89	350.000	95.66	1000.000	99.37
0.120	0.00	3.900	18.15	53.000	76.38	149.000	90.52	420.000	96.48	1190.000	99.64
0.240	0.00	7.800	30.34	63.000	79.57	177.000	91.87	500.000	97.21	1410.000	99.83
0.490	1.16	15.600	46.71	74.000	82.23	210.000	93.00	590.000	97.86	1680.000	99.95
0.700	2.90	31.000	64.39	88.000	84.75	250.000	94.00	710.000	98.50	2000.000	100.00

Operator notes:

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MALVERN

MASTERSIZER 2000

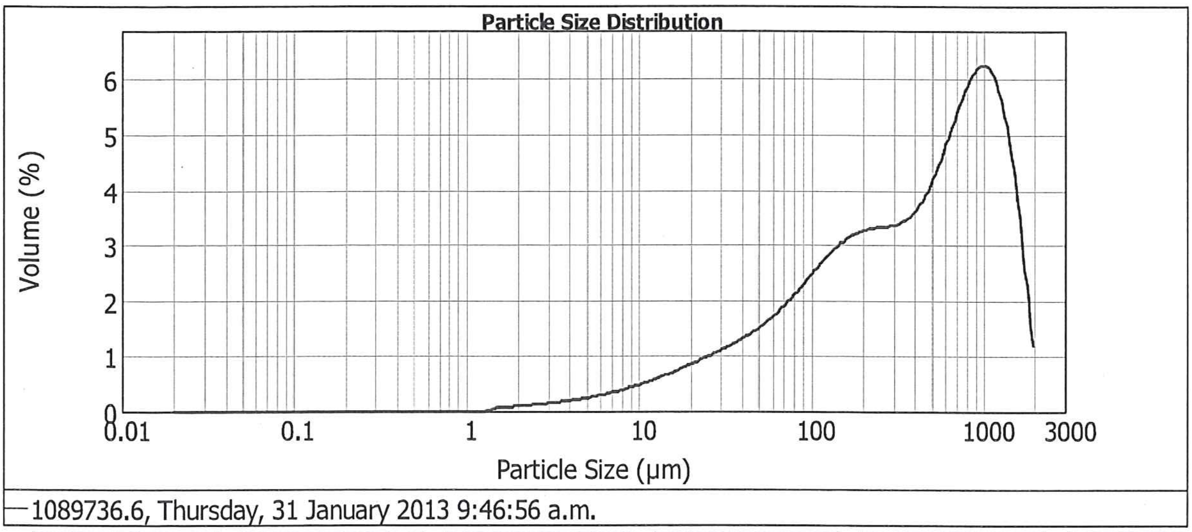
Result Analysis Report

Sample Name: HUNTERS CORNER. NON-FORECOURT	**SOP Name:** Marine Sediment	**Measured:** Thursday, 31 January 2013 9:46:56 a.m.
Sample Source & type:	**Measured by:** rodgers	**Analysed:** Thursday, 31 January 2013 9:46:58 a.m.
Sample bulk lot ref: 2013009/6	**Result Source:** Measurement	

Particle Name: Marine Sediment	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.500	**Absorption:** 0.2	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 17.28 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.633 %	**Result Emulation:** Off

Concentration: 0.1907 %Vol	**Span :** 3.132	**Uniformity:** 1	**Result units:** Volume
Specific Surface Area: 0.0816 m²/g	**Surface Weighted Mean D[3,2]:** 73.550 um	**Vol. Weighted Mean D[4,3]:** 551.141 um	**Standard Deviation** 492.366 um

d(0.1): 38.003 um **d(0.5):** 403.189 um **d(0.9):** 1300.991 um



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.00	37.000	9.78	105.000	22.04	300.000	43.33	840.000	72.58
0.060	0.00	2.000	0.17	44.000	11.27	125.000	25.09	350.000	46.75	1000.000	79.62
0.120	0.00	3.900	0.76	53.000	13.06	149.000	28.45	420.000	50.97	1190.000	86.64
0.240	0.00	7.800	1.99	63.000	14.93	177.000	31.96	500.000	55.40	1410.000	92.76
0.490	0.00	15.600	4.36	74.000	16.89	210.000	35.59	590.000	60.15	1680.000	97.55
0.700	0.00	31.000	8.41	88.000	19.28	250.000	39.36	710.000	66.28	2000.000	100.00

Operator notes:

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Hamilton, New Zealand

MASTERSIZER 2000

Result Analysis Report

Sample Name:
LAKESIDE FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013010/2

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Thursday, 31 January 2013 10:00:42 a.m.

Analysed:
Thursday, 31 January 2013 10:00:44 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.342 %

Sensitivity:
Enhanced

Obscuration:
13.41 %

Result Emulation:
Off

Concentration:
0.4634 %Vol

Specific Surface Area:
0.0262 m²/g

Span :
2.414

Surface Weighted Mean D[3,2]:
229.434 um

Uniformity:
0.734

Vol. Weighted Mean D[4,3]:
559.208 um

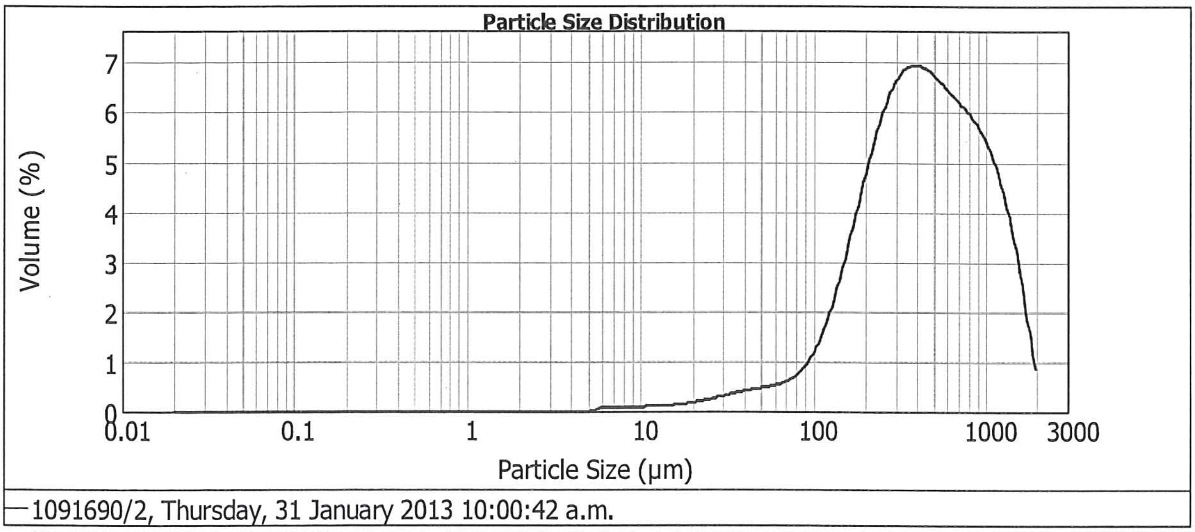
Result units:
Volume

Standard Deviation
416.161 um

d(0.1): **142.391** **um**

d(0.5): **434.043** **um**

d(0.9): **1189.962** **um**



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.00	37.000	1.94	105.000	6.21	300.000	33.43	840.000	77.73
0.060	0.00	2.000	0.00	44.000	2.41	125.000	8.05	350.000	40.26	1000.000	84.19
0.120	0.00	3.900	0.00	53.000	2.97	149.000	10.82	420.000	48.52	1190.000	90.00
0.240	0.00	7.800	0.17	63.000	3.54	177.000	14.65	500.000	56.31	1410.000	94.72
0.490	0.00	15.600	0.61	74.000	4.15	210.000	19.66	590.000	63.45	1680.000	98.24
0.700	0.00	31.000	1.53	88.000	4.99	250.000	25.92	710.000	71.10	2000.000	100.00

Operator notes:

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MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name: LAKESIDE NON-FORECOURT	**SOP Name:** Marine Sediment	**Measured:** Thursday, 31 January 2013 10:08:37 a.m.
Sample Source & type:	**Measured by:** rodgers	**Analysed:** Thursday, 31 January 2013 10:08:39 a.m.
Sample bulk lot ref: 2013010/3	**Result Source:** Measurement	

Particle Name: Marine Sediment	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.500	**Absorption:** 0.2	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 15.60 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.366 %	**Result Emulation:** Off

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Concentration: 0.4553 %Vol	**Span :** 2.800	**Uniformity:** 0.855	**Result units:** Volume
Specific Surface Area: 0.0313 m²/g	**Surface Weighted Mean D[3,2]:** 191.855 um	**Vol. Weighted Mean D[4,3]:** 540.516 um	**Standard Deviation** 436.717 um

d(0.1): 111.226 um　　**d(0.5):** 393.716 um　　**d(0.9):** 1213.556 um

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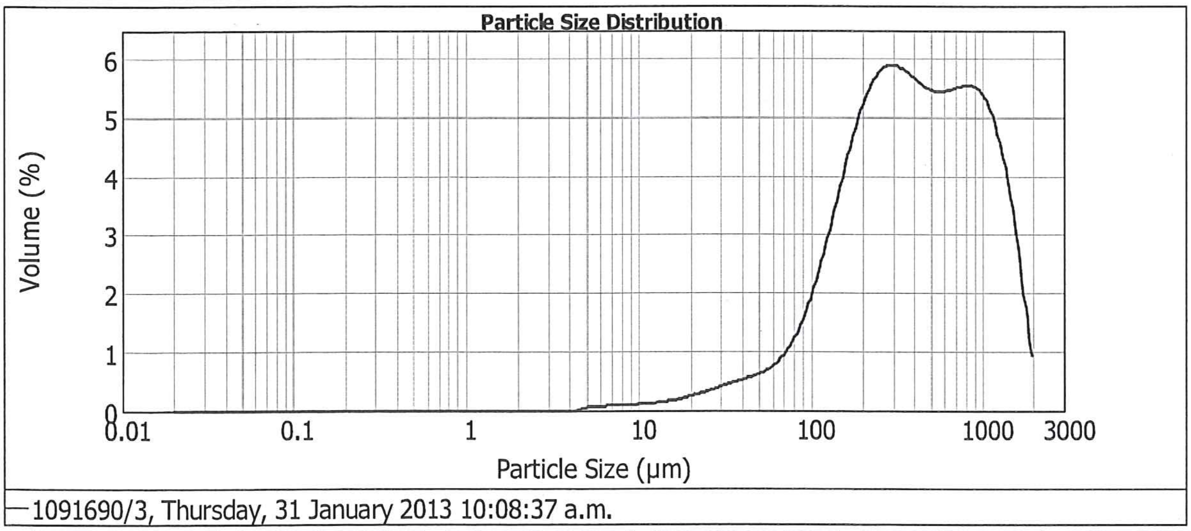

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.00	37.000	2.59	105.000	9.16	300.000	39.69	840.000	77.22
0.060	0.00	2.000	0.00	44.000	3.19	125.000	12.01	350.000	45.59	1000.000	83.48
0.120	0.00	3.900	0.00	53.000	3.93	149.000	15.88	420.000	52.38	1190.000	89.38
0.240	0.00	7.800	0.25	63.000	4.75	177.000	20.69	500.000	58.67	1410.000	94.32
0.490	0.00	15.600	0.79	74.000	5.71	210.000	26.34	590.000	64.55	1680.000	98.09
0.700	0.00	31.000	2.06	88.000	7.12	250.000	32.71	710.000	71.15	2000.000	100.00

Operator notes:

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MASTERSIZER 2000

Result Analysis Report

Sample Name:
SYLVIA PARK FORECOURT

Sample Source & type:

Sample bulk lot ref:
2013009/2

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Thursday, 31 January 2013 9:32:14 a.m.

Analysed:
Thursday, 31 January 2013 9:32:16 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0.2

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.615 %

Sensitivity:
Enhanced

Obscuration:
14.23 %

Result Emulation:
Off

Concentration:
0.2325 %Vol

Specific Surface Area:
0.0545 m²/g

Span :
2.670

Surface Weighted Mean D[3,2]:
110.049 um

Uniformity:
0.853

Vol. Weighted Mean D[4,3]:
599.794 um

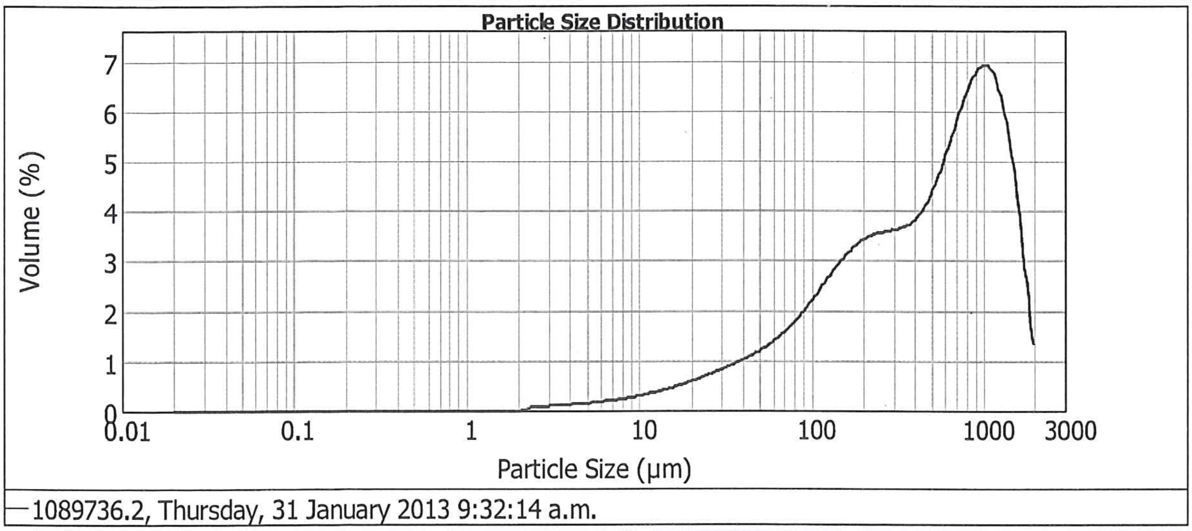
Result units:
Volume

Standard Deviation
493.672 um

d(0.1): 58.971 um

d(0.5): 479.912 um

d(0.9): 1340.439 um



Size (μm)	Vol Under %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00
2.000	0.00
3.900	0.33
7.800	1.09
15.600	2.59
31.000	5.47
37.000	6.52
44.000	7.67
53.000	9.09
63.000	10.60
74.000	12.22
88.000	14.25
105.000	16.69
125.000	19.50
149.000	22.74
177.000	26.27
210.000	30.04
250.000	34.05
300.000	38.32
350.000	41.99
420.000	46.48
500.000	51.14
590.000	56.16
710.000	62.70
840.000	69.54
1000.000	77.29
1190.000	85.08
1410.000	91.90
1680.000	97.26
2000.000	100.00

Operator notes:

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MALVERN INSTRUMENTS

MASTERSIZER 2000

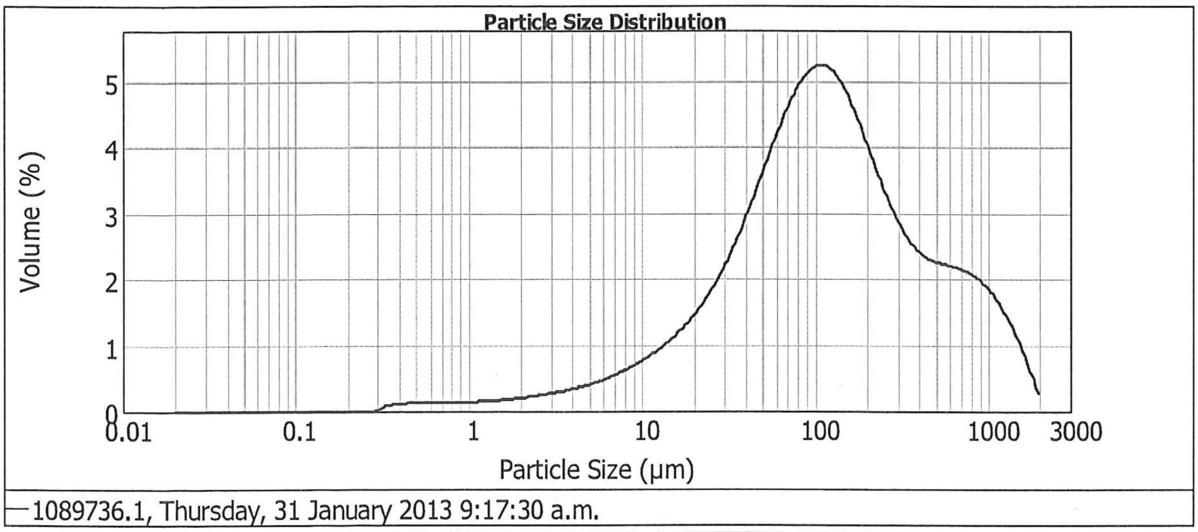
Result Analysis Report

Sample Name: SYLVIA PARK NON-FORECOURT	**SOP Name:** Marine Sediment	**Measured:** Thursday, 31 January 2013 9:17:30 a.m.
Sample Source & type:	**Measured by:** rodgers	**Analysed:** Thursday, 31 January 2013 9:17:32 a.m.
Sample bulk lot ref: 2013009/1	**Result Source:** Measurement	

Particle Name: Marine Sediment	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.500	**Absorption:** 0.2	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 23.18 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 0.303 %	**Result Emulation:** Off

Concentration: 0.0961 %Vol	**Span :** 6.008	**Uniformity:** 1.71	**Result units:** Volume
Specific Surface Area: 0.262 m²/g	**Surface Weighted Mean D[3,2]:** 22.889 um	**Vol. Weighted Mean D[4,3]:** 245.070 um	**Standard Deviation** 332.831 um

d(0.1): 18.457 um **d(0.5):** 113.295 um **d(0.9):** 699.109 um



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.050	0.00	0.980	0.90	37.000	18.80	105.000	47.39	300.000	76.89	840.000	92.52
0.060	0.00	2.000	1.65	44.000	22.16	125.000	53.35	350.000	79.63	1000.000	94.74
0.120	0.00	3.900	2.78	53.000	26.43	149.000	59.14	420.000	82.56	1190.000	96.71
0.240	0.00	7.800	4.81	63.000	31.02	177.000	64.38	500.000	85.18	1410.000	98.27
0.490	0.30	15.600	8.64	74.000	35.81	210.000	69.04	590.000	87.58	1680.000	99.43
0.700	0.61	31.000	15.93	88.000	41.40	250.000	73.18	710.000	90.22	2000.000	100.00

Operator notes: