C Boyd – Drilling Waste Disposal Monitoring Programme Biennial Report 2011-2013

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Executive summary

Colin Boyd, in conjunction with operator MI Swaco, operates two drilling waste stockpiling facilities on his property near Inglewood, within the Waitara catchment. These sites are located on adjoining properties off Derby Road North and Surrey Road. Drilling waste from the stockpiling sites is landspread over the farm-based property. This report for the period July 2011-2013 describes the monitoring programme implemented by the Taranaki Regional Council to assess the consent holder's environmental performance during the period under review, and the results and environmental effects of the consent holder's activities.

Colin Boyd holds three resource consents, and Surrey Road Landfarms Limited (a subsidiary company in relation to the landfarming operations at this site) holds one. Three of these consents permit the discharge of drilling waste onto and into land via landfarming or landspreading, and one consent permits the discharge of stormwater. The consents include a total of 64 conditions setting out the requirements that must be satisfied.

During the monitoring period, the consent holder demonstrated an overall 'improvement required' level of environmental performance and compliance with the resource consents.

The Council's monitoring programme for the period under review included 45 inspections, 54 groundwater samples, 38 water samples and six soil samples collected for analysis, eight biomonitoring surveys of receiving waters, 10 investigative samples, and the review of annual reports provided by the consent holder.

The monitoring indicated that activities at the drilling waste storage sites and the landspreading operation were not having any significant adverse effects on the environment. However, there were two incidents, one at each stockpiling site, and the Surrey Road incident resulted in minor short term effects on the Mangatengehu Stream. The incidents are discussed in Section 5.1 of this report.

During the year, the consent holder achieved an 'improvement required' level of both environmental performance and administrative compliance with the resource consents.

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents.

This report includes recommendations for the 2013-2014 monitoring year.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report is the Biennial Report for the period July 2011-June 2013 by the Taranaki Regional Council describing the monitoring programme associated with the resource consents held by Colin Boyd and Surrey Road Landfarms Limited. The consent holders in conjunction with MI Swaco operate two drilling waste stockpiling facilities and a landfarming/landspreading operation, situated on Colin Boyd's property between Inglewood and Tariki.

This report covers the results and findings of three monitoring programmes implemented by the Council in respect of the consents held, that relate to the discharge of drilling waste in the Waitara catchment. This is the fourth monitoring report to be prepared by the Taranaki Regional Council to cover the consent holders' discharges and their effects at the property covered in this report.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the Resource Management Act and the Council's obligations and general approach to monitoring sites through annual programmes, the resource consents held by Colin Boyd and Surrey Road Landfarms Limited, the nature of the monitoring programmes in place for the period under review, and a description of the activities and operations conducted at the consent holders' sites.

Sections 2-5 present the results of monitoring during the period under review, including scientific and technical data for each of the monitoring programmes.

Section 6 discusses the results, their interpretation, and their significance for the environment.

Section 7 presents recommendations to be implemented in the 2013-2014 monitoring year.

A glossary of common abbreviations and scientific terms, and a bibliography, are presented at the end of the report.

1.1.3 The Resource Management Act (1991) and monitoring

The Resource Management Act primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

(a) the neighbourhood or the wider community around a discharger, and may include cultural and social-economic effects;
(b) physical effects on the locality, including landscape, amenity and visual effects;
(c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;

(d) natural and physical resources having special significance (eg, recreational, cultural, or aesthetic):
(e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Taranaki Regional Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each discharge source. Monitoring programmes are not only based on exiting permit conditions, but also on the obligations of the Resource Management Act to assess the effects of the exercise of consents. In accordance with section 35 of the Resource Management Act 1991, the Council undertakes compliance monitoring for consents and rules in regional plans; and maintains an overview of performance of resource users against regional plans and consents. Compliance monitoring, (covering both activity and impact) monitoring, also enables the Council to continuously assess its own performance in resource management as well as that of resource users particularly consent holders. It further enables the Council to continually re-evaluate its approach and that of consent holders to resource management, and ultimately, through the refinement of methods and considered responsible resource utilization, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder/s during the period under review, this report also assigns a rating as to each Company's environmental and administrative performance.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year. **Administrative performance** is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (i.e. a defence under the provisions of the *RMA* can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

- **High** No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment .The Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

- **Good** Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or in response to unauthorised incident reports, but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

  For example:

  - High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
  - Strong odour beyond boundary but no residential properties or other recipient nearby.

- **Improvement required** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

- **Poor** Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative compliance

- **High** The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

- **Improvement required** Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

- **Poor** Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents.

1.2 Process descriptions

1.2.1 Hydrocarbon exploration and production wastes

For the purposes of disposal to land, waste from the petroleum industry can be divided into two broad categories; exploration (drilling) wastes, and production wastes. The wastes disposed of at the Boyd operations are primarily drilling waste. Fracture return fluids are not disposed of at these sites.

1.2.1.1 Drilling wastes

Waste drilling material is produced during well drilling for hydrocarbon exploration. The primary components of this waste are drilling fluids (muds) and rock cuttings.

Drilling fluids

Drilling fluids are engineered to perform several crucial tasks in the drilling of a hydrocarbon well. These include: transporting cuttings from the drill bit to the well surface for disposal; controlling hydrostatic pressure in the well; supporting the sides of the hole and preventing the ingress of formation fluids; and lubricating and cooling the drill bit and drill pipe in the hole. Oil and gas wells may be drilled with either synthetic based mud (SBM) or water based mud (WBM). As the names suggest, these are fluids with either water (fresh or saline) or synthetic oil as a base material, to which further compounds are added to modify the physical characteristics of the mud (for example mud weight or viscosity). More than one type of fluid may be used to drill an individual well. In the past, oil based muds (diesel/crude oil based) have also been used. Their use has declined since the 1980s due to their ecotoxicity; they have been replaced by SBM. SBM use olefins, paraffins or esters as a base material. While this is technically still a form of oil based fluid, these fluids have been engineered to remove polynuclear aromatic hydrocarbons, reduce the potential for bioaccumulation and accelerate biodegradation compared with OBM.

Common constituents of WBM and SBM include weighting agents, viscosifiers, thinners, lost circulation materials (LCM), pH control additives, dispersants, corrosion inhibitors, bactericides, filtrate reducers, flocculants and lubricants. Of these, the naturally occurring clay mineral barite (barium sulphate) is generally the most common additive. It is added to most drilling muds as a wetting and weighting agent.

Drilling fluids may be intentionally discharged in bulk for changes to the drilling fluid programme or at the completion of drilling. Depending on operational requirements and fluid type and properties, fluids may be re-used in multiple wells.

Cuttings

Cuttings are produced as the drill bit penetrates the underlying geological formations. They are brought to the surface in the drilling fluid where they pass over a shaker screen that separates the cuttings and drilling fluids. The drilling fluids are recycled for reuse within the drilling process, but small quantities of drilling fluids remain adhered to the cuttings. The cuttings and smaller particle material from the drill fluid treatment units drain into sumps. If sumps cannot be constructed corrals or special bins are used. During drilling this material is the only continuous discharge.

1.2.2 Landfarming process description

The landfarming process has typically been used in the Taranaki region to assist the conversion of sandy coastal sites prone to erosion into productive pasture. Landfarming is a technology that uses natural and assisted bioremediation to reduce the concentration of petroleum compounds through degradation, while simultaneously utilising the drilling muds to stabilise poor quality sandy soils for subsequent land use.

Results of an independent research project conducted by AgKnowledge Ltd (2013) have indicated that the re-contoured sand dunes, after the inclusion of the drilling wastes (as per the consents), and with the addition of appropriate fertilisers and water (irrigation) are capable of producing high quality clover-based pastures and thus increasing the value of the land from about $3-4,000/ha to $30-40,000/ha (2013). The full report is attached in Appendix V.

The landfarming process utilized more often at the coastal sites is on a single application basis. This means dedicated spreading areas receive only single applications of waste. Basic steps in the landfarming process include:

1. Drilling waste is transported from wellsites by truck (cuttings) or tanker (liquids). It may be discharged directly to land or placed in a dedicated storage pit. At the Boyd's sites cuttings arrive from site in metal 'D' bins directly collected from the wellsite.
2. The required area is prepared by scraping back and stockpiling existing pasture/topsoil and leveling out uneven ground.
3. Waste is transferred to the prepared area by excavator and truck and spread out with a bulldozer. Liquids may be discharged by tanker or a spray system.
4. Waste is allowed to dry sufficiently before being tilled into the soil to the required depth with a tractor and discs.
5. The disposal area is leveled with chains or harrows.
6. Stockpiled or brought in topsoil/clay is applied to aid stability and assist in grass establishment.
7. Fertiliser may be applied and the area is sown in crop or pasture at a suitable time of year.

Consents 6900-2 and 7559-1 allow for the disposal of drilling waste from hydrocarbon exploration activities with WBM and SBM via the landfarming process outlined above. Initial landfarming at the site revealed difficulties working with soils with higher baseline moisture content. As a result, consent 7591-1 was issued to allow for disposal via the process of landspreading.

1.2.3 Landspreading process description

The preferred method for the treatment of drilling waste at Colin Boyd's property is via landspreading (under consent **7591-1)**. A large muck spreader, shown in Photograph 1, is used for this purpose.

Photo 1 Spreader unit utilized for landspreading operations at Colin Boyd's property

An auger in the base of the spreader conveys material back and through an opening (where the size is controlled by a sliding plate) where it contacts two rapidly rotating augers and is flung up to 10 metres on either side. The deposition rate is controlled by the size of the opening at the rear of the unit and the speed of forward travel by the tractor. The waste is deposited onto existing pasture in small fragments, which are allowed some time to dry out before chain harrows and roman discs are used to till and break-up the waste which is dispersed back into the soil, shown in Photograph 2.

Photo 2 Tilling at Colin's Boyd's property post landspreading. The left of the frame shows landspread area yet to be tilled

1.3 Resource consents

1.3.1 Discharges of wastes to land

Sections 15(1)(b) and (d) of the Resource Management Act stipulate that no person may discharge any contaminant onto land if it may then enter water, or from any industrial or trade premises onto land under any circumstances, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

Colin Boyd holds discharge permit **6900-2** (supersedes expired consent 6900-1), to discharge drilling wastes (consisting of drilling cuttings and drilling fluids from water based muds and synthetic based muds), onto and into land for the purpose of temporary stockpiling prior to disposal. This permit was issued by the Taranaki Regional Council on 16 February 2011 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

Condition 1 requires adoption of the best practicable option.

Conditions 2 to 4 detail notification, record keeping, and reporting requirements.

Conditions 5 and 6 are operational requirements.

Conditions 7 and 8 set limits on contaminants in groundwater and surface water.

Conditions 9 and 10 set limits on certain parameters in the soil of the previously landfarmed areas, to be met prior to surrender.

Condition 11 is a review condition.

Colin Boyd holds discharge permit **7559-1**, to discharge drilling wastes (consisting of drilling cuttings and drilling fluids) from hydrocarbon exploration activities with water based muds and synthetic based muds onto and into land via landfarming. This permit was issued by the Taranaki Regional Council on 20 November 2009 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

Condition 1 sets out definitions of stockpiling and landfarming.

Condition 2 requires adoption of the best practicable option.

Conditions 3 and 4 require the installation of groundwater monitoring wells and provision of a management plan, prior to exercise of the consent.

Conditions 5 and 6 detail notification and sampling requirements prior to discharge.

Conditions 9 and 11 to 13 specify discharge limits and loading rates.

Conditions 7, 8, 10, 14 and 15 are operational requirements.

Conditions 16 to 20 set limits on certain parameters in the soil.

Conditions 20 and 22 relate to effects on groundwater and surface water.

Conditions 23 and 24 concern monitoring and reporting.

Conditions 25 and 26 relate to lapse and review of the consent.

Surrey Road Landfarms Limited holds discharge permit **7591-1**, to discharge drilling waste from hydrocarbon exploration activities onto and into land via landspreading This permit was issued by the Taranaki Regional Council on 21 January 2010 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

Condition 1 and 2 concern adoption of the best practicable option and notifications.

Conditions 3 and 7 to 9 are operational requirements.

Conditions 4 to 6 specify discharge limits and loading rates.

Conditions 10 to 14 set limits on certain parameters in the soil.

Conditions 15 and 16 relate to effects on groundwater and surface water.

Conditions 17 and 18 concern monitoring and reporting.

Conditions 19 and 20 relate to lapse and review of the consent.

Colin Boyd holds discharge permit **7911-1**, to discharge stormwater from a drilling waste storage site into an unnamed tributary of the Mangamawhete Stream in the Waitara River. This permit was issued by the Taranaki Regional Council on 27 September 2011 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

Condition 1 concerns adoption of the best practicable option.

Conditions 2 through to 4 specify discharge limits and operational requirements.

Condition 5 relates to effects on surface water.

Condition 6 relates to the implementation and maintenance of a contingency plan.

Condition 7 relates to the lapse and review of the consent.

Copies of the above permits are attached to this report in Appendix I.

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the Resource Management Act sets out obligations upon the Taranaki Regional Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki region and report upon these.

The Taranaki Regional Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations, and seek information from consent holders.

The monitoring programme for the Boyd Surrey, Derby Road North and landspreading consents consisted of five primary components.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Taranaki Regional Council in ongoing liaison with resource consent holders over consent conditions and their interpretation and application:

- in discussion over monitoring requirements
- preparation for any reviews
- renewals
- new consents
- advice on the Council's environmental management strategies and content of regional plans and
- consultation on associated matters.

1.4.3 Site inspections

Derby Road North site was inspected on 15 occasions, the Surrey Road site was inspected on 17 occasions, and landspread areas were inspected on 13 occasions during

the monitoring period, with regard to consents for the discharge of drilling waste. The main points of interest were the security of stockpiled drilling waste, and potential or actual discharges to receiving watercourses, including contaminated stormwater, and the effect of landspreading on existing pasture. The immediate area was surveyed for environmental effects. Additional inspections were undertaken on an investigative basis following incidents recorded at the site.

1.4.4 Chemical sampling

In total, six composite soil samples from disposal areas were collected by Council staff. The methodology utilised was compositing 10-15 soil cores (150 mm depth) taken at 10 m intervals along transects through spreading areas. These samples were analysed for chloride, conductivity, hydrocarbons, pH, SAR, sodium and total soluble salts.

Groundwater monitoring bores were sampled on nine occasions at the Derby Road North stockpiling facility, and on seven occasions at the Surrey Road stockpiling facility. Samples were analysed for pH, conductivity, TPH and BTEX, chloride, barium and total dissolved solids.

In addition, surface water samples were collected on four separate occasions along the Mangamawhete Stream in relation to stormwater discharges from the Derby Road North stockpiling facilities. Surface water samples were also obtained on five separate occasions along the Mangatengehu Stream in relation to stormwater discharges from the Surrey Road stockpiling facilities. These samples were analysed for barium, BOD, chloride, conductivity, hydrocarbons, pH and total dissolved solids.

Stormwater discharge samples were also obtained on four separate occasions in relation to both the Derby Road North and Surrey Road stockpiling facilities. These samples were analysed for ammonia, barium, BOD, chloride, conductivity, hydrocarbons, pH, suspended solids and total dissolved solids.

Investigative sampling was also conducted at both the Derby Road North and Surrey Road stockpiling facilities in relation to two separate incidents, which are further discussed in section 5.

1.4.5 Review of analytical results

The Council reviewed soil sampling results and the annual reports provided by MI Swaco on behalf of the consent holders. MI Swaco collected representative pre-disposal samples from individual waste streams prior to disposal, and receiving environment soil samples from all spreading areas post waste application. These samples were sent to an independent IANZ accredited laboratory for analysis for a wider range of contaminants. Chemical parameters tested were (all solid/sludge samples):

- pH
- chlorides
- potassium
- sodium
- total nitrogen
- barium
- heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)

- BTEX
- PAHs
- TPH (and individual hydrocarbon fractions C7-C9, C10-C14, C15-C36)

Receiving environment soil samples were also tested for electrical conductivity and sodium absorption ratio (SAR).

The Company also supplied stormwater discharge results as part of their reporting requirements.

1.4.6 Biomonitoring surveys

Eight biological surveys were performed during the monitoring period under review; four within the unnamed tributary of the Mangamawhete Stream in relation to activities at the Derby Road North site, and another four within the unnamed tributary of the Mangatengehu Stream in relation to activities at the Surrey Road site.

2. Derby Road North

2.1 Site description

Derby Road North stockpiling facility is located on the Taranaki ring plain bordering the Egmont National Park near Inglewood. In previous monitoring years this was the primary stockpiling site for muds and cuttings. At the beginning of the 2011-2012 monitoring year activity slowed at the site. During the 2012-2013 monitoring year the Surrey Road site became the primary site, and at the end of the monitoring period, the Derby site remains unused and on standby to receive waste as a contingency or secondary site if required.

The Mangamawhete Stream flows adjacent to the Derby Road North stockpiling facility. The proximity of the site to this surface water body has been taken into account in the setting of buffer distances and location of the stockpiling facilities.

The predominant soil type has been identified as gravelly sand and vegetation cover is pasture, recently converted from native bush. Average annual rainfall for the site is 1942 mm (taken from the nearby 'Stratford' monitoring station).

No consents were initially held to discharge stormwater from this stockpiling site, as it was expected to comply with the permitted activity criteria in Rule 23 of the RFWP. However, a stormwater discharge consent has since been issued for the Derby Road North site (7911-1, 27 September 2011).

Site data

Location

Word descriptor:	Derby Road North, Inglewood, Taranaki
Map reference:	E 1702545
(NZTM)	N 5653650
Mean annual rainfall:	1,942 mm
Mean annual soil temperature:	-
Mean annual soil moisture:	-
Elevation:	~500 masl
Geomorphic position:	Ring plain
Erosion / deposition:	Negligible
Vegetation:	Transitional – native bush to pasture
Parent material:	Tephra / volcaniclastic
Drainage class:	Free / well draining

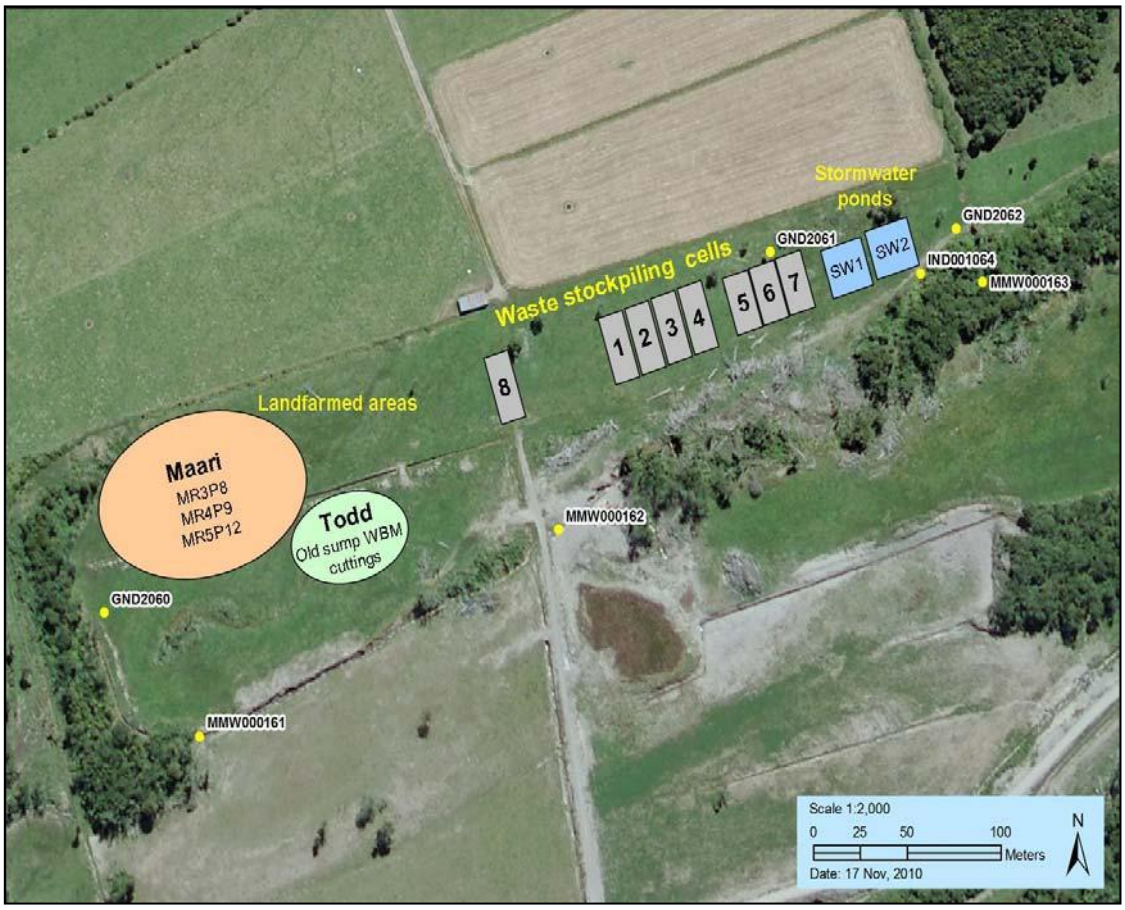

Figure 1 Aerial schematic of the Derby Road North stockpiling facilities, showing locations of storage pits, cells and sampling sites

2.2 Results

2.2.1 Inspections

Fifteen compliance monitoring inspections were carried out at the Derby Road North site during the monitoring period. A further inspection that was related to an incident is further discussed in Section 6.1 of this report. The site was also checked during surface water and groundwater sampling runs.

21 July 2011

At the time of inspection a light hydrocarbon odour was present directly downwind of the pits, however the odour did not extend past the boundary of the site. Four of the cells on site contained mud, all were secure and the cell wall integrity appeared good. No skimmer pipes were discharging and the receiving ponds were essentially free of hydrocarbon sheen. Staining and vegetation 'die-off' was present around the cells where hydrocarbons had evaporated from the cell surface. Sampling was discussed with the staff on site. It was outlined that the contents of cell 8 are thought to be causing issues with stormwater quality and the cell was to be emptied when conditions allowed.

11 October 2011

Hydrocarbon odours were present downwind of the pits during inspection; however the odour did not extend past the boundary of the site. The cells on site that contained mud appeared secure with all skimmer pipes discharging essentially clear water.

Limited foaming was observed below the discharge pipe from pit 8. The ring drain integrity appeared good and was found to be directing all liquids to the receiving ponds which were free of hydrocarbon sheen. No adverse effects were observed in the receiving waters.

24 January 2012

No objectionable odours were detected beyond the boundary, but very strong hydrocarbon odours were noted when directly downwind of the pits. All pits appeared secure and ring drains looked good. Staining was noted around the pits, but surrounding vegetation appeared healthy with tadpoles observed within some of the pits and receiving ponds (excluding the pits with heavy surface oiling or turbid liquid). No adverse effects were observed within the receiving environment.

14 March 2012

No objectionable odours were detected beyond the site boundary; however strong hydrocarbon odours were noted when downwind of the pits with heavy surface oiling. No discharge from the skimmer pits was occurring and all pit levels appeared under control. The wash-down pad also appeared clean and the liquid observed inside was essentially clear. Ring drain integrity also appeared good and receiving waters were free of surface sheen. No discharge to the receiving water was occurring during the inspection and the area appeared healthy. It was also noted that large numbers of tadpoles were present in some of the pits containing muds. All IBCs (intermediate bulk containers) containing the skimmed oils were secure. Windblown hydrocarbon staining was observed on the metalled surface around some of the pits. It was noted the following action was to be taken: ensure muds were landfarmed when weather conditions permit to ensure compliance with special condition 6 of the Resource Consent 6900-2. An Abatement notice was issued in conjunction with this (discussed further in Section 5.1).

2 April 2012

No objectionable odours were detected and the integrity of all pits, drains and piping was satisfactory. Staining was observed around the majority of the pits, which is indicative of evaporated hydrocarbons. All surrounding vegetation appeared healthy. Pit 1 had been cleaned out and the muds spread, some remaining residual mud was observed at the bottom of the pit. During inspection liquid waste from pit 7 was being pumped and discharged, approximately 25 loads (totalling 20,000 litres) had already been removed and an estimated 15-20 loads remained. The liquid was being discharged onto pasture adjacent to the pits, the operator outlined that the liquids had been applied all over at different times and the pasture response had been good. All IBCs containing skimmed oil remained secure and the lids were in place. No discharges from any skimmer pipes were occurring at the time of inspection. The stormwater pond levels were low and free of surface oils, and some contained tadpoles. Although pit 6 had been emptied, some reddish surface oiling remained, indicating more mud would have to be removed in the future. The stockpiled water treatment sludge was also inspected. It had been levelled into the paddock in which it was stored and had been mixed with a quantity of drilling muds. This area had also been disked and harrowed and generally looked good. New drilling waste material had been brought onto the site and discharged into pit 3, signage was present, yet no notification was received at the Council prior to its arrival; as required by special condition 2 of resource consent 6900-2.

30 May 2012
No objectionable odours or visible emissions were sighted during the inspection. All pits on site were free of surface oils and the liquid inside appeared turbid, as too was the liquid in the receiving ponds. No discharge from skimmer pipes was occurring and no effects were observed within the receiving environment.

12 June 2012
No objectionable odours were detected during the inspection. Integrity of the pits appeared good and no discharges from the skimmer pipes were occurring. The receiving ponds appeared slightly turbid and were not discharge to the receiving environment and all surrounding vegetation appeared healthy. Windblown staining was present around the puts which historically contained surface oils and all IBCs throughout the site were found to be secure. No adverse effects were found.

24 August 2012
No significant objectionable odours were detected, however hydrocarbon / mud odours were noted directly downwind of the pits. All pits appeared secure, with all but two free of surface oils. No skimmer pipes were discharging and all previously skimmed oils were secure within IBCs. The receiving ponds were free of hydrocarbon sheen and the receiving environment appeared unaffected.

20 November 2012
Inspection was conducted in conjunction with sampling; three groundwater bores were sampled for BTEX and TPH, then purged and sampled for other water quality parameters. The samples appeared clear of any hydrocarbon contaminants.

22 November 2012
No objectionable odours were detected at the site boundary, however strong hydrocarbon odours were noted directly downwind of the two pits which contained surface oils. All other pits at the site were free of surface oils. Discharge from the skimmer pipes to the receiving drain was free of surface sheen and the receiving ponds were clear of surface hydrocarbons, with no final discharge to the receiving waters occurring at the time of inspection. Frogs were observed within the receiving ponds and the surrounding vegetation appeared healthy with previously 'burned' pasture around the site fringes naturally regrown. All stored oil was secure within the IBCs and the wash down pad was clear with no discharge occurring.

18 January 2013
No objectionable odours were detected and no recent disposal activities had occurred. Pit integrity appeared satisfactory, however all pits were currently unlined and were full with water. The Company was subsequently informed that prior to re-commencement of any stockpiling activities at this site all storage pits would require lining with synthetic liners. Discharges from the skimmer pipes to the receiving drain were clear of rainbow sheen, with only pits 5 and 6 showing some surface oiling. No discharges were occurring from the receiving ponds upon inspection and no adverse effects were identified.

4 April 2013
No objectionable odours or visible emissions were detected and no recent disposal or storage had occurred at the site. All pit integrity appeared good and no discharges were occurring from the skimmer pipes during inspection. Pit 6 still showed some

surface oiling and the receiving ponds were both low with the final pond being 1 metre below the outlet. No adverse effects were observed within the receiving environment.

22 April 2013
No objectionable odours were detected and no recent disposal had occurred. Pits 3, 6 and 7 showed minor surface oiling from mud residues and all skimmer pipes were discharging clear water. The receiving ponds were free of hydrocarbon sheen, with the discharge into the receiving water appearing clear. No adverse effects were observed.

15 May 2013
No objectionable odours or visible emissions were detected. Pits 6 and 7 were observed to have a red surface oily layer from mud residues in the bottom of the pits. No skimmer pipes were discharging at the time of inspection and all other pits were free of muds and hydrocarbon sheen. No recent mud disposal activities had occurred. The areas where muds had historically been applied too thickly were still showing limited pasture growth, all other pasture areas inspected appeared healthy and no significant drilling mud was identified within the soil profile.

10 June 2013
No objectionable odours or visible emissions were detected and no recent stockpiling had occurred at the site. Two pits on site contained residual surface oils and skimmer pipes were discharging clear liquid in very minor volumes. The receiving ponds were clear of surface oils and the discharge into the receiving environment also appeared clear with adverse effects observed within the stream. The vegetation around the site appeared healthy with black staining present on the pit edges. All skimmed oils were contained and secure and it was noted that the ring drain was due for a clean; the site owner agreed this action would be undertaken.

2.2.2 Results of discharge monitoring

2.2.2.1 Drilling waste

No drilling waste was stored at the stockpiling facility during the latter half of the monitoring period. Some material was stored at the site during the first half of the monitoring period. This material was landspread under consent 7591-1. There was no landfarming of drilling waste under consent 6900-2.

2.2.2.2 Council stormwater results

The Council collected stormwater discharge samples from site IND001064 (refer to Figure 1) on four occasions. The results are presented in Table 1.

Table 1 Stormwater discharge results from Derby Road North stockpiling facility during the 2011 – 2013 monitoring period

Parameter	Unit	Date			
		12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Temperature	Deg.C	9.3	14.4	15.7	9.6
pH	pH	7.2	7.2	7.4	7.4
Conductivity	mS/m@20C	34.2	24.4	9.3	14.2
Suspended solids	g/m^3	16	10	19	7
Total dissolved solids	g/m^3	265	189	72	110
Chloride	g/m^3	86.2	-	17.2	27.4

Parameter	Unit	Date			
		12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Biochemical oxygen demand	g/m^3	1.5	-	10	<0.5
Ammonium	g/m^3 N	0.03	-	-	-
Barium	g/m^3	0.169	0.147	0.219	0.142
Hydrocarbons	g/m^3	2.2	1.7	<0.5	0.7

The August and October 2011 samples had slightly elevated chloride concentrations and very low concentrations of hydrocarbons, but all measured parameters were within the consent limits. Downstream receiving environment samples taken on the day (Table 11, Section 2.2.3.2), showed no significant effects from these discharges.

2.2.2.3 MI Swaco supplied stormwater results

As per the requirements of resource consents 6900-1 and 7559-1, the consent holder is obligated to supply stormwater sampling results as part of the supplied annual report. The results for the Derby Road discharge samples from the monitoring period are supplied below in Table 2.

Table 2 MI Swaco stormwater results for Derby Road stockpiling area

Parameter	Unit	Rule 23 limits	16-Dec-11	25-Jul-12
pH	pH	6-9	6.9	7.2
Suspended solids	g/m^3	100	5	9
Free Ammonia	g/m^3	0.025	<0.010	<0.010
Total Ammoniacal N	g/m^3	-	<0.010	<0.010
Total Kjeldahl Nitrogen	g/m^3	-	-	0.29
Carbonaceous biochemical oxygen demand	$g\ O_2/m^3$	5	3.7	5
Chemical oxygen demand	$g\ O_2/m^3$	-	-	18
Oil and grease	g/m^3	15	11	14
Free chlorine	g/m^3	-	-	0.11
Combined chlorine	g/m^3	0.025	-	<0.08

The MI Swaco results are generally compliant with the discharge criteria given in Rule 23 of the RFWP, the carbonaceous biochemical oxygen demand result for the July 2012 sample is right at the consent limit, and oil and grease was detected in both samples approaching, but still complying with the limit.

2.2.3 Results of receiving environment monitoring

Figure 1 shows the location of groundwater (GND), surface water (MMW) and stormwater discharge (IND) sampling sites, as well as the approximate location of stockpiling cells, stormwater ponds, and previously landfarmed waste. The area slopes gradually away from the mountain (left to right).

2.2.3.1 Council groundwater results

Three groundwater monitoring wells were installed late 2008, prior to the first delivery of drilling wastes to site. They are located up-gradient (GND2060), adjacent to pits (GND2061) and down-gradient (GND2062), as shown in Figure 1. Samples were collected from the monitoring wells on nine occasions and the results are shown in Tables 3 to 8.

Table 3 Groundwater monitoring results from bore GND2060 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26-Aug-11	03-Nov-11	19-Jan-12	25-May-12	28-Jun-12
Static water level	m	2.88	2.9	2.83	2.71	-
Temperature	Deg.C	10.6	10.8	13.2	13	-
pH	pH	6.1	6.1	6	5.9	6.1
Conductivity	mS/m@20C	6.3	7.2	6	5.3	-
Total dissolved solids	g/m^3	48.7	55.7	46.4	41	-
Chloride	g/m^3	7.8	7.5	7	7.2	7
Nitrate	g/m^3 N	0.05	<0.01	0.01	0.03	0.04
Barium	g/m^3	0.045	0.064	0.021	0.033	0.025
Benzene	g/m^3	-	-	-	-	-
Toluene	g/m^3	-	-	-	-	-
Ethylbenzene	g/m^3	-	-	-	-	-
meta-Xylene	g/m^3	-	-	-	-	-
ortha-Xylene	g/m^3	-	-	-	-	-
Hydrocarbons	g/m^3	<0.5	<0.5	<0.5	<0.5	<0.5

Table 4 Continued groundwater monitoring results from bore GND2060 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	13-Aug-12	20-Nov-12	31-Jan-13	18-Apr-13
Static water level	m	-	-	2.93	2.8
Temperature	Deg.C	10.7	11.6	13.7	13.5
pH	pH	6	6.1	6	6.1
Conductivity	mS/m@20C	5.6	6.5	5.8	5.5
Total dissolved solids	g/m^3	43.3	50.3	44.9	42.6
Chloride	g/m^3	5.4	8	7.7	6.1
Nitrate	g/m^3 N	0.02	<0.01	0.02	0.02
Barium	g/m^3	0.033	0.047	0.04	0.019
Benzene	g/m^3	-	<0.0010	-	-
Toluene	g/m^3	-	<0.0010	-	-
Ethylbenzene	g/m^3	-	<0.0010	-	-
meta-Xylene	g/m^3	-	<0.002	-	-
ortha-Xylene	g/m^3	-	<0.0010	-	-
Hydrocarbons	g/m^3	<0.5	<0.7	<0.5	<0.5

Table 5 Groundwater monitoring results from bore GND2061 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26-Aug-11	03-Nov-11	19-Jan-12	25-May-12	28-Jun-12
Static water level	m	1.58	1.1	1.57	1.66	-
Temperature	Deg.C	11.2	11.6	14.3	13.1	-
pH	pH	5.6	5.6	5.7	5.7	5.8
Conductivity	mS/m@20C	23.4	13.9	21.6	17.4	-
Total dissolved solids	g/m^3	181	108	167	135	-
Chloride	g/m^3	37.9	16.7	30.8	28.1	17.5
Nitrate	g/m^3 N	0.01	<0.01	<0.01	<0.01	0.02
Barium	g/m^3	0.121	0.05	0.079	0.095	0.021
Benzene	g/m^3	-	-	-	-	-
Toluene	g/m^3	-	-	-	-	-
Ethylbenzene	g/m^3	-	-	-	-	-
meta-Xylene	g/m^3	-	-	-	-	-
ortha-Xylene	g/m^3	-	-	-	-	-

Parameter	Unit	26-Aug-11	03-Nov-11	19-Jan-12	25-May-12	28-Jun-12
Hydrocarbons	g/m^3	<0.5	<0.5	2.7	<0.5	<0.5

Table 6 Continued groundwater monitoring results from bore GND2061 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	13-Aug-12	20-Nov-12	31-Jan-13	18-Apr-13
Static water level	m	-	-	1.9	1.36
Temperature	Deg.C	10.8	11.8	15.8	15.1
pH	pH	6.2	5.8	5.8	6
Conductivity	mS/m@20C	8	28.8	31.8	12.9
Total dissolved solids	g/m^3	61.9	222.8	246	99.8
Chloride	g/m^3	5.5	53.3	43.7	12
Nitrate	g/m^3 N	0.04	0.01	<0.01	<0.01
Barium	g/m^3	0.073	0.12	0.116	0.046
Benzene	g/m^3	-	<0.0010	-	-
Toluene	g/m^3	-	<0.0010	-	-
Ethylbenzene	g/m^3	-	<0.0010	-	-
meta-Xylene	g/m^3	-	<0.002	-	-
ortha-Xylene	g/m^3	-	<0.0010	-	-
Hydrocarbons	g/m^3	<0.5	<0.7	<0.5	<0.5

Table 7 Groundwater monitoring results from bore GND2062 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26-Aug-11	03-Nov-11	19-Jan-12	25-May-12	28-Jun-12
Static water level	m	1.28	0.8	1.16	1.31	-
Temperature	Deg.C	10.6	12.4	16.1	14	-
pH	pH	5.6	5.6	5.6	5.7	5.6
Conductivity	mS/m@20C	7.3	8.8	7.8	6.8	-
Total dissolved solids	g/m^3	56.5	68.1	60.3	52.6	-
Chloride	g/m^3	7.4	5.6	6.4	6.6	11.6
Nitrate	g/m^3 N	<0.01	<0.01	<0.01	0.01	<0.01
Barium	g/m^3	0.027	0.037	0.026	0.027	0.018
Benzene	g/m^3	-	-	-	-	-
Toluene	g/m^3	-	-	-	-	-
Ethylbenzene	g/m^3	-	-	-	-	-
meta-Xylene	g/m^3	-	-	-	-	-
ortha-Xylene	g/m^3	-	-	-	-	-
Hydrocarbons	g/m^3	<0.5	0.6	<0.5	<0.5	<0.5

Table 8 Continued groundwater monitoring results from bore GND2062 from the Derby Road North stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	13-Aug-12	20-Nov-12	31-Jan-13	18-Apr-13
Static water level	m	-	-	1.38	0.61
Temperature	Deg.C	10.7	13.1	16.1	16.1
pH	pH	5.5	5.5	5.8	5.7
Conductivity	mS/m@20C	6.3	8	8.2	10.4
Total dissolved solids	g/m^3	48.7	61.9	63.4	80.5
Chloride	g/m^3	4.8	6.2	9.4	18.1
Nitrate	g/m^3 N	0.02	<0.01	<0.01	1.52
Barium	g/m^3	0.031	0.027	0.029	0.034
Benzene	g/m^3	-	<0.0010	-	-
Toluene	g/m^3	-	<0.0010	-	-

Parameter	Unit	13-Aug-12	20-Nov-12	31-Jan-13	18-Apr-13
Ethylbenzene	g/m^3	-	<0.0010	-	-
meta-Xylene	g/m^3	-	<0.002	-	-
ortha-Xylene	g/m^3	-	<0.0010	-	-
Hydrocarbons	g/m^3	<0.5	<0.7	<0.5	<0.5

The results for barium, chloride and nitrate are well below the referenced drinking water standards (used for comparative purposes- there is no abstraction of water for consumption in the area). The results for total dissolved solids are well below the consent limit. No hydrocarbons were detected, other than at a very low level in bore GND 2062 in November 2011. In conjunction with results from the previous monitoring year, the results for barium, chloride, nitrate and TDS are presented graphically in Figures 2 to 5.

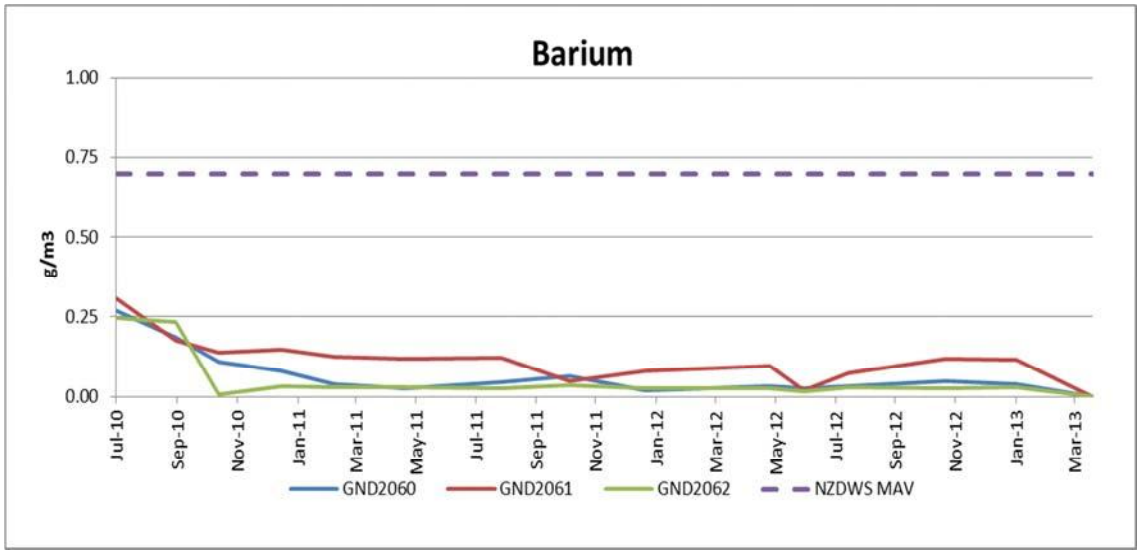

Figure 2 Barium groundwater concentrations in relation to New Zealand Drinking Water Standard limits during the 2011- 2013 monitoring period at Derby Road North stockpiling facility

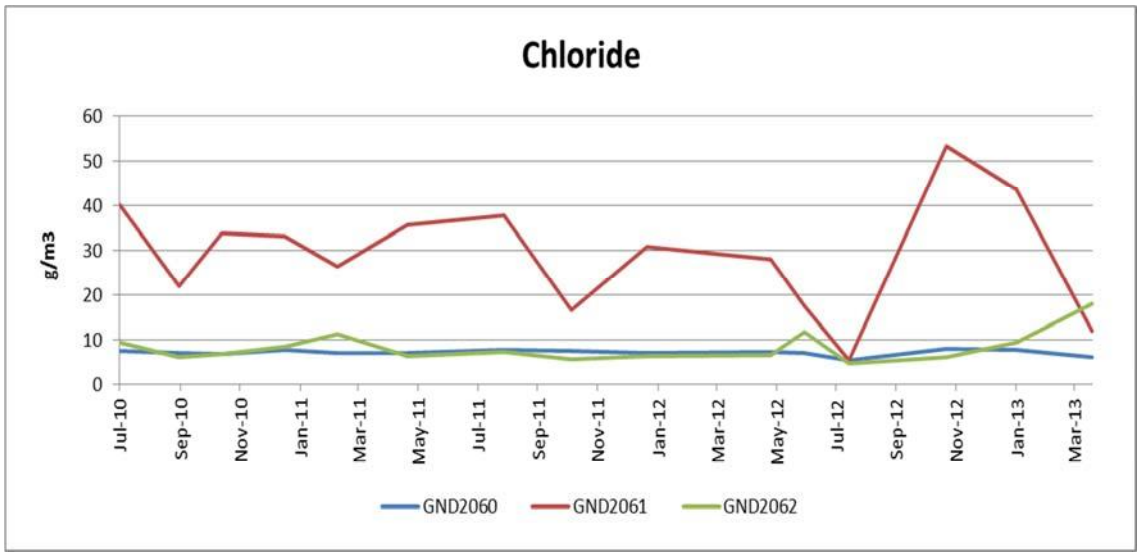

Figure 3 Chloride groundwater concentrations during the 2011- 2013 monitoring period at Derby Road North stockpiling facility

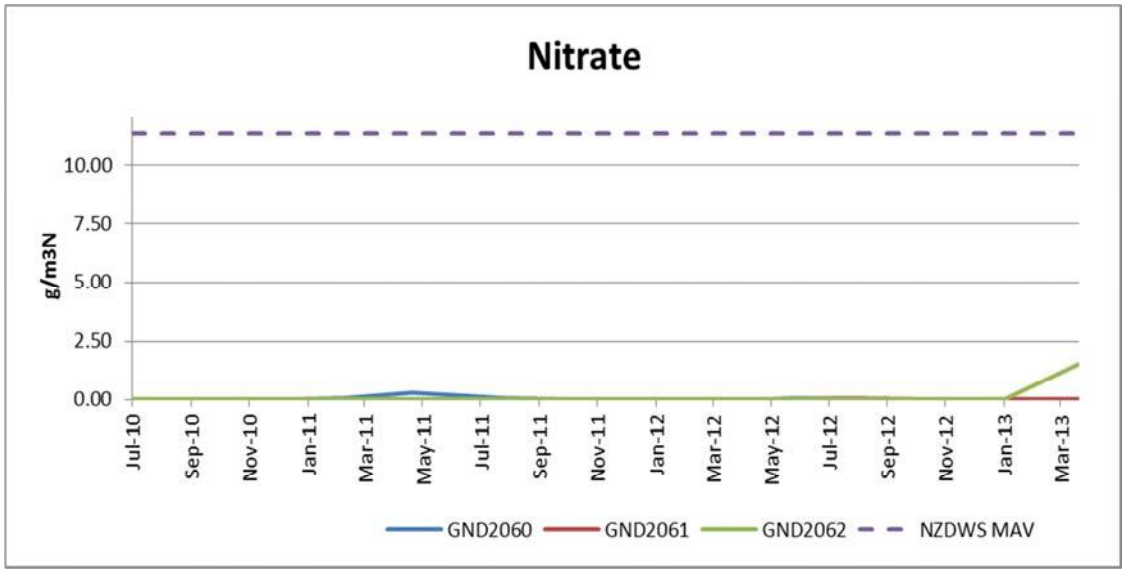

Figure 4 Nitrate groundwater concentrations in relation to New Zealand Drinking Water Standard limits during the 2011- 2013 monitoring period at Derby Road North stockpiling facility

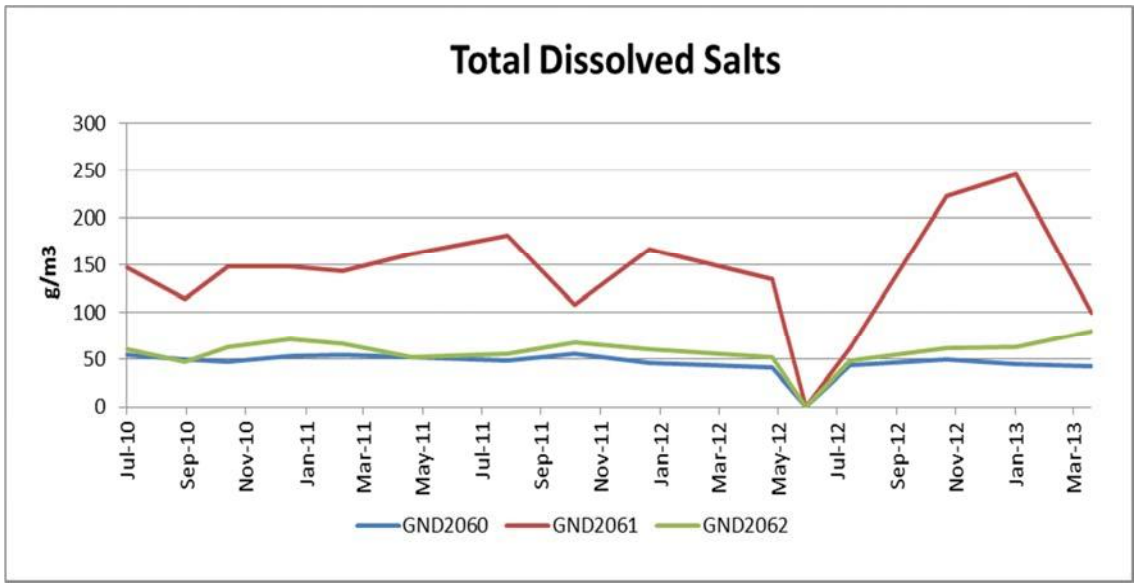

Figure 5 Total dissolved solids groundwater concentrations during the 2011- 2013 monitoring period at Derby Road North stockpiling facility

The graphs for the main groundwater quality indicators in Figures 2 - 5 show that:

- Barium concentrations have been falling during the monitoring period and there is little difference between the wells.
- Chloride at GND2061 (adjacent to the pits) is higher than the other two wells but still well below the NZDWS GV of 250 g/m^3. This could be an indication of leaching from the pits and needs to be monitored closely for any further increase.
- Nitrate concentrations are so low that they are not of concern.
- Total dissolved solids results mirror those for chloride.

2.2.3.2 Council surface water results

An unnamed tributary of the Mangamawhete Stream flows adjacent to the southern boundary of the site. On four occasions samples were collected upstream (MMW000161), midstream (MMW000162), and downstream (MMW000163). The results are shown in Tables 9 to 11.

Table 9 Results obtained from the unnamed tributary of the Mangamawhete Stream at the upstream sampling locality MMW000161 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Temperature	Deg.C	9.7	13.2	15.0	10.6
pH	pH	7	7	7.2	7.2
Conductivity	mS/m@20C	8.1	8.8	9.4	11.1
Total dissolved solids	g/m³	62.7	68.1	72.7	85.9
Chloride	g/m³	6.1	5.8	6.1	6.7
Barium	g/m³	0.03	0.026	0.025	0.028
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5

Table 10 Results obtained from the unnamed tributary of the Mangamawhete Stream at the midstream sampling locality MMW000162 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Temperature	Deg.C	9.9	13.7	15.0	10.7
pH	pH	7	7	7.2	7
Conductivity	mS/m@20C	8.1	8.5	9.2	11
Total dissolved solids	g/m³	62.7	65.8	71.2	85.1
Biochemical oxygen demand	g/m³	<0.5	<0.5	<0.5	2.3
Chloride	g/m³	6.4	5.7	6.4	6.9
Ammonia	g/m³	0.00047	-	-	-
Ammonium	g/m³ N	0.207	-	-	-
Barium	g/m³	0.034	0.027	0.028	0.033
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5

Table 11 Results obtained from the unnamed tributary of the Mangamawhete Stream at the downstream sampling locality MMW000163 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Temperature	Deg.C	10.0	13.7	15.0	10.7
pH	pH	7	7.1	7.3	7.3
Conductivity	mS/m@20C	10	9.2	9.2	11.1
Total dissolved solids	g/m³	77.4	71.2	71.2	85.9
Biochemical oxygen demand	g/m³	0.5	<0.5	<0.5	<0.5
Chloride	g/m³	11.6	7.6	6.8	7.2
Ammonia	g/m³	0.00027	-	-	-
Ammonium	g/m³ N	0.118	-	-	-
Barium	g/m³	0.041	0.031	0.033	0.033
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5

The above results do not show any significant variation between the sampling sites and indicate there is no impact on the tributary from activities at the site.

2.2.3.3 Council biomonitoring results

Biological surveys were performed on 26 January 2012, 8 May 2012, 28 November 2012 and 9 April 2013, to monitor the health of the macroinvertebrate community of an unnamed tributary of the Mangamawhete Stream, in relation to the storage of drilling waste in the vicinity. The standard 'kick-sampling' technique was used at the four sampling sites to collect streambed macroinvertebrates, the results can be compared with pre-stockpiling communities, allowing an assessment of the sites compliance with relevant consent requirements and permitted activity rules. Unfortunately, during the baseline survey undertaken in April 2009, the communities at the downstream sites had experienced significant habitat deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance.

26 January 2012

A biological survey undertaken in November 2010 following an incident related to windblown oil entering water, recorded impacts on the macroinvertebrate communities in the stream downstream of the discharge. However, the results of a more recent survey (April 2011) showed improved taxa richness and invertebrate abundances at sites 2, 3 and 4 indicating the impacts recorded at these sites in the previous survey, due to the discharge, had abated.

The January 2012 biomonitoring survey revealed that the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were significantly lower than the median scores recorded at the site in previous surveys, which indicated deterioration in the community at this site. However, the presence of two 'highly sensitive' taxa (mayfly, *Deleatidium* and stonefly, *Zelandoperla)* in this community was indicative of relatively reasonable preceding water quality. The results of this survey indicated an improvement in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits. The taxa richness and MCI score recorded at site 2 in this survey were the highest recorded to date at the site. In addition, the MCI score recorded at this site was significantly higher than recorded at any of the other sites by the current survey and was considered to be due to variability in habitat quality (e.g. bed stability and substrate composition). The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by low taxa richnesses and dominated by the low scoring 'tolerant' oligochaete worms coincident with the increased sedimentation and iron oxide deposits present at these sites. The MCI scores recorded at both sites were similar to the MCI score recorded at site 1 which indicated no recent significant impacts of any discharges into the stream from the land farming activities occurring adjacent to the stream.

Overall, the results of this summer survey presented no indication that the activities at the drilling waste stockpiling site have had adverse impacts on the macroinvertebrate communities. In general, the poor community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

8 May 2012

The May 2012 biomonitoring survey revealed that the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were higher than the median scores recorded at the site in previous surveys, which indicated improvements in the community at this

site. The presence of four 'highly sensitive' taxa (particularly the abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits and upstream of the stormwater discharge outfall. The taxa richness and MCI score recorded at site 2 in this survey were very similar to medians recorded to date at the site. In addition, the $SQMCI_s$ score recorded at this site was significantly higher than previously recorded at this site due to one numerically dominant 'highly sensitive' mayfly taxon. The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by moderate taxa richnesses and at site 4, dominated mainly by low scoring 'tolerant' taxa coincident with increased sedimentation and iron oxide deposits present at this site. The MCI score recorded at site 4 was significantly lower than the MCI score recorded at site 1 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream coincident with some habitat variability.

Overall, the results of this autumn survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts may have been compounded by habitat variability. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

28 November 2012

The November 2012 biomonitoring survey revealed that the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were higher than the median and/or maximum scores recorded at the site in previous surveys, which indicated improvements in the community at this site. The presence of five 'highly sensitive' taxa (and particularly the extreme abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits, and upstream of the stormwater discharge outfall. The taxa richness and MCI score recorded at site 2 in this survey were also higher than medians recorded to date at the site. In addition, the $SQMCI_s$ score recorded at this site was significantly higher than previously recorded at this site due to one numerically dominant 'highly sensitive' mayfly taxon. The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by relatively poor to moderate taxa richnesses and at both sites, dominated mainly by fewer taxa coincident with decreased periphyton substrate cover, but some increase in sedimentation and iron oxide deposits on the streambed at this site. The MCI scores recorded at sites 3 and 4 were significantly lower than the MCI score recorded at site 1 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream but more coincident with aspects of habitat variability.

Overall, the results of this early summer survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts are more likely to have been compounded by habitat variability. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream in comparison with similar streams elsewhere on the ringplain (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

9 April 2013

The April 2013 biomonitoring survey revealed that the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were similar to the median scores recorded at the site in previous surveys, which indicated the community at this site was in average health, despite this survey being preceded by an extended period of stable flows. The influence of these stable flows was evident in the high number of taxa present at this site (33), and the number of taxa present in abundance (eight). The presence of seven 'highly sensitive' taxa (and particularly the extreme abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits, and upstream of the stormwater discharge outfall. The taxa richness recorded at site 2 in this survey was higher than the median richness for this site, while the MCI score was similar to the median score. However, the $SQMCI_s$ score recorded at this site was significantly less than that recorded in the previous survey, and that recorded upstream in the current survey. This was due to both the reduced abundance of one 'highly sensitive' mayfly taxon, but also the increased abundance of a number of 'tolerant' taxa.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by reduced (when compared to upstream) but above average taxa richnesses and at both sites, dominated mainly by fewer taxa coincident with decreased periphyton substrate cover, but some increase in sedimentation and iron oxide deposits on the streambed at this site. The MCI scores recorded at sites 3 and 4 were not significantly different to the MCI scores recorded at sites 1 and 2, which indicated that the impacts of upstream land farming activities that were possibly recorded in the previous survey were no longer present. The deterioration in $SQMCI_S$ scores at sites 2, 3 and 4 can most likely be attributed to the subtle changes in habitat, and the extended period of low flows that preceded this survey.

Overall, the results of this late summer survey suggest that the activities at the drilling waste stockpiling site and landfarming area have not had any impacts on the macroinvertebrate communities through the reach surveyed, although some impacts caused by habitat variability were noted. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream in comparison with similar streams elsewhere on the ringplain (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

Full results are attached in Appendix III.

3. Surrey Road

3.1 Site description

Surrey Road stockpiling facility is located on the Taranaki ring plain bordering the Egmont National Park near Inglewood. The Mangatengehu Stream flows adjacent to the Surrey Road stockpiling facility. The proximity of the site to this recognised ecosystem has been taken into account in the setting of buffer distances and location of the stockpiling facilities.

The predominant soil type has been identified as gravelly sand and vegetation growth is consists of native bush which transitions into pasture. Average annual rainfall for the site is 1942 mm (taken from the nearby 'Stratford' monitoring station).

No consents are held to discharge stormwater from this stockpiling site, as it is expected to comply with the permitted activity criteria in Rule 23 of the RFWP.

Site data

Location	
Word descriptor:	Surrey Road, Inglewood, Taranaki
Map reference:	E 1701847
(NZTM)	N 5651476
Mean annual rainfall:	1,942 mm
Mean annual soil temperature:	-
Mean annual soil moisture:	-
Elevation:	~500 masl
Geomorphic position:	Ring plain
Erosion / deposition:	Negligible
Vegetation:	Transitional – native bush to pasture
Parent material:	Tephra / volcaniclastic
Drainage class:	Free / well draining

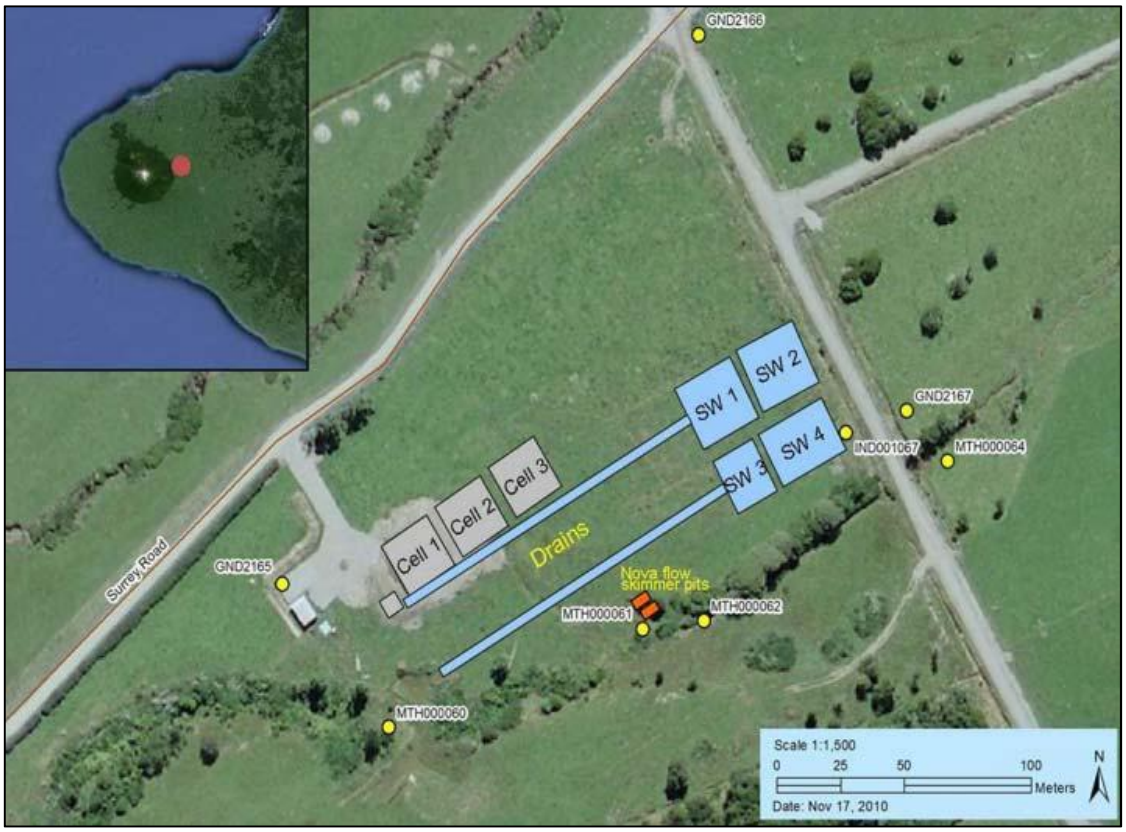

Figure 6 Aerial schematic of the Surrey Road stockpiling facilities, depicting localities of storage pits, cells and sampling localities

3.2 Results

3.2.1 Inspections

There were seventeen compliance monitoring inspections of the Surrey Road site during the monitoring period. The site is also checked during surface water and groundwater sampling runs. Incidents are discussed in Section 5.1 of this report.

21 July 2011

No objectionable odours or visible emissions were detected. The wash-pad was found to be tidy and along with the receiving ponds was free of surface sheen. All pits appeared to be empty of muds. No discharge from the skimmer pipes to the ring drain was occurring at the time of inspection and all IBCs containing skimmed oil were found to be secure. A perforated pipe was still discharging water with a hydrocarbon sheen to the receiving drain and the first pond downstream had a clear emulsified layer, the second pond was essentially free of surface oils, and the discharge to the receiving tributary appeared good. No adverse environmental effects were detected during the inspection.

11 October 2011

No odours were detected beyond the boundary. All muds were found to be secure within the pits and all skimmer pipes were discharging clear liquid into the receiving drains, which were effectively directing liquids to the pond system. The perforated pipe discharge was still showing clear hydrocarbon effects in the receiving drain.

Discharge from ponds to the receiving waters was clear, no effects were found below the mixing zone.

25 November 2011
No objectionable odours were detected beyond the site boundary. All pits appeared mostly free of mud, with the second pit discharging water from the skimmer pipe and from the perforated pipe, indicating that groundwater interaction was occurring. This is explained further in Section 5. The groundwater discharge was found to cause a rainbow sheen effect in the receiving drain. The discharge from the final pond was clear and no adverse effects were identified within the receiving waters.

24 January 2012
No objectionable odours were detected beyond the site boundary. All pits were found to be secure and generally free of surface oils and sheen with liquids appearing clear also. Tadpoles were noted within the three pits and some grasses were developing in the water and around the fringes, some roofing iron was also noted within two of the pits. No discharge from the skimmer pipes was occurring, however, the perforated pipe was discharging water with very minor visible rainbow sheen. The receiving pond had a thin layer of surface oil mixed with iron oxide bacteria from throughout the drainage channel. The discharge from the second pond was clear and no adverse effects were observed within the receiving water downstream of the final discharge.

14 March 2012
All storage pits were secure and no surface sheen was present. No discharge from the skimmer pipes was occurring, but the perforated pipe from pit 2 was discharging water with rainbow sheen to the receiving drain which was being retained effectively within the first pond. The liquid inside was observed to have a surface layer of hydrocarbons and iron oxide bacteria. The discharge from the final pond appeared to be having a slight foaming effect, yet did not extend past the mixing zone to the second receiving waters. No objectionable odours or emissions were detected.

2 April 2012
No objectionable odours or visible emissions were noted during the inspection. No recent activity was obvious at the site, with all observed pits remaining in good condition. The hydrocarbon sheen and foaming effect were still seen to be occurring from the pit 2 perforated pipe. The receiving pond was found to have a surface layer of light yellow oil (which the site staff were advised to skim as soon as practicable) approximately 50 mm thick across the entire pond, with iron oxide bacteria and water below. The second pond was observed to be turbid but clear of surface sheen and the discharge did not appear to be adversely impacting the receiving waters.

30 May 2012
No objectionable odours or visible emissions were detected. All pits appeared in good condition and contained slightly turbid liquid with no surface oil. The perforated pipe from pit 2 still appeared to be causing a rainbow sheen within the receiving drain. The first pond had the surface oils skimmed off as previously requested and appeared to be in good condition; in addition, all IBCs containing the skimmed oils were secure. The discharge from the final pond was clear and no effects were observed within the receiving environment.

12 June 2012
No objectionable odours or visible emissions were detected during the inspection. All pits were observed to be free of surface oils and all previously skimmed oils were secure within IBCs. No discharge from skimmer pipes was occurring, but the perforated pipe drain was still discharging a rainbow sheen into the receiving drain and was being retained in the first receiving pond. The discharge from the final pond appeared clear and free of sheen. No effects were observed within the receiving environment.

13 August 2012
An inspection was conducted in conjunction with stormwater and groundwater samples. Throughout the inspection it was consistently raining, and the final pond was discharging clear water at approximately 1 litre per second. No recent disposal of wastes to ponds had occurred. It was outlined to the operator that the full IBC containers should be removed from the site.

24 August 2012
No objectionable odours or visible emissions were noted and all pits appeared secure and free of surface oils. All previously skimmed oils were secure within IBCs and no skimmer pipes were discharging. The receiving ponds were free of hydrocarbon sheen, but the perforated pipes were discharging, causing a rainbow sheen within the receiving drain and on the receiving pond surface. The discharge appeared clear and the final drain was free of any rainbow sheens. The receiving environment appeared healthy.

22 November 2012
No objectionable odours or visible emissions were detected upon inspection and all pits appeared to be free of drilling muds and surface oils. The liquids within the pits were clear with grasses establishing around the fringes in the shallow water within all the pits. The perforated pipe was still discharging water with a rainbow sheen into the receiving drain and subsequently the first pond below was found to have surface oils. The discharge into the unnamed tributary from the site pond system was observed to be clear and free of sheen, although there was a minor foaming effect below the discharge pipe which did not extend past the mixing zone. All IBCs containing oils were found to be secure. It was also outlined to the site staff to consider remediating the 'perforated pipe pit' to cease the flow of hydrocarbons into groundwater and subsequently into surface water.

18 January 2013
During the inspection no objectionable odours or visible emissions were detected. No recent disposal of materials to the storage site had occurred. All pits were noted to be unlined and appeared free of surface oils. No discharges were occurring from the skimmer pipes, although the perforated pipe was observed to be discharging water with a rainbow sheen to the receiving drain. The first receiving pond had an oily surface layer and the second receiving pond had very minor surface rainbow sheen. The discharge appeared clear and no adverse effects were observed in the receiving drain. No earthworks had occurred at the site to redirect the perforated pipe around the pits as discussed previously. It was then outlined to the site staff to provide timeframes for earthworks to redirect subsurface water conveyed within the perforated pipe around the pit area.

4 April 2013
No objectionable odours or visible emissions were detected. One of the lined pits on site was receiving muds at the time of inspection. The muds were being discharged into the pits and the containers were being washed over the wash-down pit. The liquid within the containers was greyish and discharging through the receiving drain and into the first pond, the level of which was approximately 0.5 m below the outlet pipe. The second pit at the site was having work undertaken in preparation for receiving the synthetic liner. The perforated pipe was discharging into the receiving drain via a drum interceptor, which had collected some darker liquid. The discharge from the skimmer pipe appeared free of sheens, yet there was still a rainbow sheen discharging around and below the perforated pipe and drum. Further investigations found the area to be contaminated with hydrocarbons and it was suggested that the area be excavated and the material deposited into a pit for spreading. The receiving pond was found to have hydrocarbons on the surface and it was outlined by site staff that these were being recovered into IBCs. The discharge into the receiving drain was clear and no adverse effects were observed within the receiving waters. Discussions were held with site staff regarding the installation of a cut-off drain above the wash-pad as it is thought to be the route of the perforated pipe below the site.

18 April 2013
An inspection was conducted in conjunction with groundwater sampling. Cell 1 was receiving drilling muds and no wastewater discharge was occurring. Cell 2 was empty, but had recently been lined with a robust synthetic liner.

22 April 2013
Site activity had increased since the previous inspection. No objectionable odours or visible emissions were detected. A sucker truck was being washed on the pad after discharging liquid from cellar cleaning into pits, with all washings discharging into the wash pit. Discharge from the skimmer pipe appeared slightly turbid and no surface oils were noted. Two of the pits on site were now lined, one of which had a small volume of stormwater in the bottom. Cuttings bins were being discharged into the pit and washed out on the pad. All ponded water around the site appeared free of surface sheens. Discharge from the skimmer pipe was turbid and grey, the receiving ponds were also turbid and a foaming effect was observed in the receiving waters, particularly below the culverts. It was unlikely that this discharge was compliant with the RFWP rules. The discharge was discussed with the site manager and it was suggested that some surfactants may have entered with the mud from recent rig cleaning activities and was working through the system due to ongoing heavy rain. It was outlined and agreed upon that this discharge would be monitored in the interim and further investigation was to occur into possible surfactant presence and type, in addition to pumping out contaminants when the weather conditions would allow. An incident was registered, and an Abatement notice was issued in conjunction with this foaming incident (discussed further in section 5.1).

15 May 2013
No objectionable odours or visible emissions were detected during the inspection. Muds were being stored in pit 1 and the skimmer pipe had been directing to pit 3, which was approximately two thirds full. The second lined pit at the site only contained stormwater. The receiving drain was found to be empty and no skimmer pipes were discharging into it. The perforated pipe was discharging water with rainbow sheen into the other receiving drain and the receiving pond had an oily

surface layer. It was outlined that this material was to be skimmed off when more IBCs were delivered to the site. The last stormwater pond had been completely emptied and had filled with groundwater from the upstream drain, resulting in a blue-ish iron surface layer. The other two ponds which received surfactants were yet to be fully pumped out, and the liquid contained within them remained turbid and grey with an oily texture. Samples of the liquid were found to be agitated and still foamy, these results were outlined to the consent holder and it was agreed that the two ponds would be completely emptied prior to the onset of rain to prevent non-compliant discharges. Further investigations by the site operators had confirmed earlier indications that the surfactants had entered the site via cementing job wastes which were included with the muds and cuttings at the rig site. The site operators advised Council staff that, to prevent future occurrences, similar material would be discharged into a separate lined pit. To reduce the impact of the foaming, a flow arresting 'sock' was installed on the outlet from the final storm water pond so that liquid was discharged into the receiving waters at water level. Also, a gravel filter had been installed downstream of the outlet 'sock'. This final discharge point was inspected and was found to be discharging at a low rate. The discharge observed was clear and no foaming was observed within the receiving waters. It was outlined that prior to rainfall, site staff should empty the liquid from within the stormwater ponds which still contained surfactants / muds.

10 June 2013

During inspection the site was unmanned and no objectionable odours or visible emissions were detected. Two of the lined pits on site contained muds without any obvious surface oiling. The skimmer pipe had been redirected into the third pit, which had approximately one metre of freeboard available before discharge would occur. At the time of inspection this pit was unlined. A fourth pit had been dug, lined and was due to receive cementing operation wastes to prevent any further foaming (as discussed in the previous inspection). The perforated pipe was discharging water with a hydrocarbon sheen to the receiving drain, the first pond below this drain contained surface oils which were due to be skimmed off. The second pond was clear of oils but featured a distinct iron oxide layer. A second outlet had been installed using a two inch pipe and was observed to be lower than the original outlet, this original outlet has remained in response to periods of heavy rain. The discharge was clear but minor foaming was observed around the outlet. This foam had dissipated within the mixing zone and was not observed further downstream. The two ponds upstream were found to be turbid and slightly foamy when agitated, it was outlined to site staff that these ponds would need to be emptied again.

3.2.2 Results of discharge monitoring

3.2.2.1 Drilling waste

Approximately 2489 metric tonnes of drilling waste was discharged into pits at the storage site during the monitoring period. No drilling waste was landfarmed under consent 7559 during the monitoring period.

3.2.2.2 Council stormwater results

The Council collected stormwater discharge samples from site IND001067 (refer to Figure 6) on six occasions. The results are presented in Table 12.

Table 12 Stormwater discharge results from Surrey Road stockpiling facility during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12	20-Nov-12	10-Jun-13
Barium	g/m³	0.108	0.207	0.142	0.074	0.13	0.18
Biochemical oxygen demand	g/m³	-	6.8	3.6	2.3	-	5.4
Chloride	g/m³	27.6	68.8	19.7	29	120	84.5
Conductivity	mS/m@20C	16	29.5	11.4	17	64.5	39.6
Hydrocarbons	g/m³	1.3	1.4	0.5	<0.5	<0.7	0.7
Ammoniacal nitrogen	g/m³ N	0.288	-	-	-	-	-
pH	pH	7.1	6.9	7	6.7	6.3	7
Suspended solids	g/m³	10	9	8	8	100	13
Total dissolved solids	g/m³	124	228	88.2	132	-	306.4

No consent was held for the discharge and it did not meet the necessary limits to qualify as a permitted activity under Rule 23 of the RFWP. The BOD limit was breached on two occasions and the suspended solids in the November 2012 sample were at the limit. Chloride concentrations were relatively high in three of the samples, but no significant hydrocarbons were detected. These results may be attributed to the periphery drain discussed in Section 3.2.1. It is recommended this discharge be monitored closely in the 2013-2014 monitoring period, and that the consent holder be required to apply for a stormwater resource consent.

3.2.2.3 MI Swaco supplied stormwater results

MI Swaco did not include any stormwater discharge results for the Surrey Road site in their supplied annual reports. The 2012-2013 annual report supplied states that there were few discharges during the period of renewed site activity through the summer and autumn period. The site began discharging again in April 2013, which led to an incident, discussed in Section 5.1.1.

3.2.3 Results of receiving environment monitoring

3.2.3.1 Council groundwater results

Three groundwater monitoring wells were installed in late 2009, prior to the first delivery of drilling wastes to site. They are located up-gradient (GND2165) and down-gradient (GND2166, GND2167) of the site, as shown in Figure 6. Samples were collected from the monitoring wells on seven occasions. The results are presented in Tables 13 to 15.

Table 13 Groundwater monitoring results from bore GND2165 from the Surrey Road stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26 Aug 11	03 Nov 11	19 Jan 12	01 May 12	13 Aug 12	31 Jan 13	18 Apr 13
Static water level	m	2.49	1.33	2.20	3.40	-	3.18	3.24
Temperature	Deg.C	10.1	11.3	13.7	12.7	10.3	14.5	14.2
pH	pH	5.9	6.3	6.1	6.4	6.3	6.4	6.4
Conductivity	mS/m@20C	5.9	6.9	6.6	9.8	7.4	5.9	11.4
Total dissolved solids	g/m³	45.6	53.4	51.1	75.8	57.2	45.6	88.2
Chloride	g/m³	4.1	3.9	5.9	5.4	5.1	4.3	9.0
Nitrate	g/m³ N	0.22	0.09	0.12	0.36	0.29	0.07	0.11
Barium	g/m³	0.045	0.057	0.017	0.047	0.025	0.035	0.029
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5

Table 14 Groundwater monitoring results from bore GND2166 from the Surrey Road stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26 Aug 11	03 Nov 11	19 Jan 12	01 May 12	13 Aug 12	31 Jan 13	18 Apr 13
Static water level	m	1.61	1.1	1.57	1.88	-	1.94	1.49
Temperature	Deg.C	9.7	11.8	14.6	13.3	9.7	16.9	14.2
pH	pH	5.9	5.6	5.8	6	6.6	6	5.8
Conductivity	mS/m@20C	5.3	7	5.1	5.5	5.9	7.2	5.1
Total dissolved solids	g/m³	41	54.2	39.4	42.6	45.6	55.7	39.5
Chloride	g/m³	5.8	10.2	4.5	5.4	7.1	6.2	7.1
Nitrate	g/m³ N	0.56	0.79	0.14	0.28	1.94	0.36	1.54
Barium	g/m³	0.072	0.101	0.018	0.052	0.032	0.072	0.017
Hydrocarbons	g/m³	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5

Table 15 Groundwater monitoring results from bore GND2167 from the Surrey Road stockpiling facility during the 2011-2013 monitoring period

Parameter	Unit	26 Aug 11	03 Nov 11	19 Jan 12	01 May 12	13 Aug 12	31 Jan 13	18 Apr 13
Static water level	m	2.32	1.85	2.26	2.22	-	-	1.94
Temperature	Deg.C	11.8	11.8	13.1	13.7	10.1	14.5	14.9
pH	pH	5.8	5.6	5.6	5.7	5.5	5.6	5.8
Conductivity	mS/m@20C	8.9	9.1	9.6	10	8.8	9.9	15
Total dissolved solids	g/m³	68.9	70.4	74.3	77.4	68.1	76.6	116.1
Chloride	g/m³	6.2	7.4	8.4	12.4	9.5	10.7	23
Nitrate	g/m³ N	0.1	0.4	0.36	0.23	0.38	0.22	5.54
Barium	g/m³	0.13	0.117	0.027	0.08	0.062	0.097	0.041
Hydrocarbons	g/m³	<0.5	1.2	<0.5	<0.5	<0.5	<0.5	<0.5

The results for barium, chloride and nitrate are well below the drinking water standards (used for reference purposes only- there are no groundwater abstractions for consumption in the vicinity). The results for total dissolved solids are well below the consent limit. Very low concentrations of hydrocarbons were detected on a singular occurrence on 3 November 2011 at GND2166 and GND2167 (GND2167 is downslope of the stormwater ponds). The results for barium, chloride, nitrate and total dissolved solids are presented graphically in Figures 7 to 10.

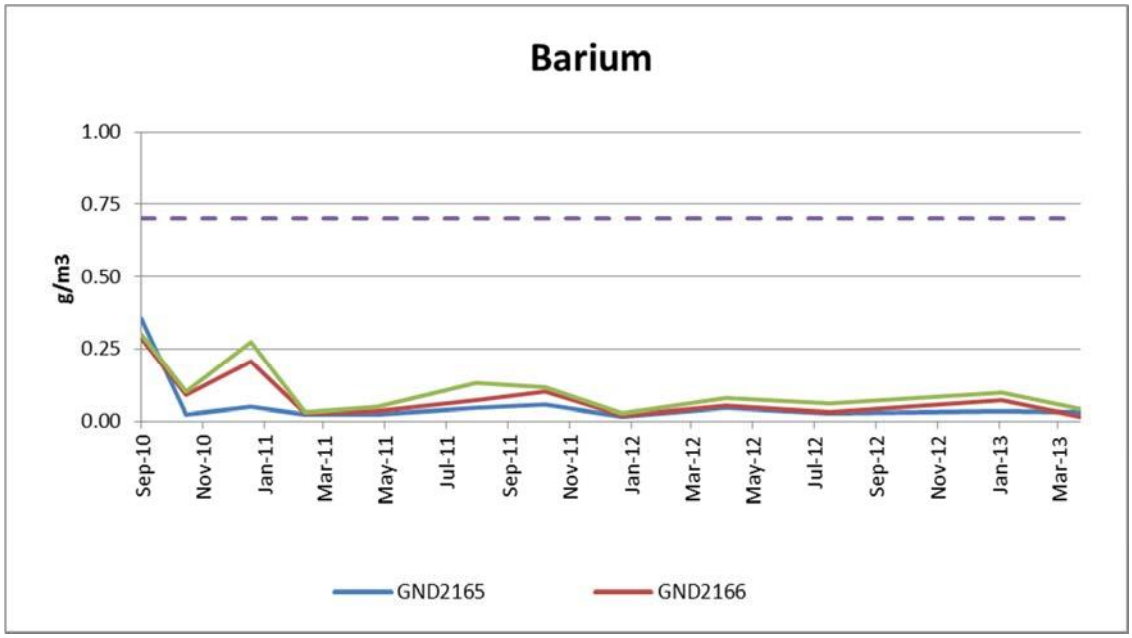

Figure 7 Barium groundwater concentrations in relation to New Zealand Drinking Water Standard limits during the 2011- 2013 monitoring period at Surrey Road stockpiling facility

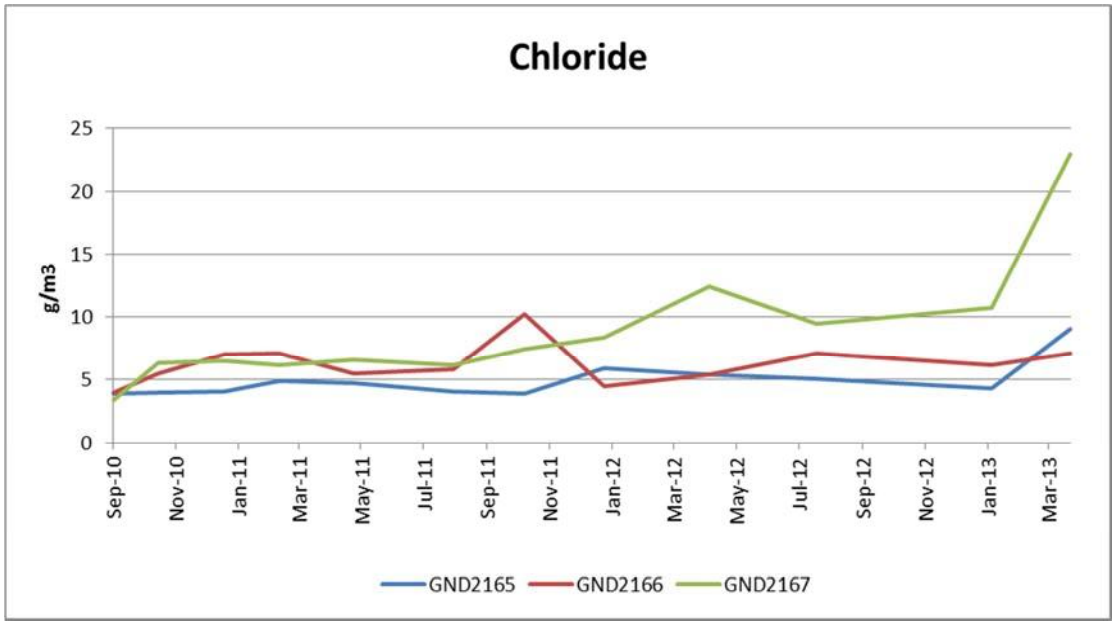

Figure 8 Chloride groundwater concentrations during the 2011- 2013 monitoring period at Surrey Road stockpiling facility

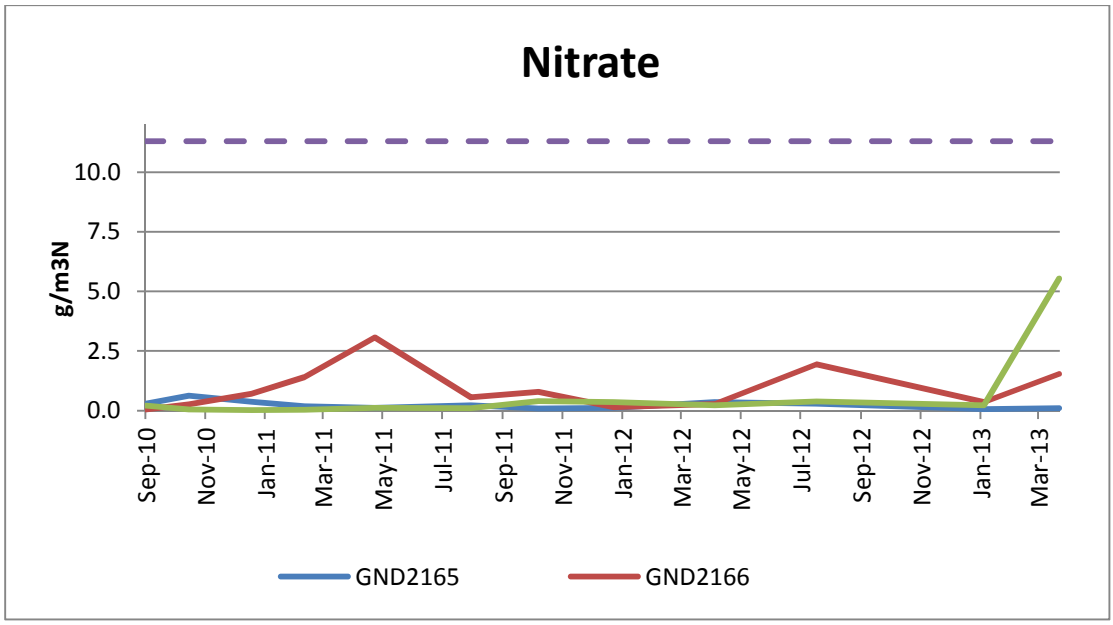

Figure 9 Nitrate groundwater concentrations in relation to New Zealand Drinking Water Standard limits during the 2011- 2013 monitoring period at Surrey Road stockpiling facility

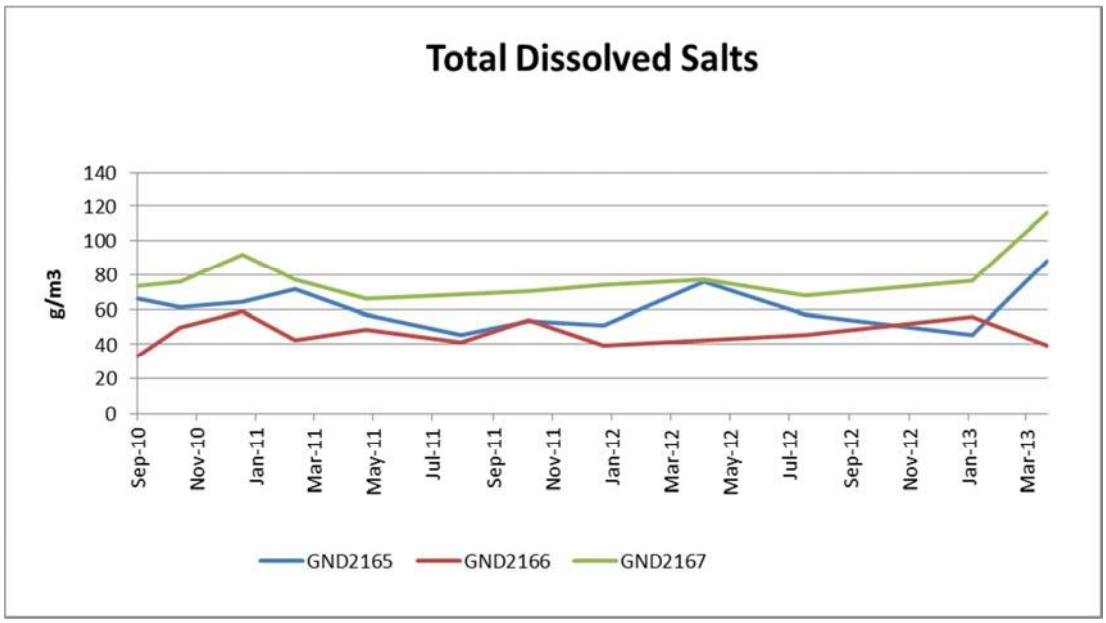

Figure 10 Total dissolved solids groundwater concentrations during the 2011- 2013 monitoring period at Surrey Road stockpiling facility

The graphs for the main groundwater quality indicators determine that:

- Barium concentrations only varied between the wells for the January 2011 sampling, and overall concentrations are well below the drinking water standards.
- Chloride results have been similar across all wells since September 2010, until more recent increases at GND2167.
- Nitrate concentrations show a spike for GND2166 in mid 2011 and 2012, and more recently an increase at GND2167.
- Total dissolved solids results reflect the chloride results, with an increase in the 2013 samples, but are well within the consent limit of 2500 g/m^3.

In general concentrations are low and differences between wells may at this time be attributed to natural variation.

3.2.3.2 Council surface water results

An unnamed tributary of the Mangatengehu Stream runs along the southern boundary of the Surrey Road stockpiling facility. On five occasions samples were collected upstream (MTH000060) and downstream (MTH000064) of the site, and on four occasions samples were obtained midstream (MTH000062) of the site. The results are shown in Tables 16 to 18.

Table 16 Results obtained from the unnamed tributary of the Mangatengehu Stream at the upstream sampling site MTH000060 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12	10-Jun-13
Temperature	Deg.C	8.5	11	13.2	9.6	10.4
pH	pH	6.7	6.7	6.8	7	7.1
Conductivity	mS/m@20C	4.6	5	5.1	6.8	7.6
Suspended solids	g/m³	-	-	-	2	2
Total dissolved solids	g/m³	35.6	38.7	39.5	-	-
Chloride	g/m³	6.7	5.4	6.2	5	6.6
Barium	g/m³	0.019	0.015	0.015	0.014	0.017
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5	0.8

Table 17 Results obtained from the unnamed tributary of the Mangatengehu Stream at the upstream sampling site MTH000062 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12
Temperature	Deg.C	8.4	11	13.5	10.2
pH	pH	6.8	6.9	7	7.1
Conductivity	mS/m@20C	4.7	5	5.1	6.8
Suspended solids	g/m³	-	-	-	6
Total dissolved solids	g/m³	36.4	38.7	39.5	-
Chloride	g/m³	6.8	5.4	6.1	5
Biochemical oxygen demand	g/m³	<0.5	-	<0.5	-
Ammonia	g/m³	0.00003	-	-	-
Ammonium	g/m³ N	0.027	-	-	-
Barium	g/m³	0.018	0.015	0.014	0.016
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5

Table 18 Results obtained from the unnamed tributary of the Mangatengehu Stream at the upstream sampling site MTH000064 during the 2011 – 2013 monitoring period

Parameter	Unit	12-Aug-11	13-Oct-11	22-Mar-12	13-Aug-12	10-Jun-13
Temperature	Deg.C	8.8	11.5	13.7	10.1	10.5
pH	pH	6.8	6.8	6.9	7	6.6
Conductivity	mS/m@20C	5.7	6.8	5.9	7.7	10.2
Suspended solids	g/m³	-	-	-	3	4
Total dissolved solids	g/m³	44.1	52.6	45.6	-	-
Chloride	g/m³	8.5	9.5	7.7	7.4	15
Biochemical oxygen demand	g/m³	<0.5	-	0.6	-	-
Ammonia	g/m³	0.00007	-	-	-	-
Ammonium	g/m³ N	0.056	-	-	-	-
Barium	g/m³	0.025	0.03	0.025	0.019	0.031
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	<0.5	0.7

The results show a slight increase in chloride and total dissolved solids at the downstream site. However, the concentrations are very low and indicate there is no impact of any significance on the tributary from activities at the site.

3.2.3.3 Council biomonitoring results

Biological surveys were performed on 26 January 2012, 8 May 2012, 28 November 2012 and 9 April 2013, to monitor the health of the macroinvertebrate community of an unnamed tributary of the Mangatengehu Stream, in relation to the storage of drilling waste in the vicinity.

Figure 11 Aerial photo displaying the biomonitoring sites in an unnamed tributary of the Mangatengehu Stream

26 January 2012

This biological survey of an unnamed tributary of the Mangatengehu Stream was performed to monitor the health of the macroinvertebrate community of an unnamed tributary of the Mangatengehu Stream, in relation to the storage of drilling waste within its vicinity. As a result of an inspection observing hydrocarbons being discharged to the stream, changes were made to the on-site drainage prior to the previous (November 2010) survey, meaning that site 2 (MTH000062) was no longer impacted by the skimmer pit discharge, and that site 3 (MTH000064) became the primary impact site. This resulted in a significant reduction in iron oxide sedimentation observed at site 2, but a significant increase in this sedimentation observed at site 3. In addition to this, site 3, the most downstream site, also suffered from significant periphyton proliferation.

The macroinvertebrate community at the upstream site had a moderately low taxa richness for such a stream at this altitude. However, the MCI score indicated a healthy community, with the presence of four 'highly sensitive' taxa. Results from the previous two surveys at site 2 indicated a recovery in the community as demonstrated by a

marked increase in MCI and SQMCI scores. However, the latest survey results show only a minor increase in MCI score and a slight decrease in the SQMCI score. This may reflect that there has been little change to the environment at the site in recent surveys in respect to iron oxide cover and periphyton cover. At the lowest site (site 3), the macroinvertebrate community recorded a much lower taxa richness and fewer 'sensitive 'taxa compared with the other two sites. Only one taxon recorded in abundance, being the very 'tolerant oligochaete worms. As a result of this significant change in community, the MCI score dropped 11 units, and the $SQMCI_S$ dropped 3.1 units, to 104 and 1.4 respectively. This is indicative of a severe deterioration in the macroinvertebrate community, and can be predominantly attributed to the significant periphyton growth observed at this site, although the increased degree of iron oxide sedimentation observed can be directly related to the change in location of the discharge point. However, results for the four surveys undertaken at this site show little change over time, despite the closer proximity of this discharge point since the first survey. Therefore, the change in discharge location has not caused degradation at this site. Overall, the influence of iron oxide sedimentation on the community was evident at all sites, especially at site 3, where periphyton growth was also severe. However, the survey results suggest that there is no indication of impacts related to the storage of drilling waste upstream of site 3.

Due to the change in location of the discharge site, it is recommended a fourth sample be included in the monitoring programme, located downstream of site 3. This will be implemented in the next end of summer survey (2012). Sites 1 and 2 should remain in the surveys, although if results indicate that the recovery at site 2 is complete, and that the macroinvertebrate community is relatively stable, then sampling of site 1 can be discontinued, with site 2 becoming the control site.

8 May 2012

In this biological survey a new secondary impact site (site 4, MTH000066) was established 100 metres downstream of the stormwater discharge in the current survey. Iron oxide was found to be a prevalent feature at all four sites sampled in the unnamed tributary of the Mangatengehu Stream. The abundance of oligochaete worms at these four sites was considered to be related to the iron oxide on the bed of the stream, providing sufficient habitat which this taxon can inhabit. A high proportion of the taxa recorded at all four sites in the tributary were 'sensitive taxa', which were indicative of reasonable preceding water quality despite the majority of these taxa only occurring as rarities.

The MCI and $SQMCI_s$ scores recorded at site 1 (MTH000060) in the current survey were significantly lower than the median scores and were the lowest ever recorded at the site previously. This was considered to be the result of slight differences in habitat sampled between the current and the previous survey. The fact that most were rare reflects the low flows observed, resulting in limited available habitat. The highest $SQMCI_s$ and MCI scores recorded in this survey were at site 2, immediately upstream of the stormwater discharge. The macroinvertebrate community at this site contained five 'highly sensitive taxa', two of which were found to be abundant and was indicative of good preceding water quality. The results of this survey demonstrated a significant decline in $SQMCI_s$ scores between site 2 and the two sites downstream of the stormwater discharge (3 and 4) and there was also a significant decrease in the MCI score recorded between sites 2 and 3. This marked decline in the macroinvertebrate communities recorded downstream of the stormwater discharge was considered to be

the result of differences in habitat between these sites. The macroinvertebrate community at site 2 was dominated by two 'sensitive 'mayflies [*Zephlebia* (moderately sensitive) and *Deleatidium* (highly sensitive taxa)] which are commonly found in rocky bedded streams with little to no periphyton growth present. At the time of this survey, only a thin film of algae was recorded in the stream bed at site 2. In contrast to this, the two mayfly taxa (*Zephlebia* and *Deleatidium*) were recorded as absent or in very low abundance at sites 3 and 4, mostly likely due to the prevalence of algal mats and filaments at both these sites which provide unfavourable habitat conditions for these taxa. In addition, orthoclad midge larvae are typically found in streams with reasonable periphyton growth, and were recorded in very high abundance at sites 3 and 4, in contrast to site 2 where this taxon was only found to be common.

Overall, the results indicated that the changes in macroinvertebrate communities upstream and downstream of the stormwater discharge were related to differences in habitat between sampling sites rather than resulting from the effects of the discharge. The results also indicated reasonable preceding water quality in the tributary at the time of the survey and were typical of the nature of this spring fed, ring plain stream arising out of the National Park.

28 November 2012

At the time of this early summer, November 2012 survey, downstream increases in iron oxide sedimentation and periphyton substrate cover at the four sites sampled in the unnamed tributary of the Mangatengehu Stream were reflected in the abundances of 'tolerant' oligochaete worms and orthoclad midges. A high proportion of the taxa recorded at all four sites in the tributary were 'sensitive' taxa, which were indicative of reasonable preceding water quality despite the majority of these taxa only occurring as rarities at each site.

In the current survey, the upstream control site (1) recorded a moderate taxa richness and relatively high MCI score, the latter higher than the median previously recorded at this site. However, the presence of a very high proportion of taxa rarities was indicative of poor habitat quality at this site. The numerical dominance by the one low scoring 'tolerant' midge resulted in a moderate $SQMCI_s$ score of 4.3 units. The $SQMCI_s$ score was lower than the $SQMCI_s$ scores which might be anticipated in a small tributary stream at such an altitude and relatively close to the National Park. Improvement in the macroinvertebrate community was recorded at site 2 which had a higher taxa richness and MCI and $SQMCI_s$ scores than those upstream. The MCI score of 128 units recorded at site 2 was insignificantly different to the score recorded upstream coincident with a slightly higher proportion of 'sensitive' taxa in the community. These differences in MCI scores are considered to be the result of slight differences in habitat quality between the sites at the time of the survey rather than the result of any activities associated with the land-farming site. At the time of the survey, the completely shaded site 2 recorded thin periphyton mats and no widespread filaments and only a minor degree of iron oxide sedimentation, which supported a macroinvertebrate community with higher proportions and abundances of 'sensitive' taxa in general. The community at this site was numerically dominated by one 'highly sensitive' taxon (mayfly) which resulted in a relatively high $SQMCI_s$ score of 6.9 units; a much improved community to that recorded at the upstream (control) site 1. The macroinvertebrate communities at the downstream sites (3 and 4) were characterised by lower taxa richnesses (poorest at site 4) and were numerically dominated by two low scoring 'tolerant' taxa with significant decreases in several individual 'sensitive' taxon abundances which were

coincident with more extensive iron oxide sedimentation and proliferations of algal periphyton (particularly cyanobacteria) substrate cover at these more open, unshaded sites.

The MCI score recorded at the furthest downstream site 4 was significantly lower than that recorded at the nearest upstream site and at the 'control' site 1 indicating that the condition of the macroinvertebrate community at the furthest downstream site was poorer than that at the upstream sites. This greater than expected (Stark and Fowles, 2009) overall deterioration along the length (500 m) of the upper reaches of the stream surveyed (which was ecologically significant between adjacent sites 3 and 4 (i.e. > 11 MCI units)) may have been due to discharge activities upstream of site 3 and/or habitat variability between sites, particularly increased substrate cover by periphyton growth and iron oxide sedimentation.

9 April 2013

This biological survey of four sites in an unnamed tributary of the Mangatengehu Stream was performed on 9 April 2013, to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the discharge of stormwater to land or to the stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ score for each site.

In the current survey, the MCI and $SQMCI_S$ score recorded at the upstream 'control' site, although higher than, or similar to, the median scores recorded at the site in previous surveys, were indicative of poor community structure at this site. The presence of many 'sensitive' taxa in this community was indicative of relatively good preceding water quality but the paucity of individual taxon abundances was indicative of poorer habitat quality.

The results of this survey indicated an improvement in the condition of the macroinvertebrate community at site 2, located between the wastes storage pits and upstream of the stormwater discharge outfall. The MCI and $SQMCI_S$ scores recorded at site 2 in this survey were above medians recorded to date at the site, and were significantly higher than that recorded at any site in the current survey.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by similar taxa richnesses as upstream, but were dominated by low scoring 'tolerant' taxa and changes in the presence or absence of certain taxa and changes in individual 'sensitive' taxon abundances coincident with marked increases in periphyton substrate cover and iron oxide deposits present at these sites. The MCI scores recorded at sites 3 and 4 were significantly lower than those recorded at sites 1 and 2 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream coincident with marked variability in physical stream habitat.

The proliferation of algae at site 3 and 4 had clearly had an influence on the macroinvertebrate community, and this also explains the significant reductions in MCI and $SQMCI_S$ scores from that recorded at site 2 upstream. What is not as simple to explain is this proliferation of algae. This will be related to a discharge rich in nutrients (most likely nitrogen) that occurs upstream, and this may be as a direct result of the stockpiling activities. However, it should be noted that a stock race also crosses immediately upstream of site 3, and this may also be a source of nutrients.

Therefore, it is recommended that the water quality sampling regime be augmented to include testing for dissolved nutrients (total nitrogen, total phosphorus and dissolved reactive phosphorus) from both the site discharge, and also in samples collected upstream and downstream of the discharge point.

Overall, the results of this late spring survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts have been compounded by habitat variability. In general however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a spring fed ringplain stream reflected the fragmentation of riparian habitat and the influence of iron-rich groundwater seepage and subsequent sedimentation along the length of stream surveyed.

Full results are attached in Appendix III.

4. Landspreading activities

Surrey Road Landfarms Limited hold discharge permit **7591-1**, to discharge drilling waste from hydrocarbon exploration activities onto and into land via landspreading. This permit was issued by the Taranaki Regional Council on 21 January 2010 under Section 87(e) of the Resource Management Act. It is due to expire on 1 June 2027.

Areas previously spread are identified in the aerial site map, Figure 12, below.

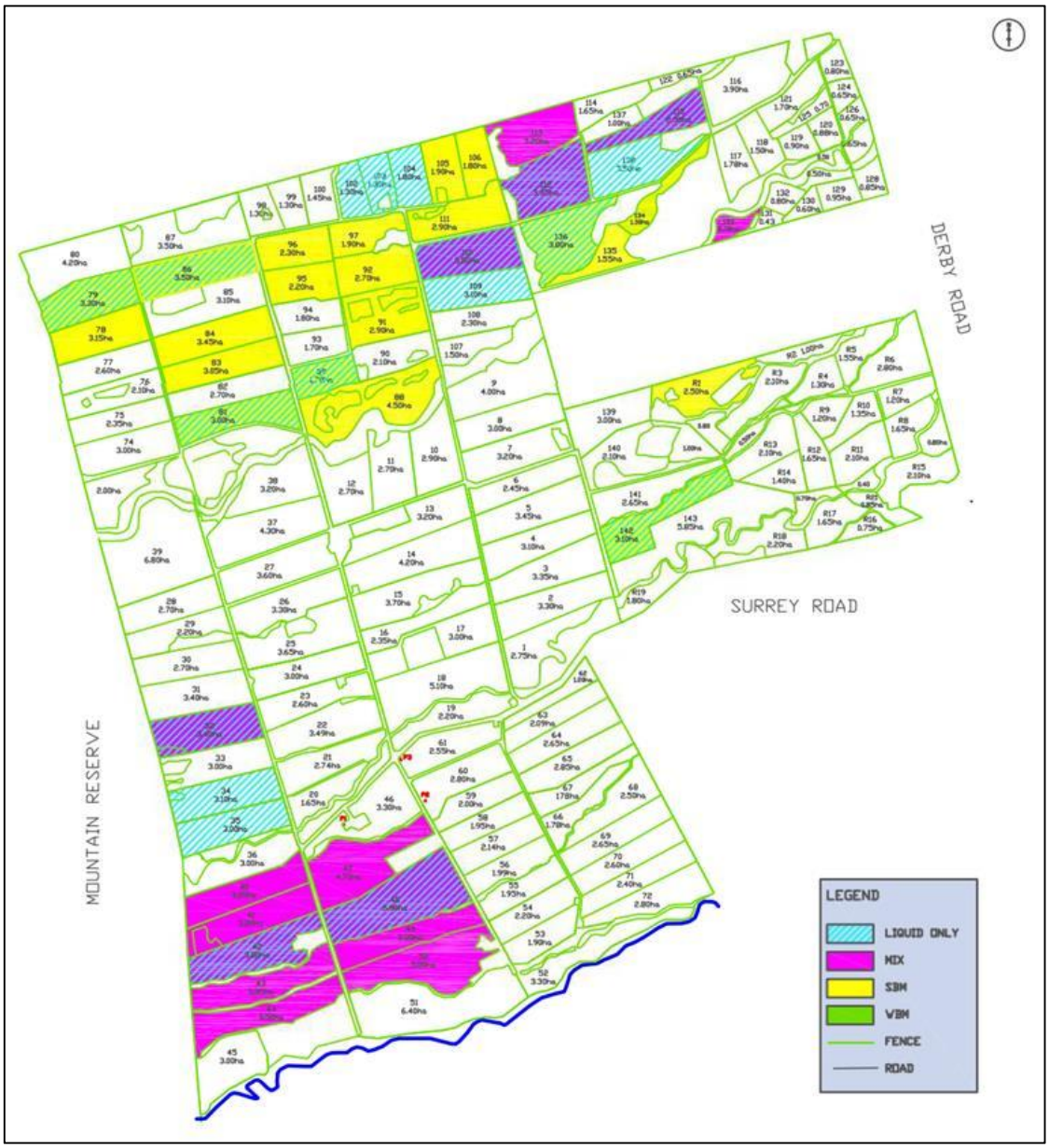

Figure 12 Aerial map of the extent of Colin Boyd's property and land spread areas as of 2012

4.1 Results

4.1.1 Inspections

Landspread areas were inspected on:

- 21 July 2011
- 11 October 2011
- 24 January 2012
- 14 March 2012
- 30 March 2012
- 2 April 2012
- 24 August 2012,
- 18 January 2013,
- 4 April 2013

- 22 April 2013
- 15 May 2013
- 31 May 2013
- 7 June 2013

Inspection of historical application areas generally showed health pasture cover and only minor amounts of drilling mud was identified within soil profiles. The areas where muds had been applied too thickly in previous years were also showing signs of pasture growth. All drains and waterways around the areas inspected appeared to be free of effects from mud spreading activities.

4.1.2 Results of discharge monitoring

4.1.2.1 MI Swaco discharge summary

During the monitoring period, the site operators spread a total of 805 m³ of SBM cuttings from the Beluga 1 well and 120 m³of SBM cuttings from the Puka 1 well.

4.1.3 Results of receiving environment monitoring

4.1.3.1 Council soil results

Six composite soil samples were collected on two separate occasions by sub-sampling to a depth of 250mm at 10m intervals in paddocks where landspreading of drilling waste had occurred. The results of this sampling are presented in Table 19.

Table 19 Soil results obtained from landspread areas during the 2011-2013 monitoring period at Colin Boyd's property

Parameter	Unit	Date and Landspread Areas					
		31-May-12 ***83***	31-May-12 ***81***	31-May-12 ***90***	31-May-12 ***89***	07-Jun-13 ***42***	07-Jun-13 ***--***
pH	pH	5.7	6.5	6.3	6.7	5.8	6
Conductivity	mS/m@20C	36.5	63.4	70.1	87.5	35.1	53.7
Total soluble salts	mg/kg	286	496	549	685	274.7	420.3
Moisture factor	nil	1.953	1.644	1.592	1.722	1.162	1.221
Chloride	mg/kg DW	30.5	41.2	118	147	36.7	40.6
Sodium	mg/kg	23.7	14.4	34.8	25.8	28	21
Hydrocarbons	mg/kg DW	110	110	1000	790	26	80

4.1.3.2 Council surface water results

The exercise of consent **7591-1** shall not result in contamination of groundwater or surface water (SC16). Four surface water samples were collected from an unnamed tributary flowing through and adjacent to paddocks where drilling wastes had been landspread. The results are presented in Table 20.

Table 20 Surface water results obtained from landspread areas during the 2011-2013 monitoring period at Colin Boyd's property

Parameter	Unit	31-May-12 ***U/S Paddock 83***	31-May-12 ***D/S Paddock 83***	31-May-12 ***D/S Paddock 81***	31-May-12 ***Mid Paddock 88***
Temperature	Deg.C	10.1	10.3	10.1	9.9
pH	pH	6.7	7	7	7.2
Conductivity	mS/m@20C	11	15.1	14.1	25.8
Total dissolved solids	g/m³	85.1	117	109	200

Parameter	Unit	31-May-12 ***U/S Paddock 83***	31-May-12 ***D/S Paddock 83***	31-May-12 ***D/S Paddock 81***	31-May-12 ***Mid Paddock 88***
Chloride	g/m³	5.3	6.7	9.1	9.1
Barium	g/m³	0.022	0.016	0.041	0.024
Hydrocarbons	g/m³	<0.5	<0.5	<0.5	0.8

The mid-paddock 88 sample shows a slight influence of spreading activities, with a trace of hydrocarbon and slightly elevated total dissolved solids, but no results pose an environmental risk at these concentrations.

4.1.3.3 MI Swaco receiving soil results

During the monitoring period MI Swaco took 21 receiving soil samples from spreading areas and submitted them to RJ Hill Laboratories for analyses. Their results are presented in full in their supplied annual report for the 2012-13 monitoring period, included in Appendix II.

The supplied results show compliance with consent conditions. No significant hydrocarbons have been detected in any of the samples, and heavy metal concentrations are well within the MfE guidelines. Sodium is currently elevated above the surrender limits to be applied in due course, but presents minimal environmental risk.

5. Investigations, interventions, incidents and discussion

The monitoring programme for the year was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During the year matters may arise which require additional activity by the Council eg provision of advice and information, or investigation of potential or actual courses of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

The Taranaki Regional Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The Unauthorised Incident Register (UIR) includes events where the company concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

In the 2011-2013 monitoring period, the Council recorded two incidents in association with activities at Colin Boyd's landfarm. Two abatement notices were issued in relation to these incidents.

5.1.1 Incident 22581 / Abatement notice 11813

Incident summary

During routine compliance monitoring at the Derby Road North stockpiling facility, it was discovered that the site was not operating within resource consent conditions. An inspection of the site found that drilling muds had exceeded the 12 month pit storage period, contravening special condition 6 of resource consent 6900-2. It was outlined to site staff that muds must be landfarmed immediately when weather conditions next permit to ensure compliance and an abatement notice (number 11813) was issued in relation to the breach of consent conditions.

Investigation summary

No additional investigation was required regarding this incident. A follow-up inspection was conducted on 2 April 2012 which confirmed the abatement notice was being complied with as the pits were in the process of being emptied.

5.1.2 Incident 23576 / Abatement notice 12011

Incident summary

An incident was registered against the Surrey Road stockpiling facility site on 22 April 2013 on the basis of suspected impact on receiving waters of the Mangatengehu Stream from the stockpiling site.

During routine compliance monitoring it was discovered that discharge from the site at Surrey Road, utilised for drilling mud storage did not meet the requirements of the permitted industrial stormwater discharge rule in the Regional Fresh Water Plan for

Taranaki. An inspection of the discharge from the site found it to be turbid and causing a foaming effect within the receiving waters and samples were collected. The site manager was made aware of the issue. It was thought that some surfactant had been used in drilling activities and the recovered material had been discharged into the drilling mud pit. This had moved through the skimmer pipes and settling pond system into the receiving waters. An abatement notice was issued requiring all non-compliant discharges to cease.

Photo 3 Observed foaming in receiving waters of the unnamed tributary of the Mangatengehu stream upon inspection on 22 April 2013 (left) and later mitigation measures consisting of 'flow arresting sock' and gabion basket on the final discharge (right)

Incident results

Samples were obtained of the discharge and unnamed tributary of the Mangatengehu stream. These sampling sites can be seen in Figure 6. The results are shown in Table 21.

Table 21 Results of samples obtained on 22 April 2013 in response to incident 23576 at Surrey Road stockpiling facility

Parameter	Unit	Sampling localities		
		IND001067	MTH000060	MTH000064
Temperature	Deg.C	14.1	13.3	13.3
pH	pH	7.5	7	7.1
Conductivity	mS/m@20C	329	6.5	22.1
Suspended solids	g/m³	400	4	35
Total dissolved solids	g/m³	2545.5	-	-
Biochemical oxygen demand	g/m³	>230	-	-
Chloride	g/m³	683	5.8	42.7
Barium	g/m³	0.69	0.018	0.3
Hydrocarbons	g/m³	14	<0.5	<0.5

Biochemical oxygen demand, suspended solids and total dissolved solids sampled from the discharge (IND001067) of the stormwater ponds at the Surrey Road

stockpiling facility, did not comply with the permitted activity conditions. This incident also breached Rule 23 of the Regional Fresh Water Plan for Taranaki, which stipulates that discharges must not produce any conspicuous scums or foams.

Investigation summary

MI Swaco conducted a comprehensive internal investigation into this incident. They contracted in an industrial chemist who identified the particular surfactant that had caused the foaming. They traced the source of the foaming back to a detergent used in the cementing process. They have since modified their site setup so that any materials arriving on site from cementing operations are isolated into a designated pit and monitored for any water discharges. They have also improved their transporting procedures and communication with transporting operators to prevent any future incidents of this nature. A follow-up inspection by Council staff confirmed the abatement notice was being complied with.

5.1.3 Investigative sampling

On 20 November 2012 Council scientific staff visited the Surrey Road site to conduct routine groundwater sampling. During the site sampling staff were concerned about the appearance of water in the periphery drain. Closer inspection of the drain revealed two perforated pipes that were both discharging at approximately half a litre per second into the periphery drain. The discharge (which had been noted by the inspecting officer and discussed with site operators) had a strong hydrocarbon odour and the water running down the drain had a distinctive sheen, and some foaming was occurring directly below the perforated pipes. Naturally occurring iron oxide sheen and staining of the substrate was also present in the drain.

Photo 4 Periphery drain, Surrey Road stockpiling looking upstream to perforated pipe 1 (left) and water discharging from perforated pipe 2 (right)

The decision was made to collect several samples from the perforated pipes, the drain and the receiving waters, to test for a wider range of hydrocarbon contaminants. Temporary sampling sites were established and are presented in Figure 13. Sample results are given in Table 22.

Figure 13 Sampling sites, Surrey Road stockpiling area 20 November 2012

Table 22 Results from samples obtained on 20 November 2012 in relation to an additional investigation regarding suspicious looking discharges around drainage at the Derby Road North stockpiling facility

Parameter	Unit	PP1	PP2	DRAIN U/S	DRAIN D/S	IND001067	U/S	D/S
pH	pH	6.3	6.7	6.9	6.6	6.3	6.3	6.7
Conductivity	mS/m@20 C	35.6	19.3	14.1	26	64.5	7.6	14.5
Suspended solids	g/m³	35	10	-	-	100	-	-
Total dissolved solids	g/m³	-	149.3	109.1	201.2	-	58.8	112.2
Chloride	g/m³	51.8	28.4	7.9	36	120	8.3	19.9
Nitrate	g/m³ N	-	-	0.02	0.02	-	0.02	0.02
Barium	g/m³	0.11	0.059	0.025	0.077	0.13	0.017	0.05
Benzene	g/m³	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Toluene	g/m³	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m³	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
meta-Xylene	g/m³	<0.002	0.002	<0.002	<0.002	0.002	<0.002	<0.002
ortha-Xylene	g/m³	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Hydrocarbons	g/m³	137	94	<0.7	97	<0.7	<0.7	<0.7

The results presented in Table 22 confirmed the presence of significant hydrocarbons in both of the perforated pipes (PP1, PP2) and in the periphery drain downstream of the perforated pipes (DRAIN D/S). However, the periphery drain discharges into two settling ponds, separated by gooseneck pipes, prior to the final discharge point (IND001067). The results from the final discharge show no hydrocarbons, but the

suspended solids result sits at the RFWP limit for a permitted activity, and chloride is elevated. The downstream receiving results differ from the upstream control results with an increase in chloride and conductivity, but levels are low and unlikely to affect overall stream health at these concentrations. No BTEX compounds were detected in any of the samples.

A meeting was held with the consent holder and the site operator to discuss the site stormwater management system and the perforated pipes. The consent holder advised that the perforated pipes were installed to drain a groundwater spring that runs through the site. Through the course of the investigative sampling it became evident that the pipes were draining the spring below the pit bases and collecting and transporting residual hydrocarbons into the periphery drain. The initial site set up used bentonite lined pits and it is likely there would have been some leaching of hydrocarbons through the pit bases into the underlying soil.

The consent holder and site operator suggested that they would monitor the drain and construct small skimmer tanks on the perforated pipes to collect and recover hydrocarbons for a trial period, and if the pipes continued to discharge they would review and modify the drainage system if required. It is recommended that the Company reviews this in the 2013-2014 year and modifies the drainage system if the hydrocarbons entering the on-site drain persist.

6. Discussion

6.1 Discussion of site performance

The Company was generally competent with the physical aspects of the landfarming processes and achieved good results with spreading procedures and pasture establishment. However, there were some operational incidents recorded against the site, and the supply of information (notifications, reporting formats, and map supply) requires improvement. The Company has acknowledged and are looking to modify their report with guidance from the Council.

The Company were cooperative in the lining of the existing pits at the Surrey Road site, and have implemented several site improvements including the erection of fencing to catch any wind-blown oil from the pit surfaces, skimming and removing excess hydrocarbon for re-use, and improved site security and waste tracking procedures. The Company have initiated a 'locked gate' policy where drivers may only access the site when it is manned and must produce required paperwork or are turned away from the site. The Company have maintained good contact with the Council and have generally been cooperative in all matters raised during the monitoring period under review, and the initiatives undertaken by the Company during the monitoring period to improve their sites and systems have been commendable.

At the end of the monitoring period, the Derby Road site remains on standby to receive waste, but is largely unused. The Company has been advised that they would be required to line all pits prior to resumption of use of the site.

Photo 5 Newly lined pits at Surrey Road stockpiling facilities

6.2 Environmental effects of exercise of consents

Monitoring indicates that there appears to be no significant adverse environmental effects due to activities at the site. Levels of contaminants in the surface soil meet the required consent conditions in the Council samples. At the time of reporting, the Company's receiving environment results had yet to be supplied. Groundwater results have not indicated that there are any significant impacts on groundwater resources from activities conducted at this site. The Company has also taken pasture samples from control and farmed sites, the results of which showed no significant difference between the samples, and the consent holder is satisfied with vegetation growth in the areas where muds have been applied. Further monitoring of the site will be undertaken to ensure that compliance with all consent limits is demonstrated prior to surrender. Due to the location of the sites and the significant distance to any neighbours no air monitoring was undertaken as effects are known to be minimal.

The foaming incident at the Surrey site led to effects that were temporary, and the Company has done well to modify site practices to reduce the potential for further similar incidents.

The Council will continue to closely monitor the perforated pipe/periphery drain aspect of the stormwater system to ensure no adverse environmental effects are detected in the receiving waters of the Mangatengehu Stream.

6.3 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Tables 23 to 26.

Table 23 Summary of performance from 16 February 2011 for Consent **6900-2** - to discharge drilling wastes [consisting of drilling cuttings and drilling fluids from water based muds and synthetic based muds], onto and into land for the purpose of temporary stockpiling

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adoption of the best practicable option	Inspection, sampling and liaison with consent holder	Yes
2. Notify TRC 48 hours prior receiving waste onto site for stockpiling	Notifications received	Yes
3. Records to be kept by consent holder and made available to the Council	Records received	Yes
4. Consent holder to report to Council by 31 August each year on records specified in SC3	Reports received for 2011-2012 and 2012-2013	12-13 Report late
5. No discharge within 25 m of surface water or property boundaries	Inspection	Yes
6. Stockpiled material to be landspread under consent 7591-1 within 12 months of arrival on site	Inspection and consent holders records	No – Incident 22581
7. Total dissolved solids in any fresh water body not to exceed 2500 g/m^3	Sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
8. No contamination of groundwater or surface water to exceed background concentrations	Sampling	Slight rise in chloride in bore 2061
9. Concentrations in soil to be met prior to expiry	Not applicable	N/A
10. Consent may not be surrendered until compliance with SC9	Not applicable	N/A
11. Optional review provision re environmental effects	Next option for review in June 2015	N/A
Overall assessment of environmental performance and compliance in respect of this consent Overall assessment of administrative performance in respect of this consent		Improvement required Good

Table 24 Summary of performance for Consent **7559-1** - to discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds onto and into land via landfarming

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Definitions of stockpiling and landfarming	N/A	N/A
2. Adoption of the best practicable option	Inspection, sampling and liaison with consent holder	Yes
3. Install groundwater monitoring wells prior to exercise of consent	Inspection	Yes
4. Approved management plan to be reviewed annually	Plan approved 4 December 2009, no update provided	No
5. Notify Council 48 hours prior to stockpiling wastes	No wastes received during period under review	Yes
6. Notify Council 48 hours prior to landfarming wastes	Not applicable. Waste landspread under consent 7591	N/A
7. Limited to wastes generated in Taranaki	Consent holders records	Yes
8. Maximum stockpiling volume of 2,000 m^3 to be landfarmed/spread within nine months	Inspection and consent holders records	Yes
9. Maximum application thickness for wastes: a) 100 mm TPH < 5% b) 50 mm TPH > 5% c) no ponded liquids 1 hr after application	Not applicable. Waste landspread under consent 7591-1	N/A
10. Landfarmed areas to be used once only	Not applicable. Waste landspread under consent 7591-1	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
11. Incorporate wastes into the soil so that the surface 250mm contains less than 5% hydrocarbons	Not applicable. Waste landspread under consent 7591-1	N/A
12. Maximum chloride loading 800 kg/ha	Not applicable. Waste landspread under consent 7591-1	N/A
13. Maximum nitrogen loading 1,000 kg/5yrs	Not applicable. Waste landspread under consent 7591-1	N/A
14. Discharge area shall be resown to pasture/crop as soon as practicable	Not applicable. Waste landspread under consent 7591-1	N/A
15. No discharge within 25 m of a water body (includes farm drains)	Not applicable. Waste landspread under consent 7591-1	N/A
16. Conductivity must be less than 400 mS/m. If background soil conductivity greater than 400 mS/m, then waste application shall not increase conductivity by more than 100 mS/m	Not applicable. Waste landspread under consent 7591-1	N/A
17. Concentration of metals in soil must comply with MfE/NZWWA guidelines	Not applicable. Waste landspread under consent 7591-1	N/A
18. Sodium absorption ratio [SAR] must be less than 18. If background soil SAR is greater than 18, then waste application shall not increase SAR by more than 1	Not applicable. Waste landspread under consent 7591-1	N/A
19. At time of expiry/cancellation/ surrender, soil hydrocarbon concentrations must comply with MfE guidelines	N/A	N/A
20. Prior to expiry/cancellation/surrender, soil parameters shall not exceed: a) conductivity 290 mS/m b) dissolved salts 2500 g/m^3 c) sodium 460 g/m^3 d) chloride 700 g/m^3	N/A	N/A
21. Total dissolved solids in surface water or groundwater shall not exceed 2500 g/m^3	Sampling	No – Incident 23576
22. No contamination of groundwater or surface water to exceed background concentrations	Sampling	No
23. Records to be kept by consent holder and made available to the Council	See SC24	N/A
24. Consent holder to report to Council by 31 August each year on records specified in SC23	Report received for 2011-2012 and 2012-2013	12-13 report late
25. Consent shall lapse on 31 Dec 2014 unless exercised	Not applicable - consent exercised	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
26. Optional review provision re environmental effects	Recommendation not to review in June 2012	N/A
Overall assessment of environmental performance and compliance in respect of this consent		Improvement required
Overall assessment of administrative performance in respect of this consent		Good

Table 25 Summary of performance for Consent **7591-1** - to discharge drilling waste from hydrocarbon exploration activities onto and into land via landspreading

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adoption of the best practicable option	Inspection, sampling and liaison with consent holder	Yes
2. Notify Council 48 hours prior to landspreading	Notifications received	Requires improvement
3. Limited to wastes generated in Taranaki	Consent holders records	Yes
4. Discharge rate shall not exceed 100 m^3/ha/yr and no ponded liquids shall remain after 1 hr	Inspection and consent holders records	Yes
5. Maximum chloride loading 800 kg/ha	Not calculated during period under review	N/A
6. Maximum nitrogen loading 1,000 kg/5yrs	Consent holders records	Yes
7. Pasture cover to be maintained at all times	Inspections	Yes
8. No waste shall be applied within: a) 12 m of boundaries b) 12 m of named streams c) 6 m of other water courses	Inspection	Yes
9. Liquid wastes which may flow overland shall not be discharged within 25 m of boundaries or water courses	Inspection	Yes
10. Soil hydrocarbon concentrations must comply with MfE guidelines: a) prior to areas being reused for landspreading b) at the time of expiry/cancellation/surrender	Not applicable - no areas reused, and consent still in force.	N/A
11. Concentration of metals in soil must comply with MfE/NZWWA guidelines	Sampling - no results provided	Yes
12. Conductivity must be less than 400 mS/m. If background soil conductivity greater than 400 mS/m, then waste application shall not increase conductivity by more than 100 mS/m	Sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
13. Sodium absorption ratio [SAR] must be less than 18. If background soil SAR is greater than 18, then waste application shall not increase SAR by more than 1	Sampling	Yes
14. Soil parameters shall not exceed: a) conductivity 290 mS/m b) dissolved salts 2500 g/m^3 c) sodium 460 g/m^3 d) chloride 700 g/m^3 prior to areas being reused for landspreading, and at the time of expiry/cancellation/surrender	Not applicable - no areas reused	N/A
15. Total dissolved solids in surface water or groundwater shall not exceed 2500 g/m^3	Sampling	Yes
16. No contamination of groundwater or surface water to exceed background concentrations	Sampling	Mostly
17. Records to be kept by consent holder and made available to the Council	See SC18	N/A
18. Consent holder to report to Council by 31 August each year on records specified in SC17	Reports received for 2011-2012 and 2012-2013	12-13 Report late
19. Consent shall lapse on 1 June 2027 unless exercised	Not applicable - consent exercised	N/A
20. Optional review provision re environmental effects	Next option for review in June 2015	N/A
Overall assessment of environmental performance and compliance in respect of this consent		Good
Overall assessment of administrative performance in respect of this consent		Requires Improvement

Table 26 Summary of performance for Consent **7911-1** – to discharge stormwater from a drilling waste storage site into an unnamed tributary of the Mangamawhete Stream in the Waitara River

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adoption of the best practicable option	Inspection and liaison with consent holder	Yes
2. Stormwater discharged shall be from a catchment area not exceeding 1.5 hectares	Inspection and liaison with consent holder	Yes
3. Discharges shall meet the following: a. pH 6.0 – 9.0 b. Suspended solids <100 gm^{-3} c. Total recoverable hydrocarbons <15 gm^{-3}	Sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
4. 25m downstream of the initial discharge point, discharges shall not exceed: a. BOD_5 <2 gm^{-3} b. Chloride <50 gm^{-3}	Sampling	Yes
c. Disposal of waste shall not result in any significant adverse environmental effects in the receiving waters	Inspection and sampling	Yes
d. Consent holder shall maintain a contingency plan	Inspection and liaison with consent holder	Yes
e. Optional review provision re environmental effects	Next option for review in June 2015	N/A
Overall assessment of environmental performance and compliance in respect of this consent Overall assessment of administrative compliance in respect of this consent		High High

N/A = not applicable

The Company's consent compliance with resource consents 6900-2 and 7559-1 required improvement. There were definite site improvements at the Surrey stockpiling site, and the site operators were helpful and proactive. However, there were technical non-compliances at both sites and the record keeping and reporting procedures should be reviewed by the Company.

Spreading activities under consent 7591-1 were generally to a good standard, but the Company have been advised to ensure notifications are provided for each occasion of spreading, containing all the required information, or enforcement action will be undertaken.

During the year under review there were two incidents recorded against the sites and two abatement notices issued to the Company for operational consent condition non-compliances. The environmental effects of these incidents are negligible, but they highlighted some operational shortcomings, that the Company are working well to resolve.

The overall rating for the C. Boyd drilling waste disposal programme, as per the criteria given in Section 1.1.4 is 'improvement required 'concerning both environmental and administrative performance and compliance with the resource consents.

6.4 Recommendations from the 2010-2011 Annual Report

In the 2010-2011 Annual Report, it was recommended:

1. THAT the monitoring programme for the Derby Road North site in the 2011-2012 year, remain unchanged from that for 2010-2011.

2. THAT the monitoring programme for the Surrey Road site in the 2011-2012 year, remain unchanged from that for 2010-2011.

3. THAT the monitoring programme for landspreading activities in the 2011-2012 year, remain unchanged from that for 2010-2011, unless the level of site activity changes.

4. THAT the option for a review of resource consents **7559-1** and **7591-1** in June 2012, as set out in conditions of the consents, not be exercised, on the grounds that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of the consents.

All recommendations were implemented.

6.5 Alterations to monitoring programmes for 2013-2014

In designing and implementing the monitoring programmes for air/water discharges in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring emissions/discharges and effects, and subsequently reporting to the regional community. The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that for 2013-2014 the monitoring programmes for the stockpiling and landspreading activities at Colin Boyd's property be changed from that for the 2012-2013 monitoring year to include testing for TPH and BTEX in all water samples to standardise monitoring with other drilling waste disposal sites.

A recommendation to this effect is attached to this report.

7. Recommendations

1. THAT the monitoring programme for the Derby Road North site in the 2013-2014 year, is changed from that for 2011-2013 to include sampling for BTEX and TPH in all water samples.

2. THAT the monitoring programme for the Surrey Road site in the 2013-2014 year, is changed from that for 2011-2013 to include sampling for BTEX and TPH in all water samples.

3. THAT the monitoring programme for landspreading activities in the 2013-2014 year, remain unchanged from that for 2011-2013, unless the level of site activity changes.

4. THAT the consent holder addresses the discharge of residual hydrocarbons into the surface water drain.

5. THAT the consent holder is either required to apply for a stormwater consent for the Surrey Road stockpiling site, as stormwater discharges from site were not within the RFWP Rule 23 limits, or, modifies the pond and drainage system to prevent any discharges of water from the storage pits into the stormwater system and then into the Mangatengehu Stream.

Glossary of common terms and abbreviations

The following abbreviations and terms may be used within this report:

Al*	Aluminium.
As*	Arsenic.
Biomonitoring	Assessing the health of the environment using aquatic organisms.
BTEX	MAH's benzene, toluene, ethylbenzene and xylene.
BOD	Biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate.
BODF	Biochemical oxygen demand of a filtered sample.
Bund	A wall around a tank to contain its contents in the case of a leak.
CBOD	Carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate.
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample.
COD	Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction.
Condy	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m.
Cu*	Copper.
Cumec	A volumetric measure of flow- 1 cubic metre per second (1 m^3s^{-1}).
DO	Dissolved oxygen.
DRP	Dissolved reactive phosphorus.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Ent	Enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample.
F	Fluoride.
FC	Faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.

Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish what were the circumstances/events surrounding an incident including any allegations of an incident.
l/s	Litres per second.
MAHs	Monocyclic aromatic hydrocarbons, molecules consist of a single six-sided hydrocarbon ring.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
Mixing zone	The zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point.
NH_4	Ammonium, normally expressed in terms of the mass of nitrogen (N).
NH_3	Unionised ammonia, normally expressed in terms of the mass of nitrogen (N).
NO_3	Nitrate, normally expressed in terms of the mass of nitrogen (N.)
NTU	Nephelometric Turbidity Unit, a measure of the turbidity of water.
O&G	Oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons).
OW	Oily waste.
PAHs	Polycyclic aromatic hydrocarbons, molecules consist of more than two six-sided hydrocarbon rings.
Pb*	Lead.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
PM_{10}	Relatively fine airborne particles (less than 10 micrometre diameter).
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	*Resource Management Act* 1991 and including all subsequent amendments.
SBM	Synthetic based mud.
SS	Suspended solids.
SQMCI	Semi quantitative macroinvertebrate community index.
Temp	Temperature, measured in °C (degrees Celsius).
Turb	Turbidity, expressed in NTU.

UI	Unauthorised Incident.
UIR	Unauthorised Incident Register – contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan.
WBM	Water based mud.
Zn*	Zinc.

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form.

For further information on analytical methods, contact the Council's laboratory.

Bibliography and references

Ministry for the Environment 1999: Guidelines for assessing and managing petroleum hydrocarbon contaminated sites in New Zealand.

Ministry for the Environment and New Zealand Water and Wastes Association 2003: Guidelines for the safe application of biosolids to land in New Zealand.

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M-I Swaco 2010: Consent 6900-1, Condition 26 Annual Records, Boyd Landfarm, Inglewood.

M-I Swaco 2010: Consent 7559-1, Condition 23 Annual Records, Boyd Landfarm, Inglewood.

M-I Swaco 2010: Consent 7591-1, Condition 17 Annual Records, Surrey Road Landfarm, Inglewood.

M-I Swaco 2012: Consent 6900-1, Condition 26 Annual Records, Boyd Landfarm, Inglewood.

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Taranaki Regional Council 2005: Guidelines for the control of drilling waste disposal onto and into land.

Taranaki Regional Council, 2010: Boyd Landfarm Monitoring Programme Annual Report 2008-2009. Technical Report 2009-53.

Taranaki Regional Council, 2011: CD Boyd Drilling Waste Disposal Monitoring Programmes Annual Report 2009-2010. Technical Report 2010-78

Taranaki Regional Council, 2012: CD Boyd Drilling Waste Disposal Monitoring Programmes Annual Report 2010-2011. Technical Report 2011-48

Appendix I

Resource consents

TARANAKI REGIONAL COUNCIL
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Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	Colin David Boyd P O Box 44 INGLEWOOD 4347
Decision Date:	27 September 2011
Commencement Date:	27 September 2011

Conditions of Consent

Consent Granted:	To discharge stormwater from a drilling waste storage site into an unnamed tributary of the Mangamawhete Stream in the Waitara River at or about (NZTM) 1702717E-5653665N
Expiry Date:	1 June 2027
Review Date(s):	June 2013, June 2015, June 2021
Site Location:	Derby Road North, Inglewood
Legal Description:	Lot 2 DP 344156 [Discharge source & site]
Catchment:	Waitara
Tributary:	Manganui Mangamawhete

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act.

Special conditions

1. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any adverse effects on the environment from the exercise of this consent.

2. The stormwater discharged shall be from a catchment area not exceeding 1.5 hectares.

3. Constituents of the discharge shall meet the standards shown in the following table.

Constituent	Standard
pH	Within the range 6.0 to 9.0
suspended solids	Concentration not greater than 100 gm^{-3}
total recoverable hydrocarbons	Concentration not greater than 15 gm^{-3}

This condition shall apply before entry of the treated stormwater into the receiving waters at a designated sampling point approved by the Chief Executive, Taranaki Regional Council.

4. After allowing for reasonable mixing, within a mixing zone extending twenty five metres downstream of the discharge point to the unnamed tributary of the Mangamawhete Stream, the discharge shall not, either by itself or in combination with other discharges, cause the following:

   a) the carbonaceous filtered biochemical oxygen demand [BOD_5] to exceed 2 gm^{-3}, or
   b) the chloride concentration to exceed 50 gm^{-3}.

5. After allowing for reasonable mixing, within a mixing zone extending twenty five metres downstream of the discharge point, the discharge shall not, either by itself or in combination with other discharges, give rise to any or all of the following effects in the receiving water:

   a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
   b) any conspicuous change in the colour or visual clarity;
   c) any emission of objectionable odour;
   d) the rendering of fresh water unsuitable for consumption by farm animals;
   e) any significant adverse effects on aquatic life.

6. The consent holder shall maintain a contingency plan. The contingency plan shall be adhered to in the event of a spill or emergency and shall, to the satisfaction of the Chief Executive, Taranaki Regional Council, detail measures and procedures to be undertaken to prevent spillage or accidental discharge of contaminants not authorised by this consent and measures to avoid, remedy or mitigate the environmental effects of such a spillage or discharge.

7. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2015 and/or June 2021, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 27 September 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

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Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	Colin David Boyd P O Box 44 INGLEWOOD 4347
Decision Date:	16 February 2011
Commencement Date:	16 February 2011

Conditions of Consent

Consent Granted:	To discharge drilling wastes [consisting of drilling cuttings and drilling fluids from water based muds and synthetic based muds], onto and into land for the purpose of temporary stockpiling prior to disposal at or about (NZTM) 1702545E-5653650N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	Derby Road North, Inglewood
Legal Description:	Lot 2 DP 344156 [Discharge site]
Catchment:	Waitara
Tributary:	Manganui Mangamawhete

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council [the Council] all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act.

Special conditions

1. The consent holder shall adopt the best practicable option [as defined section 2 of the Resource Management Act 1991] to prevent or minimise any actual or potential effects on the environment arising from the discharge.

Notifications, monitoring and reporting

2. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to permitting drilling wastes onto the site for stockpiling, from each well drilled. Notification shall include the following information:

    a) the consent number;
    b) the name of the well[s] from which the waste was generated;
    c) the type of waste to be stockpiled; and
    d) the volume of waste to be stockpiled.

3. The consent holder shall keep records of the following:

    a) wastes from each individual well;
    b) composition of wastes [including concentrations of chloride, nitrogen and total petroleum hydrocarbons];
    c) stockpiling area[s];
    d) volumes and weights of material stockpiled;
    e) dates of commencement and completion of stockpiling events;
    f) the results of analysis;

    and shall make the records available to the Chief Executive, Taranaki Regional Council.

4. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 3, for the period of the previous 12 months, 1 July to 30 June.

Operational requirements

5. There shall be no discharge of drilling waste to land, within 25 metres of surface water or of property boundaries.

6. All material must be spread on to land in accordance with consent 7591-1 as soon as practicable, but no later than twelve months after being brought onto the site.

Receiving environment limits - water

7. The exercise of this consent shall not result in the concentration of total dissolved salts in any fresh water body exceeding 2500 g/m^3.

8. Other than as provided for in condition 7, the exercise of this consent shall not result in any contaminant concentration, within surface water or groundwater, which after reasonable mixing, exceeds the background concentration for that particular contaminant.

Receiving environment limits - soil

9. From 1 March 2027 [three months prior to the consent expiry date], constituents in the soil of previously landfarmed areas shall not exceed the standards shown in the following table:

Constituent	Standard
conductivity	290 mS/m
chloride	700 mg/kg
sodium	460 mg/kg
total soluble salts	2500 mg/kg
MAHs PAHs TPH	Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand [Ministry for the Environment, 1999]. Tables 4.12 and 4.15, for soil type sand.

MAHs - benzene, toluene, ethylbenzene, xylenes
PAHs - napthalene, non-carc. [pyrene], benzo(a)pyrene eq.
TPH - total petroleum hydrocarbons [C_7-C_9, C_{10}-C_{14}, C_{15}-C_{36}]

The requirement to meet these standards shall not apply if, before 1 March 2027, the consent holder applies for a new consent to replace this consent when it expires.

10. This consent may not be surrendered at any time until the standards in condition 9 have been met.

Review

11. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2015 and/or June 2021, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 16 February 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Consent 7591-1

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Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	Surrey Road Landfarms Limited P O Box 44 INGLEWOOD
Consent Granted Date:	21 January 2010

Conditions of Consent

Consent Granted:	To discharge drilling waste from hydrocarbon exploration activities onto and into land via landspreading at or about (NZTM) 1701750E-5652370N
Expiry Date:	1 June 2027
Review Date(s):	June 2011, June 2012, June 2015, June 2021
Site Location:	Surrey Road, Inglewood
Legal Description:	Lot 2 DP 344156, Secs 9, 10 , & Pt Sec 13 Blk XII Egmont SD, Secs 17 & 18 Blk XVI Egmont SD
Catchment:	Waitara
Tributary:	Mangamawhete Mangatengehu Waipuku

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General conditions

a. The consent holder shall pay to the Council all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act

Special conditions

1. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any adverse effects on the environment from the exercise of this consent. For the purpose of this consent, the best practicable option will include undertaking the landspreading of drilling waste during extended periods of dry weather.

2. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to landspreading waste from each separate storage cell. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be landspread;
   d) the volume and weight of the waste to be landspread;
   e) the concentration of chlorides, nitrogen and hydrocarbons in the waste; and
   f) the specific location and area over which the waste will be landspread.

   In order to demonstrate compliance with conditions 4, 5 and 6 of this consent.

3. The exercise of this consent is limited to wastes generated within the Taranaki region.

Discharge limits

4. Drilling waste shall be applied to land at a rate not exceeding 100 m^3/ha/yr, and in a rate and manner such that no ponded liquids remain after one hour.

5. The exercise of this consent shall not result in a chloride loading exceeding 800 kg/ha.

6. The nitrogen loading [including that from any application of nitrogen fertiliser] over any area where drilling wastes are applied, shall not exceed 1000 kilograms per hectare over any 5 year period.

7. The consent holder shall maintain pasture cover at all times in areas used for the landspreading of drilling waste.

8. No drilling waste shall be discharged within:

   a) 12 metres of property boundaries; or
   b) 12 metres of the Mangamawhete, Mangatengehu and Waipuku Streams; or
   c) 6 metres of any other surface water course [including farm drains].

9. Any liquid drilling waste which may flow overland, shall not be discharged within 25 metres of property boundaries or surface water courses [including farm drains].

Receiving environment limits for soil

10. The concentration of hydrocarbons in the soil shall comply with the guideline values for sandy silt set out in Tables 4.12 and 4.15 of the "Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand" [MfE, 1999]. This condition shall apply:

    a) prior to drilling wastes being discharged onto an area that has previously been used for the disposal of drilling wastes via landspreading; and
    b) at the time of expiry, cancellation, or surrender of this consent.

11. The concentration of metals in the soil layer containing the discharge shall comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the "Guidelines for the safe application of biosolids to land in New Zealand" [MfE and NZWWA 2003].

12. The conductivity of the soil layer containing the discharge shall be less than 400 mS/m, or alternatively, if the background soil conductivity exceeds 400 mS/m, the application of waste shall not increase the soil conductivity by more than 100 mS/m.

13. The sodium absorption ratio [SAR] of the soil layer containing the discharge shall be less than 18, or alternatively if the background soil SAR exceeds 18, the application of waste shall not increase the SAR by more than 1.

14. Soil parameters shall not exceed the following limits: chloride, 700 mg/kg; conductivity, 290 mS/m; sodium, 460 mg/kg; and total soluble salts, 2500 mg/kg. This condition shall apply:

    a) prior to drilling wastes being discharged onto an area that has previously been used for the disposal of drilling wastes via landspreading; and
    b) at the time of expiry, cancellation, or surrender of this consent.

Receiving environment limits for water

15. The exercise of this consent shall not result in a level of total dissolved salts within any surface water or groundwater of more than 2500 g/m^3.

16. The exercise of this consent shall not result in any contaminant concentration, within surface water or groundwater, which exceeds the background concentration for that particular contaminant, as determined by the Chief Executive, Taranaki Regional Council.

Monitoring and reporting

17. The consent holder shall keep records of the following:

    a) wastes from each individual well
    b) composition of wastes, including concentrations of chloride, nitrogen and total hydrocarbons
    c) landspreading areas, including a map showing individual disposal areas with GPS co-ordinates
    d) volumes and weights of wastes landspread
    e) dates of commencement and completion of landspreading events
    f) details of monitoring, including sampling locations, sampling methods and the results of analysis

    and shall make the records available to the Chief Executive, Taranaki Regional Council.

18. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 17, for the period of the previous 1 July to 30 June.

Lapse and review

19. This consent shall lapse on the 31 March 2015, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

20. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2011 and/or June 2012 and/or June 2013 and/or June 2014 and/or June 2015 and/or June 2021 for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time, or to take into account any Act of Parliament, regulations, national policy statement, and national environmental standard which is relevant to this consent.

Signed at Stratford on 21 January 2010

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Consent 7559-1

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Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	Colin David Boyd P O Box 44 INGLEWOOD 4347
Consent Granted Date:	20 November 2009

Conditions of Consent

Consent Granted:	To discharge drilling wastes [consisting of drilling cuttings and drilling fluids] from hydrocarbon exploration activities with water based muds and synthetic based muds onto and into land via landfarming at or about (NZTM) 1701847E-5651476N
Expiry Date:	1 June 2027
Review Date(s):	June 2010, June 2011, June 2012, June 2013, June 2014, June 2015, June 2021
Site Location:	Surrey Road, Inglewood
Legal Description:	Sec 17 & 18 Blk XIV Egmont SD
Catchment:	Waitara
Tributary:	Mangamawhete Mangatengehu

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General conditions

a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.

b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.

c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:

i) the administration, monitoring and supervision of this consent; and
ii) charges authorised by regulations.

Special conditions

1. For the purposes of this consent the following definitions shall apply:

a) stockpiling means a discharge of drilling wastes from vehicles, tanks, or other containers onto land, but without subsequently spreading, or incorporating into the soil within 24 hours of such discharge; and
b) landfarming means the discharge of drilling waste onto land, subsequent spreading, incorporation into the soil and re-sowing into pasture or crop.

2. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any adverse effects on the environment from the exercise of this consent. For the purpose of this consent, the best practicable option will include undertaking the landfarming of drilling waste during extended periods of dry weather.

Requirements prior to exercise of consent

3. Prior to the exercise of this consent, the consent holder shall install a minimum of three groundwater monitoring wells. The wells shall be at locations and to depths, that enable the collection of groundwater samples [to assess any changes in groundwater quality] to the satisfaction of the Chief Executive, Taranaki Regional Council. The wells shall be installed in accordance with NZS 4411:2001 and all associated costs shall be met by the consent holder.

4. Prior to the exercise of this consent, the consent holder shall provide, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a landfarming and stockpiling management plan to demonstrate the activity will be conducted to comply with all of the conditions of this consent. The management plan shall be reviewed annually and shall include as a minimum:

   a) control of site access;
   b) procedures for notification to Council of disposal activities;
   c) procedures for the receipt and stockpiling of drilling wastes onto the site;
   d) procedures for the management of stormwater recovered from, or discharging from, the drilling waste stockpiling area;
   e) methods used for the mixing and testing of different waste types;
   f) procedures for landfarming drilling wastes [including means of transfer from stockpiling area, means of spreading, and incorporation into the soil];
   g) contingency procedures;
   h) sampling regime and methodology; and
   i) post-landfarming management, monitoring and site reinstatement.

Notification and sampling requirements prior to discharge

5. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to permitting drilling wastes onto the site for stockpiling, from each well drilled. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be stockpiled; and
   d) the volume of waste to be stockpiled.

6. The consent holder shall notify the Chief Executive, Taranaki Regional Council, [by emailing worknotification@trc.govt.nz.] at least 48 hours prior to landfarming stockpiled material. Notification shall include the following information:

   a) the consent number;
   b) the name of the well[s] from which the waste was generated;
   c) the type of waste to be landfarmed;
   d) the volume and weight of the waste to be landfarmed;
   e) the concentration of chlorides, nitrogen and hydrocarbons in the waste; and
   f) the specific location and area over which the waste will be landfarmed.

   In order to demonstrate compliance with conditions 9, 12 and 13 of this consent.

Discharge limits

7. The exercise of this consent is limited to wastes generated within the Taranaki region.

8. The stockpiling of material authorised by this consent shall be limited to a maximum volume of 2,000 cubic metres at any one time on the site. All stockpiled material must be landfarmed within nine months of being brought onto the site.

9. For the purposes of landfarming, drilling wastes shall be applied to land in a layer not exceeding:

   a) 100 mm thick for wastes with a hydrocarbon concentration less than 50,000 mg/kg dry weight; or
   b) 50 mm thick for wastes with a hydrocarbon concentration equal to or greater than 50,000 mg/kg dry weight; and
   c) in a rate and manner such that no ponded liquids remain after one hour, for all wastes;

   prior to incorporation into the soil.

10. An area of land used for the landfarming of drilling wastes in accordance with condition 9 of this consent shall not be used for any subsequent discharges of drilling waste.

11. As soon as practicable following the application of drilling wastes to land, the consent holder shall incorporate the material into the soil to a depth of at least 250 mm so that the hydrocarbon concentration at any point in the soil/waste mix is less than 50,000 mg/kg dry weight.

12. The exercise of this consent shall not result in a chloride loading exceeding 800 kg/ha.

13. The nitrogen loading [including that from any application of nitrogen fertiliser] over any area where drilling wastes are applied, shall not exceed 1000 kilograms per hectare over any 5 year period.

14. As soon as practicable following the landfarming of drilling wastes the discharge area shall be re-sown into pasture [or into crop]. If revegetation cannot be established within two months of the discharge, the consent holder shall undertake appropriate land stabilisation measures to minimise wind and/or stormwater erosion.

15. No discharge shall take place within 25 metres of a water body [including farm drains], or property boundary.

Receiving environment limits for soil

16. The conductivity of the soil layer containing the discharge shall be less than 400 mS/m, or alternatively, if the background soil conductivity exceeds 400 mS/m, the application of waste shall not increase the soil conductivity by more than 100 mS/m.

17. The concentration of metals in the soil layer containing the discharge shall comply with the guidelines for heavy metals in soil set out in Table 7.1, Section 7 of the "Guidelines for the safe application of biosolids to land in New Zealand" [MfE and NZWWA 2003].

18. The sodium absorption ratio [SAR] of the soil layer containing the discharge shall be less than 18, or alternatively if the background soil SAR exceeds 18, the application of waste shall not increase the SAR by more than 1.

19. At the time of expiry, cancellation, or surrender of this consent the concentrations of hydrocarbons in the soil shall comply with the guideline values for sandy silt set out in Tables 4.12 and 4.15 of the "Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand" [MfE, 1999].

20. At the time of expiry, cancellation, or surrender of this consent soil parameters shall not exceed the following limits: chloride, 700 mg/kg; conductivity, 290 mS/m; sodium, 460 mg/kg; and total soluble salts, 2500 mg/kg.

Receiving environment limits for water

21. The exercise of this consent shall not result in a level of total dissolved salts within any surface water or groundwater of more than 2500 g/m^3.

22. The exercise of this consent shall not result in any contaminant concentration, within surface water or groundwater, which exceeds the background concentration for that particular contaminant, as determined by the Chief Executive, Taranaki Regional Council.

Monitoring and reporting

23. The consent holder shall keep records of the following:

    a) wastes from each individual well [including records of all additives used at the wellsite during the drilling process]
    b) composition of wastes, including concentrations of chloride, nitrogen and total hydrocarbons
    c) stockpiling area[s]
    d) volumes of material stockpiled
    e) landfarming area[s], including a map showing each individual disposal area and GPS co-ordinates
    f) volumes and weights of wastes landfarmed
    g) dates of commencement and completion of stockpiling and landfarming events
    h) treatments applied
    i) details of monitoring, including sampling locations, sampling methods and the results of analysis

    and shall make the records available to the Chief Executive, Taranaki Regional Council.

24. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, by 31 August of each year, a report on all records required to be kept in accordance with condition 23, for the period of the previous 1 July to 30 June.

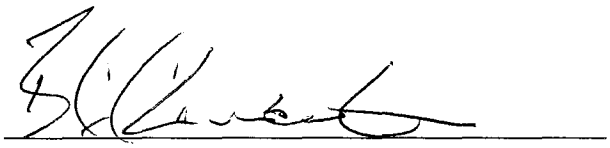
Lapse and review

25. This consent shall lapse on the 31 December 2014, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

26. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2010 and/or June 2011 and/or June 2012 and/or June 2013 and/or June 2014 and/or June 2015 and/or June 2021 for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time, or to take into account any Act of Parliament, regulations, national policy statement, and national environmental standard which is relevant to this consent.

Signed at Stratford on 20 November 2009

For and on behalf of
Taranaki Regional Council



Chief Executive

Appendix II

MI Swaco supplied annual report

1359220

MI SWACO

A Schlumberger Company

ANNUAL RECORDS FOR

CONSENT# 6900-1

CONSENT# 7559-1

BOYD LANDFARMS
SURREY ROAD
DERBY ROAD
INGLEWOOD

31 JULY 2013

MI SWACO
A Schlumberger Company

Status of Derby Rd and Surrey Rd Land Farm Facilities:

No product has been accepted at the Derby Rd landfarm within the last 12 months.

In February 2013, we began installing a permathene plastic liner to Cell#1 at the Surrey Road landfarm, to meet recent changes in TRC requirements.

Cell #2 was also fitted with a similar liner in April 2013.

Drilling waste arrived at the Surrey Road landfarm as from 1st March 2013 until 12th August 2013.

Drilling waste was received from two wells, stored in two separate cells at Surrey Road landfarm.

Cell #1 contains 976 metric tonnes of drilling cuttings.
Cell #2 contains 1513 metric tonnes of drilling cuttings.

The summer and autumn 2013 drought resulted in the stormwater ponds not discharging until late April 2013. The subsequent discharge showed foam present downstream. Samples of the foam and from stormwater pond SW#4 were analysed by both Hill Laboratories and also a specialist research chemist.

The surfactant was identified as part of the rig cementing process, and a specialised new lined cell was built (Cell #4) to isolate further products containing that surfactant.

Immediate action led to the prevention of any further discharge into the stream, and stormwater discharge from both storage cells was routed into a third storage pond by repositioning the skimmer pipes. This has been a successful solution.

Soil samples were taken from 21 paddocks, including re-testing of paddock #31 which showed excessive conductivity in the Taranaki Regional Council Report March 2012 on the Boyd Surrey Road landfarm (page 30, 4.3.1 table 10). The latest testing shows the conductivity to be within acceptable levels.

The 21 recent soil samples have a also been tested for heavy metals.

No landspreading of solid drilling waste was performed from the Surrey Road landfarm during the past year (July 2012 to July 2013), and may commence during the summer of 2013/2014 in accordance with the weather conditions.

Hill Laboratories
BETTER TESTING BETTER RESULTS

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Hamilton 3240, New Zealand

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	MI Swaco	**Lab No:**	1165183 SPv1
Contact:	Ross Henry	**Date Registered:**	09-Aug-2013
	C/- MI Swaco	**Date Reported:**	20-Aug-2013
	C/- MI-NZ Limited	**Quote No:**	34979
	PO Box 7100	**Order No:**	658
	Fitzroy	**Client Reference:**	
	NEW PLYMOUTH 4341	**Submitted By:**	Ross Henry

Sample Type: Soil

Sample Name:		31	32	34	35	78
Lab Number:		1165183.1	1165183.2	1165183.3	1165183.4	1165183.5
pH	pH Units	5.7	5.7	5.7	5.6	5.6
Total Nitrogen	%	0.57	0.40	0.71	0.40	0.47
Soluble Salts (Field)	%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/kg	24	28	22	28	14
Total Soluble Salts*	mg/L	145.2	138.6	218	158.4	92.4
Electrical Conductivity (Sat Paste)*	mS/cm	0.2	0.2	0.3	0.2	0.1
Nitrate-N (Sat Paste)*	mg/L	9	5	17	8	3
Ammonium-N (Sat Paste)*	mg/L	3	2	3	2	1
Phosphorus (Sat Paste)*	mg/L	< 1	< 1	2	< 1	< 1
Potassium (Sat Paste)*	mg/L	10	9	21	11	9
Calcium (Sat Paste)*	mg/L	12	12	21	12	10
Magnesium (Sat Paste)*	mg/L	1	2	3	3	2
Sodium (Sat Paste)*	mg/L	16	12	16	14	7
Sodium Absorption Ratio*		1.1	0.9	0.9	0.9	0.5
Soil Sample Depth*	mm	75-150	75-150	75-150	75-150	75-150
Volume Weight	g/mL	0.74	0.83	0.72	0.91	0.90

Sample Name:		79	81	83	84	86
Lab Number:		1165183.6	1165183.7	1165183.8	1165183.9	1165183.10
pH	pH Units	6.1	6.1	5.6	5.9	6.5
Total Nitrogen	%	0.41	0.38	0.61	0.42	0.37
Soluble Salts (Field)	%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/kg	10	12	26	14	24
Total Soluble Salts*	mg/L	105.6	178.2	118.8	72.6	125.4
Electrical Conductivity (Sat Paste)*	mS/cm	0.2	0.3	0.2	0.1	0.2
Nitrate-N (Sat Paste)*	mg/L	8	14	5	3	5
Ammonium-N (Sat Paste)*	mg/L	< 1	3	2	3	2
Phosphorus (Sat Paste)*	mg/L	< 1	< 1	2	1	< 1
Potassium (Sat Paste)*	mg/L	5	8	6	5	6
Calcium (Sat Paste)*	mg/L	14	29	18	6	15
Magnesium (Sat Paste)*	mg/L	2	2	3	< 1	2
Sodium (Sat Paste)*	mg/L	11	11	8	10	9
Sodium Absorption Ratio*		0.7	0.5	0.5	1.0	0.6
Soil Sample Depth*	mm	75-150	75-150	75-150	75-150	75-150
Volume Weight	g/mL	0.77	0.97	0.76	0.88	0.86

Sample Name:		88	89	92	95	96
Lab Number:		1165183.11	1165183.12	1165183.13	1165183.14	1165183.15
pH	pH Units	6.1	6.1	6.0	5.8	5.7
Total Nitrogen	%	0.51	0.48	0.61	0.62	0.68

Sample Type: Soil						
Sample Name:		88	89	92	95	96
Lab Number:		1165183.11	1165183.12	1165183.13	1165183.14	1165183.15
Soluble Salts (Field)	%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/kg	22	22	18	32	14
Total Soluble Salts*	mg/L	205	132.0	125.4	125.4	290
Electrical Conductivity (Sat Paste)*	mS/cm	0.3	0.2	0.2	0.2	0.4
Nitrate-N (Sat Paste)*	mg/L	18	4	4	4	36
Ammonium-N (Sat Paste)*	mg/L	2	3	2	2	4
Phosphorus (Sat Paste)*	mg/L	< 1	< 1	2	< 1	< 1
Potassium (Sat Paste)*	mg/L	16	10	8	4	10
Calcium (Sat Paste)*	mg/L	25	16	10	19	40
Magnesium (Sat Paste)*	mg/L	3	2	1	1	3
Sodium (Sat Paste)*	mg/L	14	9	15	6	23
Sodium Absorption Ratio*		0.7	0.6	1.2	0.4	0.9
Soil Sample Depth*	mm	75-150	75-150	75-150	75-150	75-150
Volume Weight	g/mL	0.75	0.83	0.85	0.72	0.68

Sample Name:		97	102	103	104	111
Lab Number:		1165183.16	1165183.17	1165183.18	1165183.19	1165183.20
pH	pH Units	5.6	5.4	5.4	5.5	5.7
Total Nitrogen	%	0.65	0.87	0.46	0.60	0.41
Soluble Salts (Field)	%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Chloride	mg/kg	34	14	18	24	22
Total Soluble Salts*	mg/L	211	171.6	92.4	138.6	112.2
Electrical Conductivity (Sat Paste)*	mS/cm	0.3	0.3	0.1	0.2	0.2
Nitrate-N (Sat Paste)*	mg/L	15	8	3	9	5
Ammonium-N (Sat Paste)*	mg/L	4	4	2	6	2
Phosphorus (Sat Paste)*	mg/L	< 1	1	1	< 1	< 1
Potassium (Sat Paste)*	mg/L	9	13	5	10	6
Calcium (Sat Paste)*	mg/L	32	16	8	9	14
Magnesium (Sat Paste)*	mg/L	4	4	2	< 1	2
Sodium (Sat Paste)*	mg/L	10	12	7	18	7
Sodium Absorption Ratio*		0.4	0.7	0.6	1.5	0.5
Soil Sample Depth*	mm	75-150	75-150	75-150	75-150	75-150
Volume Weight	g/mL	0.68	0.79	0.95	0.78	0.82

Sample Name:		142				
Lab Number:		1165183.21				
pH	pH Units	6.0	-	-	-	-
Total Nitrogen	%	0.63	-	-	-	-
Soluble Salts (Field)	%	< 0.05	-	-	-	-
Chloride	mg/kg	20	-	-	-	-
Total Soluble Salts*	mg/L	138.6	-	-	-	-
Electrical Conductivity (Sat Paste)*	mS/cm	0.2	-	-	-	-
Nitrate-N (Sat Paste)*	mg/L	14	-	-	-	-
Ammonium-N (Sat Paste)*	mg/L	2	-	-	-	-
Phosphorus (Sat Paste)*	mg/L	< 1	-	-	-	-
Potassium (Sat Paste)*	mg/L	6	-	-	-	-
Calcium (Sat Paste)*	mg/L	21	-	-	-	-
Magnesium (Sat Paste)*	mg/L	2	-	-	-	-
Sodium (Sat Paste)*	mg/L	6	-	-	-	-
Sodium Absorption Ratio*		0.3	-	-	-	-
Soil Sample Depth*	mm	75-150	-	-	-	-
Volume Weight	g/mL	0.72	-	-	-	-

Analyst's Comments

Samples 1-21 Comment:
Sub-soil analysis is generally conducted to investigate whether the soil is appropriate for deep root development of plants such as grape-vines. Nutrient uptake from subsoil is generally very low so the nutrient levels reported for subsoil are less important than pH, Aluminium (exchangeable) and Soluble Salts (field).

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: Soil

Test	Method Description	Default Detection Limit	Samples
Sample Registration*	Samples were registered according to instructions received.	-	1-21
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1-21
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-21
Total Nitrogen	Dumas combustion.	0.04 %	1-2, 4-21
Soluble Salts (Field)	1:5 soil:water extraction followed by potentiometric determination of conductivity. Calculated by EC (mS/cm) x 0.35.	0.05 %	1-21
Chloride	Saturated Calcium Sulphate extraction followed by Potentiometric Titration.	1 mg/kg	1-21
Total Nitrogen*	Determined by NIR, calibration based on Total N by Dumas combustion.	0.04 %	3
Total Soluble Salts*	Saturated Paste extraction followed by potentiometric conductivity determination (25°C).	1.0 mg/L	1-21
Electrical Conductivity (Sat Paste)*	Saturated Paste extraction followed by potentiometric conductivity determination (25°C).	0.1 mS/cm	1-21
Nitrate-N (Sat Paste)*	Saturated Paste extraction followed by Salicylate colorimetry.	1 mg/L	1-21
Ammonium-N (Sat Paste)*	Saturated Paste extraction followed by Berthelot colorimetry.	1 mg/L	1-21
Phosphorus (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-21
Potassium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-21
Calcium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-21
Magnesium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-21
Sodium (Sat Paste)*	Saturated Paste extraction followed by ICP-OES.	1 mg/L	1-21
Sodium Absorption Ratio (SAR)*	Calculation from the sodium, calcium and magnesium determined on a Saturated Paste extract.	0.2	1-21
Volume Weight	The weight/volume ratio of dried, ground soil.	0.01 g/mL	1-21

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.

Sukhjeet Singh DipTech (Science)
Technologist - Agriculture Division

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ANALYSIS REPORT

Client:	MI Swaco	**Lab No:**	1165317
Contact:	Ross Henry	**Date Registered:**	09-Aug-2013
	C/- MI Swaco	**Date Reported:**	22-Aug-2013
	C/- MI-NZ Limited	**Quote No:**	34979
	PO Box 7100	**Order No:**	658
	Fitzroy	**Client Reference:**	
	NEW PLYMOUTH 4341	**Submitted By:**	Ross Henry

Sample Type: Soil

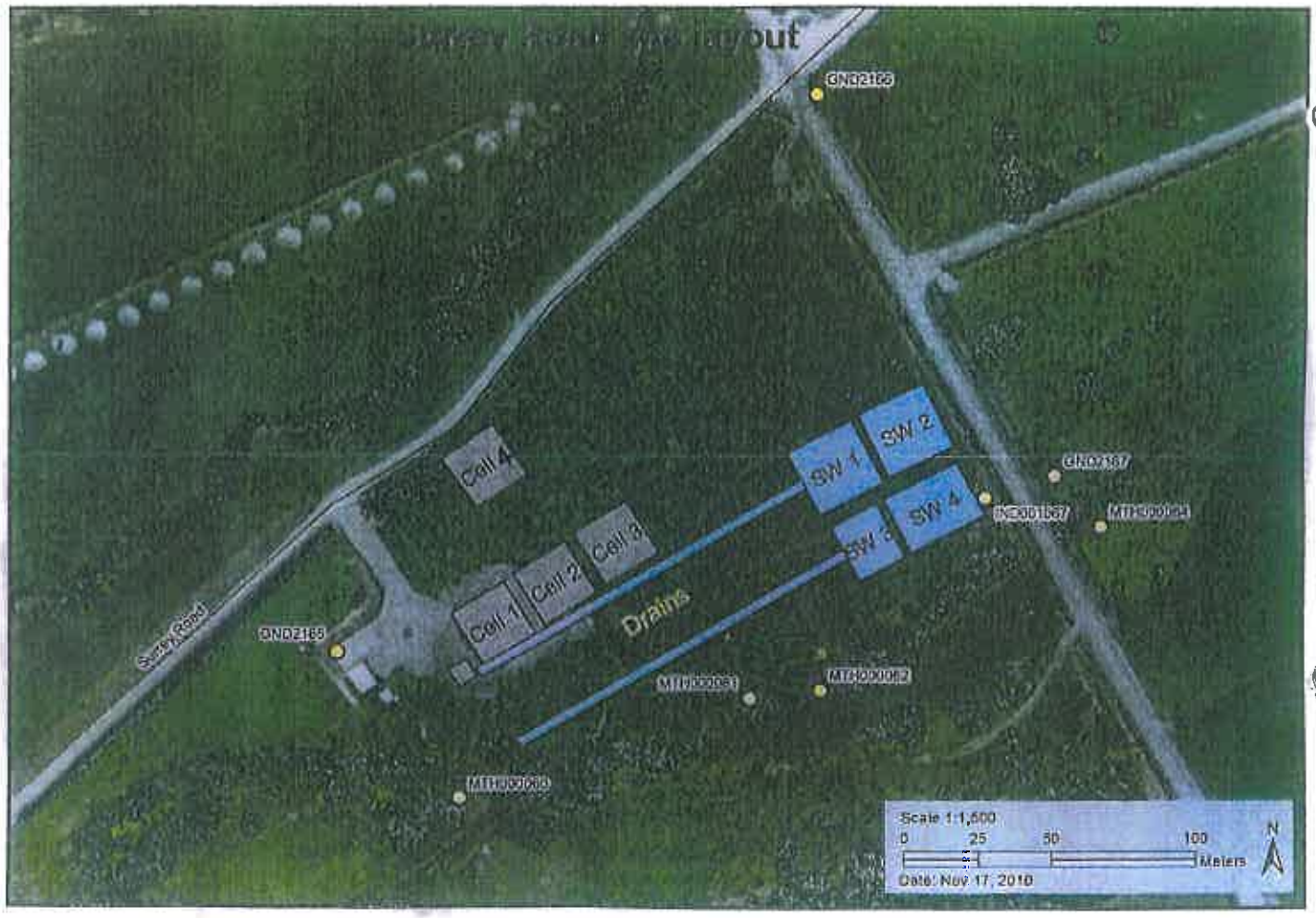
Sample Name:		31	32	34	35	78
Lab Number:		1165317.1	1165317.2	1165317.3	1165317.4	1165317.5
Individual Tests						
Dry Matter	g/100g as rcvd	65	72	49	65	59
Density*	g/mL at 20°C	1.51 #1	1.76 #1	1.42 #1	-	1.40 #1
Total Recoverable Barium	mg/kg dry wt	32	54	46	32	68
Total Recoverable Sodium	mg/kg dry wt	450	590	490	530	580
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	< 0.10	0.19	0.11	< 0.10
Total Recoverable Chromium	mg/kg dry wt	5	5	5	5	6
Total Recoverable Copper	mg/kg dry wt	43	56	43	53	58
Total Recoverable Lead	mg/kg dry wt	5.5	4.2	9.4	5.0	4.7
Total Recoverable Mercury	mg/kg dry wt	0.11	< 0.10	0.11	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Recoverable Zinc	mg/kg dry wt	24	30	23	23	26
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.07	< 0.06	< 0.11	< 0.07	< 0.14
Toluene	mg/kg dry wt	< 0.07	< 0.06	< 0.11	< 0.07	< 0.14
Ethylbenzene	mg/kg dry wt	< 0.07	< 0.06	< 0.11	< 0.07	< 0.14
m&p-Xylene	mg/kg dry wt	< 0.14	< 0.12	< 0.3	< 0.14	< 0.3
o-Xylene	mg/kg dry wt	< 0.07	< 0.06	< 0.11	< 0.07	< 0.14
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Acenaphthylene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Benzo[a]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Benzo[k]fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Chrysene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Fluoranthene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Fluorene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Naphthalene	mg/kg dry wt	< 0.17	< 0.16	< 0.3	< 0.17	< 0.19
Phenanthrene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Pyrene	mg/kg dry wt	< 0.04	< 0.04	< 0.05	< 0.04	< 0.04
Total Petroleum Hydrocarbons in Soil						

Sample Type: Soil						
	Sample Name:	31	32	34	35	78
	Lab Number:	1165317.1	1165317.2	1165317.3	1165317.4	1165317.5
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 10	< 10	< 14	< 11	< 11
C10 - C14	mg/kg dry wt	< 20	< 20	< 30	< 30	< 30
C15 - C36	mg/kg dry wt	< 40	< 40	< 60	< 50	75
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 70	< 70	< 100	< 80	< 80

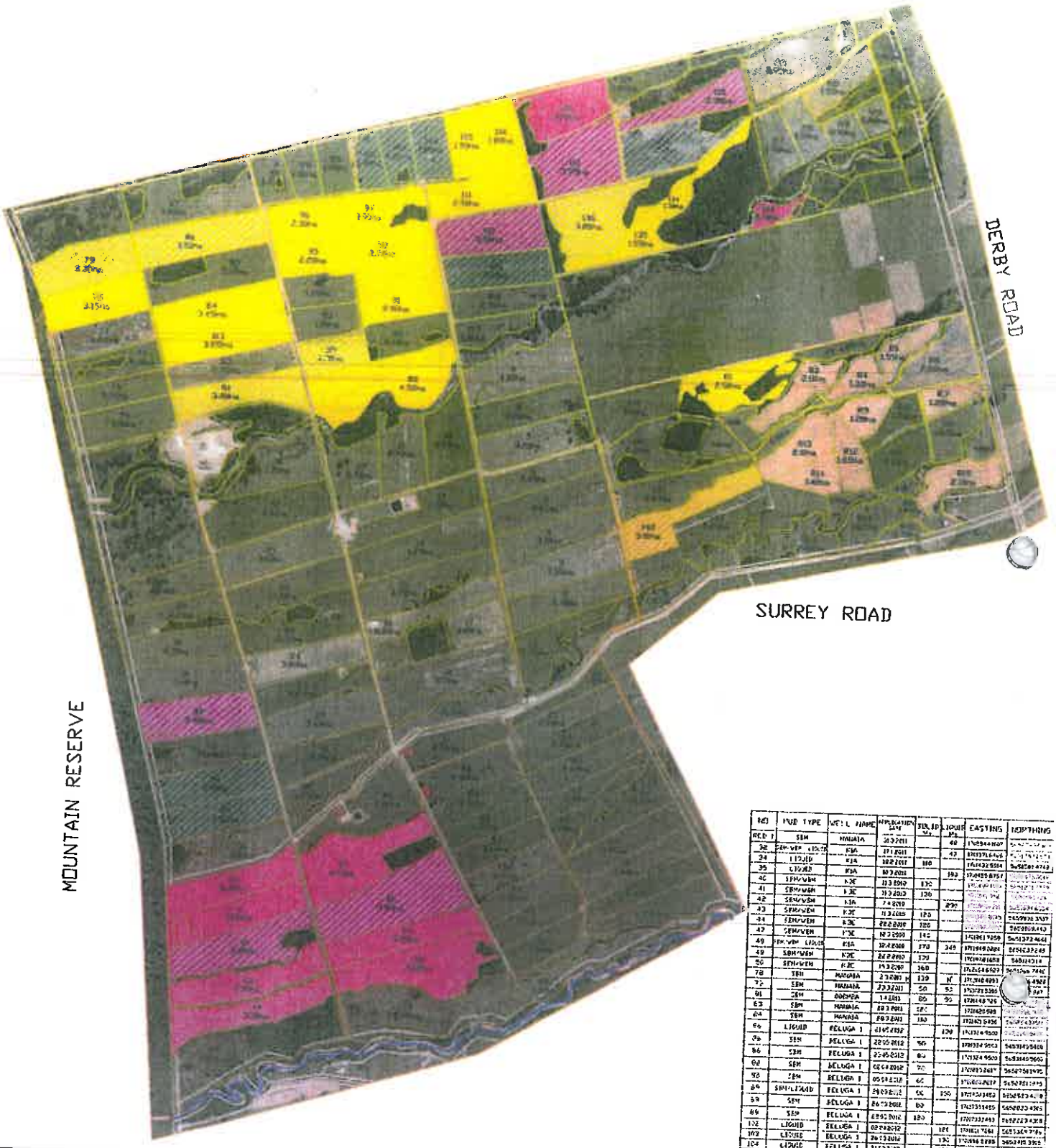
	Sample Name:	79	81	83	84	86
	Lab Number:	1165317.6	1165317.7	1165317.8	1165317.9	1165317.10
Individual Tests						
Dry Matter	g/100g as rcvd	62	77	65	55	69
Density*	g/mL at 20°C	1.60 #1	1.70 #1	1.32 #1	-	-
Total Recoverable Barium	mg/kg dry wt	47	75	37	35	43
Total Recoverable Sodium	mg/kg dry wt	700	970	520	670	610
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	< 2	< 2	< 2	< 2	< 2
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt	6	6	6	6	5
Total Recoverable Copper	mg/kg dry wt	51	44	44	42	37
Total Recoverable Lead	mg/kg dry wt	4.9	2.9	5.8	4.4	4.6
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	3	3	< 2	< 2	< 2
Total Recoverable Zinc	mg/kg dry wt	30	34	27	28	23
BTEX in Soil by Headspace GC-MS						
Benzene	mg/kg dry wt	< 0.13	< 0.06	< 0.12	< 0.15	< 0.12
Toluene	mg/kg dry wt	< 0.13	< 0.06	< 0.12	< 0.15	< 0.12
Ethylbenzene	mg/kg dry wt	< 0.13	< 0.06	< 0.12	< 0.15	< 0.12
m&p-Xylene	mg/kg dry wt	< 0.3	< 0.11	< 0.3	< 0.3	< 0.3
o-Xylene	mg/kg dry wt	< 0.13	< 0.06	< 0.12	< 0.15	< 0.12
Polycyclic Aromatic Hydrocarbons Screening in Soil						
Acenaphthene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Acenaphthylene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Anthracene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Benzo[a]anthracene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Benzo[k]fluoranthene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Chrysene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Fluoranthene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Fluorene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Naphthalene	mg/kg dry wt	< 0.17	< 0.14	< 0.18	< 0.2	< 0.17
Phenanthrene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Pyrene	mg/kg dry wt	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	< 11	< 9	< 11	< 12	< 10
C10 - C14	mg/kg dry wt	< 30	< 20	< 30	< 30	< 20
C15 - C36	mg/kg dry wt	< 50	< 40	< 50	< 50	< 40
Total hydrocarbons (C7 - C36)	mg/kg dry wt	< 80	< 70	< 80	< 90	< 70

	Sample Name:	88	89	92	95	96
	Lab Number:	1165317.11	1165317.12	1165317.13	1165317.14	1165317.15
Individual Tests						
Dry Matter	g/100g as rcvd	67	55	57	52	52
Density*	g/mL at 20°C	-	1.59 #1	1.53 #1	1.42 #1	-

Surrey Rd Site Plan:



Derby Rd Site Plan:



NO	PUD TYPE	WELL NAME	APPLICATION DATE	VOLUME	LIQUID	EASTING	NORTHING
RCD 1	SBM	MANAIA	30/7/2011		40		
32	SBM/VBM	KIA	1/11/2011		42		
34	LIQUID	KIA	18/2/2012	180			
35	LIQUID	KIA	18/2/2012				
40	SBM/VBM	KIA	30/3/2011		180		
41	SBM/VBM	KIA	31/3/2010	130			
42	SBM/VBM	KIA	31/3/2010	130			
43	SBM/VBM	KIA	7/4/2010		200		
44	SBM/VBM	KIA	31/3/2010	120			
47	SBM/VBM	KIA	28/2/2010	120			
48	SBM/VBM	KIA	28/2/2010	140			
49	SBM/VBM LIQUID	KIA	28/2/2010	170	340		
49	SBM/VBM	KIA	28/2/2010	170			
50	SBM/VBM	KIA	28/2/2010	120			
78	SBM	KIA	19/3/2010	160			
72	SBM	MANAIA	2/3/2011	120			
81	SBM	MANAIA	2/3/2011	60	80		
62	SBM	BOOMER	1/4/2011	60	90		
63	SBM	MANAIA	8/3/2011	180			
64	SBM	MANAIA	8/3/2011	180			
66	LIQUID	BELUGA 1	6/12/2012		170		
86	SBM	BELUGA 1	22/05/2012	160			
86	SBM	BELUGA 1	22/05/2012	80			
92	SBM	BELUGA 1	02/08/2012	70			
93	SBM	BELUGA 1	05/08/2012	60			
84	SBM/LIQUID	BELUGA 1	29/08/2012	50	150		
89	SBM	BELUGA 1	26/10/2011	80			
89	SBM	BELUGA 1	26/10/2012	120			
102	LIQUID	BELUGA 1	02/08/2012		120		
102	LIQUID	BELUGA 1	26/10/2012		130		
104	LIQUID	BELUGA 1	31/10/2012		120		
104	LIQUID	BELUGA 1	12/07/2012		120		
101	LIQUID	BELUGA 1	26/10/2012		140		
88	SBM	MANAIA	16/3/2011	50			
90	SBM	MANAIA	16/3/2011	70			
94	SBM	MANAIA	16/3/2011	50			
97	SBM	MANAIA	16/3/2011		170		
105	SBM	MANAIA	16/3/2011	60			
106	SBM	MANAIA	16/3/2011				
109	LIQUID	MANAIA	9/4/2011		80		
110	SBM/VBM	MANAIA	1/4/2011		160		
111	SBM	MANAIA	28/3/2011	80			
112	SBM/VBM	BELUGA 1	17/8/2011		120		
113	SBM/VBM	BELUGA 1	23/12/2011	60			
115	SBM/VBM	BELUGA 1	11/8/2011		150		
133	SBM/VBM	BEL					
138	SBM	MAN	15/3/2011	80	40		
139	SBM	MAN	15/3/2011	80	40		
140	SBM	MAN	15/3/2011	80			
142	SBM	MANAIA	23/3/2011	80	120		
143	SBM	BEL	23/3/2011	80	120		
144	SBM	MANAIA	23/3/2011	80	120		
145	SBM	MANAIA	23/3/2011	80	120		
146	SBM	MANAIA	23/3/2011	80	120		
147	SBM	MANAIA	23/3/2011	80	120		
148	SBM	MANAIA	23/3/2011	80	120		
149	SBM	MANAIA	23/3/2011	80	120		
150	SBM	MANAIA	23/3/2011	80	120		
151	SBM	MANAIA	23/3/2011	80	120		
152	SBM	MANAIA	23/3/2011	80	120		
153	SBM	MANAIA	23/3/2011	80	120		
154	SBM	MANAIA	23/3/2011	80	120		
155	SBM	MANAIA	23/3/2011	80	120		
156	SBM	MANAIA	23/3/2011	80	120		
157	SBM	MANAIA	23/3/2011	80	120		
158	SBM	MANAIA	23/3/2011	80	120		
159	SBM	MANAIA	23/3/2011	80	120		
160	SBM	MANAIA	23/3/2011	80	120		
161	SBM	MANAIA	23/3/2011	80	120		
162	SBM	MANAIA	23/3/2011	80	120		
163	SBM	MANAIA	23/3/2011	80	120		
164	SBM	MANAIA	23/3/2011	80	120		
165	SBM	MANAIA	23/3/2011	80	120		
166	SBM	MANAIA	23/3/2011	80	120		
167	SBM	MANAIA	23/3/2011	80	120		
168	SBM	MANAIA	23/3/2011	80	120		
169	SBM	MANAIA	23/3/2011	80	120		
170	SBM	MANAIA	23/3/2011	80	120		
171	SBM	MANAIA	23/3/2011	80	120		
172	SBM	MANAIA	23/3/2011	80	120		
173	SBM	MANAIA	23/3/2011	80	120		
174	SBM	MANAIA	23/3/2011	80	120		
175	SBM	MANAIA	23/3/2011	80	120		
176	SBM	MANAIA	23/3/2011	80	120		
177	SBM	MANAIA	23/3/2011	80	120		
178	SBM	MANAIA	23/3/2011	80	120		
179	SBM	MANAIA	23/3/2011	80	120		
180	SBM	MANAIA	23/3/2011	80	120		
181	SBM	MANAIA	23/3/2011	80	120		
182	SBM	MANAIA	23/3/2011	80	120		
183	SBM	MANAIA	23/3/2011	80	120		
184	SBM	MANAIA	23/3/2011	80	120		
185	SBM	MANAIA	23/3/2011	80	120		
186	SBM	MANAIA	23/3/2011	80	120		
187	SBM	MANAIA	23/3/2011	80	120		
188	SBM	MANAIA	23/3/2011	80	120		
189	SBM	MANAIA	23/3/2011	80	120		
190	SBM	MANAIA	23/3/2011	80	120		
191	SBM	MANAIA	23/3/2011	80	120		
192	SBM	MANAIA	23/3/2011	80	120		
193	SBM	MANAIA	23/3/2011	80	120		
194	SBM	MANAIA	23/3/2011	80	120		
195	SBM	MANAIA	23/3/2011	80	120		
196	SBM	MANAIA	23/3/2011	80	120		
197	SBM	MANAIA	23/3/2011	80	120		
198	SBM	MANAIA	23/3/2011	80	120		
199	SBM	MANAIA	23/3/2011	80	120		
200	SBM	MANAIA	23/3/2011	80	120		

LEGEND

- LIQUID ONLY
- MIX
- SBM
- VBM
- FENCE
- ROAD

NOTES

1. CO ORDINATE SYSTEN - NZTM2000
2. HEIGHTS ABOVE SEA LEVEL

DERBY AND SURREY ROAD
LANDSPREAD DISPOSAL SITE PLAN
SHOWING AREAS OF DISPOSAL

NO.	DATE	BY	CHD	DESCRIPTION
1	25-8-11	BP	CW	ADD PADDOCKS & LANDSPREAD INFO
1	01-11-12	BP	CW	ADD NEW LANDSPREAD INFO

DRAWN BY BP 01-11-2012
PROJECT No. 102
LOCATION SURREY ROAD
SCALE 1 : 1500

DRAWING No. MI SWACO 101 RE 1

GPS SOLUTIONS FREEPHONE 0800 756 764
CELLPHONE 027 477 6971

NO.	MUD TYPE	WELL NAME	APPLICATION DATE	SOLID M3	LIQUID M3	EASTING	NORTHING	AREA /Ha.
RED 1	SBM	MANAIA	31.3.2011					
32	SBM/WBM LIQUID	K1A	17.1.2011		40	1702844.1007	5652779.0369	2.50
34	LIQUID	K1A	18.2.2011	110		1701371.6466	5651757.2574	3.40
35	LIQUID	K1A	10.3.2011		190	1701432.5514	5651561.4748	3.10
40	SBM/WBM	K3E	11.3.2010	130		1701455.8797	5651475.0048	3.00
41	SBM/WBM	K3E	11.3.2010	130		1701492.1158	5651271.3579	3.20
42	SBM/WBM	K1A	7.4.2010		290	1701512.756	5651190.724	3.20
43	SBM/WBM	K3E	11.3.2010	120		1701521.6211	5651094.6354	3.80
44	SBM/WBM	K3E	22.2.2010	120		1701545.8045	5650992.3507	3.35
47	SBM/WBM	K3E	12.3.2010	140		1701557.7892	5650909.443	3.50
48	SBM/WBM LIQUID	K1A	12.4.2010	170	340	1701861.7859	5651373.4661	4.70
49	SBM/WBM	K3E	22.2.2010	100		1701949.0284	5651239.249	5.90
50	SBM/WBM	K3E	15.3.2010	160		1701978.1652	565143.14	3.20
78	SBM	MANAIA	2.3.2011 M	130	M	1702004.6929	5651066.7448	5.00
79	SBM	MANAIA	23.3.2011	50	90	1701040.4093	5652946.4928	3.15
81	SBM	008M2A	1.4.2011	80	90	1701021.5305	5653061.987	3.30
83	SBM	MANAIA	28.3.2011	120		1701449.729	5652706.3823	3.00
84	SBM	MANAIA	28.3.2011	110		1701420.905	5652856.1608	3.05
86	LIQUID	BELUGA 1	21.05.2012		130	1701401.5436	5652943.1511	3.45
86	SBM	BELUGA 1	22.05.2012	50		1701324.9500	5653140.5600	3.50
86	SBM	BELUGA 1	23.05.2012	80		1701324.9500	5653140.5600	3.50
88	SBM	BELUGA 1	02.04.2012	70		1701324.9500	5653140.5600	3.50
88	SBM	BELUGA 1	05.04.2012	60		1701880.2617	5652751.1995	4.50
89	SBM/LIQUID	BELUGA 1	20.03.2012	80	130	1701880.2617	5652751.1995	4.50
89	SBM	BELUGA 1	26.03.2012	80		1701730.1480	5652823.4308	1.70
89	SBM	BELUGA 1	28.03.2012	120		1701730.1480	5652823.4308	1.70
102	LIQUID	BELUGA 1	02.04.2012		120	1701730.1480	5652823.4308	1.70
103	LIQUID	BELUGA 1	26.03.2012		190	1701801.7281	5653389.7186	1.30
104	LIQUID	BELUGA 1	21.03.2012		130	1701886.5895	5653415.3915	1.30
104	LIQUID	BELUGA 1	22.03.2012		30	1701801.7281	5653431.6192	1.80
104	LIQUID	BELUGA 1	26.03.2012		140	1701801.7281	5653431.6192	1.80
92	SBM	MANAIA	16.3.2011	50		1701801.7281	5653431.6192	1.80
95	SBM	MANAIA	16.3.2011	70		1701880.9803	5653141.5536	2.70
96	SBM	MANAIA	16.3.2011	20		1701650.4624	5653102.5932	2.20
97	SBM	MANAIA	15.3.2011		170	1701629.1445	5653205.2419	2.30
105	SBM	MR2P1	30.3.2010	120		1701838.4469	5653251.7244	1.90
106	SBM	MR2P1	30.3.2010	100		1702086.3883	5653451.5115	1.90
109	LIQUID	MANAIA	9.9.2010		20	1702185.2255	5653468.9424	1.80
110	SBM/WBM	MANAIA	2.6.2010		380	1702181.9172	5653079.0521	3.10
111	SBM	MANAIA	28.3.2011	120		1702151.6533	5653186.6314	3.50
112	SBM/WBM	BELUGA 1	17.6.2010		430	1702129.2835	5653302.9184	2.90
113	SBM/WBM	MANGAHEWA A/ MR3P8/MR4P9/M R5P12	23.4.2009	600		1702400.5903	5653403.0924	3.95
115	SBM/WBM	BELUGA 1	1.12.2010		190	1702366.1241	5653556.1796	3.20
133	SBM/WBM	BELUGA 1				1702713.8302	5653586.2504	2.30
134	SBM	MR1P7 / MR2P1	18.3.2010	120	40	1702947.5999	5653281.2916	070
135	SBM	MR1P7 / MR2P1	18.3.2010	120	40	1702679.6848	5653306.816	1.30
136	SBM	MR1P7 / MR2P1	8.9.2010	90	120	1702585.4113	5653198.2808	1.55
138	LIQUID	BELUGA 1	18.6.2010		370	1702442.6169	5653242.1715	3.80
142	SBM	MANAIA	28.3.2011	150	150	1702646.6426	5653461.9277	3.50
						1702742.882	5652416.2866	3.10

MI SWACO

A Schlumberger Company

ANNUAL RECORDS FOR

CONSENT 6900-1

CONSENT 7559-1

BOYD LANDFARM

INGLEWOOD

JULY 31 2012

Summary of status of landfarms.

The Surrey Road landfarm still remains empty, with no stored drilling waste on site.

All previously stored material at the Derby Road site has now been spread from cells 1,2,7 & 8. These cells are now empty.

119.49 cubic metres of drilling waste was received in March/April 2012 at the Derby Road landfarm under the consent 6900-1. This material is stored in cell 3, and will be spread over the coming summer period.

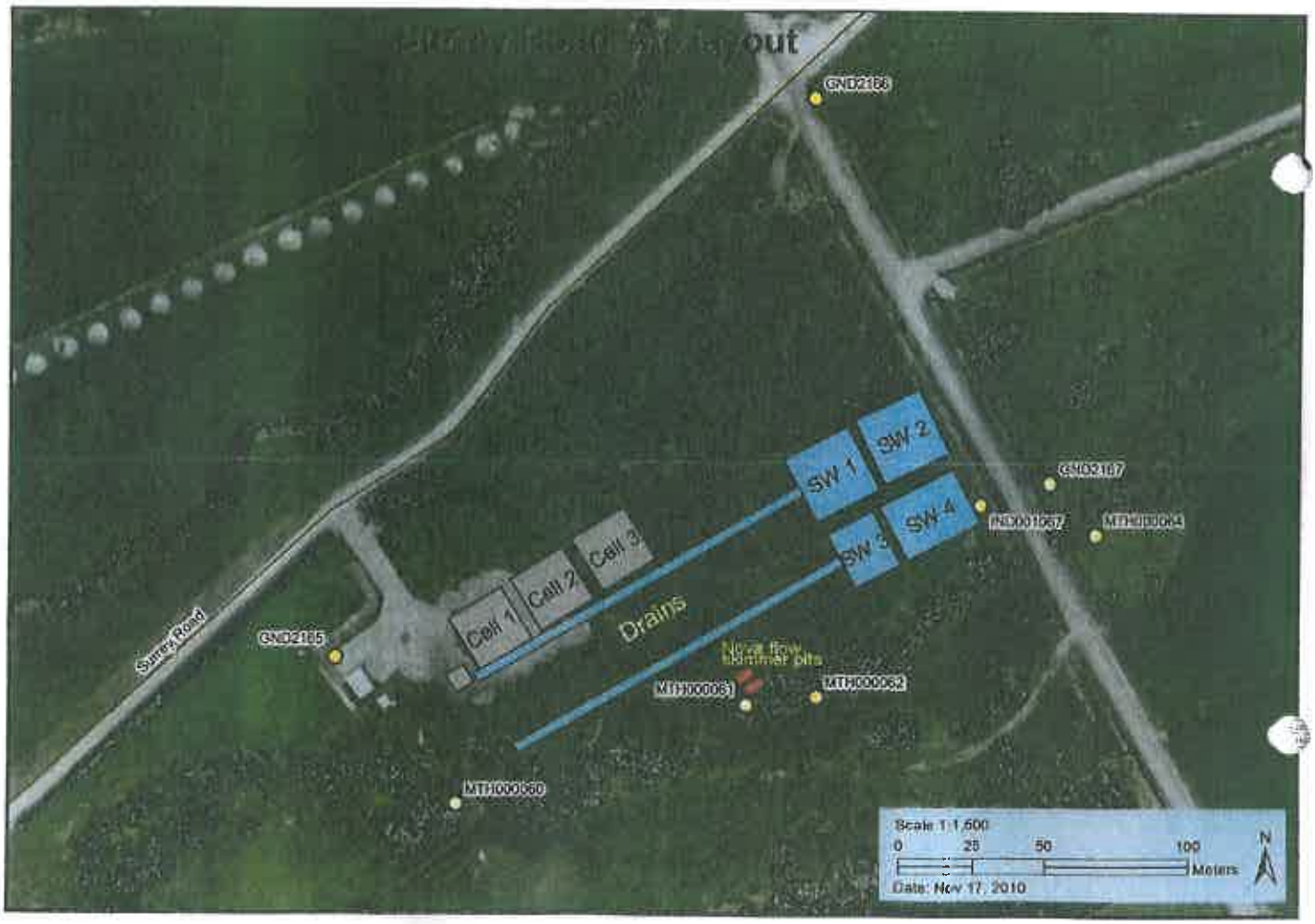
A change was made to our monitoring procedure of stormwater this season, following suggestions by Shane Reynolds from TRC.
Previously only one BOD (Biochemical Oxygen Demand) sample downstream from the stormwater discharge point. Now we also take an upstream BOD sample as a base line to show actual differences caused by our stormwater.
This has been very successful, and has shown our stormwater to have a very minor effect on the stream, well within TRC limits.

Colin Boyd has refined his landspreading machinery and techniques this season. He has purchased a very large set of discs, towed behind a bulldozer or large tractor. After the drilling waste was landspread, the paddocks were later cultivated with the discs. This results in the material being incorporated into the soil to a depth of at least 300mm. Colin has demonstrated this procedure to John Cooper from TRC. The results have been very successful, and has shown excellent plant health and growth in the subsequent sown pasture.

Inspections of previously landspread areas from past seasons still shown excellent pasture health, showing a slight line where there was no spreading near drains in some paddocks. We attribute this to minerals from the drilling waste being of benefit to the pasture.

Derby Rd Site Plan:

Surrey Rd Site Plan:



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MASTER DRILLING WASTE SUMMARY - DERBY ROAD LANDFARM

DWM No.	*Type of Waste*	*Waste Origin*	*Project*	*Wellsite*	*Total Waste, MT*	*S.G*	*Total Waste, m3*	*Period received at Site*	*PIT*	*Notified TRC?*	*Landspread*		*Drop dead L/S date*
010	SBM Cuttings	KEA	LMP	Puka 1			119.5	23/03/12-24/4/12	3		Stored		
009	SBM Cuttings	KEA	LMP	Beluga 1	1207	1.5	805	09/05/10-30/06/10	1,2,7,8		Now Spread		
TOTAL DRILLING WASTE RECEIVED TO DATE					**1207**		**924.5**						
					MT		**M3**						

Drilling Waste Summary - Derby Rd Landfarm

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:	MI Swaco	**Lab No:**	879632	SPv1
Contact:	Ross Henry	**Date Registered:**	22-Mar-2011	
	C/- MI Swaco	**Date Reported:**	31-Mar-2011	
	MI-NZ Ltd	**Quote No:**		
	PO Box 7100	**Order No:**	MIPN004235	
	Fitzroy	**Client Reference:**	Soil & Water	
	NEW PLYMOUTH 4341	**Submitted By:**	Ross Henry	

Sample Type: Sludge

	Sample Name:	Cell 1 Derby Rd (Solid Fraction) 16-Mar-2011 2:00 pm	Cell 7 Derby Rd (Solid Fraction) 16-Mar-2011 2:00 pm	Cell 8 Derby Rd (Solid Fraction) 16-Mar-2011 2:00 pm		
	Lab Number:	879632.1	879632.2	879632.3		
Individual Tests						
Dry Matter	g/100g as rcvd	42	62	72	-	-
Total Nitrogen*	g/100g as rcvd	0.23	0.11	0.15 #1	-	-
Total Petroleum Hydrocarbons in Soil						
C7 - C9	mg/kg dry wt	280	420	95	-	-
C10 - C14	mg/kg dry wt	71,000	33,000	43,000	-	-
C15 - C36	mg/kg dry wt	153,000	89,000	132,000	-	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt	220,000	122,000	175,000	-	-

Analyst's Comments

#1 It should be noted that the replicate analyses performed on this sample as part of our in-house Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample. The average of the results of the replicate analyses has been reported.

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: Sludge

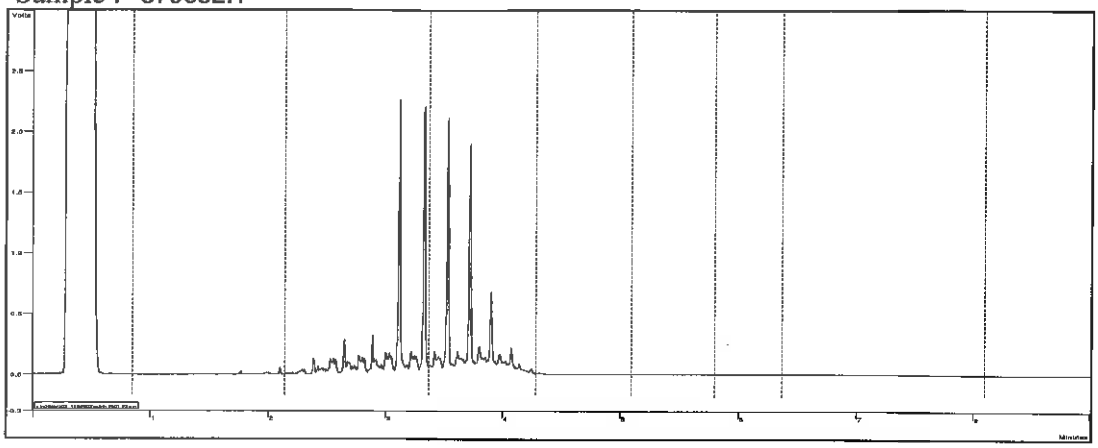
Test	Method Description	Default Detection Limit	Samples
Total Petroleum Hydrocarbons in Soil	Sonication extraction in DCM, Silica cleanup, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines. Tested on as received sample	-	1-3
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. US EPA 3550.	0.10 g/100g as rcvd	1-3
Total Nitrogen*	Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g as rcvd	1-3

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

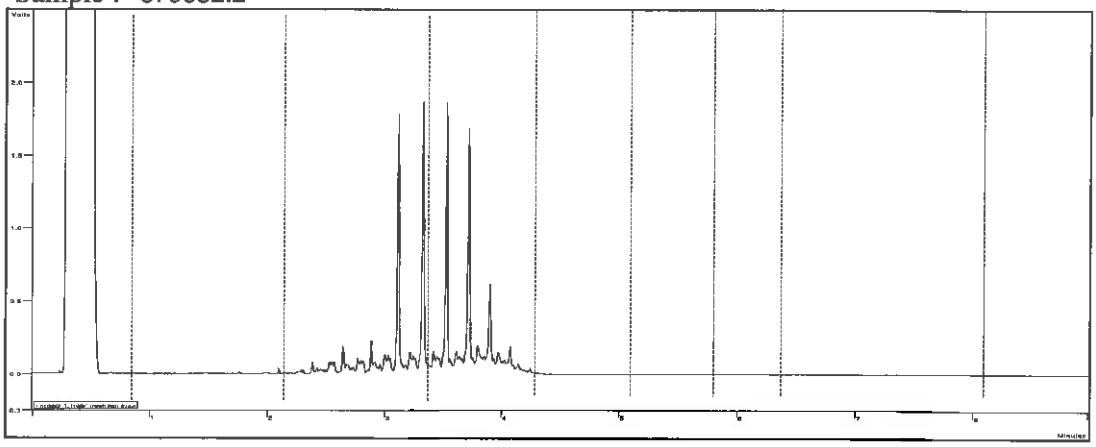
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

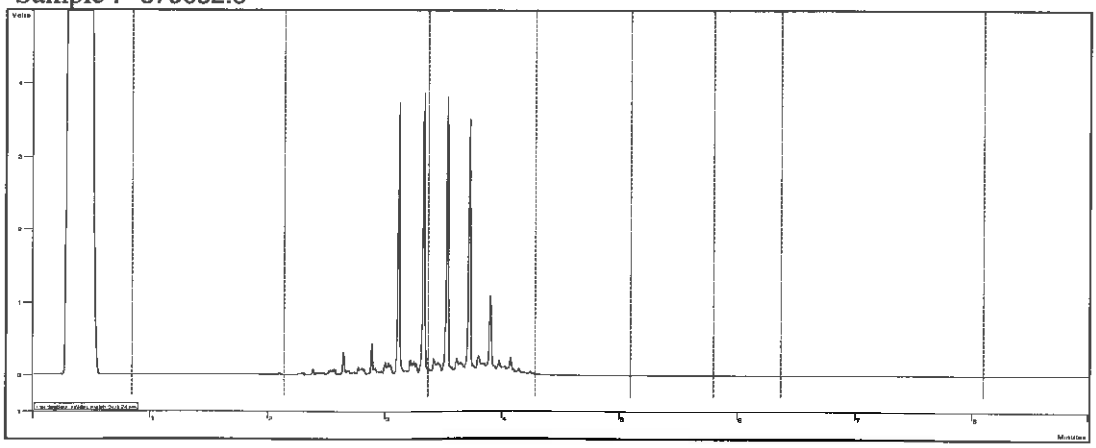
Sample : 879632.1



Sample : 879632.2



Sample : 879632.3



C7 C10 C15 C20 C25 C30 C34 C44

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:	MI Swaco	**Lab No:**	964634	SPv1
Contact:	Ross Henry	**Date Registered:**	21-Dec-2011	
	C/- MI Swaco	**Date Reported:**	09-Jan-2012	
	C/- MI-NZ Ltd	**Quote No:**		
	PO Box 7100	**Order No:**	MIPN005060	
	Fitzroy	**Client Reference:**		
	NEW PLYMOUTH 4341	**Submitted By:**	Ross Henry	

Sample Type: Aqueous

Sample Name:		Derby SW2 16-Dec-2011 2:00 pm	Derby SW2 Outlet Sample 16-Dec-2011 2:00 pm	Derby SW2 Upstream Sample 16-Dec-2011 2:00 pm		
Lab Number:		964634.1	964634.2	964634.3		
pH	pH Units	6.9	-	-	-	-
Total Suspended Solids	g/m³	5	-	-	-	-
Free Ammonia*	g/m³ at 20°C	< 0.010	-	-	-	-
Total Ammoniacal-N	g/m³	< 0.010	-	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	3.7	3.8	< 1.0	-	-
Oil and Grease	g/m³	11	-	-	-	-

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
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	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/m³	1
Free Ammonia*	Calculation from NH4N, pH, Temperature (Calculations based on data for distilled water). APHA Table 8010:VI 21st ed. 2005.	0.010 g/m³ at 20°C	1
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4^+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 21st ed. 2005.	0.010 g/m³	1
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. Analysed at; 25 Te Aroha Street, Hamilton. APHA 5210 B 21st ed. 2005.	1.0 g O_2/m³	1-3
Oil and Grease	Sample filtration through filter aid, Soxhlet extraction, gravimetric determination of extracted Oil & Grease. APHA 5520 D 21st ed. 2005.	4 g/m³	1

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.

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

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	MI Swaco	**Lab No:**	1030153	SPv1
Contact:	Ross Henry	**Date Registered:**	27-Jul-2012	
	C/- MI Swaco	**Date Reported:**	07-Aug-2012	
	C/- MI-NZ Ltd	**Quote No:**	34979	
	PO Box 7100	**Order No:**	MIPN005883	
	Fitzroy	**Client Reference:**	Soil & Water	
	NEW PLYMOUTH 4341	**Submitted By:**	Ross Henry	

Sample Type: Aqueous

		Sample Name:	Derby SW2 25-Jul-2012 11:00 am	Upstream Sample 25-Jul-2012 11:00 am			
		Lab Number:	1030153.1	1030153.2			
Individual Tests							
pH	pH Units		7.2	-	-	-	-
Total Suspended Solids	g/m³		9	-	-	-	-
Free Ammonia*	g/m³ at 20°C		< 0.010	-	-	-	-
Total Ammoniacal-N	g/m³		< 0.010	-	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³		0.29	-	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³		5	< 2	-	-	-
Chemical Oxygen Demand (COD)	g O_2/m³		18	-	-	-	-
Oil and Grease	g/m³		14	-	-	-	-
Chlorine, Free & Combined							
Free Chlorine	g/m³		0.11	-	-	-	-
Combined Chlorine	g/m³		< 0.08	-	-	-	-

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

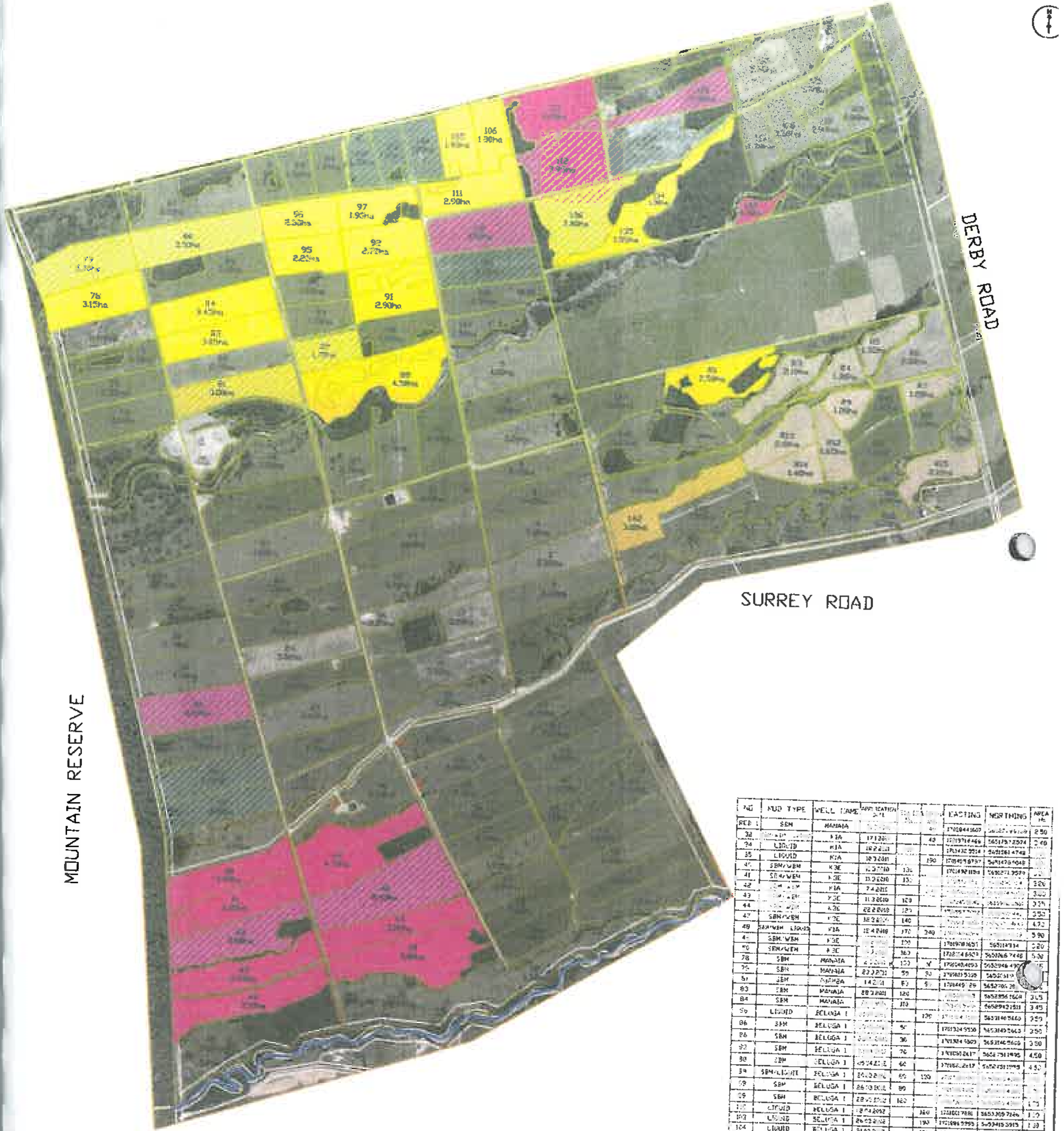
Test	Method Description	Default Detection Limit	Samples
Chlorine, Free & Combined	DPD Colorimetric	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	1
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	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/m³	1
Free Ammonia*	Calculation from NH4N, pH, Temperature (Calculations based on data for distilled water). APHA Table 8010:VI 21st ed. 2005.	0.010 g/m³ at 20°C	1
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 21st ed. 2005.	0.010 g/m³	1
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} C. (modified) 4500 NH_3 F (modified) 21st ed. 2005.	0.10 g/m³	1
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. Analysed at Hill Laboratories - Microbiology; 1 Clow Place, Hamilton. APHA 5210 B 21st ed. 2005.	2 g O_2/m³	1-2
Chemical Oxygen Demand (COD), trace level	Dichromate/sulphuric acid digestion in Hach tubes, colorimetry. Trace Level method. APHA 5220 D 21st ed. 2005.	6 g O_2/m³	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Oil and Grease	Sample filtration through filter aid, Soxhlet extraction, gravimetric determination of extracted Oil & Grease. APHA 5520 D 21st ed. 2005.	4 g/m³	1

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.

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



NO	MUD TYPE	WELL NAME	APPLICATION DATE	[illegible]	[illegible]	EASTING	NORTHING	AREA Ha
REF 1	SBM	MANAIA	[illegible]		40	1705844.1607	[illegible]	2.50
32	[illegible]	KIA	17.1.2011		42	1701971.6466	5651757.2574	2.40
34	LIQUID	KIA	16.2.2011	[illegible]		1703432.9914	5651561.4748	[illegible]
35	LIQUID	KIA	10.3.2011		190	1701459.8737	5651475.4048	[illegible]
40	SBM/WBM	K3E	11.3.2010	130		1701492.1194	5651271.9579	[illegible]
41	SBM/WBM	K3E	11.3.2010	130		[illegible]	[illegible]	3.26
42	[illegible]	KIA	7.4.2010		[illegible]	[illegible]	[illegible]	3.00
43	[illegible]	K3E	11.3.2010	100		[illegible]	[illegible]	3.25
44	[illegible]	K3E	22.2.2010	120		[illegible]	[illegible]	3.50
47	SBM/WBM	K3E	18.3.2010	140		[illegible]	[illegible]	4.72
48	SBM/WBM LIQUID	KIA	12.4.2010	170	240	[illegible]	[illegible]	5.90
49	SBM/WBM	K3E	[illegible]	100		1701978.1651	565114.9314	2.20
50	SBM/WBM	K3E	[illegible]	360		[illegible]	5650066.7448	5.00
78	SBM	MANAIA	[illegible]	100	V	1700040.4893	5652946.49[illegible]	[illegible]
79	SBM	MANAIA	23.2.2011	55	90	1701821.5109	[illegible]	[illegible]
81	SBM	MANAIA	14.2.2011	50	50	[illegible]	[illegible]	[illegible]
83	SBM	MANAIA	28.2.2011	120		[illegible]	5652956.1669	3.15
84	SBM	MANAIA	[illegible]	110		[illegible]	5652942.1511	3.45
56	LIQUID	BELUGA 1	[illegible]		120	[illegible]	5653140.5660	3.50
86	SBM	BELUGA 1	[illegible]	50		1701324.9550	5653140.5663	3.50
88	SBM	BELUGA 1	[illegible]	36		1701324.9509	5653140.5660	3.50
92	SBM	BELUGA 1	[illegible]	70		1701069.2417	5652751.1995	4.50
90	SBM	BELUGA 1	25.04.2012	60		1701062.2617	5652751.1995	4.52
39	SBM/LIQUID	BELUGA 1	24.05.2012	50	120	[illegible]	[illegible]	[illegible]
99	SBM	BELUGA 1	26.03.2012	80		[illegible]	[illegible]	[illegible]
99	SBM	BELUGA 1	22.05.2012	160		[illegible]	[illegible]	[illegible]
102	LIQUID	BELUGA 1	12.04.2012		360	1701001.7881	5653309.7266	1.10
103	LIQUID	BELUGA 1	26.03.2012		190	1701891.5995	5653415.5915	1.50
104	LIQUID	BELUGA 1	21.03.2012		130	1701601.7291	5653431.6192	1.50
104	LIQUID	BELUGA 1	22.03.2012		50	[illegible]	5653431.6192	[illegible]
104	LIQUID	BELUGA 1	26.03.2012		240	1701601.7281	5653431.6192	[illegible]
92	SBM	MANAIA	16.3.2011	50		[illegible]	[illegible]	2.70
95	SBM	MANAIA	16.3.2011	70		[illegible]	[illegible]	[illegible]
96	SBM	MANAIA	16.3.2011	20		1701629.1445	5653205.2419	2.20
97	SBM	MANAIA	15.3.2011		170	[illegible]	[illegible]	[illegible]
105	SBM	MR2P1	30.3.2010	120		[illegible]	[illegible]	[illegible]
106	SBM	MR2P1	30.3.2010	160		[illegible]	[illegible]	[illegible]
109	LIQUID	MANAIA	9.9.2010		20	[illegible]	[illegible]	[illegible]
110	SBM/WBM	MANAIA	2.6.2010		360	1702159.6533	5653286.6364	[illegible]
111	SBM	MANAIA	28.7.2011	120		1702121.2635	5653302.9124	2.00
112	SBM/WBM	BELUGA 1	17.6.2010		[illegible]	[illegible]	[illegible]	3.95
113	SBM/WBM	[illegible]	23.4.2009	[illegible]		1702366.1341	[illegible]	3.00
115	SBM/WBM	BELUGA 1	11.2.2010		190	[illegible]	[illegible]	2.70
131	SBM/WBM	BELUGA 1				1702947.5799	[illegible]	[illegible]
134	SBM	[illegible]	13.3.2010	120	40	[illegible]	5653206.616	[illegible]
135	SBM	[illegible]	18.3.2010	110	45	[illegible]	[illegible]	1.55
136	SBM	MR2P1	2.9.2010	95	120	1702442.6469	[illegible]	2.50
138	LIQUID	BELUGA 1	15.6.2010		370	1702646.6421	5651441.9277	3.50
142	SBM	MANAIA	[illegible]	[illegible]	150	[illegible]	[illegible]	[illegible]

LEGEND

- LIQUID ONLY
- MIX
- SBM
- WBM
- FENCE
- ROAD

COORDINATE SYSTEM : NZTM2000
HEIGHTS ABOVE SEA LEVEL

GPS SOLUTIONS FREEPHONE 0800 752 705
DATA AGENTS CELLPHONE 027 477 6271

DERBY AND SURREY ROAD LANDSPREAD DISPOSAL SITE PLAN SHOWING AREAS OF DISPOSAL

NO.	DATE	BY	CHD	DESCRIPTION
1	25-8-11	BP	CW	ADD PADDOCKS & LANDSPREAD INFO
1	01-11-12	BP	CW	ADD NEW LANDSPREAD INFO

DRAWN BY	BP	01-11-2012
PROJECT No.	102	
LOCATION	SURREY ROAD	
SCALE	1 : 1500	

DRAWING No. MI SWACO 101 REV 1

NO.	MUD TYPE	WELL NAME	APPLICATION DATE	DEPTH (m)	LOCATION (m)	EASTING	NORTHING	AREA (Ha.)
PED 1	SBM	MANAIA	21.3.2011		40	1702344.1107	5653279.0049	2.50
32	SBM/WBM LIQUID	KIA	17.1.2011		40	1701371.6466	5651757.2574	3.40
34	LIQUID	KIA	16.2.2011	110		1701432.5514	5651561.4748	3.10
35	LIQUID	KIA	16.3.2011		190	1701495.5797	5651475.0042	3.40
40	SBM/WBM	K3E	11.3.2010	150		1701492.1198	5651671.2879	3.20
41	SBM/WBM	K3E	11.3.2010	130		1701512.756	5651130.784	3.20
42	SBM/WBM	KIA	7.4.2010		290	1701521.6211	5651094.6354	3.80
43	SBM/WBM	K3E	11.3.2010	120		1701545.2045	5650992.3707	3.35
44	SBM/WBM	K3E	22.3.2010	120		1701557.7893	5650909.443	3.50
47	SBM/WBM	K3E	12.3.2010	140		1701961.7859	5651373.4661	4.70
48	SBM/WBM LIQUID	KIA	18.4.2010	170	140	1701949.0284	5651239.249	5.90
49	SBM/WBM	K3E	22.3.2010	100		1701978.1652	5651143.14	3.20
50	SBM/WBM	K3E	15.3.2010	160		1702004.6929	5651066.7448	5.00
78	SBM	MANAIA	2.3.2011 M	130	M	1701040.4093	5652946.4923	3.15
79	SBM	MANAIA	23.3.2011	50	90	1701021.5305	5653061.987	3.30
81	SBM	008M2A	1.4.2011	80	90	1701449.729	5652706.3823	3.00
83	SBM	MANAIA	28.3.2011	120		1701420.905	5652956.1608	3.05
84	SBM	MANAIA	28.3.2011	110		1701401.5436	5652943.1511	3.45
86	LIQUID	BELUGA 1	21.05.2012		130	1701324.9500	5653140.5600	3.50
86	SBM	BELUGA 1	22.05.2012	50		1701324.9500	5653140.5600	3.50
86	SBM	BELUGA 1	23.05.2012	80		1701324.9500	5653140.5600	3.50
88	SBM	BELUGA 1	02.04.2012	70		1701380.2617	5652751.1995	4.50
88	SBM	BELUGA 1	05.04.2012	60		1701380.2617	5652751.1995	4.50
89	SBM/LIQUID	BELUGA 1	20.03.2012	80	130	1701730.1480	5652823.4308	1.70
89	SBM	BELUGA 1	26.03.2012	80		1701730.1480	5652823.4308	1.70
89	SBM	BELUGA 1	28.03.2012	120		1701730.1480	5652823.4308	1.70
102	LIQUID	BELUGA 1	02.04.2012		120	1701801.7281	5653389.7186	1.30
103	LIQUID	BELUGA 1	26.03.2012		190	1701936.5205	5653415.3915	1.30
104	LIQUID	BELUGA 1	21.03.2012		130	1701801.7281	5653431.6192	1.90
104	LIQUID	BELUGA 1	22.03.2012		30	1701801.7281	5653431.6192	1.20
104	LIQUID	BELUGA 1	26.03.2012		140	1701801.7281	5653431.6192	1.80
92	SBM	MANAIA	16.3.2011	50		1701990.9803	5653141.5536	2.70
95	SBM	MANAIA	16.3.2011	70		1701650.4624	5653105.5932	2.20
96	SBM	MANAIA	16.3.2011	20		1701629.1445	5653205.2419	2.30
97	SBM	MANAIA	15.3.2011		170	1701838.4469	5653451.7244	1.90
105	SBM	MR2P1	30.3.2010	120		1702086.3883	5653451.5115	1.80
106	SBM	MR2P1	30.3.2010	100		1702185.2255	5653468.9424	1.80
109	LIQUID	MANAIA	9.9.2010		20	1702181.9172	5653079.0321	3.10
110	SBM/WBM	MANAIA	9.6.2010		380	1702151.6553	5653186.6314	3.50
111	SBM	MANAIA	28.3.2011	120		1702129.2835	5653202.9124	2.90
112	SBM/WBM	BELUGA 1	17.6.2010		430	1702400.5903	5653430.0924	3.95
113	SBM/WBM	MANGAREWA A/ MP3P8/MP4P9/M P5P12	23.4.2009	600		1702366.1241	5653556.1796	3.20
115	SBM/WBM	BELUGA 1	1.10.2010		190	1702713.8302	5653566.2504	2.30
133	SBM/WBM	BELUGA 1				1702947.5999	5653281.2916	070
134	SBM	MRIP7 / MP2P1	18.3.2010	120	40	1702679.6843	5653306.616	1.30
135	SBM	MRIP7 / MP2P1	18.3.2010	120	40	1702595.4112	5653198.2808	1.55
136	SBM	MRIP7 / MP2P1	8.9.2010	90	120	1702449.6159	5653242.1715	2.80
138	LIQUID	BELUGA 1	10.6.2010		370	1702646.6426	5653461.9277	1.50
142	SBM	MANAIA	28.3.2011	150	150	1702742.882	5652419.2966	3.10

Appendix III

Biomonitoring surveys

To	Job Manager, David Olsen;
From	Scientific Officer - Freshwater Biology, Katrina Spencer
Document	1007603
Report No	KS001
Date	14 February 2012

Biomonitoring of an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site, January 2012.

Introduction

This biological survey was the first of two programmed for the 2011-2012 monitoring year. Due to a delay caused by weather, this survey was undertaken in January 2012 which equates to a summer survey. The second biological survey will be undertaken as a late-summer survey in 2012.

The survey is intended to monitor the health of the macroinvertebrate community of an unnamed tributary of the Mangatengehu Stream, in relation to the disposal of drilling waste to land within its vicinity. The site receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharges to the unnamed tributary. No consent is held to discharge to the tributary from the skimmer pits, as it is intended for this discharge to comply with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that the discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life. The results of previous surveys performed in relation to this site are discussed in the references at the end of this report.

Methods

Three sites were sampled in this biological survey. During the initial survey, undertaken in April 2010, the control site (site 1) was established in the unnamed tributary, upstream of a minor access culvert. Site 2 was established downstream of the skimmer pit discharge, and site 3 was downstream of a race, downstream of any stormwater discharges from the site. As a result of an inspection observing hydrocarbons entering the stream, changes were made to the on site drainage. These changes were made between the April 2010 and November 2010 surveys. The result was that site 2 was located upstream of any discharge from the site, and site 3 became the primary impact site. The stormwater discharge is now entering the unnamed tributary just upstream of the race crossing, approximately 35 metres upstream of site 3. The sampling site locations are presented in Table 1 and Figure 1.

The standard 'kick-sampling' technique was used at these three sites (Table 1) to collect streambed macroinvertebrates on 26 January 2012. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site

Site number	Site code	Grid reference (NZTM)	Location
1	MTH000060	1702050-5651525	Upstream of Drilling Waste Stockpiling site
2	MTH000062	1701930-5651465	Approximately 85m upstream of the spring and skimmer pit discharge
3	MTH000064	1702050-5651525	Approximately 35m downstream of the skimmer pit discharge

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Boyd Drilling Waste Stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these

products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this morning (0930 to 1050 NZST) survey there was a steady, moderate flow at all sites. Due to significant iron oxide content, the flow at all sites was uncoloured but cloudy, and iron oxide was present on the bed at all sites. The degree of iron oxide smothering was relatively unchanged at all sites, although a slight improvement was noted for site 3, when compared with previous surveys.

Site 1 was completely shaded, due to the stream margins consisting of mature remnant native vegetation. Site 2 was also completely shaded, but by less intact remnant native vegetation, while site 3 was unshaded. This lack of shade meant that site 3 could support widespread growths of algal mats and patchy growths of filamentous algae, while site 2 supported patchy mats, and site 1 only had a slippery algal film.

The substrate at each sampled site was similar, with cobbles and gravels predominant. Some finer substrate was also present, mostly as sand, but silt was also important at all sites.

Macroinvertebrate communities

Table 2 provides a summary of the results for the current survey sampled in relation to the Surrey Road drilling waste stockpiling site together with historical results. The full results are presented in Table 3. Also included in Table 2 is a predicted MCI score, taken from Stark and Fowles (2009). While the unnamed tributary partially rises in the National Park it is more appropriate to consider it as originating outside of the National Park but close to the park boundary. An equation (EQN12 p17) provided by Stark and Fowles (2009) allows for the prediction of MCI values for ring plain streams originating outside of the national park using altitude as an environmental variable. Based on this equation, the predicted MCI score for the sites monitored is 104 units.

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site. Also given are historical data for these sites and predicted MCI scores, Stark and Fowles (2009).

Site No.	Number of samples	No of taxa			$SQMCI_s$ value			MCI value			Predicted MCI score
		Median	Range	Current Survey	Median	Range	Current Survey	Median	Range	Current Survey	
1	3	18	18-20	20	4.9	3.5-5.4	4.5	125	112-127	115	104
2	3	16	5-27	30	4.7	1.6-6.3	6.0	118	80-127	128	104
3	3	10	9-11	10	1.6	1.4-2.5	1.4	96	96-98	104	104

Site 1

Twenty taxa were found at site 1 (Table 2). This is two more than recorded in the previous survey, and a moderately low richness for this type of stream, being so near to the National Park. It is likely that this low richness is a reflection of the slight habitat smothering by iron oxide, and the nature of the substrate, being difficult to collect a sample.

The community consisted primarily of 'sensitive' taxa (70%), including five 'highly sensitive' taxa, reflecting good preceding water quality conditions. This equated to an MCI score of 115, which is lower than that recorded in the previous survey and but is also more than the predicted score. This MCI score is within the range of scores that could be expected from this

type of stream at this altitude, and a good result, considering the habitat disturbance caused by the increased iron oxide sediment. The community was dominated by only three taxa, being the 'tolerant' oligochaete worms and *Austrosimulium* sandfly and, 'moderately sensitive' *Zephlebia* group of mayfly. The abundance of oligochaete worms is considered to be related to the iron oxide on the bed of the stream, providing sufficient silty habitat which this taxon can inhabit.

The resultant SQMCI score of 4.5 was not high, and again, this is related to the smothering of habitat caused by the iron oxide.

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangatengehu Stream, sampled on 26 January 2012

Taxa List	Site Number	MCI score	1	2	3
	Site Code		MTH000060	MTH000062	MTH000064
	Sample Number		FWB12053	FWB12054	FWB12055
ANNELIDA	Oligochaeta	1	A	A	VA
MOLLUSCA	*Potamopyrgus*	4	C	-	-
CRUSTACEA	Talitridae	5	-	-	R
	Paranephrops	5	R	A	-
EPHEMEROPTERA	*Acanthophlebia*	9	-	R	-
	Ameletopsis	10	-	R	-
	Austroclima	7	C	A	-
	Deleatidium	8	R	VA	-
	Nesameletus	9	-	R	-
	Zephlebia group	7	A	R	R
PLECOPTERA	*Acroperla*	5	-	R	-
	Austroperla	9	-	C	R
	Spaniocerca	8	R	R	-
	Stenoperla	10	-	R	-
	Zelandobius illiesi	10	R	C	-
COLEOPTERA	Elmidae	6	-	C	-
	Ptilodactylidae	8	C	C	-
TRICHOPTERA	*Hydrobiosis*	5	R	R	-
	Hydrochorema	9	R	R	-
	Orthopsyche	9	-	R	-
	Plectrocnemia	8	-	R	R
	Psilochorema	6	R	C	R
DIPTERA (TRUE FLIES)	*Aphrophila*	5	-	R	R
	Eriopterini	5	C	R	-
	Hexatomini	5	R	R	-
	Limonia	6	-	-	R
	Paralimnophila	6	R	-	-
	Zelandotipula	6	R	R	-
	Harrisius	6	R	R	-
	Orthocladiinae	2	R	A	C
	Polypedilum	3	-	C	R
	Tanypodinae	5	-	R	-
	Tanytarsini	3	-	R	-
	Paradixa	4	R	-	-
	Austrosimulium	3	A	A	-
		No of taxa	20	30	10
		MCI	115	128	104
		SQMCIs	4.5	6.0	1.4
		EPT (taxa)	8	16	4
		%EPT (taxa)	40	53	40
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 2

Thirty taxa were recorded at site 2. This is a slight increase from the previous survey, and a very significant improvement from the initial survey, which recorded only 5 taxa. This marked

improvement is directly related to the change in location of the discharge point which occurred in mid-2010.

The community consists of a high proportion of 'sensitive' taxa (83%), including a very high abundance of the 'highly sensitive' *Deleatidium* mayfly, indicating good preceding water quality conditions. Two moderately sensitive taxa, (freshwater crayfish *Paranephrops* and *Austroclima* mayfly) and three tolerant taxa (Oligochaet worms, Orthoclad midge larvae and *Austrosimulium* sand fly larvae) were also found to be abundant. This community recorded an MCI score of 128 units and an $SQMCI_S$ score of 6.0 units.

Table 4 shows a significant improvement in the MCI and SQMCI scores recorded over the previous three surveys for this site. In the previous survey report (document no. 922595), this improvement was attributed to the removal of the skimmer pit discharge from the upstream of this site. The results from this latest survey show only a minor increase in the MCI score survey for the site. This may indicate that the recovery of the community is stabilising, possibly associated with the fact that there has been little change in the iron oxide levels in the stream between the two most recent surveys.

Table 4 Summary of total number of taxa, MCI and SQMCI scores for all surveys undertaken at each site to date

	Site 1			Site 2			Site 3		
	MTH000060			MTH000062			MTH000064		
Sample date	Taxa no	MCI	SQMCI	Taxa no	MCI	SQMCI	Taxa no	MCI	SQMCI
27-Apr-10	20	125	5.4	5	80	1.6	10	98	1.4
17-Nov-10	18	112	4.9	16	118	4.7	9	96	1.6
11-Apr-11	18	127	3.5	27	127	6.3	11	96	2.5
26-Jan-12	20	115	4.5	30	128	6	10	104	1.4

Site 3

This site recorded a richness of only ten taxa which similar to that in the previous survey and is a sharp drop of twenty taxa from site 2 upstream (Table 3). It was noted during sampling that this site had significant periphyton cover and also notable iron oxide smothering, and this has severely restricted the macroinvertebrate community.

'Tolerant'oligochaete worms were the most abundant taxa found at site 3 along with orthoclad midge larvae which were common. Seventy percent of the taxa at the site were 'sensitive' and all were recorded as rarities. In comparison to site 2, there is a notable absence of sensitive taxa which has led to a significant deterioration in the MCI Score (Stark, 1998), with a drop of 24 units to 104. This is also significantly less than that recorded at site 1 (Stark, 1998). In addition, and due predominantly to the reduction in the abundance of 'sensitive' taxa, the SQMCI score also dropped significantly, to a low result of 1.4 units. This in part can be attributed to the significant periphyton growth observed at the site. The continued prevalence of iron oxide sedimentation observed at site 3 is also likely to be affecting the macroinvertebrate community at the site. The increased presence of iron oxide sedimentation at the site in more recent surveys appears to be associated with the change in location of the discharge point mid-way through 2010. In summary, the periphyton and iron oxide sedimentation has had the greatest influence on the community at this site, and there is no indication of impacts related to the storage of drilling waste upstream.

Conclusions

This January 2012 biological survey of an unnamed tributary of the Mangatengehu Stream was performed to monitor the health of the macroinvertebrate community of an unnamed tributary of

the Mangatengehu Stream, in relation to the storage of drilling waste within its vicinity. As a result of an inspection observing hydrocarbons being discharged to the stream, changes were made to the on-site drainage prior to the previous (November 2010) survey, meaning that site 2 was no longer impacted by the skimmer pit discharge, and that site 3 became the primary impact site. This resulted in a significant reduction in iron oxide sedimentation observed at site 2, but a significant increase in this sedimentation observed at site 3. In addition to this, site 3, the most downstream site, also suffered from significant periphyton proliferation.

The macroinvertebrate community at the upstream site had a moderately low taxa richness for such a stream at this altitude. However, the MCI score indicated a healthy community, with the presence of four 'highly sensitive' taxa. Results from the previous two surveys at site 2 indicated a recovery in the community as demonstrated by a marked increase in MCI and SQMCI scores. However, the latest survey results show only a minor increase in MCI score and a slight decrease in the SQMCI score. This may reflect that there has been little change to the environment at the site in recent surveys in respect to iron oxide cover and periphyton cover.

At the lowest site (site 3), the macroinvertebrate community recorded a much lower taxa richness and fewer 'sensitive 'taxa compared with the other two sites. Only one taxon recorded in abundance, being the very 'tolerant oligochaete worms. As a result of this significant change in community, the MCI score dropped 11 units, and the $SQMCI_S$ dropped 3.1 units, to 104 and 1.4 respectively. This is indicative of a severe deterioration in the macroinvertebrate community, and can be predominantly attributed to the significant periphyton growth observed at this site, although the increased degree of iron oxide sedimentation observed can be directly related to the change in location of the discharge point. However, results for the four surveys undertaken at this site show little change over time, despite the closer proximity of this discharge point since the first survey. Therefore, the change in discharge location has not caused degradation at this site.

Overall, the influence of iron oxide sedimentation on the community was evident at all sites, especially at site 3, where periphyton growth was also severe. However, the survey results suggest that there is no indication of impacts related to the storage of drilling waste upstream of site 3.

Due to the change in location of the discharge site, it is recommended a fourth sample be included in the monitoring programme, located downstream of site 3. This will be implemented in the next end of summer survey (2012). Sites 1 and 2 should remain in the surveys, although if results indicate that the recovery at site 2 is complete, and that the macroinvertebrate community is relatively stable, then sampling of site 1 can be discontinued, with site 2 becoming the control site.

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Biomonitoring of an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site, May 2012.

Introduction

This biological survey was the second of two programmed for the 2011-2012 monitoring year, intended to monitor the health of the macroinvertebrate community of an unnamed tributary of the Mangatengehu Stream, in relation to the disposal of drilling waste to land within its vicinity.

The site located off Surrey Road, receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharges to the land in the vicinity of the unnamed tributary. No consent is held to discharge to the tributary from the skimmer pits, as it is intended for this discharge to comply with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that the discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life.

The results of previous surveys performed in relation to this site are discussed in the references at the end of this report.

Methods

This biomonitoring survey was undertaken at four sites on 8 May 2012 (Table 1 and Figure 1). In the initial survey undertaken in April 2010, site 1 was established as a 'control site', upstream of the drilling stockpile area and sites 2 and 3 were established downstream of the skimmer pit discharge. During an inspection of the site in mid-2010, an unauthorised discharge of hydrocarbons was observed entering the stream. As a consequence of this inspection, changes were made to the on site drainage. These changes were made between the April 2010 and November 2010 surveys. The result was that site 2 was located upstream of any discharge from the sites, and site 3 became the primary impact site. The stormwater discharge from the site now enters the unnamed tributary immediately upstream of the race crossing, approximately 35 metres upstream of site 3. A new secondary impact site (site 4) was established 100 metres downstream of the stormwater discharge in the current survey.

The standard 'kick-sampling' technique was used at all four sites (Table 1) to collect streambed macroinvertebrates. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site

Site Number	Site code	Location	Sample method	Time of sampling (NZST)	Temperature (°C)
1	MTH000060	Upstream of drilling waste stockpiling site	Kick	1205	10.8
2	MTH000062	Approximately 85 metres upstream of the spring and skimmer pit discharge	Kick	1130	10.3
3	MTH000064	Approximately 35 metres downstream of the skimmer pit discharge	Kick	1050	10.5
4	MTH000066	Approximately 100 metres downstream, of the skimmer pit discharge	Kick	1034	10.7

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Boyd Drilling Waste Stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark *et al*, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the

highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

This May 2012 survey followed a period of 11 days since a fresh in excess of three times median flow, and 11 days since a fresh in excess of seven time median flow. In the month prior to this survey, there had been two fresh events, one of which exceeded the 3 times median flow and one which exceeded 7 times median flow. However, for the majority of this period the flows were less than or equal to the median flow in the tributary.

A very low, swift flow of uncoloured cloudy water was recorded at site 1 in this survey. The substrate at this site was predominantly coarse gravels, fine gravels and sand. In this shaded section of stream, only a slippery film of algae was recorded.

Similar to site 1, there was a very low, swift flow of uncoloured water recorded at site 2, except that the water at this site was clear. Cobbles, coarse and fine gravels dominated the bed of the stream at this site which was also completely shaded. Slippery algal mats along with patchy woody/leafy debris were recorded in this completely shaded site.

Sites 3 and 4 recorded a low, swift flow of uncoloured and clear water and both sites were unshaded. At both sites, the bed substrate primarily consisted of cobbles, coarse and fine gravels. The periphyton recorded at site 3 included widespread algal mats and patchy filamentous algae, while at site 4, both algal mats and filamentous algae were found to be present in the stream during this survey. Prevalent growths of benthic cyanobacteria were also recorded at site 3.

Iron oxide was recorded at all four sites in the unnamed tributary of the Mangatangehu Stream as noted in previous surveys.

Macroinvertebrate communities

Table 2 provides a summary of the results for the current survey sampled in relation to the Surrey Road drilling waste stockpiling site together with historical results. Table 3 summarises statistics for ring plain streams arising outside of the national park 'control' sites located at a similar altitude to the sample sites. The full results from this current survey are presented in Table 4.

Site 1

A total of twenty taxa were recorded at site 1 upstream of the storage area, which represented the highest number of taxa ever recorded at the site and was the same as the previous survey undertaken in January 2012 (Tables 2 and 4).

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site. Also given are historical data for these sites and predicted MCI scores, Stark and Fowles (2009).

Site No.	No of taxa				MCI value			SQMCIs values			
	No. of samples	Median	Range	Current Survey	Median	Range	Current Survey	No. Samples	Median	Range	Current Survey
1	4	19	18-20	20	120	112-127	106	4	4.7	3.5-5.4	2.3
2	4	22	5-30	20	123	80-128	115	4	5.4	1.6-6.3	5.2
3	4	10	9-11	10	97	96-104	104	4	1.5	1.4-2.5	1.9
4	1	-	-	21	-	-	107	1	-	-	2.1

Table 3 Range and median number of taxa, MCI values and $SQMCI_s$ scores for ring plain streams rising outside of the Egmont National Park at a similar altitude ((TRC, 1999 (updated 2011)).

	No. of taxa	MCI value	$SQMCI_s$ value
No. Samples	16	16	13
Range	8-33	87-126	3.0-7.5
Median	24	116	6.5

The community consisted primarily of 'sensitive' taxa (65%), including five 'highly sensitive'taxa, reflecting reasonably good preceding water quality conditions (Table 4). This equated to an MCI score of 106 units which was the lowest MCI score ever recorded at the site and was significantly (Stark, 1998) lower than the median score for the site of 120 units. However, this result was also well within the range of MCI scores recorded for other ring plain streams rising outside of the National Park at a similar altitude (TRC,1999 (updated 2011)) (Tables 2 and 3).

The numerical dominance of low scoring 'tolerant' oligochaete worms (very abundant) recorded at this site in the current survey was reflected in the $SQMCI_s$ score of 2.3 units, the lowest score ever recorded at the site (Table 2). This result was significantly (Stark, 1998) lower than the median and lowest $SQMCI_s$ scores recorded at the site in previous surveys and was also lower than the median score recorded at other 'control' streams at the same altitude (TRC,1999(updated 2011)) (Tables 2 and 3). The abundance of oligochaete worms was considered to be related to the prevalence of iron oxide on the bed of the stream, providing sufficient silty habitat which this taxon can inhabit.

Site 2

Twenty taxa were recorded at site 2 in the current survey, two taxa less than the median yet well within the range recorded at the site previously (Table 2). Although this result was ten taxa less than that recorded at this site in the previous survey, it still represented a marked improvement in the community from the initial survey in which only five taxa were recorded. This marked improvement is directly related to the change in location of the discharge point which occurred in mid-2010. This taxa richness was also the same as that recorded at site 1 in the current survey.

Table 4 Macroinvertebrate fauna of an unnamed tributary of the Mangatengehu Stream, sampled on 8 May 2012

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MTH000060	MTH000062	MTH000064	MTH000066
	Sample Number		FWB12262	FWB12261	FWB12260	FWB12259
NEMATODA	Nematoda	3	-	-	R	-
ANNELIDA (WORMS)	Oligochaeta	1	VA	A	VA	VA
MOLLUSCA	*Potamopyrgus*	4	C	-	-	R
	Sphaeriidae	3	R	-	-	-
CRUSTACEA	Ostracoda	1	R	-	-	R
	Paranephrops	5	R	R	R	R
EPHEMEROPTERA	*Ameletopsis*	10	-	R	-	-
	Austroclima	7	R	-	-	R
	Deleatidium	8	R	A	-	-
	Zephlebia group	7	C	A	R	C
PLECOPTERA	*Acroperla*	5	-	R	R	-
	Austroperla	9	-	-	R	C
	Spaniocerca	8	R	R	-	R
	Stenoperla	10	R	-	-	-
COLEOPTERA	Elmidae	6	R	R	R	R
	Ptilodactylidae	8	C	-	-	R
	Scirtidae	8	R	C	-	-
TRICHOPTERA	*Costachorema*	7	-	-	-	R
	Hydrobiosis	5	R	R	R	R
	Hydrochorema	9	-	R	R	R
	Orthopsyche	9	-	R	-	-
	Polyplectropus	6	-	-	-	R
	Psilochorema	6	C	C	C	C
	Oxyethira	2	-	-	-	R
	Pycnocentria	7	-	R	-	-
	Triplectides	5	-	R	-	-
DIPTERA	*Aphrophila*	5	-	-	R	C
	Eriopterini	5	C	R	R	-
	Hexatomini	5	R	-	-	R
	Limonia	6	-	-	R	-
	Zelandotipula	6	-	-	R	R
	Orthocladiinae	2	C	C	VA	XA
	Polypedilum	3	-	R	-	R
	Paradixa	4	R	-	-	-
	Empididae	3	-	C	R	-
	Austrosimulium	3	R	C	-	-
		No of taxa	20	20	16	21
		MCI	106	115	104	107
		SQMCIs	2.3	5.2	1.9	2.1
		EPT (taxa)	7	11	6	9
		%EPT (taxa)	35	55	38	43

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

The community comprised of a moderately high proportion of 'sensitive' taxa (75%), including the abundant 'highly sensitive' mayfly *Deleatidium*, indicating relatively good preceding water quality (Table 2). The 'moderately sensitive' mayfly *Zephlebia* and tolerant' oligochaete worms were also found to be in abundance. This community recorded an MCI score of 115 units which was less than the median score recorded for the site previously (120 units) and similar to the median score for other 'control' sites at a similar altitude (TRC,1999 (updated 2011)) (Table 2 and 4). However, it was higher than the MCI score recorded at site 1 in the current survey.

The two numerically dominant 'sensitive taxa' (mayfly *Deleatidium* and *Zephlebia*), tempered by the abundance of the 'tolerant' taxon (oligochaete worms) resulted in a moderately high $SQMCI_s$ score of 5.2 units (Tables 2 and 4). This result was marginally less than the median recorded at this site previously but was significantly higher than the $SQMCI_s$ score recorded at site 1 in this survey.

Site 3

Sixteen taxa were recorded at site 3 which represented the highest number taxa ever recorded at this site previously (Table 2). However, this result was four taxa less than that recorded at sites 1 and 2 in the current survey.

The community at this site was dominated by two very abundant 'tolerant' taxa, oligochaete worms and orthoclad midge larvae (Table 4). Seventy five per cent of the taxa at the site were 'sensitive' and the majority of these taxa were recorded as rarities. An MCI score of 104 units was recorded at this site which was the highest score ever recorded at the site in previous surveys and was comparable to the MCI score recorded at site 1 but less than that at site 2 in this same survey. This MCI score of 104 units was significantly lower (Stark, 1998) than the median score recorded at other 'control sites' on the ring plain originating outside of the National Park but was within the range of the scores for these sites (TRC,1999 (updated 2011))(Tables 2 and 3).

The numerical dominance of the two very low scoring 'tolerant' taxa (oligochaete worms and orthoclad midge larvae) resulted in a $SQMCI_s$ score of 1.9 units (Tables 2 and 4). This very low $SQMCI_s$ score was marginally higher than the median previously recorded at the site and was significantly (Stark, 1998) lower than the score recorded at site 2 yet only slightly less than the score at site 1.

Site 4

A total of twenty one taxa were recorded the newly established site 4 approximately 65 metres downstream of the discharge. This taxa richness was the highest recorded across all four sites sampled in this survey and was well within the range of total number of taxa recorded at other 'control sites' of a similar altitude (TRC, 1999(updated 2011)) (Tables 2 and 3).

The moderately high proportion of 'sensitive' taxa (71%) recorded at this site was reflected in the moderate MCI score of 107 units. This MCI score was comparable to those scores recorded at sites 1 and 3 and less than that recorded at site 2. In addition, this score was significantly (Stark, 1998) lower than the median MCI score recorded for 'control sites' located on ring plain streams originating outside of the National Park (TRC,1999 (updated 2011)) (Tables 2 and 3).

Similar to site 3, two 'tolerant' taxa (oligochaete worms and orthoclad midge larvae) numerically dominated the community at this site in this survey (Table 4). This was reflected in the moderately low $SQMCI_s$ score of 2.1 units, which was marginally higher than the score recorded at site 3 in the same survey, similar to the score at site 1 and significantly lower than at site 2.

Discussion and conclusions

In this May 2012 survey, iron oxide was found to be a prevalent feature at all four sites sampled in the unnamed tributary of the Mangatengehu Stream. The abundance of oligochaete worms at these four sites was considered to be related to the iron oxide on the bed of the stream, providing sufficient habitat which this taxon can inhabit.

A high proportion of the taxa recorded at all four sites in the tributary were 'sensitive taxa', which were indicative of reasonable preceding water quality despite the majority of these taxa only occurring as rarities.

The MCI and $SQMCI_s$ scores recorded at site 1 in the current survey were significantly lower than the median scores and were the lowest ever recorded at the site previously. This was considered to be the result of slight differences in habitat sampled between the current and the previous survey. The fact that most were rare reflects the low flows observed, resulting in limited available habitat.

The highest $SQMCI_s$ and MCI scores recorded in this survey were at site 2, immediately upstream of the stormwater discharge. The macroinvertebrate community at this site contained five 'highly sensitive taxa', two of which were found to be abundant and was indicative of good preceding water quality.

The results of this survey demonstrated a significant decline in $SQMCI_s$ scores between site 2 and the two sites downstream of the stormwater discharge (3 and 4) and there was also a significant decrease in the MCI score recorded between sites 2 and 3. This marked decline in the macroinvertebrate communities recorded downstream of the stormwater discharge was considered to be the result of differences in habitat between these sites. The macroinvertebrate community at site 2 was dominated by two 'sensitive'mayflys (*Zephlebia* (moderately sensitive) and *Deleatidium* (highly sensitive taxa)) which are commonly found in rocky bedded streams with little to no periphyton growth present. At the time of this survey, only a thin film of algae was recorded in the stream bed at site 2. In contrast to this, the two mayfly taxa (*Zephlebia* and *Deleatidium*) were recorded as absent or in very low abundance at sites 3 and 4 mostly likely due to the prevalence of algal mats and filaments at both these sites which provide unfavourable habitat conditions for these taxa. In addition, orthoclad midge larvae are typically found in streams with reasonable periphyton growth, and were recorded in very high abundance at sites 3 and 4 in contrast to site 2 were this taxon was only found to be in common.

Overall, the results indicated that the changes in macroinvertebrate communities upstream and downstream of the stormwater discharge were related to differences in habitat between sampling sites rather than resulting from the effects of the discharge. The results also indicated reasonable preceding water quality in the tributary at the time of the survey and were typical of the nature of this spring fed, ring plain stream arising out of the National Park.

Summary

A four site biomonitoring survey was undertaken in May 2012 in an unnamed tributary of Mangatengehu Stream, to monitor the health of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity.

The macroinvertebrate communities recorded in the tributary at all four sites were reflective of the prevalence of iron oxide in the bed of the stream with the high abundance of oligochaete

worms present at these sites. These communities also comprised a moderately high proportion of 'sensitive' taxa which was indicative of reasonable preceding water quality despite the majority of these taxa occurring as rarities or in low abundance which was related to the low flows. The MCI and $SQMCI_s$ scores recorded at these sites were generally reflective of the nature the available habitat.

The results of this survey showed a significant difference in $SQMCI_s$ score between site 2,(the closest upstream site to the discharge), and the two sites downstream of the stormwater discharge(sites 3 and 4). Differences in habitat between these sites were considered to be the main driver for the changes in the macroinvertebrate communities at these sites. For example, two 'sensitive' taxa commonly found in rocky bedded streams with minimal periphyton growth were recorded in abundance at site 2 which exhibited these conditions. However, these two taxa were either absent or in very low abundance at the two downstream sites in which there was a proliferation of periphyton growth in the bed of the stream,which presented less favourable conditions for these taxa. The prevalence of periphyton growths in the bed of the stream at these two downstream sites most likely resulted in the numerical dominance of orthoclad midge larvae that thrive under these conditions.

Overall, these survey results indicated that there was no evidence of any impacts on the macroinvertebrate communities in the unnamed tributary relating to the discharge of stormwater from the stockpile area in the vicinity of the tributary and upstream of sites 3 and 4.

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To	Job Manager, David Olson
From	Scientific Officers - Freshwater Biology, Katrina Smith and Chris Fowles
Document	1148640
Report No	KS018
Date	18 February 2013

Biomonitoring of an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road land farm, January 2012

Introduction

This biological survey was the first of two scheduled surveys for the 2011-2012 monitoring period, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangamawhete Stream, in relation to the stockpiling and discharge of drilling waste to land within its vicinity. The site receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharged to the unnamed tributary. Initially, no consent was held to discharge to the tributary from the skimmer pits, as it was intended that no discharges to surface water would occur unless they complied with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that any discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life. However, during the 2010-2011 monitoring period several non-compliant discharge events occurred (TRC, 2012) culminating in a requirement for a consent to discharge (7911-1) which was issued in September 2011. This consent to discharge stormwater provides for a 25 metre mixing zone within the stream.

A baseline survey was undertaken in April 2009, prior to any receipt of drilling wastes at the site. Unfortunately, at the time of the baseline survey the communities at the downstream sites had experienced significant habitat deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance. The upstream control site was relatively unaffected. This makes future comparisons with results difficult, as a recovery from the disturbance and sedimentation may mask any impact from drilling waste disposal activities, if any such impact occurs.

Methods

Four sites were sampled in this survey. The control site (site 1) was established in the unnamed tributary, alongside the upstream boundary of the land treatment area. Site 2 was established between the land treatment area and the storage pits, and site 3 was established just downstream of the skimmer pit discharge point. A fourth site was established approximately 200m downstream of the skimmer pit discharge. This fourth site provides comparative information, should deterioration be recorded at sites 2 or 3. The sampling site locations are presented in Table 1 and Figure 1.

The standard 'kick-sampling' technique was used at these four sites (Table 1) to collect streambed macroinvertebrates on 26 January 2012. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MMW000161	E1702317 N5653463	Upstream of drilling waste stockpiling site	450
2	MMW000162	E1702508 N5653560	Downstream of land spreading area	440
3	MMW000163	E1702734 N5653676	Downstream of skimmer pit discharge	435
4	MMW000165	E1702900 N5653750	200m downstream of skimmer pit discharge	430

Table 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road drilling waste stockpiling activities

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results

At the time of this midday survey there was a steady, moderate flow at all sites. Due to significant iron oxide infiltration, the flow at all sites was uncoloured but cloudy. The stream bed was orange as a result of the significant amount of iron oxide sedimentation present at these sites.

Site 1 was partially shaded, due to a high steep bank on the northern side, with growths of slippery algal mats and patchy filaments. Site 2 was unshaded, with growths of slippery algal mats and patchy algal filaments while the lower two sites (site 3 and 4) were completely shaded, due to the stream margins consisting of mature remnant native vegetation. This shading restricted algal growth, although both sites supported some slippery algal films.

The substrate at sites 1, 2 and 3 predominantly consisted of boulders, cobbles and gravels and was relatively well packed. At site 4, the bed substrate was primarily gravels and sand resulting in a relatively unstable bed. The presence of a debris dam downstream of site 4 may have contributed to the accumulation of softer bed material at this site. Consequently, the habitat at this site was poorer.

Macroinvertebrate communities

Table 2 provides a summary of the results from previous surveys sampled in relation to the Derby Rd drilling waste stockpiling site along with current. The full results from the current survey are presented in Table 3.

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site on 26 January 2012 and a summary of historical data for these sites (April 2009 to April 2011).

Site No.	N	No of taxa			MCI value			$SQMCI_s$ value		
		Median	Range	Jan 2012	Median	Range	Jan 2012	Median	Range	Jan 2012
1	4	22	15-28	12	107	87-114	93	5.8	3.2-7.1	4.0
2	4	13	6-14	16	99	80-100	109	2.8	2.0-3.1	2.6
3	4	16	5-19	10	100	88-109	90	4.2	2.8-5.9	2.5
4	4	15	6-18	8	92	73-104	93	3.6	2.4-5.7	2.1

Site 1

A relatively poor richness of twelve taxa was found at site 1 (Table 2), five fewer than recorded by the previous survey and three less than the lowest number of taxa previously recorded at this site. There were two taxa recorded as abundant; one 'moderately sensitive' taxon (free-living caddisfly (*Hydrobiosis*)) and one 'tolerant' taxon (orthoclad midges). The community consisted of a moderate proportion (58%) of 'sensitive' taxa, which included two' highly sensitive' taxa (mayfly, *Deleatidium* and stonefly, *Zelandoperla*). The relatively high proportion of 'tolerant' taxa contributed to the MCI score of 93 units which was significantly lower than the historical median but within the range of scores recorded at the site previously.

A moderately low SQMCIs score of 4.0 units was recorded, significantly lower than the median for the site but slightly above the minimum (3.2 units) recorded by previous surveys. This result reflected the numerical co-dominance of one 'moderately sensitive' caddisfly taxon (*Hydrobiosis*) with one low scoring 'tolerant' taxon (orthoclad midges).

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangamawhete Stream, sampled on 26 January 2012

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MMW000161	MMW000162	MMW000163	MMW000165
	Sample Number		FWB12056	FWB12057	FWB12058	FWB12059
ANNELIDA (WORMS)	Oligochaeta	1	C	C	A	A
	Lumbricidae	5	-	R	-	-
MOLLUSCA	*Potamopyrgus*	4	-	-	-	R
EPHEMEROPTERA (MAYFLIES)	*Deleatidium*	8	C	-	R	-
	Nesameletus	9	-	R	-	-
PLECOPTERA (STONEFLIES)	*Zelandoperla*	8	R	R	-	-
HEMIPTERA (BUGS)	*Saldula*	5	-	R	-	-
COLEOPTERA (BEETLES)	Elmidae	6	R	R	-	-
	Dytiscidae	5	-	R	-	-
	Ptilodactylidae	8	-	R	-	-
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	-	R	R	R
TRICHOPTERA (CADDISFLIES)	*Costachorema*	7	R	R	-	-
	Hydrobiosis	5	A	C	R	-
	Psilochorema	6	-	-	R	R
DIPTERA (TRUE FLIES)	*Aphrophila*	5	-	R	-	-
	Eriopterini	5	C	C	C	R
	Hexatomini	5	R	-	R	-
	Limonia	6	-	R	-	-
	Paralimnophila	6	-	-	-	R
	Zelandotipula	6	-	-	-	R
	Orthocladiinae	2	A	VA	C	R
	Polypedilum	3	R	-	R	-
	Muscidae	3	R	-	-	-
	Austrosimulium	3	R	R	C	-
	No of taxa		12	16	10	8
	MCI		93	109	90	93
	SQMCIs		4.0	2.6	2.5	2.1
	EPT (taxa)		4	4	3	1
	%EPT (taxa)		33	25	30	13

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 2

A moderate richness (sixteen taxa) was recorded at site 2, four more than recorded at site 1 and the highest richness recorded to date at this site. The community was comprised of a high proportion of 'sensitive' taxa (81%), but the majority of these were rarities (less than five individuals per taxon). The high proportion of 'sensitive' taxa was reflected in the moderately high MCI score of 109 units, nine units higher than the maximum score recorded at this site to date.

The community was numerically dominated by only one taxon, 'tolerant' orthoclad midges which resulted in the low $SQMCI_s$ score of 2.6 units, which was significantly below the score recorded at site 1 although only slightly lower than the median to date for this site (2.8 units).

Site 3

A relatively poor richness (ten taxa) was recorded at this site, six taxa fewer than the median but within the range of results recorded at the site previously. This community richness was two taxa lower than that recorded at site one and four taxa less than recorded at site 2. The community at site 3 was comprised of a moderate proportion of 'sensitive' taxa (60%) resulting in the MCI score of 90 units. This score was ten units below the median but within the range of MCI scores recorded at this site by previous surveys. The score was also a significant (Stark, 1998) 19 units lower than the score recorded at site 2 although only three units lower than the score at the upstream 'control' site.

The low scoring 'tolerant' oligochaete worms numerically dominated the community at site 3 which resulted in the lowest $SQMCI_s$ score recorded to date at the site (2.5 units). This $SQMCI_s$ score was significantly lower than the historical median score and also the score recorded at site 1 in this survey, but similar to the score at site 2.

Site 4

A poor richness of eight taxa was recorded at site 4, the lowest richness at any of the four sites at the time of the current survey. This richness was five taxa below the historical median for the site but within the range of results to date.

The community was comprised of a moderate proportion of 'sensitive' taxa (62%), but all of these were recorded as rarities. This contributed to the MCI score of 93 units, one unit higher than the median for the site. This score was equal with that recorded at site 1 and very similar to that at the nearest upstream site (3).

The low $SQMCI_s$ score of 2.1 units was due to the numerical dominance of the community by the very low scoring 'tolerant' oligochaete worms. This $SQMCI_s$ score was significantly lower than the median recorded at the site previously and also the $SQMCI_s$ score recorded at the upstream 'control' site (1). However, it was similar to the scores recorded at sites 2 and 3 in this survey.

Discussion and conclusions

This summer, January 2012 biological survey was performed to monitor the 'health' of the macroinvertebrate community of an unnamed tributary of the Mangamawhete Stream, in

relation to the storage and spreading of drilling waste within its vicinity. The results can be compared with pre-stockpiling communities, allowing an assessment of compliance with relevant consent requirements . Unfortunately, during the baseline survey undertaken in April 2009, the communities at the downstream sites had experienced significant deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance.

A biological survey undertaken in November 2010 following an incident related to windblown oil entering water, recorded impacts on the macroinvertebrate communities in the stream downstream of the discharge. However, the results of a more recent survey (April 2011) showed improved taxa richness and invertebrate abundances at sites 2, 3 and 4 indicating the impacts recorded at these sites in the previous survey, due to the discharge, had abated.

In the current survey, the upstream control site (1) recorded low taxa richness and a moderately low MCI score which was significantly lower than the median previously recorded at the site. However, the presence of two 'highly' sensitive taxa (mayfly, *Deleatidium* and the stonefly, *Zelandoperla*) was indicative of reasonable preceding water quality in the stream. The numerical co-dominance of the low scoring 'tolerant' orthoclad midge larvae and the 'moderately sensitive' free living caddisfly (*Hydrobiosis*) resulted in an $SQMCI_s$ score of 4.0 units. This $SQMCI_s$ score was significantly higher than the $SQMCI_s$ scores recorded at the three downstream sites due to the numerical dominance of the 'sensitive' taxa at this site.

A slight improvement in the macroinvertebrate community was recorded at site 2 which had the highest taxa richness and MCI score of the current survey. The MCI score of 109 units recorded at site 2 was significantly higher than the scores recorded at the three other sites surveyed (1, 3 and 4) due the presence of a much higher proportion of 'sensitive' taxa in the community. These significant differences in MCI scores are considered to be the result of slight differences in habitat quality between the sites at the time of the survey rather than the result of any discharges from the land-farming site. At the time of the survey, the stream bed at site 2 was well compacted and consisted mainly of cobbles and boulders which may have improved the habitat quality at this site by providing bed stability and varied habitat. The bed substrate at the other three sites was generally less well compacted and therefore more prone to disturbance during high flows. Site 2 also recorded thin periphyton mats and patchy filaments which would have supported a more diverse macroinvertebrate community compared to the two downstream sites which only contained thin periphyton mats. However, the community at this site was numerically dominated by a low scoring 'tolerant' taxon (orthoclad midges) which resulted in a low $SQMCI_s$ score of 2.6 units.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by low taxa richness and numerically dominated by the low scoring 'tolerant' oligochaete worms which was related to the sedimentation and iron oxide present at these sites.

The MCI score recorded at the furthest downstream site 4 was identical with that recorded at the upstream site 1 and the score at site 3 was only three units less than at site 1. These results indicate that the conditions of the macroinvertebrate communities at the two most downstream sites were fairly consistent with the upstream 'control' site and provide no indication of any adverse impact on the macroinvertebrate communities from the storage of drilling wastes.

Summary

This January 2012 biological survey of an unnamed tributary of the Mangamawhete Stream was performed to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the consented discharge of stormwater to the stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCIs scores for each site.

In the current survey, the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were significantly lower than the median scores recorded at the site in previous surveys which indicated a deterioration in the community at this site. However, the presence of two 'highly sensitive' taxa (mayfly, *Deleatidium* and stonefly, *Zelandoperla)* in this community was indicative of relatively reasonable preceding water quality.

The results of this survey indicated an improvement in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits. The taxa richness and MCI score recorded at site 2 in this survey were the highest recorded to date at the site. In addition, the MCI score recorded at this site was significantly higher than recorded at any of the other sites by the current survey and was considered to be due to variability in habitat quality (e.g. bed stability and substrate composition).

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by low taxa richnesses and dominated by the low scoring 'tolerant' oligochaete worms coincident with the increased sedimentation and iron oxide deposits present at these sites. The MCI scores recorded at both sites were similar to the MCI score recorded at site 1 which indicated no recent significant impacts of any discharges into the stream from the land farming activities occurring adjacent to the stream.

Overall, the results of this summer survey present no indication that the activities at the drilling waste stockpiling site have had adverse impacts on the macroinvertebrate communities. In general, the poor community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

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To Job Manager, David Olson
From Scientific Officers - Freshwater Biology, Chris Fowles and Katrina Smith
Document 1180274
Report No CF579
Date 5 April 2013

Biomonitoring of an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road land farm, May 2012

Introduction

This biological survey was the second of two scheduled surveys for the 2011-2012 monitoring period, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangamawhete Stream, in relation to the stockpiling and discharge of drilling waste to land within its vicinity. The site receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharged to the unnamed tributary. No consent was held to discharge to the tributary from the skimmer pits, as it was intended that no discharges to surface water would occur unless they complied with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that any discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life. However, during the 2010-2011 monitoring period several non-compliance discharge events were recorded (TRC, 2012) culminating in the requirement for a consent to discharge which was issued in September 2011. This consent to discharge stormwater (7911-1) provided for a 25 metre mixing zone in the tributary.

A baseline survey was undertaken in April 2009, prior to any receipt of drilling wastes at the site. Unfortunately, at the time of the baseline survey the communities at the downstream sites had experienced significant habitat deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance. The upstream control site was relatively unaffected. This makes temporal comparisons with results difficult, as recovery from the original disturbance and sedimentation may mask any impact from drilling waste disposal activities, if any such impact occurs.

Methods

Four sites were sampled in this survey. The control site (site 1) was established in the unnamed tributary, alongside the upstream boundary of the land treatment area. Site 2 was established between the land treatment area and the storage pits, and site 3 was established just downstream of the skimmer pit discharge point. A fourth site was established approximately 200m downstream of the skimmer pit discharge. This fourth site provides comparative information, should deterioration be recorded at sites 2 or 3. The sampling site locations are presented in Table 1 and Figure 1.

The standard 'kick-sampling' technique was used at these four sites (Table 1) to collect streambed macroinvertebrates on 8 May 2012. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road drilling waste stockpiling activities

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MMW000161	E1702317 N5653463	Upstream of drilling waste stockpiling site	450
2	MMW000162	E1702508 N5653560	Downstream of land spreading area	440
3	MMW000163	E1702734 N5653676	Downstream of skimmer pit discharge	435
4	MMW000165	E1702900 N5653750	200m downstream of skimmer pit discharge	430

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
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A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this early afternoon survey there was a swift, moderate flow at all sites. Due to significant iron oxide infiltration, the flow at all sites was uncoloured but cloudy. The stream bed was orange as a result of the significant amount of iron oxide sedimentation present at 'these sites' and most prevalent at sites 2 and 3. There was a noticeable surface sheen at site 2.

Site 1 was partially shaded, due to a high steep bank on the northern side, with growths of slippery thin algal mats and patchy filaments. Site 2 was unshaded, with growths of slippery thin algal mats but widespread algal filaments while the lower two sites (site 3 and 4) were completely shaded, due to the stream margins consisting of mature remnant native vegetation. This shading restricted algal growth at both sites to slippery, thin algal mats.

The substrate at all sites predominantly consisted of boulders, cobbles and gravels and was relatively well packed with the exception of a slightly looser substrate at site 4.

Macroinvertebrate communities

Table 2 provides a summary of the results from previous surveys sampled in relation to the Derby Rd drilling waste stockpiling site along with current. The full results from the current survey are presented in Table 3.

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site on 8 May 2012 and a summary of historical data for these sites (April 2009 to January 2012).

Site No.	N	No of taxa			MCI value			$SQMCI_s$ value		
		Median	Range	May 2012	Median	Range	May 2012	Median	Range	May 2012
1	5	20	12-28	18	103	87-114	109	4.8	3.2-7.1	6.0
2	5	13	6-16	13	99	80-109	100	2.7	2.0-3.1	4.9
3	5	15	5-19	12	93	88-109	100	4.0	2.5-5.9	5.9
4	5	11	6-18	14	93	73-104	91	2.6	2.1-5.7	3.7

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangamawhete Stream, sampled on 8 May 2012

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MMW000161	MMW000162	MMW000163	MMW000165
	Sample Number		FWB12266	FWB12265	FWB12264	FWB12263
ANNELIDA (WORMS)	Oligochaeta	1	A	C	R	A
MOLLUSCA	*Potamopyrgus*	4	R	R	-	R
CRUSTACEA	Ostracoda	1	-	-	-	R
	Isopoda	5	-	-	R	-
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	R	-	-	-
	Deleatidium	8	VA	A	A	A
	Nesameletus	9	R	-	-	-
PLECOPTERA (STONEFLIES)	*Zelandoperla*	8	R	R	R	R
COLEOPTERA (BEETLES)	Elmidae	6	R	-	-	-
	Ptilodactylidae	8	-	R	-	-
	Scirtidae	8	C	-	-	-
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	R	-	R	R
TRICHOPTERA (CADDISFLIES)	*Costachorema*	7	R	C	R	R
	Hydrobiosis	5	C	-	R	-
	Psilochorema	6	C	R	R	R
	Oxyethira	2	-	R	-	-
DIPTERA (TRUE FLIES)	*Aphrophila*	5	-	R	-	-
	Eriopterini	5	C	C	C	C
	Limonia	6	-	R	-	-
	Zelandotipula	6	R	-	-	-
	Orthocladiinae	2	A	A	C	A
	Polypedilum	3	R	-	R	R
	Ephydridae	4	-	-	-	R
	Muscidae	3	R	-	-	-
	Austrosimulium	3	C	R	C	A
	Stratiomyidae	5	-	-	-	R
		No of taxa	18	13	12	14
		MCI	109	100	100	91
		SQMCIs	6.0	4.9	5.9	3.7
		EPT (taxa)	7	4	5	4
		%EPT (taxa)	39	31	42	29

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1

A moderate richness of 18 taxa was found at site 1 (Table 2), six more than recorded by the previous survey and two less than the median number of taxa previously recorded at this site. There were three taxa recorded in abundance; one 'highly sensitive' taxon (mayfly (*Deleatidium*)) and two 'tolerant' taxa (orthoclad midges and oligochaete worms). The community was comprised of a relatively high proportion (67%) of 'sensitive' taxa, which included four 'highly sensitive' taxa (two mayflies, scirtid beetles, and one stonefly). This relatively high proportion of 'sensitive taxa contributed to the MCI score of 109 units which was six units above the historical median and a significant 16 units higher than the score recorded by the previous survey, three months earlier.

A moderately high SQMCIs score of 6.0 units was recorded, significantly higher than the median for the site recorded by previous surveys. This result reflected the numerical

dominance of the community by one high scoring 'highly sensitive' taxon (mayfly (*Deleatidium*)).

Site 2

A poorer richness (thirteen taxa) was recorded at site 2, five taxa fewer than recorded at site 1 but equivalent with the median richness recorded to date at this site. The community was comprised of a moderate proportion of 'sensitive' taxa (61%), but the majority of these were rarities (less than five individuals per taxon). The relatively high proportion of 'sensitive' taxa was reflected in the moderate MCI score of 100 units, one unit higher than the median score recorded at this site to date and an insignificant nine units lower than the score at the upstream 'control' site. There were two significant decreases in individual taxon abundances (both 'sensitive' taxa) between sites.

The community was numerically dominated by only two taxa, the 'highly sensitive' mayfly (*Deleatidium*) and 'tolerant' orthoclad midges, which resulted in the moderate $SQMCI_s$ score of 4.9 units, which was lower than the score recorded at site 1 although higher than the maximum to date for this site (by 1.8 units).

Site 3

A relatively poor richness (twelve taxa) was recorded at this site, three taxa fewer than the median richness but within the range of results recorded at the site previously. However, eight of these taxa were present only as rarities (ie less than 5 individuals per taxon). This community richness was six taxa lower than that recorded at site 1 and one taxon less than recorded at site 2. The community at site 3 was comprised of a moderate proportion of 'sensitive' taxa (67%) resulting in the MCI score of 100 units. This score was seven units above the median of MCI scores recorded at this site by previous surveys. The score was also equal with the score recorded at site 2 and nine units lower than the score at the upstream 'control' site.

The high scoring 'highly sensitive' mayfly continued to numerically dominate the community at site 3 which resulted in the equal highest $SQMCI_s$ score recorded to date at the site (5.9 units). This $SQMCI_s$ score was significantly higher than the historical median score and the previous survey's score, and also was very similar to the score recorded at site 1 in this survey.

Site 4

A moderate richness of 14 taxa was recorded at site 4, which was within two taxa of richnesses at the nearest two upstream sites at the time of the current survey. This richness was three taxa above the historical median for the site but within the range of results to date.

The community was comprised of a moderate proportion of 'sensitive' taxa (50%), but a majority of these were recorded as rarities. This contributed to the MCI score of 91 units, two units lower than the median for the site. This score was significantly lower than that recorded at site 1 (by 18 units) and nine units lower than that at the nearest upstream site (3).

The lower $SQMCI_s$ score of 3.7 units principally was due to the numerical dominance of the community by three low scoring 'tolerant' taxa (oligochaete worms, orthoclad midges, and sandfly (*Austrosimulium*)). However, this $SQMCI_s$ score was significantly higher than the median recorded at the site to date (due to an abundance of one 'highly sensitive' taxon) but lower than $SQMCI_s$ scores recorded at the upstream 'control' site (1) and at sites 2 and 3 in this survey, coincidental with a looser substrate at site 4.

Discussion and conclusions

This autumn, May 2012 biological survey was performed to monitor the 'health' of the macroinvertebrate community of an unnamed tributary of the Mangamawhete Stream, in relation to the storage and spreading of drilling waste within its vicinity and the consented stormwater discharge to the stream. The results can be compared with pre-stockpiling communities, allowing an assessment of compliance with relevant consent requirements . Unfortunately, during the baseline survey undertaken in April 2009, the communities at the downstream sites had experienced significant deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance.

A biological survey undertaken in November 2010 following an incident related to windblown oil entering water, recorded impacts on the macroinvertebrate communities in the stream downstream of the discharge. However, the results of more recent surveys (April 2011and January 2012) showed improved taxa richnesses and invertebrate abundances at sites 2, 3 and 4 indicating the impacts recorded at these sites, due to the discharge, had abated.

In the current survey, the upstream control site (1) recorded a moderate taxa richness and MCI score, the latter higher than the median previously recorded at the site. However, the presence of four 'highly' sensitive taxa(one in abundance) was indicative of reasonable habitat and preceding water quality in the stream. The numerical dominance by the high scoring 'sensitive' mayfly resulted in a moderate $SQMCI_s$ score of 6.0 units. This $SQMCI_s$ score was higher than the $SQMCI_s$ scores recorded at the three downstream sites due to a greater numerical dominance by the 'highly sensitive' taxon at this site.

A slight deterioration in the macroinvertebrate community was recorded at site 2 which had a lower taxa richness and MCI score than those upstream. The MCI score of 100 units recorded at site 2 was insignificantly lower than the score recorded upstream due to the presence of a slightly lower proportion of 'sensitive' taxa in the community. These differences in MCI scores are considered to be the result of slight differences in habitat quality between the sites at the time of the survey rather than the result of any discharges from the land-farming site. At the time of the survey, the stream bed at sites 1, 2, and 3 were well compacted and consisted mainly of cobbles and boulders which may have improved the habitat quality by providing bed stability and varied habitat. The substrate at the other site (4) was generally less well compacted and therefore more prone to disturbance during high flows. The open site 2 recorded thin periphyton mats but widespread filaments which may have supported amacroinvertebrate community with lower proportions and abundances of 'sensitive' taxa in general. However, the community at this site was still dominated by a single 'highly sensitive' taxon (mayfly) which resulted in a moderate $SQMCI_s$ score of 5.9 units.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by lower taxa richnesses and at site 4 was numerically dominated by three additional low scoring 'tolerant' taxa which was coincident with some sedimentation and iron oxide present at this site.

The MCI score recorded at the furthest downstream site 4 was significantly lower than that recorded at the upstream site 1 indicating that the condition of the macroinvertebrate community at the furthest downstream site was poorer than that at the upstream 'control' site. This overall deterioration along the length (700 m) of the stream reach surveyed (although ecologically insignificant between adjacent sites ie <11 MCI units) may have been

due to drilling wastes, storage and/or discharge activities nearby, and/or more subtle habitat variability between sites.

Summary

This May 2012 biological survey of an unnamed tributary of the Mangamawhete Stream was performed to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the consented discharge of stormwater to the stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCIs scores for each site.

In the current survey, the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were higher than the median scores recorded at the site in previous surveys which indicated improvements in the community at this site. The presence of four 'highly sensitive' taxa (particularly the abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits and upstream of the stormwater discharge outfall. The taxa richness and MCI score recorded at site 2 in this survey were very similar to medians recorded to date at the site. In addition, the $SQMCI_s$ score recorded at this site was significantly higher than previously recorded at this site due to one numerically dominant 'highly sensitive' mayfly taxon.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by moderate taxa richnesses and at site 4, dominated mainly by low scoring 'tolerant' taxa coincident with increased sedimentation and iron oxide deposits present at this site. The MCI score recorded at site 4 was significantly lower than the MCI score recorded at site 1 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream coincident with some habitat variability.

Overall, the results of this autumn survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts may have been compounded by habitat variability. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

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To	Job Manager, David Olson
From	Scientific Officers - Freshwater Biology, Chris Fowles and Katrina Smith
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Biomonitoring of an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road land farm, November 2012

Introduction

This biological survey was the first of two scheduled surveys for the 2012-2013 monitoring period, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangamawhete Stream, in relation to the stockpiling and discharge of drilling waste to land within its vicinity. The site receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharged to the unnamed tributary. No consent was held to discharge to the tributary from the skimmer pits, as it was intended that no discharges to surface water would occur unless they complied with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that any discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life. However, during the 2010-2011 monitoring period several non-compliance discharge events were recorded (TRC, 2012) culminating in the requirement for a consent to discharge which was issued in September 2011. This consent to discharge stormwater (7911-1) provided for a 25 metre mixing zone in the tributary.

A baseline survey was undertaken in April 2009, prior to any receipt of drilling wastes at the site. Unfortunately, at the time of the baseline survey the communities at the downstream sites had experienced significant habitat deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance. The upstream control site was relatively unaffected. This makes temporal comparisons with results difficult, as recovery from the original disturbance and sedimentation may mask any impact from drilling waste disposal activities, if any such impact occurs.

Methods

Four sites were sampled in this survey. The control site (site 1) was established in the unnamed tributary, alongside the upstream boundary of the land treatment area. Site 2 was established between the land treatment area and the storage pits, and site 3 was established just downstream of the skimmer pit discharge point. A fourth site was established approximately 200m downstream of the skimmer pit discharge. This fourth site provides comparative information, should deterioration be recorded at sites 2 or 3. The sampling site locations are presented in Table 1 and Figure 1.

The standard 'kick-sampling' technique was used at these four sites (Table 1) to collect streambed macroinvertebrates on 28 November 2012. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road drilling waste stockpiling activities

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MMW000161	E1702317 N5653463	Upstream of drilling waste stockpiling site	450
2	MMW000162	E1702508 N5653560	Downstream of land spreading area	440
3	MMW000163	E1702734 N5653676	Downstream of skimmer pit discharge	435
4	MMW000165	E1702900 N5653750	200m downstream of skimmer pit discharge	430

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this late morning-early afternoon survey there was a swift, moderate flow at all sites. Due to significant upstream iron oxide seepage into this stream, the flow at all sites was uncoloured but slightly cloudy. The stream bed was orange as a result of the significant amount of oxidised ferrous iron sedimentation present at these sites but more prevalent at sites 2 and 3.

Site 1 was only partially shaded, due to a high steep bank on the northern side, with growths of slippery thin algal mats and patchy filaments. Site 2 was unshaded, with growths of slippery thin algal mats but widespread algal filaments while the lower two sites (site 3 and 4) were completely shaded, due to the stream margins consisting of mature remnant native vegetation, which restricted algal growth at both sites to slippery, thin algal mats, with no filamentous algae present.

The substrate at all sites predominantly consisted of boulders, cobbles and gravels and was relatively well packed.

Macroinvertebrate communities

Table 2 provides a summary of the results from previous surveys sampled in relation to the Derby Rd drilling waste stockpiling site along with current survey results. The full results from the current survey are presented in Table 3.

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site on 28 November 2012 and a summary of historical data for these sites (April 2009 to May 2012).

Site No.	N	No of taxa			MCI value			$SQMCI_s$ value		
		Median	Range	Nov 2012	Median	Range	Nov 2012	Median	Range	Nov 2012
1	6	19	12-28	22	106	87-114	110	5.4	3.2-7.1	7.4
2	6	13	6-16	20	100	80-109	106	2.8	2.0-4.9	7.4
3	6	14	5-19	13	97	88-109	98	4.2	2.5-5.9	4.6
4	6	13	6-18	21	92	73-104	89	3.2	2.1-5.7	6.8

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangamawhete Stream, sampled on 28 November 2012

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MMW000161	MMW000162	MMW000163	MMW000165
	Sample Number		FWB12453	FWB12454	FWB12455	FWB12456
ANNELIDA (WORMS)	Oligochaeta	1	A	A	C	C
	Lumbricidae	5	-	R	-	-
MOLLUSCA	*Gyraulus*	3	-	-	-	R
	Potamopyrgus	4	R	-	R	C
CRUSTACEA	Copepoda	5	-	-	-	R
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	R	-	-	-
	Austroclima	7	-	R	-	-
	Deleatidium	8	XA	XA	A	VA
	Nesameletus	9	C	-	-	-
	Zephlebia group	7	R	-	R	-
PLECOPTERA (STONEFLIES)	*Zelandoperla*	8	R	-	-	-
HEMIPTERA (BUGS)	*Saldula*	5	-	R	-	-
COLEOPTERA (BEETLES)	Elmidae	6	C	R	-	-
	Ptilodactylidae	8	-	R	-	-
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	R	-	R	C
TRICHOPTERA (CADDISFLIES)	*Costachorema*	7	R	R	-	-
	Hydrobiosis	5	A	C	-	-
	Hydrochorema	9	-	R	-	-
	Plectrocnemia	8	R	R	R	R
	Polyplectropus	6	-	-	-	R
	Psilochorema	6	R	R	R	R
	Oxyethira	2	R	R	-	-
DIPTERA (TRUE FLIES)	*Aphrophila*	5	A	C	R	-
	Eriopterini	5	C	C	C	C
	Hexatomini	5	R	-	-	R
	Limonia	6	-	R	-	-
	Harrisius	6	-	-	-	R
	Orthocladiinae	2	C	A	A	C
	Polypedilum	3	R	R	C	R
	Tanypodinae	5	R	C	R	R
	Ceratopogonidae	3	-	-	-	R
	Empididae	3	-	-	-	R
	Psychodidae	1	-	-	-	R
	Austrosimulium	3	C	C	R	C
	Stratiomyidae	5	R	-	-	-
	Tanyderidae	4	-	-	-	R
ACARINA (MITES)	Acarina	5	-	-	-	R
		No of taxa	22	20	13	21
		MCI	110	106	98	89
		SQMCIs	7.4	7.4	4.6	6.8
		EPT (taxa)	9	7	4	4
		%EPT (taxa)	41	35	31	19

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1

A moderate richness of 22 taxa was found at site 1 (Table 2), four more than recorded by the previous survey and three more than the median number of taxa previously recorded at this site. There were four taxa recorded in abundance; one 'highly sensitive' taxon [(extremely abundant mayfly (*Deleatidium*))]; two 'moderately sensitive' taxa [free-living caddisfly (*Hydrobiosis*) and cranefly (*Aphrophila*)]; and one 'tolerant' taxon [oligochaete worms]. The community was comprised of a relatively high proportion (73%) of 'sensitive' taxa, which included four 'highly sensitive' taxa (two mayflies, one stonefly, and one caddisfly). This relatively high proportion of 'sensitive taxa contributed to the MCI score of 110 units which was four units above the historical median and very similar to the score recorded by the previous survey, six months earlier.

A high $SQMCI_s$ score of 7.4 units was recorded, significantly higher than the median for the site recorded by previous surveys. This result reflected the numerical dominance of the community by one high scoring 'highly sensitive' taxon (mayfly (*Deleatidium*)) which was extremely abundant, and also the dominant taxon at the time of the previous (autumn) survey.

Site 2

A similar richness (20 taxa) was recorded at site 2, two taxa fewer than recorded at site 1 but four taxa more than the maximum richness recorded to date at this site. The community was comprised of a moderate proportion of 'sensitive' taxa (75%), although a majority of these were rarities (less than five individuals per taxon). The relatively high proportion of 'sensitive' taxa was reflected in the moderate MCI score of 106 units, six units higher than the median score recorded at this site to date and an insignificant four units lower than the score at the upstream 'control' site. There was only one significant decrease in individual taxon abundance (a 'highly sensitive' taxon) between sites.

The community was numerically dominated by only three taxa, the extremely abundant 'highly sensitive' mayfly (*Deleatidium*) and 'tolerant' oligochaete worms and orthoclad midges. However, the extreme abundance of the mayfly resulted in the high $SQMCI_s$ score of 7.4 units, which was equal with the score recorded at site 1 and much higher than the maximum to date for this site (by 2.5 units).

Site 3

A relatively poor richness (13 taxa) was recorded at this site, one taxon fewer than the median richness but within the range of results recorded at the site previously. However, eight of these taxa were present only as rarities (i.e. less than 5 individuals per taxon). This community richness was nine taxa lower than that recorded at site 1 and seven taxa less than recorded at site 2. The community at site 3 was comprised of a moderate proportion of 'sensitive' taxa (62%) resulting in the MCI score of 98 units. This score was very similar to the median of MCI scores recorded at this site by previous surveys. The score was an insignificant 8 units lower than the score recorded at site 2 but a significant 12 units (Stark, 1998) lower than the score at the upstream 'control' site.

The high scoring 'highly sensitive' mayfly continued to numerically dominate the community along with the 'tolerant' orthoclad midges at site 3, which resulted in a moderate $SQMCI_s$ score (4.6 units) recorded at the site. This $SQMCI_s$ score was slightly higher than the historical median score but a significant 2.8 units lower than the scores recorded at sites 1 and 2 in this survey.

Site 4

A moderate richness of 21 taxa was recorded at site 4, which was very similar to richnesses at upstream sites 1 and 2, and 8 taxa more than at the nearest upstream site at the time of the current survey. This richness was three taxa above the historical maximum for the site.

The community was comprised of a moderate proportion of 'sensitive' taxa (52%), but many of these taxa were recorded as rarities. This contributed to the MCI score of 89 units, three units lower than the median for the site. This score was significantly (Stark, 1998) lower than that recorded at site 1 (by 21 units) and nine units lower than that at the nearest upstream site (3).

The moderate $SQMCI_s$ score of 6.8 units principally was due to the numerical dominance of the community by only one, 'highly sensitive' taxon [very abundant mayfly (*Deleatidium*)], the only taxon characteristic of this community. This $SQMCI_s$ score was significantly higher than the median recorded at the site to date (due to an abundance of the one 'highly sensitive' taxon) and more similar to $SQMCI_s$ scores recorded at the upstream 'control' site (1) and site 2 in this survey, coincidental with a more compact substrate and a much finer iron oxide coating than usual at site 4.

Discussion and conclusions

This early summer, November 2012 biological survey was performed to monitor the 'health' of the macroinvertebrate community of an unnamed tributary of the Mangamawhete Stream, in relation to the storage and spreading of drilling waste within its vicinity and the consented stormwater discharge to the stream. The results can be compared with pre-stockpiling communities, allowing an assessment of compliance with relevant consent requirements . Unfortunately, during the baseline survey undertaken in April 2009, the communities at the downstream sites had experienced significant deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance.

A biological survey undertaken in November 2010 following an incident related to windblown oil entering water, recorded impacts on the macroinvertebrate communities in the stream downstream of the discharge. However, the results of more recent surveys (April 2011, January 2012, and May 2012) showed improved taxa richnesses and invertebrate abundances at sites 2, 3 and 4 indicating the impacts recorded at these sites, due to the discharge, had abated.

In the current survey, the upstream control site (1) recorded a moderate taxa richness and MCI score, both higher than the medians previously recorded at the site. However, the presence of five 'highly' sensitive taxa (one in extreme abundance) was indicative of reasonable habitat and preceding water quality in the stream. The numerical dominance by the high scoring 'sensitive' mayfly resulted in a relatively high $SQMCI_s$ score of 7.4 units which was higher than or equal with the $SQMCI_s$ scores recorded at the three downstream sites mainly due to a greater numerical dominance by the 'highly sensitive' taxon at this site.

Minimal deterioration in the macroinvertebrate community was recorded at site 2 which had a lower taxa richness and MCI score than those upstream. The MCI score of 106 units recorded at site 2 was insignificantly lower than the score recorded upstream due to a very similar proportion of 'sensitive' taxa in these communities. The difference in MCI scores is considered to be the result of slight differences in habitat quality between the sites at the

time of the survey rather than the result of any discharges from the land-farming site. At the time of the survey, the stream bed at sites 1, 2, and 3 were well compacted and consisted mainly of cobbles and boulders which may have improved the habitat quality by providing bed stability and varied habitat. The substrate at the other site (4) was slightly less well compacted and therefore more prone to disturbance during high flows. The open site 2 recorded thin periphyton mats but widespread filaments which may have supported a macroinvertebrate community with lower proportions and abundances of 'sensitive' taxa in general. However, the community at this site was still numerically dominated by one 'highly sensitive' taxon (mayfly) which resulted in the relatively high $SQMCI_s$ score of 7.4 units, although an additional 'tolerant' taxon characterised the community structure.

The macroinvertebrate communities at the two downstream sites (3 and 4) generally were characterised by lower taxa richness (site 3) and slightly fewer characteristic taxa and slightly lower proportions of 'sensitive' taxa which were coincident with some sedimentation and iron oxide present on the streambed particularly at site 3.

The MCI scores recorded at the furthest downstream sites 3 and 4 were significantly lower than that recorded at the upstream site 1 indicating that the condition of the macroinvertebrate community at these downstream sites was poorer than that at the upstream 'control' site. This overall deterioration along the length (700 m) of the stream reach surveyed which was greater (by about 15 units) than predicted (Stark and Fowles, 2009), although ecologically insignificant between adjacent sites (i.e. <11 MCI units) may have been due to drilling wastes, storage and/or discharge activities nearby, but more likely due to subtle habitat variability between sites.

Summary

This November 2012 biological survey of an unnamed tributary of the Mangamawhete Stream was performed to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the consented discharge of stormwater to the stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCIs scores for each site.

In the current survey, the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were higher than the median and/or maximum scores recorded at the site in previous surveys which indicated improvements in the community at this site. The presence of five 'highly sensitive' taxa (and particularly the extreme abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits, and upstream of the stormwater discharge outfall. The taxa richness and MCI score recorded at site 2 in this survey were also higher than medians recorded to date at the site. In addition, the $SQMCI_s$ score recorded at this site was significantly higher than previously recorded at this site due to one numerically dominant 'highly sensitive' mayfly taxon.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by relatively poor to moderate taxa richnesses and at both sites, dominated

mainly by fewer taxa coincident with decreased periphyton substrate cover, but some increase in sedimentation and iron oxide deposits on the streambed at this site. The MCI scores recorded at sites 3 and 4 were significantly lower than the MCI score recorded at site 1 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream but more coincident with aspects of habitat variability.

Overall, the results of this early summer survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts are more likely to have been compounded by habitat variability. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream in comparison with similar streams elsewhere on the ringplain (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

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To Job Manager, David Olsen;
From Scientific Officers-Freshwater Biology, Chris Fowles and Katrina Smith
Document 1242712
Report No CF585
Date 3 September 2013

Biomonitoring of an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site, November 2012.

Introduction

This biological survey was the first of two programmed for the 2012-2013 monitoring year, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangatengehu Stream, in relation to the disposal of drilling waste to land within its vicinity.

The site located off Surrey Road, receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharges to the land in the vicinity of the unnamed tributary. No consent is held to discharge to the tributary from the skimmer pits, as it is intended for this discharge to comply with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that the discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life.

The results of previous surveys performed in relation to this site are discussed in the references at the end of this report.

Methods

This biomonitoring survey was undertaken at four sites on 28 November 2012 (Table 1 and Figure 1). At the time of the initial survey undertaken in April 2010, site 1 was established as a 'control site', upstream of the drilling stockpile area and sites 2 and 3 were established downstream of the skimmer pit discharge. During an inspection of the site in mid-2010, an unauthorised discharge of hydrocarbons was observed entering the stream. As a consequence of this inspection, changes were made to the on site drainage. These changes were made between the April 2010 and November 2010 surveys. The result was that site 2 was located upstream of any discharge from the sites, and site 3 became the primary impact site. The stormwater discharge from the site now enters the unnamed tributary immediately upstream of the race crossing, approximately 35 metres upstream of site 3. A new, secondary impact site (site 4) was established 100 metres downstream of the stormwater discharge at the time of the previous survey (in May, 2012).

The standard 'kick-sampling' technique was used at all four sites (Table 1) to collect streambed macroinvertebrates. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road drilling waste stockpiling activities

Site Number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MTH000060	E1701830 N5651430	Upstream of drilling waste stockpiling site	495
2	MTH000062	E1701954 N5651468	Approximately 85 metres upstream of the spring and skimmer pit discharge	495
3	MTH000064	E1702050 N5651525	Approximately 35 metres downstream of the skimmer pit discharge	490
4	MTH000066	E1702102 N5651582	Approximately 100 metres downstream, of the skimmer pit discharge	485

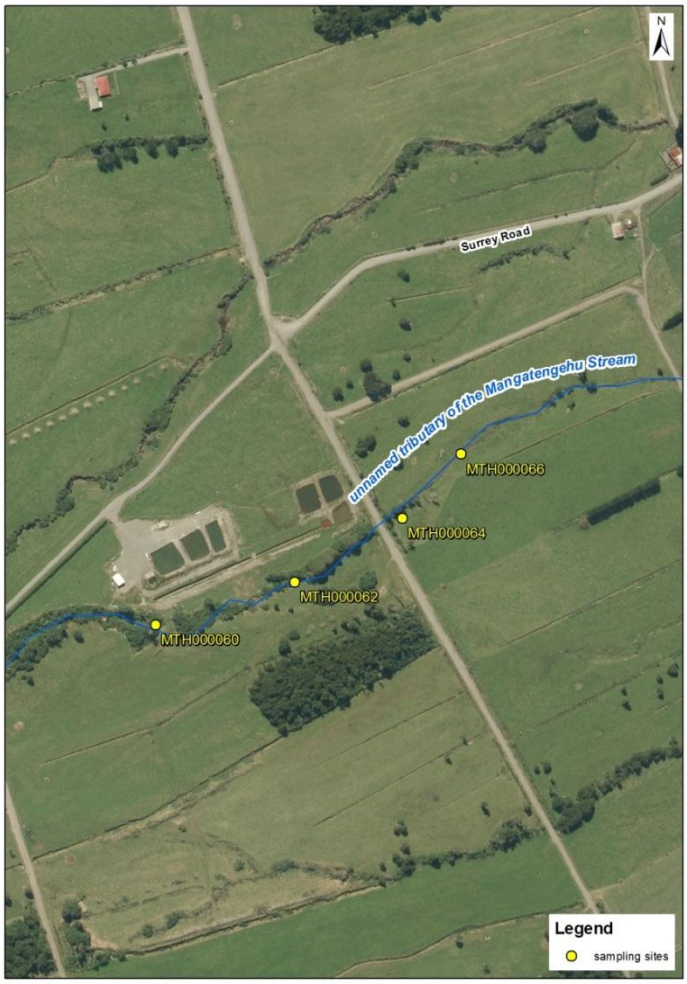

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark *et al*, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 19 98 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

This November 2012 survey followed a period of 11 days since a fresh in excess of three times median flow, and 25 days since a fresh in excess of seven times median flow. In the month prior to this survey, there had been five fresh events, one of which exceeded the 3 times median flow and another which exceeded 7 times median flow. However, for the majority of this period the flows were close to the median flow in the tributary.

A low, swift flow of uncoloured, clear water was recorded at site 1 in this survey. The substrate at this site was predominantly fine gravels; and coarser gravels and sand, with very fine iron oxide sedimentation. In this partially shaded section of stream, only a slippery algal film was recorded.

There was a low, swift flow of uncoloured, clear water recorded at site 2. Cobbles, coarse and fine gravels dominated the bed of the stream at this site where there was also a minor amount of iron oxide sediment. Slippery algal mats and patchy leafy debris were recorded at this completely shaded site.

Sites 3 and 4 recorded a low, swift flow of uncoloured, clear water with site 3 partially shaded and site 4 unshaded. At both sites, the bed substrate primarily consisted of cobbles, coarse and fine gravels. The periphyton recorded at both sites included widespread algal mats and patchy filamentous algae at the time of this survey. Widespread growths of benthic cyanobacteria were also recorded at both sites and iron oxide sediment was also widespread at both sites.

Macroinvertebrate communities

Table 2 provides a summary of the results for the current survey sampled in relation to the Surrey Road drilling waste stockpiling site together with a summary of historical results. The full results from this current survey are presented in Table 3.

Table 2 Number of taxa, MCI, and SQMCI$_s$ values for an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site, and a summary of historical data for these sites (April 2010 to May 2012)

Site No.	Number of taxa				MCI value			SQMCI$_s$ value		
	No. of samples	Median	Range	Nov 2012	Median	Range	Nov 2012	Median	Range	Nov 2012
1	5	20	18-20	17	115	106-127	124	4.5	2.3-5.4	4.3
2	5	20	5-30	24	118	80-128	128	4.2	1.6-6.3	6.9
3	5	10	9-16	16	98	96-104	119	1.6	1.4-2.5	3.6
4	1	21	-	12	107	-	97	2.1	-	2.1

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangatengehu Stream, sampled on 28 November 2012

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MTH000060	MTH000062	MTH000064	MTH000066
	Sample Number		FWB12449	FWB12450	FWB12451	FWB12452
NEMATODA	Nematoda	3	-	-	-	R
ANNELIDA (WORMS)	Oligochaeta	1	-	C	A	VA
	Lumbricidae	5	-	-	-	R
MOLLUSCA	*Potamopyrgus*	4	R	R	-	-
CRUSTACEA	*Paranephrops*	5	-	R	R	-
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	-	R	-	-
	Austroclima	7	C	C	R	C
	Deleatidium	8	-	VA	R	R
	Neozephlebia	7	-	R	-	-
	Nesameletus	9	-	R	-	-
	Zephlebia group	7	R	A	C	-
PLECOPTERA (STONEFLIES)	*Acroperla*	5	-	R	R	R
	Austroperla	9	R	-	C	-
	Spaniocerca	8	R	C	-	-
	Stenoperla	10	R	C	-	-
	Zelandobius	5	-	R	-	-
	Zelandobius illiesi	10	-	C	-	-
	Zelandoperla	8	-	R	R	-
COLEOPTERA (BEETLES)	Elmidae	6	-	C	-	R
	Ptilodactylidae	8	R	R	R	R
	Scirtidae	8	R	-	-	-
	Staphylinidae	5	-	R	-	-
TRICHOPTERA (CADDISFLIES)	*Costachorema*	7	-	-	R	-
	Hydrochorema	9	R	R	R	-
	Psilochorema	6	R	R	R	-
	Oxyethira	2	R	-	-	-
DIPTERA (TRUE FLIES)	*Aphrophila*	5	-	R	C	A
	Eriopterini	5	R	-	R	R
	Hexatomini	5	R	-	-	-
	Paralimnophila	6	-	R	-	-
	Zelandotipula	6	R	-	-	-
	Harrisius	6	R	-	-	-
	Orthocladiinae	2	A	A	A	VA
	Polypedilum	3	-	R	R	-
	Empididae	3	-	-	-	R
	Austrosimulium	3	R	-	-	-
		No of taxa	17	24	16	12
		MCI	124	128	119	97
		SQMCIs	4.3	6.9	3.6	2.1
		EPT (taxa)	7	14	9	3
		%EPT (taxa)	41	58	56	25

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1

Survey results to date at this site are illustrated in Figure 2.

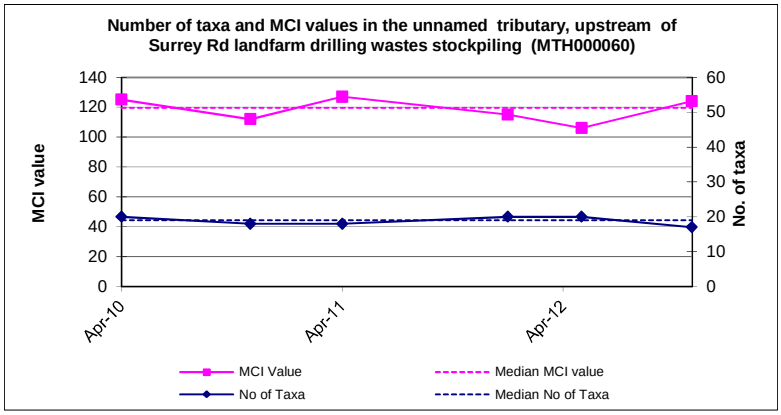

Figure 2 Taxa richnesses and MCI scores recorded to date at site 1.

A moderate richness of 17 taxa was recorded at site 1 upstream of the storage area, which was one taxon fewer than recorded at the site to date, although the range had previously been very narrow (Table 2 and Figure 2).

There was only one taxon recorded in abundance; a tolerant taxon [orthoclad midges] while the majority of taxa (88%) were recorded as rarities, an indication of the poor habitat quality at this site. However, the community was comprised of a relatively high proportion (76%) of 'sensitive' taxa which included six 'highly sensitive' taxa (three stoneflies, two beetles, and one caddisfly). This high proportion of 'sensitive' taxa contributed to the MCI score of 124 units which was nine units above the historical median and a significant (Stark, 1998) 18 units higher than the score recorded by the previous survey, six months earlier.

A relatively low $SQMCI_s$ score of 4.3 units was recorded, but similar to the median for the site recorded by previous surveys. This score reflected the numerical dominance by the 'tolerant' orthoclad midges in particular and to a lesser extent, the common mayfly, *Austroclima*. [Note: the low abundances within nearly all taxa were indicative of a poorly established community which might be anticipated to show wide temporal variability in MCI and $SQMCI_s$ scores].

Site 2

Survey results to date at this site are illustrated in Figure 3.

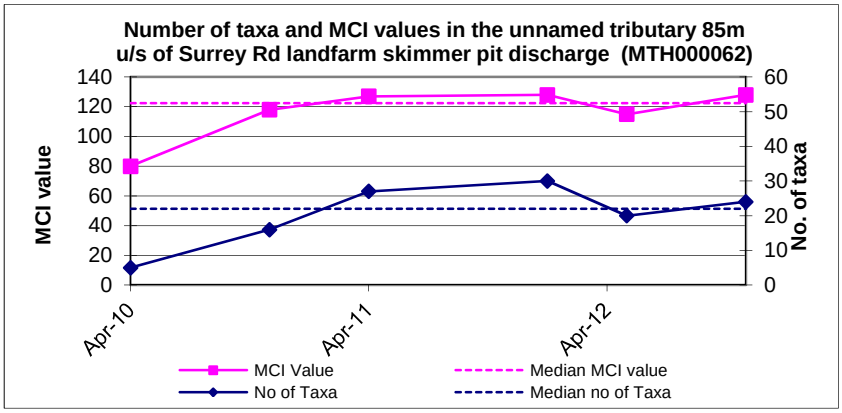

Figure 3 Taxa richnesses and MCI scores recorded to date at site 2

A moderately high richness of 24 taxa was recorded at site 2 in the current survey, four taxa more than the median yet well within the range recorded at the site previously (Table 2 and Figure 3). Although this result was six taxa less than the maximum recorded at this site previously, it represented a marked improvement in the community from the initial survey in which only five taxa were recorded. This marked improvement has been directly related to the change in location of the discharge point (to further downstream) which occurred in mid-2010 and also to additional skimmer pit/spring drainage provided at the stockpiling site (see Figure 1). This taxa richness was seven more than that recorded at site 1 in the current survey.

The community was comprised of a high proportion of 'sensitive' taxa (83%) but a significant proportion of these were rarities (less than five individuals per taxon). The high proportion of 'sensitive' taxa was reflected in the high MCI score of 128 units, ten units higher than the median score recorded at this site to date and an insignificant four units higher than the score at the upstream 'control' site. There were two significant increases in individual taxon abundances (both 'sensitive' taxa) between sites 1 and 2.

The community was characterised by one 'highly sensitive' taxon [mayfly (*Deleatidium*)]; one 'moderately sensitive' taxon [mayfly (*Austroclima*)]; and one 'tolerant' taxon [orthoclad midges], indicative of some improvement in community structure in a downstream direction. However, it was numerically dominated by only one taxon, the 'highly sensitive' mayfly (*Deleatidium*) which resulted in the relatively high $SQMCI_s$ score of 6.9 units, which was significantly higher than the score recorded at site 1 and higher than the maximum to date for this site (by 0.6 unit).

Site 3

Survey results to date at this site are illustrated in Figure 4.

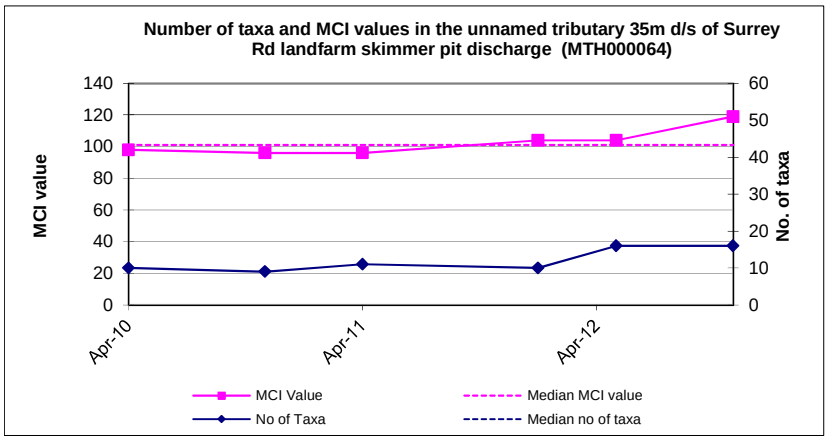

Figure 4 Taxa richnesses and MCI scores recorded to date at site 3.

A moderate richness (16 taxa) was recorded at this site which was equivalent with the maximum richness recorded at the site previously. However, eleven of these taxa (69% of richness) were present only as rarities (i.e. less than five individuals per taxon). This community richness was one taxon lower than that recorded at site 1 but eight taxa less than recorded at site 2. The community at site 3 also was comprised of a high proportion of 'sensitive' taxa (81%) resulting in the MCI score of 119 units. This score was a significant 15 units (Stark, 1998) above the maximum of MCI scores recorded at this site by previous surveys, although the score was 9 units lower than the score recorded at site 2 and five units lower than the score at the upstream 'control' site.

The community was characterised however, by only two taxa, both 'tolerant' taxa [oligochaete worms and orthoclad midges], which together with a significant decrease in three individual 'sensitive' taxa abundances, were consistent with the marked proliferation in algal mats (cyanobacteria in particular) and filamentous algae, and increased iron oxide substrate cover at this partially shaded site.

The numerical domination by the two 'tolerant' taxa resulted in a significant downstream decrease of 3.3 units in $SQMCI_s$ score (to 3.6 units) between sites 2 and 3. This score however, was 1.1 units higher than previously recorded at this site (Table 2) due to the additional presence of three 'sensitive' taxa which were common (Table 3).

Site 4

Survey results for this site to date are illustrated in Figure 5.

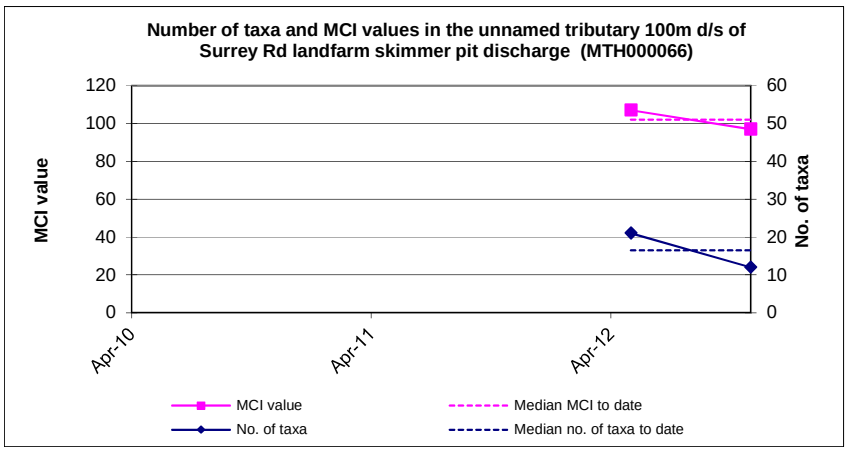

Figure 5 Taxa richnesses and MCI scores recorded to date at site 4

A relatively poor richness of 12 taxa was recorded at the recently established site 4, approximately 65 metres downstream of the skimmer pit discharge area. This taxa richness was the lowest recorded at the four sites sampled in this survey and was well below the number of taxa recorded at this site on the previous and only sampling occasion to date (Figure 5).

The moderately high proportion of 'sensitive' taxa (67%) recorded at this site was reflected in the moderate MCI score of 97 units. This MCI score was 10 units lower than recorded at the time of the previous survey and was significantly lower than that recorded at site 1 (by 27 units) and 22 units lower than that at the nearest upstream site (3).

The lower $SQMCI_s$ of 2.1 units principally was due to the numerical dominance of the community by two low scoring 'tolerant' taxa (oligochaete worms and orthoclad midges). This $SQMCI_s$ score was also lower than scores recorded at the upstream 'control' site (1) and at sites 2 and 3 in this survey, coincidental with profuse cyanobacteria algal substrate cover, patchy filamentous algae, and widespread iron oxide sedimentation covering the substrate of this open (unshaded) site.

Discussion and conclusions

At the time of this early summer, November 2012 survey, downstream increases in iron oxide sedimentation and periphyton substrate cover at the four sites sampled in the unnamed tributary of the Mangatengehu Stream were reflected in the abundances of 'tolerant' oligochaete worms and orthoclad midges .

A high proportion of the taxa recorded at all four sites in the tributary were 'sensitive' taxa, which were indicative of reasonable preceding water quality despite the majority of these taxa only occurring as rarities at each site.

In the current survey, the upstream control site (1) recorded a moderate taxa richness and relatively high MCI score, the latter higher than the median previously recorded at this site. However, the presence of a very high proportion of taxa rarities was indicative of poor habitat quality at this site. The numerical dominance by the one low scoring 'tolerant' midge resulted in a moderate $SQMCI_s$ score of 4.3 units. The $SQMCI_s$ score was lower than the $SQMCI_s$ scores which might be anticipated in a small tributary stream at such an altitude and relatively close to the National Park.

Improvement in the macroinvertebrate community was recorded at site 2 which had a higher taxa richness and MCI and $SQMCI_s$ scores than those upstream. The MCI score of 128 units recorded at site 2 was insignificantly different to the score recorded upstream coincident with a slightly higher proportion of 'sensitive' taxa in the community. These differences in MCI scores are considered to be the result of slight differences in habitat quality between the sites at the time of the survey rather than the result of any activities associated with the land-farming site. At the time of the survey, the completely shaded site 2 recorded thin periphyton mats and no widespread filaments and only a minor degree of iron oxide sedimentation which supported a macroinvertebrate community with higher proportions and abundances of 'sensitive' taxa in general. The community at this site was numerically dominated by one 'highly sensitive' taxon (mayfly) which resulted in a relatively high $SQMCI_s$ score of 6.9 units; a much improved community to that recorded at the upstream (control) site 1.

The macroinvertebrate communities at the downstream sites (3 and 4) were characterised by lower taxa richnesses (poorest at site 4) and were numerically dominated by two low scoring 'tolerant' taxa with significant decreases in several individual 'sensitive' taxon abundances which were coincident with more extensive iron oxide sedimentation and proliferations of algal periphyton (particularly cyanobacteria) substrate cover at these more open, unshaded sites.

The MCI score recorded at the furthest downstream site 4 was significantly lower than that recorded at the nearest upstream site and at the 'control' site 1 indicating that the condition of the macroinvertebrate community at the furthest downstream site was poorer than that at the upstream sites. This greater than expected (Stark and Fowles, 2009) overall deterioration along the length (500 m) of the upper reaches of the stream surveyed (which was ecologically significant between adjacent sites 3 and 4 (i.e. > 11 MCI units)) may have been due to discharge activities upstream of site 3 and/or habitat variability between sites, particularly increased substrate cover by periphyton growth and iron oxide sedimentation.

Summary

This November 2012 biological survey of an unnamed tributary of the Mangatengehu Stream was performed to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the discharge of stormwater to land or to the stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_s$ score for each site.

In the current survey, the MCI and $SQMCI_s$ score recorded at the upstream 'control' site, although higher than, or similar to, the median scores recorded at the site in previous surveys, were indicative of poor community structure at this site. The presence of many 'sensitive' taxa in this community was indicative of relatively good preceding water quality but the paucity of individual taxon abundances was indicative of poorer habitat quality.

The results of this survey indicated an improvement in the condition of the macroinvertebrate community at site 2, located between the wastes storage pits and upstream of the stormwater discharge outfall. The taxa richness and MCI score recorded at site 2 in this survey were above medians recorded to date at the site. In addition, the $SQMCI_s$ score recorded at this site was significantly higher than previously recorded at this site due to one numerically dominant 'highly sensitive' mayfly taxon.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by lower taxa richnesses and dominated by low scoring 'tolerant' taxa and several significant decreases in individual 'sensitive' taxon abundances coincident with marked increases in periphyton substrate cover and iron oxide deposits present at these sites. The MCI score recorded at site 4 was significantly lower than the MCI score recorded at sites 1 and 3 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream coincident with marked variability in physical stream habitat.

Overall, the results of this late spring survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts have been compounded by habitat variability. In general however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a spring fed ringplain stream reflected the fragmentation of riparian habitat and the influence of iron-rich groundwater seepage and subsequent sedimentation along the length of stream surveyed.

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To	Job Manager, David Olson
From	Scientific Officer - Freshwater Biology, Bart Jansma
Document	1265333
Report No	BJ213
Date	16 October 2013

Biomonitoring of an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road land farm, April 2013

Introduction

This biological survey was the second of two scheduled surveys for the 2012-2013 monitoring period, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangamawhete Stream, in relation to the stockpiling and discharge of drilling waste to land within its vicinity. The site receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharged to the unnamed tributary. No consent was held to discharge to the tributary from the skimmer pits, as it was intended that no discharges to surface water would occur unless they complied with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that any discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life. However, during the 2010-2011 monitoring period several non-compliance discharge events were recorded (TRC, 2012) culminating in the requirement for a consent to discharge which was issued in September 2011. This consent to discharge stormwater (7911-1) provided for a 25 metre mixing zone in the tributary.

A baseline survey was undertaken in April 2009, prior to any receipt of drilling wastes at the site. Unfortunately, at the time of the baseline survey the communities at the downstream sites had experienced significant habitat deterioration due to the realignment of the tributary, and also the discharge of significant amounts of sediment through associated land disturbance. The upstream control site was relatively unaffected. This makes temporal comparisons with results difficult, as recovery from the original disturbance and sedimentation may mask any impact from drilling waste disposal activities, if any such impact occurs.

Methods

Four sites were sampled in this survey. The control site (site 1) was established in the unnamed tributary, alongside the upstream boundary of the land treatment area. Site 2 was established between the land treatment area and the storage pits, and site 3 was established just downstream of the skimmer pit discharge point. A fourth site was established approximately 200m downstream of the skimmer pit discharge. This fourth site provides comparative information, should deterioration be recorded at sites 2 or 3. The sampling site locations are presented in Table 1 and Figure 1.

The standard 'kick-sampling' technique was used at these four sites (Table 1) to collect streambed macroinvertebrates on 9 April 2013. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream in relation to the Derby Road drilling waste stockpiling activities

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MMW000161	E1702317 N5653463	Upstream of drilling waste stockpiling site	450
2	MMW000162	E1702508 N5653560	Downstream of land spreading area	440
3	MMW000163	E1702734 N5653676	Downstream of skimmer pit discharge	435
4	MMW000165	E1702900 N5653750	200m downstream of skimmer pit discharge	430

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

At the time of this late morning-early afternoon survey there was a steady, low flow at all sites. It is worth noting that this survey was undertaken following an extended period of low flows, which will have influenced the invertebrate communities of this tributary. Due to significant upstream iron oxide seepage into this stream, the flow at all sites was uncoloured but cloudy. The stream bed was also affected by this iron oxide seepage, with iron oxide sedimentation being observed at all sites.

Site 1 was only partially shaded, due to a high steep bank on the northern side, with growths of patchy algal mats. Site 2 was unshaded, with patchy growths of algal mats and algal filaments, while the lower two sites (site 3 and 4) were completely shaded, due to the stream margins consisting of mature remnant native vegetation, which restricted algal growth at both sites to slippery, thin algal mats, with no filamentous algae present.

The substrate at all sites predominantly consisted of boulders, cobbles and gravels and was relatively well packed.

Macroinvertebrate communities

Table 2 provides a summary of the results from previous surveys sampled in relation to the Derby Rd drilling waste stockpiling site along with current survey results. The full results from the current survey are presented in Table 3.

Table 2 Number of taxa, MCI and $SQMCI_s$ values for an unnamed tributary of the Mangamawhete Stream, sampled in relation to the Derby Rd drilling waste stockpiling site on 9 April 2013 and a summary of historical data for these sites.

Site No.	N	No of taxa			MCI value			$SQMCI_s$ value		
		Median	Range	Apr 2013	Median	Range	Apr 2013	Median	Range	Apr 2013
1	7	20	12-28	33	109	87-114	108	3.0	3.2-7.4	6.2
2	7	13	6-20	27	100	80-109	106	2.9	2.0-7.4	3.9
3	7	13	5-19	19	98	88-109	109	4.4	2.5-5.9	3.1
4	7	14	6-21	24	91	73-104	104	3.7	2.1-6.8	4.0

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangamawhete Stream, sampled on 9 April 2013

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MMW000161	MMW000162	MMW000163	MMW000165
	Sample Number		FWB13187	FWB13188	FWB13189	FWB13190
NEMERTEA	Nemertea	3	-	C	-	-
ANNELIDA	Oligochaeta	1	VA	VA	VA	A
	Lumbricidae	5	R	-	-	-
MOLLUSCA	*Potamopyrgus*	4	A	C	-	C
CRUSTACEA	Copepoda	5	-	-	-	R
	Ostracoda	1	VA	VA	C	C
EPHEMEROPTERA	*Austroclima*	7	C	R	R	C
	Coloburiscus	7	R	-	-	-
	Deleatidium	8	XA	VA	A	A
	Nesameletus	9	VA	A	-	R
	Zephlebia group	7	R	-	-	R
PLECOPTERA	*Austroperla*	9	-	-	R	-
	Spaniocerca	8	-	R	-	-
	Zelandobius	5	R	-	-	-
	Zelandoperla	8	R	R	R	-
COLEOPTERA	Elmidae	6	A	C	-	-
	Hydraenidae	8	R	-	-	-
	Ptilodactylidae	8	R	R	R	R
	Scirtidae	8	R	R	-	R
MEGALOPTERA	*Archichauliodes*	7	-	R	R	C
TRICHOPTERA	*Costachorema*	7	R	R	-	-
	Hydrobiosis	5	A	A	C	C
	Neurochorema	6	-	R	-	-
	Orthopsyche	9	C	R	R	R
	Polyplectropus	6	R	-	C	R
	Psilochorema	6	A	A	A	C
	Oxyethira	2	R	C	-	-
	Pycnocentria	7	R	-	R	-
	Triplectides	5	-	-	-	R
DIPTERA	*Aphrophila*	5	C	A	-	-
	Eriopterini	5	C	C	C	R
	Hexatomini	5	R	-	-	R
	Limonia	6	R	-	-	-
	Paralimnophila	6	-	-	R	-
	Zelandotipula	6	R	-	-	-
	Orthocladiinae	2	C	A	C	A
	Polypedilum	3	C	R	A	A
	Tanypodinae	5	-	R	-	-
	Paradixa	4	R	R	-	R
	Empididae	3	-	R	R	R
	Psychodidae	1	R	-	-	-
	Austrosimulium	3	R	R	R	A
	Tanyderidae	4	-	-	-	R
ACARINA (MITES)	Acarina	5	R	-	-	-
		No of taxa	33	27	19	24
		MCI	108	106	109	104
		SQMCIs	6.2	3.9	3.1	4.0
		EPT (taxa)	13	10	9	9
		%EPT (taxa)	39	37	47	38

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1

A high richness of 33 taxa was found at site 1 (Table 2), eleven more than recorded by the previous survey, thirteen more than the median number of taxa recorded at this site and five more than the maximum richness of the short historical record. There were eight taxa recorded in abundance; two 'highly sensitive' taxa [(mayfly (extremely abundant *Deleatidium,* very abundant *Nesameletus*))]; three 'moderately sensitive' taxa [elmid beetles, free-living caddisfly (*Hydrobiosis* & *Psilochorema*)]; and three 'tolerant' taxa [oligochaete worms, *Potamopyrgus* snails and ostracod seed shrimp]. This high taxa richness and high number of taxa present in abundance is a direct reflection of the stable flows, allowing new taxa to establish and some to increase in abundance, as they were not flushed away by recent floods.

The community was comprised of a relatively high proportion (73%) of 'sensitive' taxa, which included seven 'highly sensitive' taxa (two mayflies, one stonefly, three beetles and one caddisfly). This relatively high proportion of 'sensitive' taxa contributed to the MCI score of 108 units which was very similar to the historical median and very similar to the score recorded by the previous survey (Figure 2).

A moderately high $SQMCI_s$ score of 6.2 units was recorded, similar to the median for the site recorded by previous surveys but significantly less than that recorded in the previous survey (7.4). This result reflected the numerical dominance of the community by one high scoring 'highly sensitive' taxon (mayfly (*Deleatidium*)) which was extremely abundant, and also the dominant taxon at the time of the previous (spring) survey.

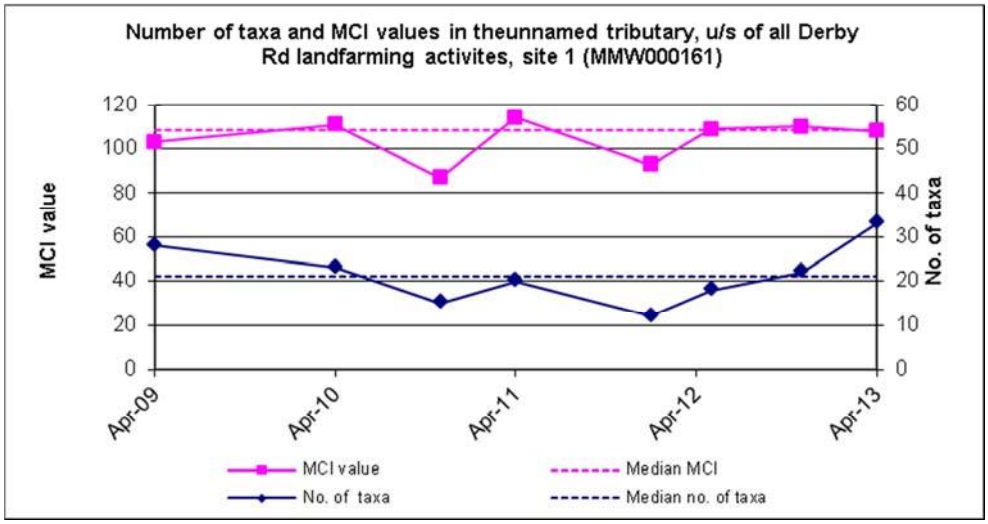

Figure 2 Numbers of macroinvertebrate taxa and MCI values recorded at site 1 in the unnamed tributary

Site 2

A slightly lower richness (27 taxa) was recorded at site 2, six taxa fewer than recorded at site 1 but seven taxa more than the maximum richness recorded to date at this site (Table 2, Figure 3). The community was comprised of a moderate proportion of 'sensitive' taxa (63%), although a majority of these were rarities (less than five individuals per taxon). The relatively high proportion of 'sensitive' taxa was reflected in the moderate MCI score of 106 units, six units higher than the median score recorded at this site to date and an insignificant two units lower than the score at the upstream 'control' site. There was only one significant change in individual taxon abundance (a 'tolerant' taxon) between sites.

The community was numerically dominated by eight taxa, two 'highly sensitive' mayfly taxa (*Deleatidium* and *Nesameletus*), three 'moderately sensitive' taxa [free-living caddisfly (*Hydrobiosis* & *Psilochorema*)]; and three 'tolerant' taxa [oligochaete worms, ostracod seed shrimp and orthoclad midges]. However, the abundance of two very 'tolerant' taxa contributed to a reduced $SQMCI_s$ score of 3.9 units, which was significantly less than the score recorded at site 1, but significantly higher than the median to date for this site (by 2.5 units).

Although the communities at this site are in slightly poorer condition than that recorded at site 2, as indicated by the $SQMCI_s$ score, this is likely related to the open habitat of this site, which was compounded by the low flows that preceded this survey. There was still a good proportion of 'sensitive' taxa present, some in abundance, and this indicates that water quality had been moderate preceding this survey.

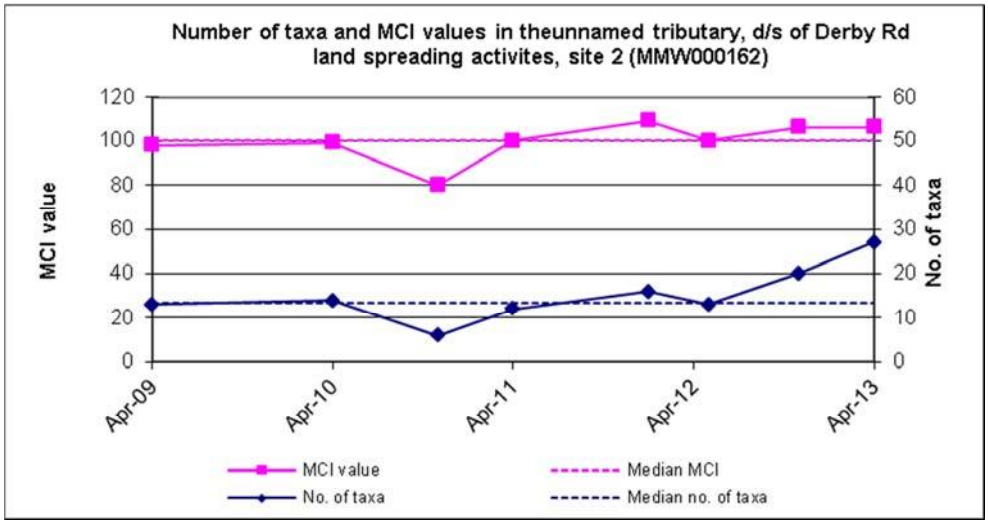

Figure 3 Numbers of macroinvertebrate taxa and MCI values recorded at site 2 in the unnamed tributary

Site 3

A moderate richness (19 taxa) was recorded at this site, six taxa more than the median richness, and equal to the maximum richness recorded to date (Table 2, Figure 4). However, ten of these taxa were present only as rarities (i.e. less than 5 individuals per taxon). This community richness was fourteen taxa lower than that recorded at site 1 and eight taxa less than recorded at site 2. The community at site 3 was comprised of a moderate proportion of 'sensitive' taxa (68%) resulting in the MCI score of 109 units. This score was significantly higher than the median of MCI scores recorded at this site by previous surveys, and equal to the maximum score recorded at this site to date. The score was similar to that at sites 1 and 2.

Low scoring 'tolerant' oligochaete worms continued to numerically dominate the community, although the 'highly sensitive' mayfly *Deleatidium* was also recorded in abundance, which resulted in a moderately low $SQMCI_s$ score (3.1 units) recorded at the site. This $SQMCI_s$ score was slightly lower than the historical median score but 0.8 units lower than that recorded at site 1, and a significant 3.1 units less that that recorded at site 1 in this survey (Stark, 1998).

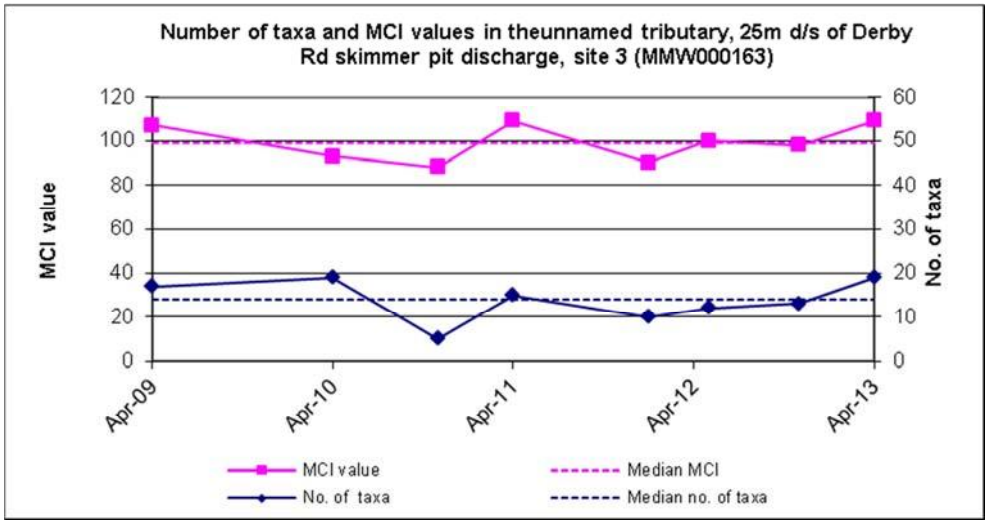

Figure 4 Numbers of macroinvertebrate taxa and MCI values recorded at site 3 in the unnamed tributary

With regard to abundant taxa and index scores, the results at site 3 were quite similar to that recorded at site 2 in the current survey. The community richness and MCI score were also slightly better than that recorded in the previous survey, which concluded that there may have been some influence from drilling wastes storage and/or discharge activities nearby. It was also concluded that the results were compounded by subtle differences in habitat. The current survey indicates recovery from that recorded in the previous survey, despite reduced habitat conditions. Overall, this indicates that there was little influence from the skimmer pit discharge, with the main influence being the unshaded reach immediately upstream of site 3. This makes sense, as an important source of macroinvertebrate recruitment is downstream drift.

Site 4

A moderate richness of 24 taxa was recorded at site 4, which was similar to richnesses at upstream sites 2 and 3, but nine taxa less than that recorded at site 1. This richness was three taxa above the historical maximum for the site (Table 2).

The community was comprised of a moderate proportion of 'sensitive' taxa (63%), but many of these taxa were recorded as rarities (Table 3). This contributed to the MCI score of 104 units, thirteen units higher than the median for the site, and equal to the maximum score previously recorded at this site (Figure 5). This score was similar to that recorded at all upstream sites, and significantly (Stark, 1998) higher than that recorded at this site in the previous survey.

The moderately low $SQMCI_s$ score of 4.0 units was principally due to the numerical dominance of the community by four 'tolerant' taxa (oligochaete worms, orthoclad and *Polypedilum* midge larvae and sandfly larvae (*Austrosimulium*). This $SQMCI_s$ score was similar to the median recorded at the site to date and similar to $SQMCI_s$ scores recorded at sites 2 and 3, but not the upstream 'control' site (1).

The results at site 4 in the current survey are above average, and the MCI score is an improvement on that recorded in the previous survey. As with site 3, the previous survey suggested that there may have been some impact from upstream landfarming activities. The current survey indicates that there has been some recovery since then.

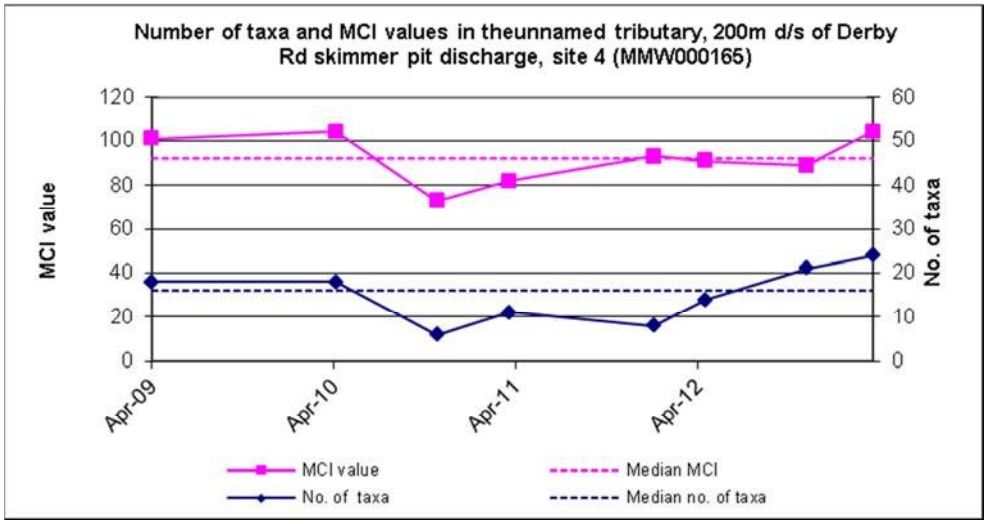

Figure 5 Numbers of macroinvertebrate taxa and MCI values recorded at site 4 in the unnamed tributary

The MCI scores recorded at the furthest downstream sites 3 and 4 were significantly lower than that recorded at the upstream site 1 indicating that the condition of the macroinvertebrate community at these downstream sites was poorer than that at the upstream 'control' site. This overall deterioration along the length (700 m) of the stream reach surveyed which was greater (by about 15 units) than predicted (Stark and Fowles, 2009), although ecologically insignificant between adjacent sites (i.e. <11 MCI units) may have been due to drilling wastes, storage and/or discharge activities nearby, but more likely due to subtle habitat variability between sites.

Summary and conclusions

On 9 April 2013, a four site macroinvertebrate survey of an unnamed tributary of the Mangamawhete Stream was performed to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the consented discharge of stormwater to the stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCIs scores for each site.

In the current survey, the MCI and $SQMCI_s$ scores recorded at the upstream 'control' site were similar to the median scores recorded at the site in previous surveys, which indicated the community at this site was in average health, despite this survey being preceded by an extended period of stable flows. The influence of these stable flows was evident in the high number of taxa present at this site (33), and the number of taxa present in abundance (eight). The presence of seven 'highly sensitive' taxa (and particularly the extreme abundance of the mayfly, *Deleatidium)* in this community was indicative of relatively good preceding water quality and habitat at this site.

The results of this survey indicated an insignificant deterioration in the condition of the macroinvertebrate community at site 2, located between the land treatment area and the storage pits, and upstream of the stormwater discharge outfall. The taxa richness recorded at site 2 in this survey was higher than the median richness for this site, while the MCI score was similar to the median score. However, the $SQMCI_s$ score recorded at this site was significantly less than that recorded in the previous survey, and that recorded upstream in the current survey. This was due to both the reduced abundance of one 'highly sensitive' mayfly taxon, but also the increased abundance of a number of 'tolerant' taxa.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by reduced (when compared to upstream) but above average taxa richnesses and at both sites, dominated mainly by fewer taxa coincident with decreased periphyton substrate cover, but some increase in sedimentation and iron oxide deposits on the streambed at this site. The MCI scores recorded at sites 3 and 4 were not significantly different to the MCI scores recorded at sites 1 and 2, which indicated that the impacts of upstream land farming activities that were possibly recorded in the previous survey were no longer present. The deterioration in $SQMCI_S$ scores at sites 2, 3 and 4 can most likely be attributed to the subtle changes in habitat, and the extended period of low flows that preceded this survey.

Overall, the results of this late summer survey suggest that the activities at the drilling waste stockpiling site and landfarming area have not had any impacts on the macroinvertebrate communities through the reach surveyed, although some impacts caused by habitat variability were noted. In general, however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a ringplain stream in comparison with similar streams elsewhere on the ringplain (Stark & Fowles, 2009) reflect the paucity of riparian and other habitat and the influence of iron-rich groundwater seepage along the length of stream surveyed.

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Document 1266057
Report No BJ214
Date 18 October 2013

Biomonitoring of an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road Drilling Waste Stockpiling site, April 2013.

Introduction

This biological survey was the second of two programmed for the 2012-2013 monitoring year, intended to monitor the health of the macroinvertebrate communities of an unnamed tributary of the Mangatengehu Stream, in relation to the disposal of drilling waste to land within its vicinity.

The site located off Surrey Road, receives drilling wastes, which are stored on site, and then eventually spread over land. Drainage of water from the storage pits flows through at least two skimmer pits. From here it is either pumped out for removal, or discharges to the land in the vicinity of the unnamed tributary. No consent is held to discharge to the tributary from the skimmer pits, as it is intended for this discharge to comply with permitted activity rule 23 of the Regional Fresh Water Plan for Taranaki. A condition of this permitted activity rule is that the discharge shall not give rise to (amongst other effects), any significant adverse effects on aquatic life.

The results of previous surveys performed in relation to this site are discussed in the references at the end of this report.

Methods

This biomonitoring survey was undertaken at four sites on 9 April 2013 (Table 1 and Figure 1). At the time of the initial survey undertaken in April 2010, site 1 was established as a 'control site', upstream of the drilling stockpile area and sites 2 and 3 were established downstream of the skimmer pit discharge. During an inspection of the site in mid-2010, an unauthorised discharge of hydrocarbons was observed entering the stream. As a consequence of this inspection, changes were made to the on site drainage. These changes were made between the April 2010 and November 2010 surveys. The result was that site 2 was located upstream of any discharge from the sites, and site 3 became the primary impact site. The stormwater discharge from the site now enters the unnamed tributary immediately upstream of the race crossing, approximately 35 metres upstream of site 3. A new, secondary impact site (site 4) was established 100 metres downstream of the stormwater discharge during the May 2012 survey.

The standard 'kick-sampling' technique was used at all four sites (Table 1) to collect streambed macroinvertebrates. The 'kick-sampling' technique is very similar to protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream in relation to the Surrey Road drilling waste stockpiling activities

Site Number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	MTH000060	E1701830 N5651430	Upstream of drilling waste stockpiling site	495
2	MTH000062	E1701954 N5651468	Approximately 85 metres upstream of the spring and skimmer pit discharge	495
3	MTH000064	E1702050 N5651525	Approximately 35 metres downstream of the skimmer pit discharge	490
4	MTH000066	E1702102 N5651582	Approximately 100 metres downstream, of the skimmer pit discharge	485

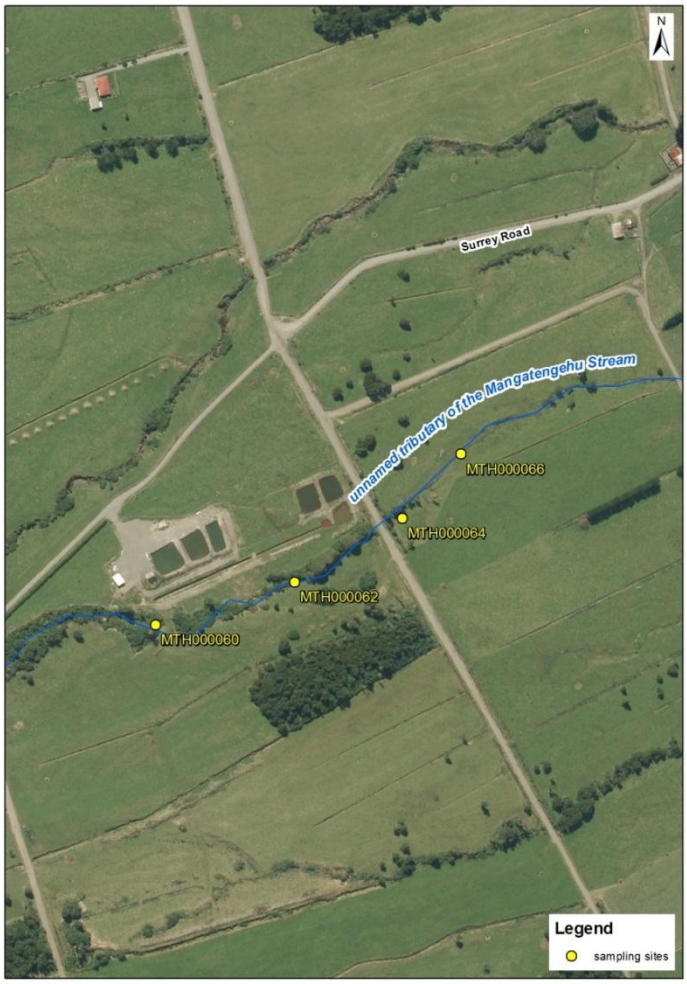

Figure 1 Biomonitoring sites in an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark *et al*, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= 20-99 individuals;
VA (very abundant)	= 100-499 individuals;
XA (extremely abundant)	= 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 19 98 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Results and discussion

This April 2013 survey followed a period of 21 days since the nearby Manganui River experienced a fresh in excess of three and seven times median flow. That was the only large fresh to occur since 5 February 2013, and although there had been a number of minor freshes in the month prior to this survey, it illustrates that these streams had experienced a relatively stable flow in the months preceding this survey.

A low, swift flow of uncoloured, clear water was recorded at site 1 in this survey. The substrate at this site was predominantly fine and coarse gravels with some cobble. There was very fine iron oxide sedimentation noted on the bed. In this completely shaded section of stream, only a slippery algal film was recorded.

There was a low, steady flow of uncoloured, cloudy water recorded at site 2. Cobbles, coarse and fine gravels dominated the bed of the stream at this site where there was also a minor amount of iron oxide sediment. Slippery algal mats and patchy leafy debris were recorded at this completely shaded site.

Sites 3 and 4 also recorded a low, steady flow of uncoloured, cloudy water with site 3 partially shaded and site 4 unshaded. At both sites, the bed substrate primarily consisted of cobbles, coarse and fine gravels, although there was also slightly more sand and silt than that observed at sites 1 and 2. The periphyton recorded at site 3 included widespread thick algal mats and patchy filamentous algae, while at site 4, filamentous algae was widespread, and the algal mats were only present as a slippery film. Iron oxide sediment was also widespread at both sites.

Macroinvertebrate communities

Table 2 provides a summary of the results for the current survey sampled in relation to the Surrey Road drilling waste stockpiling site together with a summary of historical results. The full results from this current survey are presented in Table 3.

Table 2 Number of taxa, MCI, and SQMCI$_s$ values for an unnamed tributary of the Mangatengehu Stream, sampled in relation to the Surrey Road drilling waste stockpiling site, and a summary of historical data for these sites

Site No.	Number of taxa				MCI value			SQMCI$_s$ value		
	No. of samples	Median	Range	Apr 2013	Median	Range	Apr 2013	Median	Range	Apr 2013
1	6	19	17-20	21	120	106-127	115	4.4	2.3-5.4	5.0
2	6	22	5-30	24	123	80-128	128	5.6	1.6-6.9	6.5
3	6	11	9-16	18	101	96-119	103	1.8	1.4-3.6	2.8
4	2	17	12-21	24	102	97-107	109	2.1	2.1-2.1	3.4

Table 3 Macroinvertebrate fauna of an unnamed tributary of the Mangatengehu Stream, sampled on 1 April 2013

Taxa List	Site Number	MCI score	1	2	3	4
	Site Code		MTH000060	MTH000062	MTH000064	MTH000066
	Sample Number		FWB13183	FWB13184	FWB13185	FWB13186
NEMATODA	Nematoda	3	R	-	R	-
ANNELIDA	Oligochaeta	1	A	C	A	VA
	Lumbricidae	5	-	-	-	R
MOLLUSCA	*Potamopyrgus*	4	R	R	-	R
CRUSTACEA	Ostracoda	1	R	-	-	R
	Paracalliope	5	A	-	-	-
EPHEMEROPTERA	*Austroclima*	7	-	-	R	-
	Deleatidium	8	C	VA	C	A
	Neozephlebia	7	-	R	-	-
	Nesameletus	9	-	-	-	R
	Zephlebia group	7	C	C	C	C
PLECOPTERA	*Austroperla*	9	R	R	R	R
	Spaniocerca	8	R	R	R	-
	Stenoperla	10	C	R	-	R
	Zelandobius	5	R	R	-	-
	Zelandobius illiesi	10	R	C	-	-
	Zelandoperla	8	-	R	-	R
COLEOPTERA	Elmidae	6	R	R	R	C
	Ptilodactylidae	8	C	R	-	R
	Scirtidae	8	C	C	-	C
MEGALOPTERA	*Archichauliodes*	7	-	-	R	R
TRICHOPTERA	*Costachorema*	7	-	R	-	-
	Hydrobiosis	5	-	R	-	C
	Hydrochorema	9	-	R	-	-
	Orthopsyche	9	C	R	-	-
	Polyplectropus	6	-	-	R	-
	Psilochorema	6	R	C	C	A
	Oxyethira	2	-	-	R	R
DIPTERA	*Aphrophila*	5	-	-	C	A
	Eriopterini	5	R	-	-	R
	Limonia	6	-	-	R	-
	Zelandotipula	6	-	R	-	-
	Orthocladiinae	2	C	A	VA	A
	Polypedilum	3	C	A	A	C
	Tanypodinae	5	-	-	-	R
	Paradixa	4	-	R	R	R
	Empididae	3	-	-	R	R
	Austrosimulium	3	R	R	-	-
		No of taxa	21	24	18	24
		MCI	115	128	103	109
		SQMCIs	5.0	6.5	2.8	3.4
		EPT (taxa)	9	14	7	8
		%EPT (taxa)	43	58	39	33

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1

Survey results to date at this site are illustrated in Figure 2.

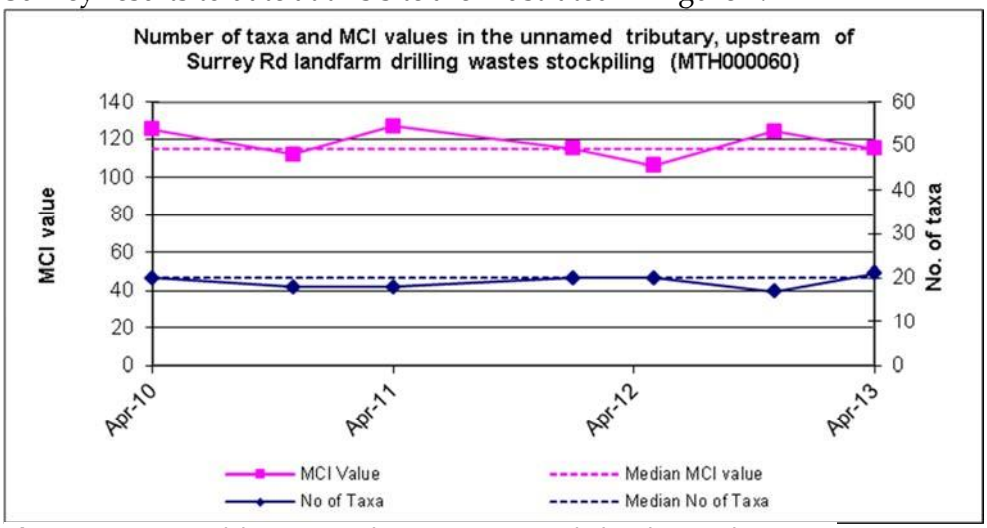

Figure 2 Taxa richnesses and MCI scores recorded to date at site 1.

A moderate richness of 21 taxa was recorded at site 1 upstream of the storage area, which was one taxon higher than recorded at the site to date, although the range had previously been very narrow (Table 2 and Figure 2).

There were only two taxa recorded in abundance; a 'tolerant' taxon [oligochaete worms], and a 'moderately sensitive' taxon (*Paracalliope* amphipods), and a slight majority of taxa (52%) were recorded as rarities, an indication of the poor habitat quality at this site. However, the community was comprised of a moderately high proportion (67%) of 'sensitive' taxa which included eight 'highly sensitive' taxa (one mayfly, four stoneflies, two beetles, and one caddisfly). This high proportion of 'sensitive' taxa contributed to the MCI score of 115 units which was five units less than the historical median and nine units lower than the score recorded by the previous survey, six months earlier.

A moderate $SQMCI_s$ score of 5.0 units was recorded, but similar to the median for the site recorded by previous surveys. This score reflected the number of 'highly sensitive' taxa recorded as common, but also that 'tolerant' oligochaete worms were recorded as abundant. [Note: the low abundances within nearly all taxa were indicative of a poorly established community which might be anticipated to show wide temporal variability in MCI and $SQMCI_s$ scores].

In general these results indicate that although habitat was limited, as indicated by the number of rarities in the community, the stable flows that preceded this survey allowed the community to be more established than that recorded in most previous surveys undertaken at this site. This community recorded a moderately high MCI score, and a moderate $SQMCI_S$ score. This, coupled with the number of 'highly sensitive' taxa in the community, indicated that water quality in the weeks prior to this survey had been good.

Site 2

Survey results to date at this site are illustrated in Figure 3.

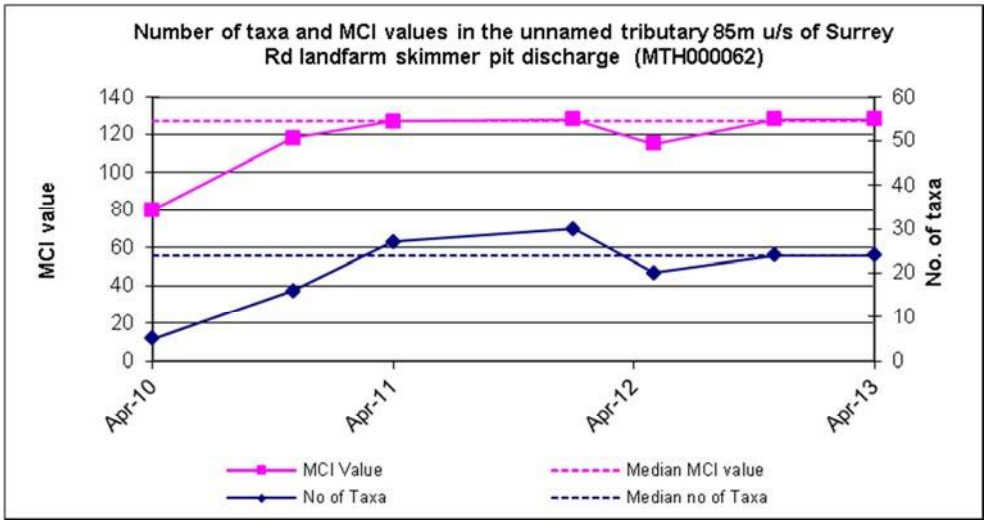

Figure 3 Taxa richnesses and MCI scores recorded to date at site 2

A moderately high richness of 24 taxa was recorded at site 2, two taxa more than the median yet well within the range recorded at the site previously (Table 2 and Figure 3). Although this result was six taxa less than the maximum recorded at this site previously, it represented a marked improvement in the community from the initial survey in which only five taxa were recorded. This marked improvement has been directly related to the change in location of the discharge point (to further downstream) which occurred in mid-2010 and also to additional skimmer pit/spring drainage provided at the stockpiling site (see Figure 1). This taxa richness was three more than that recorded at site 1 in the current survey.

The community was comprised of a high proportion of 'sensitive' taxa (75%) but a significant proportion of these were rarities (less than five individuals per taxon). The high proportion of 'sensitive' taxa was reflected in the high MCI score of 128 units, five units higher than the median score recorded at this site to date and a significant thirteen units higher than the score at the upstream 'control' site (Stark, 1998). There were two significant changes in individual taxon abundances (both 'sensitive' taxa) between sites 1 and 2.

The community was characterised by one 'highly sensitive' taxon [mayfly (*Deleatidium*)]; and two 'tolerant' taxa [orthoclad and *Polypedilum* midges], indicative of some improvement in community structure in a downstream direction. However, it was numerically dominated by only one taxon, the 'highly sensitive' mayfly (*Deleatidium*) which resulted in the relatively high $SQMCI_s$ score of 6.5 units, which was significantly higher than the score recorded at site 1 and only 0.4 unit less than the maximum to date for this site.

This community is showing a continuation of the good results recorded since 2010, subsequent to the change in discharge location. Since that date, this site has frequently recorded amongst the highest MCI and $SQMCI_s$ scores of this survey, and the current survey is no exception. As with site 1 there was a high proportion of rarities in the community, but overall the results indicate good preceding water quality.

Site 3

Survey results to date at this site are illustrated in Figure 4.

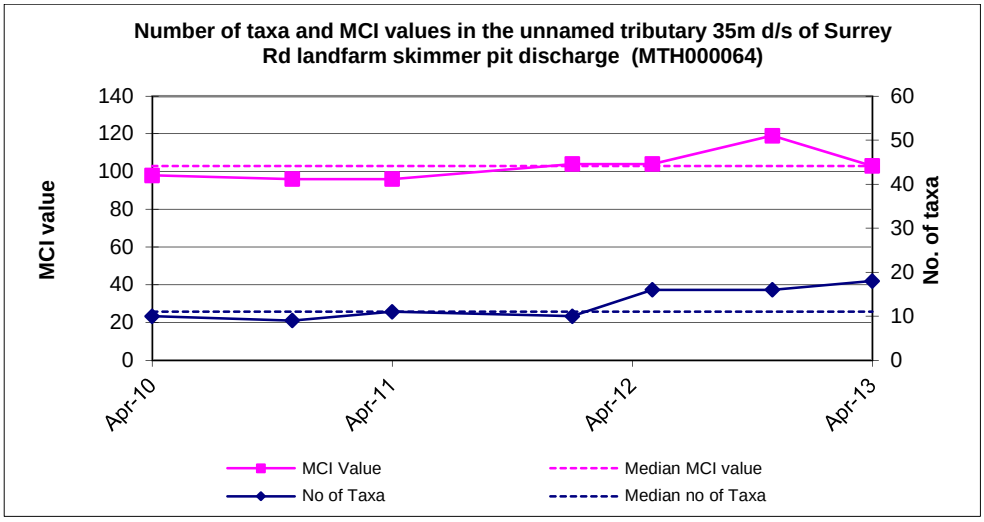

Figure 4 Taxa richnesses and MCI scores recorded to date at site 3.

A moderately high richness (18 taxa) was recorded at this site which was two more than the maximum richness recorded at the site previously. However, eleven of these taxa (61% of richness) were present only as rarities (i.e. less than five individuals per taxon). This community richness was two taxa lower than that recorded at site 1 but six taxa less than that recorded at site 2. The community at site 3 was comprised of a moderate proportion of 'sensitive' taxa (61%) resulting in the MCI score of 103 units. This score was a similar to the median for this site, but a significant 16 units (Stark, 1998) less than the maximum MCI score, which was recorded in the previous survey (Figure 4), and a significant 25 units (Stark, 1998) less than that recorded at site 2 and twelve units lower than the score at the upstream 'control' site.

The community was characterised however, by only three taxa, all 'tolerant' taxa [oligochaete worms and orthoclad and *Polypedilum* midges], which together with a significant decrease in three individual 'sensitive' taxa abundances, were consistent with the marked proliferation in algal mats (cyanobacteria in particular) and filamentous algae, and increased iron oxide substrate cover at this partially shaded site.

The numerical domination by the three 'tolerant' taxa resulted in a significant downstream decrease of 3.7 units in $SQMCI_s$ score (to 2.8 units) between sites 2 and 3. This score was 0.8 units less than that recorded in the previous survey, but still significantly higher than the median for this site (Stark, 1998) (Table 2).

The proliferation of algae at this site is the primary influence on the macroinvertebrate community, and this also explains the significant reductions in MCI and $SQMCI_S$ scores from that recorded at site 2 upstream. What is not as simple to explain is this proliferation of algae. This will be related to a discharge rich in nutrients (primarily nitrogen) that occurs upstream, and this may be as a direct result of the stockpiling activities. However, it should be noted that a stock race also crosses immediately upstream of site 3, and this may also be a source of nutrients.

Site 4

Survey results for this site to date are illustrated in Figure 5.

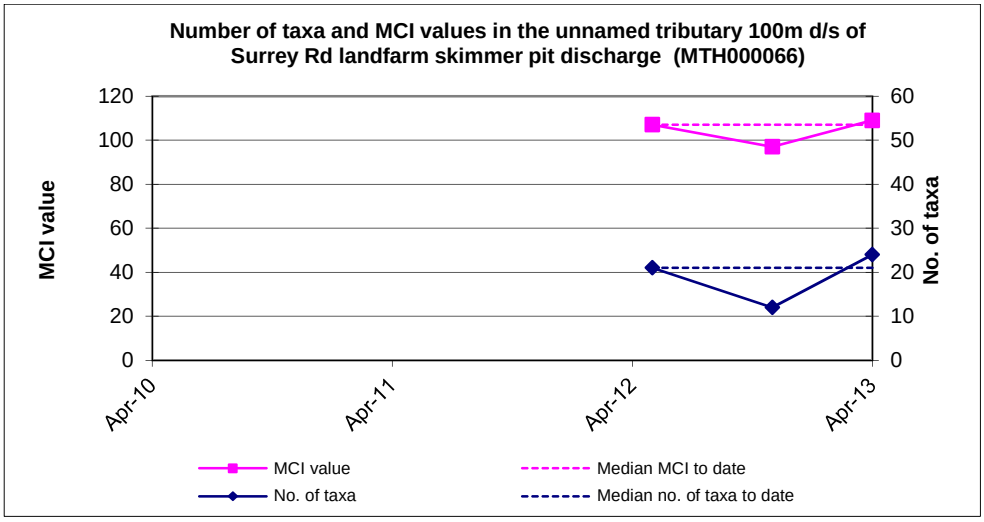

Figure 5 Taxa richnesses and MCI scores recorded to date at site 4

A moderate richness of 24 taxa was recorded at the recently established site 4, approximately 65 metres downstream of the skimmer pit discharge area. This taxa richness was similar to that recorded at the other three sites sampled in this survey and was three taxa more than that recorded to date at this site. It was also 12 taxa more than that recorded in the previous survey (Figure 5).

The moderately high proportion of 'sensitive' taxa (66%) recorded at this site was reflected in the moderate MCI score of 109 units. Although this MCI score was significantly less than that recorded at site 2 upstream, it was 8 units higher than that recorded in the previous survey, and six units higher than that recorded at the nearest upstream site (3).

The $SQMCI_s$ of 3.4 units was principally due to the numerical dominance of the community by one low scoring 'tolerant' taxon (oligochaete worms), although one 'tolerant' taxon (orthoclad midges), one 'moderately sensitive' taxon (free-living caddisfly *Psilochorema*) and one 'highly sensitive' mayfly (*Deleatidium*). This $SQMCI_s$ score was significantly less than that recorded at sites 1 and 2 upstream, but was 0.6 unit higher than that recorded at site 3. This low score was coincidental with profuse filamentous algal substrate cover, and widespread iron oxide sedimentation covering the substrate of this open (unshaded) site.

These results indicate a possible subtle recovery from that recorded at site 3, although these results still indicate significant deterioration from that recorded at site 2. There was a change at this site in terms of algal community, with a change from significant cover of thick algal mats at site 3, to significant cover of filamentous algae at site 4. This is likely related to the shading experienced at these sites. This has not caused much change in the invertebrate community, although the presence of *Deleatidium* mayfly in abundance is a good result.

Summary and conclusions

This biological survey of four sites in an unnamed tributary of the Mangatengehu Stream was performed on 9 April 2013, to monitor the 'health' of the macroinvertebrate community of the tributary, in relation to the storage of drilling waste within its vicinity and the discharge of stormwater to land or to the stream. Samples were processed to provide number of taxa (richness), MCI, and $SQMCI_S$ score for each site.

In the current survey, the MCI and $SQMCI_S$ score recorded at the upstream 'control' site, although higher than, or similar to, the median scores recorded at the site in previous surveys, were indicative of poor community structure at this site. The presence of many 'sensitive' taxa in this community was indicative of relatively good preceding water quality but the paucity of individual taxon abundances was indicative of poorer habitat quality.

The results of this survey indicated an improvement in the condition of the macroinvertebrate community at site 2, located between the wastes storage pits and upstream of the stormwater discharge outfall. The MCI and $SQMCI_S$ scores recorded at site 2 in this survey were above medians recorded to date at the site, and were significantly higher than that recorded at any site in the current survey.

The macroinvertebrate communities at the two downstream sites (3 and 4) were characterised by similar taxa richnesses as upstream, but were dominated by low scoring 'tolerant' taxa and changes in the presence or absence of certain taxa and changes in individual 'sensitive' taxon abundances coincident with marked increases in periphyton substrate cover and iron oxide deposits present at these sites. The MCI scores recorded at sites 3 and 4 were significantly lower than those recorded at sites 1 and 2 which indicated the possibility of recent impacts of discharges into the stream from the land farming activities occurring adjacent to the stream coincident with marked variability in physical stream habitat.

The proliferation of algae at site 3 and 4 has clearly had an influence on the macroinvertebrate community, and this also explains the significant reductions in MCI and $SQMCI_S$ scores from that recorded at site 2 upstream. What is not as simple to explain is this proliferation of algae. This will be related to a discharge rich in nutrients (most likely nitrogen) that occurs upstream, and this may be as a direct result of the stockpiling activities. However, it should be noted that a stock race also crosses immediately upstream of site 3, and this may also be a source of nutrients.

Therefore, it is recommended that the water quality sampling regime be augmented to include testing for dissolved nutrients (total nitrogen, total phosphorus and dissolved reactive phosphorus) from both the site discharge, and also in samples collected upstream and downstream of the discharge point.

Overall, the results of this late spring survey suggest that the activities at the drilling waste stockpiling site and landfarming area may have had some impacts on the macroinvertebrate communities through the reach surveyed but such impacts have been compounded by habitat variability. In general however, poorer community richnesses and diversities of the macroinvertebrate communities within this upper reach (near the source) of a spring fed ringplain stream reflected the fragmentation of riparian habitat and the influence of iron-rich groundwater seepage and subsequent sedimentation along the length of stream surveyed.

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Appendix IV

Enforcement documentation

No. 12011
Document: 1189260

ABATEMENT NOTICE UNDER SECTIONS 322 & 324 OF THE RESOURCE MANAGEMENT ACT 1991

To: CD Boyd
PO Box 44
Inglewood
4347

Taranaki Regional Council gives notice that you must cease (or you are prohibited from commencing) the following action:

1. Cease the discharge of contaminated storm water and waste water from Surrey Road Landfarm, authorised by Resource Consent 7559-1.

The location to which this abatement notice applies is:

Surrey Road, Inglewood
SEC 17 BLK XIV EGMONT SD

You must comply with this abatement notice within the following period:

By 29 April 2013

You must continue to comply with this abatement notice after that date.

This notice is issued under:

Section 322(1)(a)(i) of the Resource Management Act 1991, which states that:

(1) An abatement notice may be served on any person by an enforcement officer—

(a) Requiring that person to cease, or prohibiting that person from commencing, anything done or to be done by or on behalf of that person that, in the opinion of the enforcement officer,—

(i) Contravenes or is likely to contravene this Act, any regulations, a rule in a plan, or a resource consent; or

The reasons for this notice are:

2. Enforcement Officer, John Cooper, visited the property on 22 April 2013 and found that:
    - The final settling pond was discharging to the receiving waters,
    - The discharge was turbid and causing a foaming effect within the receiving waters,
    - Samples and photographs were taken.

3. Rule 23 of the Regional Fresh Water Plan for Taranaki states the following:

    3. The discharge shall not give rise to any of the following effects in the receiving waters after reasonable mixing:

        - *The production of ay conspicuous oil or grease films, scums or foams, or floatable or suspended materials;*

4. Section 15(1)(a) of the Resource Management Act 1991 prohibits the discharge of contaminant to water unless that discharge is expressly allowed by a national environmental standard or other regulations, a rule in a regional plan, or a resource consent.

5. The discharge of water on 22 April 2013 contravened Rule 23 of the Regional Fresh Water Plan for Taranaki and therefore contravened section 15(1)(a) of the Resource Management Act 1991.

6. Contravention of section 15(1)(a) of the Resource Management Act 1991 is an offence under section 338(1)(a) of the Resource Management Act 1991.

7. This notice has been issued to you to require you to take the action as set out in clause 1 because in the opinion of the enforcement officer that issued this notice, this action is necessary to ensure compliance by you/on your behalf with section 15(1)(a) of the Resource Management Act 1991/regulations/a rule in a plan/a proposed plan/a resource consent and also necessary to avoid/remedy/mitigate any actual/likely adverse effect on the environment relating to any land of which you are the owner/occupier.

If you do not comply with this notice, you may be prosecuted under section 338 of the Resource Management Act 1991 (unless you appeal and the notice is stayed as explained below), or an infringement notice may be served on you under section 343C of the Resource Management Act 1991.

You have the right to appeal to the Environment Court against the whole or any part of this notice. If you wish to appeal, you must lodge a notice of appeal in form 49 with the Environment Court within 15 working days of being served with this notice.

An appeal does not automatically stay the notice and so you must continue to comply with it unless you also apply for a stay from an Environment Judge under section 325(3A) of the Resource Management Act 1991 (*see* form 50). To obtain a stay, you must lodge both an appeal and a stay with the Environment Court.

You also have the right to apply in writing to Taranaki Regional Council to change or cancel this notice in accordance with section 325A of the Resource Management Act 1991.

The Taranaki Regional Council authorised the enforcement officer who issued this notice. Its address is:

Taranaki Regional Council
Private Bag 713
Stratford 4352

Phone: (06) 765 7127
Facsimile: (06) 765 5097

The enforcement officer is acting under the following authorisation:

A warrant of authority issued by the Taranaki Regional Council, pursuant to section 38 of the Resource Management Act 1991, authorising the officer to carry out specified functions and powers as an enforcement officer under the Resource Management Act 1991 including issue of abatement notices.

…….
John Cooper
Enforcement Officer
Taranaki Regional Council
Warrant No. 174

24 April 2013

No. 11813
Document: 1021953

ABATEMENT NOTICE UNDER SECTIONS 322 & 324 OF THE RESOURCE MANAGEMENT ACT 1991

To: Colin D Boyd
PO Box 44
Inglewood 4347

Taranaki Regional Council gives notice that you must take the following action:

Undertake works to spread all stockpiled drilling mud which has been stockpiled onsite for longer than twelve months, onto and into land to ensure compliance with special condition 6 of Resource Consent 6900-2.

Apply the mud onto and into land in a manner in accordance with the relevant special conditions of Resource Consent 7591-1.

The location to which this abatement notice applies is:

Mud storage: Lot 2 DP 344156.

Land spreading: Lot 2 DP 344156, Secs 9, 10, & pt Sec 13 Blk XII Egmont SD, Secs 17 & 18 Blk XVI Egmont SD.

You must comply with this abatement notice within the following period:

1 May 2012.

You must continue to comply with this abatement notice after that date.

This notice is issued under:

Section 322(1)(b)(ii) of the Resource Management Act 1991, which states that:

(1) An abatement notice may be served on any person by an enforcement officer—

(b) Requiring that person to do something that, in the opinion of the enforcement officer, is necessary to ensure compliance by or on behalf of that person with this Act, any regulations, a rule in a plan or a proposed plan, or a resource consent, and also necessary to avoid, remedy, or mitigate any actual or likely adverse effect on the environment—

(ii) Relating to any land of which the person is the owner or occupier.

The reasons for this notice are:

1. Investigating Officer, John Cooper, visited the property on 14 March 2012 and found that:

.

- Drilling mud which was brought onto site longer than twelve months prior to the inspection remained stockpiled within several pits.

2. Section 15(1)(d) of the Resource Management Act 1991 provides that no person may discharge any contaminant from any industrial or trade premises onto or into land unless the discharge is expressly allowed by a rule in a regional plan and in any relevant proposed regional plan, a resource consent, or regulations.

3. The stockpiled material discovered on 14 March 2012 contravened special condition 6 of Resource Consent 6900-2 and therefore contravened section 15(1)(d) of the Resource Management Act 1991.

4. Contravention of section 15(1)(d) of the Resource Management Act 1991 is an offence under section 338(1)(a) of the Resource Management Act 1991.

5. This notice has been issued to you to require you to take the action as set out in clause 1 because in the opinion of the enforcement officer that issued this notice, this action is necessary to ensure compliance by you/on your behalf with section 15(1)(d) of the Resource Management Act 1991/regulations/a rule in a plan/a proposed plan/a resource consent and also necessary to avoid/remedy/mitigate any actual/likely adverse effect on the environment relating to any land of which you are the owner/occupier.

If you do not comply with this notice, you may be prosecuted under section 338 of the Resource Management Act 1991 (unless you appeal and the notice is stayed as explained below), or an infringement notice may be served on you under section 343C of the Resource Management Act 1991.

You have the right to appeal to the Environment Court against the whole or any part of this notice. If you wish to appeal, you must lodge a notice of appeal in form 49 with the Environment Court within 15 working days of being served with this notice.

An appeal does not automatically stay the notice and so you must continue to comply with it unless you also apply for a stay from an Environment Judge under section 325(3A) of the Resource Management Act 1991 (*see* form 50). To obtain a stay, you must lodge both an appeal and a stay with the Environment Court.

You also have the right to apply in writing to Taranaki Regional Council to change or cancel this notice in accordance with section 325A of the Resource Management Act 1991.

The Taranaki Regional Council authorised the enforcement officer who issued this notice. Its address is:

Taranaki Regional Council
Private Bag 713
Stratford 4352

Phone: (06) 765 7127
Facsimile: (06) 765 5097

The enforcement officer is acting under the following authorisation:

A warrant of authority issued by the Taranaki Regional Council, pursuant to section 38 of the Resource Management Act 1991, authorising the officer to carry out specified functions and powers as an enforcement officer under the Resource Management Act 1991 including issue of abatement notices.

…….
John Cooper
Enforcement Officer
Taranaki Regional Council
Warrant No. 174

20 March 2012

Appendix V

Agknowledge landfarm review report

The Taranaki Landfarms

are they

"Fit for Purpose"

A report

Commissioned by Taranaki Regional Council

Undertaken by

Dr D C Edmeades
agKnowledge Ltd
PO Box 9147, Hamilton, 3240.

September 2013

EXECUTIVE SUMMARY

1. Waste products (rock cuttings and drilling muds) from the oil exploration industry in Taranaki are being incorporated into re-contoured formed sand dunes and re-sown back to pasture (a process referred to as Landfarming). This process is controlled by resource consents issued by the Taranaki Regional Council. Three Landfarms have been completed to date and are now being farmed commercially (2 under irrigation).

2. The drilling muds contain potential contaminants: petrochemical residues, barium, heavy metals and salts. The question arises: are these reformed soils 'fit-for-purpose' - in this case pastoral farming and especially dairy farming.

3. As required by the consents regular soil samples were collected and analysed during the disposal process. These results were summarised and examined relative to the permitted limits for the various potential contaminants.

4. The completed sites were visited and the pasture and soils inspected. Soil and pasture samples were collected and analysed for all potential contaminants. These results were compared to the properties of normal New Zealand pastorals soils.

5. It is concluded from this body of evidence that these modified soils are 'fit –for-purpose". The concentrations of: nutrients (macro and micro), heavy metals and soluble salts in these soils and pasture are similar to normal New Zealand soils. The form of barium present is as environmentally benign barite, and there is no evidence of accumulation of petrochemical residues.

6. The process of Landfarming these otherwise very poor soils, together with appropriate management (irrigation, fertiliser and improved pastures) has increased the agronomic value of the land from about $3-5000/ha to $30-40,000/ha.

BRIEF

1. The Taranaki Regional Council (TRC) has consented several oil exploration companies to dispose of 'drilling muds' at several sites on coastal sands around the region.

2. The drilling muds are initially stored at the sites and, after the sand dunes have been levelled, this material is applied to the surface (at < 100mm thick) and then incorporated into the re-contoured sandy soils (at a minimum depth of 250mm depth). Once this process is completed the modified soils are fertilised (not more the 200 kg N/ha) and sown down to clover–based pasture. This whole process is controlled by criteria set out in resource consents.

3. Three sites (referred to as landfarms) have been completed to date and are currently being used for pastoral farming. One site (Browns, commenced 2006, completed 2011) is not irrigated and runs dry stock. The other 2 sites (Schrider, commenced 2004, completed 2010, and Geary, commenced 2001, completed 2006) are under pivot irrigation and used for dairy farming. Note there is a small area at the Geary site, which is not irrigated.

4. The TRC has retained agKnowledge Ltd to determine whether these landfarms are "fit for purpose", in this case fit for pastoral farming and in particular dairying.

5. Specifically this brief excludes any consideration as to the off-site effects of the landfarms (possible movement of contaminants via runoff or leaching) and does not consider whether the compliance criteria set out in the consents were met or otherwise.

METHODOLOGY

6. Drilling muds consist of a) the cuttings (mainly solid) of the underlying strata of rocks from the drill bit b) drilling fluids (bentonite based mud and slurry including proprietary additives used to either lubricate the drilling process or to control the in-well pressure and conditions. This includes barium sulphate which is used as a wetting and weighting agent and c) drilling wastes (liquid) containing well water and petrochemical residues. There are 3 classes of drilling fluids: water-based, (WBM), oil based (OBM) and synthetic (SBM) (Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1).

7. Given the general composition of the drilling muds, this report investigates the following aspects of the completed landfarms:

    a. What is the current soil fertility of the modified soils with respect to growing clover-based pasture for ruminants and in particular dairy cows?

b. What are the heavy metal and barium concentrations in the soils and pastures and are there any implications for soil, pasture and animal health and production?
c. Are there any petrochemical residues in the soils and pasture, which may affect soil, plant and animal health?

8. Two sites, Geary and Schrider, were visited on July 4 2013 and soils samples (0-75mm – the standard depth for determining soil fertility) and mixed-pasture samples were collected for an initial investigation, using the standard sampling protocols.

9. The 3 completed landfarms were visited on 5 August 2013 and on this occasion two sets of soil (0-75mm) and mixed pasture samples were collected from the following sites: Schrider (irrigated), Geary (irrigated and non-irrigated) and Brown (non-irrigated). One set were sealed in clip-tight plastic bags for analysis of petroleum hydrocarbon (PCH) residues and the other set were used to determine the concentrations of the full suit of elements including the macro, micro and heavy metals plus barium.

10. The TRC provided the full records of the soil tests (0-250mm) undertaken as per the consents, during the process of disposal of the drilling muds, at each site. This data was summarized.

11. Throughout this the report the criteria for the safe disposal of heavy metals, barium and petroleum hydrocarbons (as set down by a number of authorities) are used as part (other matters are also considered) of the assessment process. In applying these criteria it is assumed that they have been set at levels to ensure the protection of soil, pasture, animal and human health.

RESULTS

Pasture Assessment

At the time of the second site visit (5 August 2013) the pastures were assessed as follows:

Table 1: Visual assessment of the pastures at the three sites.

Site	Assessment	Rating
Schrider (irrigated)	Ryegrass dominant pasture, vigorous. Very little clover some showing signs of potassium deficiency. Excreta patches obvious. Some flats weeds and poor pasture grasses.	6/10
Geary (irrigated)	Vigorous ryegrass pasture with about 20% clover. Excreta patches not apparent. Very few weeds.	8/10
Geary (non-irrigated)	Assorted weeds abundant, excreta patches prominent, Some low value browntop and Yorkshire fog. Ryegrass and clover only in excreta patches.	2/10
Brown (non-irrigated)	Assorted weeds abundant, excreta patches prominent, Ryegrass and clover only in excreta patches.	2/10

Importantly, there were abundant earthworm casts on all sites indicating considerable soil biological activity. The earthworm can be regarded as the 'canary in the mine' with respect to soil biological activity.

Soil Properties

The general properties of the modified soils (0-75mm, the standard depth for soil fertility assessment) are given in Table 2 and indicate low levels of cation exchange capacity (CEC), anion storage capacity (ASC), organic matter (OM) and organic nitrogen (ON), reflecting their sandy nature and past history (low quality pasture). The amounts of soluble salts (SS) and the exchangeable sodium percentage (referred to in the documentation incorrectly as the sodium absorption, SAR) are low and the soil calcium (Ca) and sodium (Na) levels are consistent with the normal levels found in pastoral soils.

Table 2: Soil chemical properties (0-75mm) at the three landfarms sites.

Site	CEC (me/100 gm)	ASC (%)	OM (%)	ON (%)	SS (%)	Ca (MAF units)	Na (MAF units)	SAR (%)
Schrider	9	11	2.6	0.13	0.01	7	7	1.1
Geary Irrigated	7	11	2.2	0.16	0.02	5	10	2.0
Geary Non irrigated	9	16	3.5	0.21	0.02	6	7	1.2
Brown	9	34	3.4	0.14	0.01	6	4	0.6
Typical	*10-30*	*20-80*	*5-20*	*0.1-0.4*	*0.05-0.30*	*5-20*	*3-10*	*1-2*

As required by the consent agreements, routine soil testing (0-250mm) was undertaken on all three sites during the process of disposal of the drilling muds. The results for each site are summarized in Tables 3 a,b,c:

Table 3a. Chemical characteristics of the soil (0-250mm) at the Schrider site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1] & units	No. over limit
Conductivity (disposal)	51	32 <0.02	0.13	<0.02	400 mS/m	0
Conductivity (expiry)	53	44 < 0.02	1.3	<0.02	290 mS/m	0
Soluble salts	53	43 <0.05	0.46	<0.05	0.25 %	2
SAR	47	1.1	3.1	0.3	18	0
Sodium	31	482	790	310	460 g/m3	14
Chloride	50	145	1360	4	700g/m3	3

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

Table 3b. Chemical characteristics of the soil (0-250mm) at the Geary site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1]& units	No. over limit
Conductivity (disposal)	33	30 <0.02	0.37	<0.02	400 mS/m	0
Conductivity (expiry)	33	29 <0.02	0.37	<0.02	290 mS/m	0
Soluble salts	33	32 <0.05	0.13	<0.05	0.25 %	0
SAR	38	1.0	3.7	0.1	18	0

Sodium	13	481	600	310	460 g/m3	7
Chloride	36	28	356	4	700 g/m3	0

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

Table 3c. Chemical characteristics of the soil (0-250mm) at the Brown site during disposal.

Soil Property	No. samples	Average	Max	Min	Limit[1]& units	No. over limit
Conductivity (disposal)		No given			400 mS/m	0
Conductivity (expiry)		No given			290 mS/m	0
Soluble salts	5	all < 0.05	<0.05	-	0.25 %	0
SAR	17	2.4	18	0.3	18	0
Sodium	17	80	530	7	460 g/m3	7?
Chloride	31	98	550	5.9	700 g/m3	0

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

The soil property which most frequently exceeded the limit was the soil Na concentrations. The limit of 460 gm/m^3 soil, is (assuming a soil bulk density of about 1) equivalent to a MAF soil Na reading of about 20. Thus, while some elevated soil Na levels were recorded during the disposal process the current levels (0-75 mm) are normal (Table 2). This is also apparent in the SAR levels. The likely reason for this is that Na (and the same applies to chloride) are very mobile and will readily leach out of soils, especially sandy soils with a good rainfall and under irrigation, noting that in the New Zealand situation Na and Cl are environmentally benign.

In any case note that the problems that occur when soil Na levels are elevated (loss of soil structure and impeded drainage together with plant sensitivity to salinity) normally arise on heavy soils in arid climates. Furthermore, higher than normal soil Na levels and hence better than normal pasture Na concentration (see later) can only be beneficial to animal health in the New Zealand setting.

Soil Fertility

Soils

The soil tests (Table 4) indicate that, in terms of optimizing production from clover-based pastures, the sites are deficient with respect to potassium (K) and sulphur (S). The site with the best overall soil fertility is 'Geary irrigated' and this is reflected in the superior pasture on this site (Table 1). The poor pasture on the 2 non-irrigated sites (Brown, Geary non-irrigated) can be explained by the lack of irrigation resulting in moisture stress together with the poor underlying soil fertility.

Table 4: Soil nutrient levels (0-75mm) at the three landfarms sites (units are as used in the standard MAF soil testing protocol)

Site	pH	Olsen P	K	Sulphate S	Organic S	Mg
Schrider	6.0	24	2	4	3	23
Geary Irrigated	6.3	28	5	12	3	37
Geary Non irrigated	6.2	38	7	6	3	22

Brown	6.6	22	2	8	4	13
Optimal[1]	*5.8-6.0*	*35-40*	*7-10*	*10-12*	*10-12*	*8-10*

Notes 1) assuming a high producing dairy farm

Pasture

The concentrations of macro (Table 5a) and micro (Table 5b) nutrients in the mixed-pasture samples from the 4 sites are given below. Mixed-pasture analysis provides information relating to the nutrient value of the pastures for, in this case, ruminants.

Table 5a: Macronutrient concentrations (%) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	**Pasture macronutrient concentration (%)**						
	N	**P**	**K**	**S**	**Mg**	**Ca**	**Na**
Schrider	4.43 (2.66)	0.44 (0.43)	2.51 (1.69	0.37 (0.40)	0.29 (0.38)	0.57 (0.64)	0.79 (1.11)
Geary Irrigated	4.44	0.47	3.59	0.40	0.33	0.38	0.55
Geary non-irrigated	3.92 (4.11)	0.46 (0.45)	3.62 (2.73)	0.37 (0.41)	0.30 (0.31)	0.39 (0.39)	0.54 (0.45)
Brown	4.15	0.40	3.51	0.36	0.24	0.64	0.47
Typical	*4.5-5.5*	*0.30-0.40*	*2.0-4.00*	*0.25-0.35*	*0.15-0.22*	*0.25-0.50*	*0.1-0.3*

Table 5b: Micronutrient concentrations (ppm) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	**Pasture micronutrient concentrations (ppm)**							
	Mn	**Zn**	**Cu**	**Fe**	**Co**	**Mo**	**Se**	**B**
Schrider	54 (58)	31 (33)	6.4 (6.3)	230 (818)	0.16 (0.27)	0.34 (<0.05)	0.31 (0.48)	6.0 (7.3
Geary Irrigated	86	32	7.6	2057	0.87	0.59	0.14	9.7
Geary non-irrigated	79 (84)	28 (34)	9.2 (10.9)	1124 (930)	0.46 (0.23)	0.46 (0.41)	0.02 (0.02)	7.7 (7.5)
Brown	65	31	9.3	351	0.18	2.38	<0.01	6.9
Typical	*20-50*	*10-20*	*5-10*	*45-65*	*0.04-0.10*	*0.1-1.0*	*>0.03*	*13-16*

These results indicate that the nutrient levels in the pastures from these landfarm sites are typical of New Zealand pastures except that:

a) The pasture sodium (Na) levels are elevated due to enrichment from the soils either from sea sprays or from the drilling muds. Either way this is of no consequence and can only be a benefit to animal health.
b) The manganese (Mn) and zinc (Zn) levels appear to the greater than normal but are nevertheless not sufficiently high to give rise to animal health problems.
c) The iron (Fe) levels are elevated. This is most likely due to contamination from the soil as frequently occurs on 'normal' soils and in any case is of little practical consequence.
d) The cobalt (Co) and molybdenum (Mo) are above the minimum levels for optimal health.

e) The selenium (Se) levels on 2 sites are below the minimum level for optimal animal production as is frequently the case for many New Zealand soils. This can be readily corrected with fertiliser Se.

The combined soil and pasture results suggest that there is nothing unusual about the soils and pastures at these landfarms, relative to normal conditions, which occur routinely throughout New Zealand. Furthermore, they indicate that providing the soil fertility is optimised and there is little moisture stress (i.e. they are irrigated), high quality productive and healthy clover-based pastures can be grown on these landfarms.

If the constraints (soil fertility and moisture) were removed it should be possible to grow at least 15 tonnes DM/ha annually, and assuming they are used for dairying, would put the value of the landfarms at about $30-40,000/ha. In their natural state (i.e. before land farming) they were growing low-quality feed and used for dry-stock farming only. There original value would be about $3-4000/ha.

Heavy Metals

Soil (Routine Sampling 0-250mm)

The results from the monitoring of the soils (0-250mm) during the process of disposal of the drilling muds, as required under the consents, are summarized for each site in Table 6 a, b, c:

In all cases the heavy metal concentrations were well below the guideline limits set by the Ministry for the Environment (2003) for the disposal of biosolids.

Table 6a: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Schrider site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	47	46 < 2[2]	4	< 2	20
Cd	47	all < 0.10[2]	< 0.10	-	1
Cr	50	15	23	8	600
Cu	50	13	25	9	100
Pb	50	3	23	1	300
Ni	50	8	11	5	60
Zn	50	71	100	33	300
Hg	41	all < 0.01[2]	< 0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

Table 6b: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Geary site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	33	all < 2[2]	<2	-	20
Cd	33	all < 0.1[2]	<0.10	-	1
Cr	33	15	20	8	600
Cu	33	17	32	7	100
Pb	33	14	48	1	300
Ni	33	7	11	5	60
Zn	33	72	113	33	300
Hg	33	all < 0.1[2]	<0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

Table 6c: Summary of heavy metal concentrations (ppm) in the soil (0-250mm) at the Brown site.

Element	No. samples	Average	Max.	Min.	Limit[1]
As	24	17 < 2[2]	5	< 2	20
Cd	24	22 < 0.10[2]	0.27	< 0.10	1
Cr	24	11	19	7	600
Cu	24	21	41	15	100
Pb	24	3	8	1	300
Ni	24	6	10	4	60
Zn	24	74	120	49	300
Hg	24	all < 0.01[2]	<0.10	-	1

Note 1) from the Ministry for the Environment 2003
2) for some elements and on some occasions the results were reported at being less than a given limit. It is not realistic in such cases to give an arithmetic mean and hence some indication of the distribution of the results is recorded.

The heavy metal concentrations in the soils (0-250mm), as measured during the process of disposal, were all much less than the set limits, at all three sites.

Soil (normal pastoral soil levels)

The heavy metal concentrations in soils (0-100mm) from surveys conducted from various regions of New Zealand under pasture and non-farmed land uses are summarized in Appendix 1. The Table below (Table 7) compares these typical concentrations (0-100mm) with those found at the three landfarm sites (0-75mm).

Table 7: Comparison of the heavy metal concentrations (ppm) in typical New Zealand pastoral and non-farmed soils (0-100mm) and in the soils (0-75mm) at the three sites; Schrider, Geary and Brown.

Element	Range in mean/median values in NZ farmed or (non-farmed) soils)[1]	Site					
		Schrider		Geary			Brown[2]
				Sample 1[2]	Sample 2[2]		
		Sample 1[2]	Sample 2[2]	Non-irrigated	Non irrigated	Irrigated	Sample 1
Arsenic (As)	3-9 (3-5)	<2	<2	<2	<2	<2	2
Cadmium (Cd)	0.1-0.8 (0.1-0.14)	<0.1	0.11	<0.1	<0.1	<0.1	<0.1
Chromium (Cr)	8-18 (12-18)	nd	11	nd	11	11	8
Copper (Cu)	10-20 (10-16)	nd	11	nd	20	13	21
Lead (Pb)	6-16 (9-16)	1.6	1.8	3.2	3	1.4	3.6
Nickel (Ni)	4-14 (4-14)	nd	5	nd	5	5	4
Zinc (Zn)	7-79 (28-66)	nd	55	nd	53	57	57
Mercury (Hg)	0.07-0.20 (0.11-0.19)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Notes 1) from Appendix 1.
2) samples 1 collected 4 July 2013, samples 2 collected 8 August 2013.

The samples collected on the three landfarms (Schrider, Geary and Brown), were from the depth 0-75mm (the normal depth for testing soil nutrients). The range in the median and mean above, from the surveys, are for soils to a depth of 0-100mm. Data from Waikato survey (Waikato Regional Council 2011) shows that top-soils (0-100mm) are enriched relative to the sub-soils (100-200mm) for Cd, Cr, Cu, Ni but not for the other heavy metals. Thus, the results above for the landfarms (0-75mm) are likely to be elevated to some extend relative to the typical ranges given in Table 7.

These results indicate that the soil heavy metal concentrations are at the low end of the ranges for both farmed (dairying) and non-farmed soils (referred to in the respective reports as either native, indigenous and background).

Pasture (normal levels)

The available information on the heavy metal concentrations in pastures in New Zealand is summarized in Appendix 2.

Table 8: Heavy metal concentrations (ppm) in mixed-pasture from the three sites for samples collected 5 August 2013 (Figures in parenthesis are from samples collected 4 July 2013).

Site	Pasture heavy metal and barium concentrations (ppm)						
	As	**Cd**	**Hg**	**Pb**	**Cr**	**Ni**	**Ba**
Schrider	<0.1 (<0.1)	0.022 (0.033)	0.013 (0.028)	0.039 (0.079)	0.460 (<0.1)	<1 (<1)	42 (33)
Geary Irrigated	<0.1	0.011	<0.01	0.072	0.750	<1	74
Geary non-irrigated	<0.1 (<0.10)	0.025 (0.027)	0.011 (0.029)	0.102 (0.112)	0.600 (0.160)	<1 (<1)	>100 (97)
Brown	<0.1	0.073	0.011	0.104	0.520	<1	71
***Typical*[1]**	*0.07-0.24*	*0.03-0.29*	*na*	*0.10-1.8*	*0.31-0.49*	*0.10-0.20*	*na*

Note 1) see Appendix 2

Consistent with the soil data, these results indicate that there is nothing unusual about the heavy metal concentrations in the pastures from these landfarms relative to normal levels reported for New Zealand pastures.

Barium

Barium sulphate (Barite) is used during the drilling process (Alberta Environment 2009), as noted. This chemical form of barium is practically insoluble and therefore environmentally benign, unlike other barium salts (e.g. barium chloride and nitrate) (Menzies et al 2008). There are currently no guidelines in New Zealand for the disposal of biosolids containing barite. The Canadian Authorities (Alberta Environment 2009) have set remediation guidelines for agricultural land at 10,000 ppm (Barite containing sites) and 750 ppm (non-barite sites).

Table 9 summarizes the soil barium (Ba) data (0-250mm) collected during the disposal phase for the three sites.

Table 9: Total barium (Ba) concentrations (ppm) in the soils (0-250mm) at the three sites during the disposal phase.

Site	No. samples	Average	Max	Min	Limit[1]	No. over limit
Schrider	54	528	5500	17	750 ppm	6
Geary	39	1265	5400	90	750 ppm	11
Brown	15	1860	3200	40	750 ppm	13

Note 1) Taranaki Regional Council, undated, ref: PCDOCS\FRODO\98943\1.

This data suggests that the Ba limit (assuming a non-barite source of Ba) was exceeded at some times, however none of the sites reached levels of 10,000 ppm the guideline for barite sites.

The Alberta Environment (2009) guidelines specify a simple procedure to determine whether barite is present at a specific site. If the extractable Ba (in 0.1M Calcium chloride at a 1:10 ratio) exceeds 250 ppm then it is assumed it is a non-barite site. The results below show that the extractable Ba levels are well below the 250-ppm limit leading to the conclusion that the only source of Ba at these sites is the environmentally benign barite form.

Table 10. The concentrations of extractable and total barium (Ba) in soils and in pastures at the 3 landfarm sites

Site	Extractable Ba (ppm)	Total Ba (ppm)	Pasture Ba (ppm)
Schrider	24	7800	42 (33)
Geary (irrigated)	36	760	74
Geary (non-irrigated)	46	2400	>100 (97)
Brown	31	930	71

This being so, the limit for safe disposal (viz. < 10,000 ppm) applies and this was never exceeded during the disposal process. This is consistent with the measured Ba concentrations in the pastures (Table 8) which indicate levels in the ppm range and not in the percent (%) range as might be expected for a divalent cation such as calcium (Ca) or magnesium (Mg) (c.f. table 5a and 8). This is consistent with the view that barite is not considered bioavailable (Alberta Environment 2009).

Petroleum Hydrocarbons

Soils

The guidelines for the management of petrochemical hydrocarbons (PHC) (Ministry for the Environment 2011) require the monitoring of 3 representative types of PHCs:

a) TPH (Total Petroleum Hydrocarbons) in three classes: C7-C9, C10-C14 and C15-36.
b) BTEX: which includes benzene, toluene, ethyl-benzene and xylene.
c) PAH (Polycyclic aromatic hydrocarbons).

Levels of each PHC are set for screening purposes, meaning that if these levels are exceeded, further investigation is recommended.

The measured concentrations of these classes of PHC in the soil (0-250mm) collected during the disposal process for each site are given in tables 11a,b,c below:

Table 11a. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Schrider site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	55	50< 8	12	<8	120	0
	C10-C14	55	44< 20	5020	<10	58	3
	C15-C36	55	21<30	19000	<30	4000	4
BTEX	Benzene	43	13<0.05	0.26	<0.03	1.1	0
	Toluene	43	35<0.06	3.23	<0.03	68	0
	Ethylbenzene	43	35<0.05	1.93	<0.03	53	0
	o-xylene	43	23<0.05	4.68	<0.03	48	0
	m&p-xylene	43	31<0.09	13	<0.05	48	0
PAH	Benzo[a]pyrene	37	12<0.02	0.07	<0.02	0.027	1
	Napthelene	37	13<0.10	7.1	<0.10	7.2	0
	Pyrene	37	30<0.09	0.72	<0.02	160	0

Note 1) screening limit set by Ministry for the Environment 2011

Table 11b. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Geary site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	32	all<8	<8	-	120	0
	C10-C14	32	29<20	49	<10	58	0
	C15-C36	32	17<30	1400	<30	4000	0
BTEX	Benzene	28	25<0.05	0.20	<0.05	1.1	0
	Toluene	28	25<0.06	0.20	<0.05	68	0
	Ethylbenzene	28	25<0.05	0.20	<0.05	53	0
	o-xylene	28	21<0.05	0.13	<0.02	48	0
	m&p-xylene	28	25<0.09	<0.20	<0.05	48	0
PAH	Benzo[a]pyrene	19	16<0.02	0.40	<0.02	0.027	1
	Napthelene	19	18<0.10	0.12	<0.02	7.2	1
	Pyrene	19	18<0.09	0.19	<0.02	160	0

Note 1) screening limit set by Ministry for the Environment 2011

Table 11c. Concentrations of various petroleum hydrocarbons (PHC) in the soils (0-250mm) at the Brown site.

PHC		No. samples	Average	Max.	Min	Limit[1]	No. over limit
TPH	C7-C9	57	36<8	16	<8	120	0
	C10-C14	57	28<20	5500	<20	58	23
	C15-C36	57	5<30	13500	<30	4000	14
BTEX	Benzene	26	16<0.05	0.08	<0.05	1.1	0
	Toluene	26	16<0.06	0.08	<0.05	68	0
	Ethylbenzene	26	16<0.05	0.16	<0.05	53	0
	xylene	26	14<0.10	0.24	<0.10	48	0
PAH	Benzo[a]pyrene	26	8<0.025	0.028	<0.025	0.027	2
	Napthelene	26	8<0.12	0.30	<0.12	7.2	0
	Pyrene	26	23<0.09	0.28	<0.09	160	0

Note 1) screening limit set by Ministry for the Environment 2011

During the process of disposal there were some occasions when the limits, particularly of TPHs, and particularly on the Brown site, were exceeded. Despite this the BTEX and PAH screening limits were rarely exceeded.

Petrochemical hydrocarbons are biodegradable (Ministry for the Environment 2011) under aerobic soil conditions (as is the case on these sandy soils) and it is likely that the higher rate of exceedances on the Brown site is because this is the most recently completed site. It is anticipated that with time these levels will decline noting that the numerous earthworm casts at all sites indicated an active biomass. This is confirmed by the fact that the TPH concentrations (0-75mm) measured in August 2013 (Table 12) were below the levels of detection on all sites (Table 12).

Table 12: Concentrations of total petrochemical hydrocarbons (TPH) in the soils (0-75mm) at the three landfarm sites (samples collected 5 Aug 2013).

Site	Total Petrochemical Hydrocarbon[1] (TPH) (ppm)			
	C7-C9	C10-C14	C15-C36	Total (C7-C36)
Schrider	<8	<20	<40	<70
Geary Irrigated	<10	<20	<40	<70
Geary non-irrigated	<8	<20	<40	<70
Brown	<8	<20	<40	<70

Note 1) see Appendix 3 for the full results including BTEX and PAH.

The possibility that the TPH levels in these topsoils (0-75mm) underestimate the concentrations in the full profile (i.e. 0-250mm), either due to uneven placement of the drilling wastes in the profile, or their movement down the profile, can be set aside because of the method of disposal required under the consents (surface applied not more than 100mm and incorporated to a depth > 250 mm) and the fact that TPHs are not water soluble.

Pasture

The measured concentrations of these classes of PHCs in the pasture from each site are given in table 13 below:

Table 13: Concentrations of total petrochemical hydrocarbons (TPH) in the pastures at the three landfarm sites (samples collected 5 Aug 2013).

Site	Total Petrochemical Hydrocarbon[1] (TPH) (ppm)			
	C7-C9	C10-C14	C15-C36	Total (C7-C36)
Schrider	<8	<20	58	58
Geary Irrigated	<8	<20	86	86
Geary non-irrigated	<8	<20	71	71
Brown	<8	<20	81	81

1) see Appendix 3 for the full results including BTEX and PAH.

Once again the levels of C7-C9 and C10-C14 TPHs are below the detection limits, as for the soils, but there are higher order TPHs (C15-C36) in the pasture, which

are not present in the soil. The likely explanation for this is that plants manufacture waxes, which are represented in the C15-C36 group of TPH (*pers. comm*. Jo Cavanagh, Landcare Research Ltd)

The concentrations of individual PAHs in the pasture are given in Appendix 3 and for most, the levels are below the detection limit. Plants do not manufacture these compounds and hence any levels above the limit of detection are likely due to plant uptake. However the levels are so low that it is unlikely they would cause a problem in terms of pasture growth, animal health or food quality.

This is consistent with the results from monitoring the concentrations of these compounds in milk from these farms. None have been found (*pers. com*. Mr Andy Fowler, Fonterra, Hamilton).

CONCLUSIONS

Based on the available evidence it is concluded that the Taranaki 'Landfarms' are 'fit for purpose' in terms of pastoral farming and particular dairy farming. This conclusion is based on considering the concentrations of nutrients (both macro and micro), heavy metals, barium and petrochemical hydrocarbons residues in both the soils and pastures at 3 sites.

The re-contoured sand dunes, after the inclusion of the drilling wastes (as per the consents), and with the addition of appropriate fertilisers and water (irrigation) are capable of producing high quality clover-based pastures and thus increasing the value of the land from about $3-4000/ha to $30-40,000/ha.

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Appendix 1a: Heavy metal concentrations (ppm) in non-farmed soils (0-100mm).

Heavy metal	Source of data			
	Rural Auckland[1] (indigenous)	Waikato[2] (background)	Wellington[3] (native)	Range in mean/median values
Arsenic (As)	3.3	5.1 (1-25)	3 (<2-10)	3-5
Cadmium (Cd)	0.14	0.11 (0.03-0.30)	0.10 (<0.1-0.30)	0.10-0.14
Chromium (Cr)	12.5	18 (1-50)	12 (6-18)	12-18
Copper (Cu)	10.1	16 (4-55)	12 (6-22)	10-16
Lead (Pb)	15.8	11 (3-32)	9 (3-15)	9-16
Nickel (Ni)	4.8	3.9 (0.56-21)	14 (16-2-22)	4-14
Zinc (Zn)	40.2	28 (11-58)	66 (40-104)	28-66
Mercury (Hg)	0.11	0.19 (0.19-0.5)	ng	0.11-0.19

Notes 1) Concentrations of Selected Trace Elements for Various Land Uses and Soil Orders within Rural Auckland. Auckland Council Technical Report 2012/021

2) Soil Quality and Trace Element Monitoring in the Waikato Region. Waikato Regional Council Technical Report 2011/13

3) Soil quality and stability in the Wellington Region. State and Trends. Great Wellington Regional Council. 2012

Appendix 1b: Heavy metal concentrations (ppm) in dairy or farmed soils (0-100mm).

Heavy metal	Source of data					
	Auckland (dairying) [1]	Bay of Plenty (dairying) [2]	Waikato[3] (farmed)	Wellington[4] (dairying)	Malborough [6] (dairying)	Range in mean/ median values
Arsenic (As)	3.3	4.9 (SE 1.2)	8.6 (0.70-94)	4 (<2-30)	5.1	3-9
Cadmium (Cd)	0.59	0.75 (SE 0.09)	0.71 (0.10-2.0)	0.5 (0.23-1.3)	0.42	0.1-0.8
Chromium (Cr)	13.1	7.6 (SE 0.8)	14 (1-220)	17 (9.8 – 50)	27	8-18
Copper (Cu)	16	16.1 (SE 3.7)	24 (3-250)	13 (6.8-35)	20	10-20
Lead (Pb)	14.7	5.6 (SE 0.6)	16 (3-95)	16 (7.3-32)	15	6-16
Nickel (Ni)	5.5	6.1 (SE 1.0)	6 (1-34)	12 (4-24)	13	4-14
Zinc (Zn)	43.1	72 (SE 17.8)	62 (1-258)	79 (33-120)	81	7-79
Mercury (Hg)	0.2	0.07 (SE 0.01)	0.16 (0.03-0.5)	ng	ng	0.07-0.20

Appendix 2: Heavy metal concentrations (ppm) in pasture reported in the literature and the Maximum Permissible Levels (MPL) in complete rations.

Heavy metal	**Longhurst[1]**	**Quin[2]**	**Typical**	**MPL[3]**
As	0.07-0.24	ng[4]	0.07-0.24	2
Cd	0.03-0.29	0.05 – 0.08	0.03-0.29	1
Cr	ng	0.34-0.46	0.31-0.49	ng
Cu	9-14	5.4-11.7	5.4-14	ng
Pb	0.10-0.35	0.76-1.80	0.10-1.8	5
Ni	ng	< 0.10-0.20	0.10-0.20	ng
Zn	6.5-40	22-37	6.5-37	ng
Hg	ng	ng	ng	0.10

Notes
1) Longhurst et. al. 2004. Range in mean concentrations across soil groups and plant species
2) Quin and Syers 1978. Range in values for control treatment
3) Maximum permitted levels in complete rations for ruminants (Suttle N. F. 2010)
4) ng = not given

Appendix 3: Laboratory results showing the concentrations of all petrochemical hydrocarbons in 4 soils samples and 4 pasture samples.

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Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Eurofins NZ Laboratory Services Ltd	**Lab No:**	1168389	SPv2
Contact:	S Stiles-Jones	**Date Registered:**	17-Aug-2013	
	C/- Eurofins NZ Laboratory Services Ltd	**Date Reported:**	29-Aug-2013	
	PO Box 281	**Quote No:**	56330	
	HAMILTON 3240	**Order No:**	168833HM	
		Client Reference:	3256047	
		Submitted By:	S Stiles-Jones	

Amended Report

This report replaces an earlier report issued on the 26 Aug 2013 at 1:33 pm
Sample IDs have been amended at the client's request.

Sample Type: Soil

		Sample Name:	13508240 (Brown) 09-Aug-2013	13508241 (Geary Unirrig) 09-Aug-2013	13508242 (Geary irrig) 09-Aug-2013	13508243 (Schrider) 09-Aug-2013	
		Lab Number:	1168389.1	1168389.2	1168389.3	1168389.4	
Individual Tests							
Dry Matter	g/100g as rcvd		80	84	75	84	-
BTEX in Soil by Headspace GC-MS							
Benzene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Toluene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Ethylbenzene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
m&p-Xylene	mg/kg dry wt		< 0.10	< 0.10	< 0.12	< 0.10	-
o-Xylene	mg/kg dry wt		< 0.05	< 0.05	< 0.06	< 0.05	-
Polycyclic Aromatic Hydrocarbons Screening in Soil							
Acenaphthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Acenaphthylene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[a]anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[a]pyrene (BAP)	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[b]fluoranthene + Benzo[j]fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[g,h,i]perylene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Benzo[k]fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Chrysene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Dibenzo[a,h]anthracene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Fluoranthene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Fluorene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Naphthalene	mg/kg dry wt		< 0.14	< 0.14	< 0.16	< 0.13	-
Phenanthrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Pyrene	mg/kg dry wt		< 0.03	< 0.03	< 0.04	< 0.03	-
Total Petroleum Hydrocarbons in Soil							
C7 - C9	mg/kg dry wt		< 8	< 8	< 10	< 8	-
C10 - C14	mg/kg dry wt		< 20	< 20	< 20	< 20	-
C15 - C36	mg/kg dry wt		< 40	< 40	< 40	< 40	-
Total hydrocarbons (C7 - C36)	mg/kg dry wt		< 70	< 70	< 70	< 70	-

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: Soil			
Test	**Method Description**	**Default Detection Limit**	**Samples**
TPH + PAH + BTEX profile	Sonication extraction, SPE cleanup, GC & GC-MS analysis	-	1-4
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.

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

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ANALYSIS REPORT

Client:	Eurofins NZ Laboratory Services Ltd	**Lab No:**	1165426	SPv1
Contact:	K Rhodes	**Date Registered:**	09-Aug-2013	
	C/- Eurofins NZ Laboratory Services Ltd	**Date Reported:**	23-Aug-2013	
	PO Box 281	**Quote No:**		
	HAMILTON 3240	**Order No:**	168833HM	
		Client Reference:	9640618	
		Submitted By:	K Rhodes	

Sample Type: Plant Material

Sample Name:		13P02588	13P02589	13P02590	13P02591	
Lab Number:		1165426.1	1165426.2	1165426.3	1165426.4	
Polycyclic Aromatic Hydrocarbons in Biomatter						
Acenaphthene	mg/kg	0.0009	0.0007	0.0006	0.0010	-
Acenaphthylene	mg/kg	< 0.0005	< 0.0005	< 0.0005	0.0006	-
Anthracene	mg/kg	0.0009	0.0023	0.0005	0.0014	-
Benzo[a]anthracene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Benzo[a]pyrene (BAP)	mg/kg	0.0003	< 0.0002	0.0003	< 0.0002	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg	0.0004	0.0003	0.0003	0.0002	-
Benzo[g,h,i]perylene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Benzo[k]fluoranthene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Chrysene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Dibenzo[a,h]anthracene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Fluoranthene	mg/kg	0.0008	0.0004	0.0004	0.0004	-
Fluorene	mg/kg	0.0014	0.0013	0.0010	0.0015	-
Indeno(1,2,3-c,d)pyrene	mg/kg	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-
Naphthalene	mg/kg	0.006	0.007	0.005	0.011	-
Phenanthrene	mg/kg	0.0028	0.0021	0.0016	0.0018	-
Pyrene	mg/kg	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-
Total Petroleum Hydrocarbons in Biota						
C7 - C9	mg/kg as rcvd	< 8	< 8	< 8	< 8	-
C10 - C14	mg/kg as rcvd	< 20	< 20	< 20	< 20	-
C15 - C36	mg/kg as rcvd	81	71	86	58	-
Total hydrocarbons (C7 - C36)	mg/kg as rcvd	81	71	86	< 60	-

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: Plant Material

Test	Method Description	Default Detection Limit	Samples
Homogenisation of Biological samples for Organics Tests	Mincing, chopping, or blending of sample to form homogenous sample fraction.	-	1-4
Polycyclic Aromatic Hydrocarbons in Biomatter		-	1-4
Total Petroleum Hydrocarbons in Biota	Sonication extraction, Alumina cleanup, GC-FID analysis	-	1-4

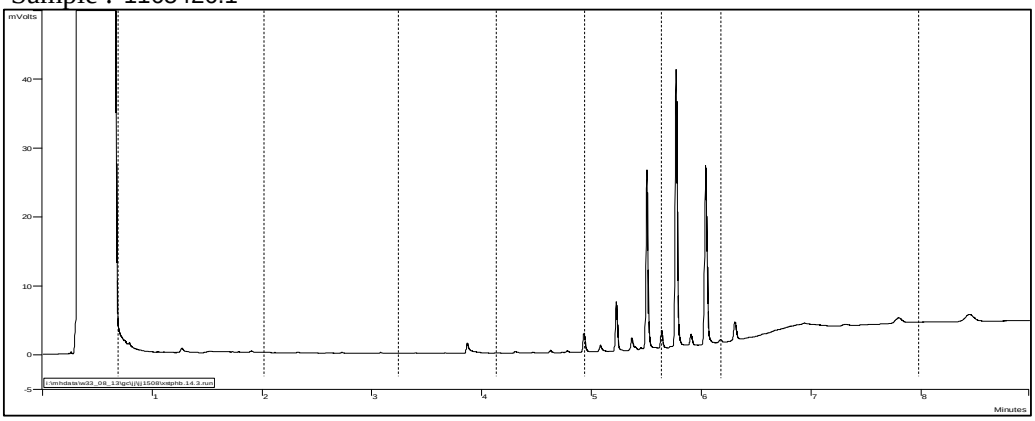
Sample Type: Plant Material			
Test	**Method Description**	**Default Detection Limit**	**Samples**
TPH in Biota extraction by Sonication (Instrument Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4
TPH in Biota extraction by Sonication (Storage Vial)	Sonication extraction, Silica cleanup, GC-FID analysis.	-	1-4

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

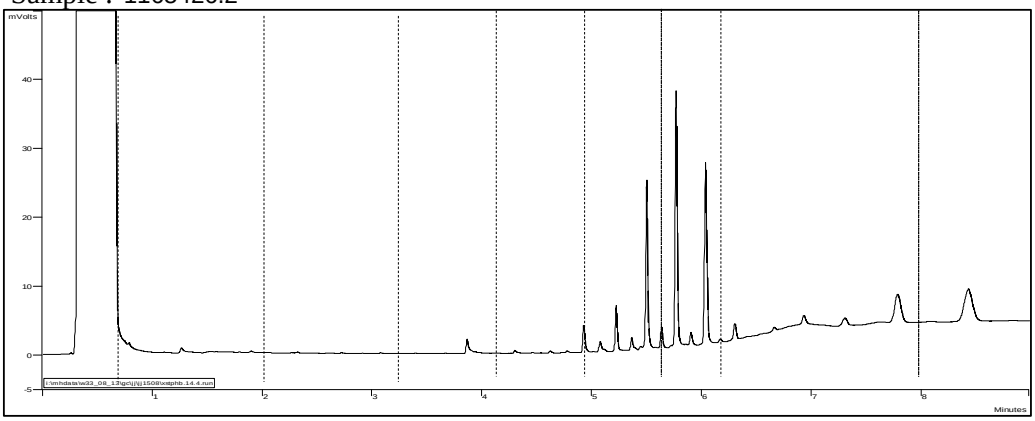
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

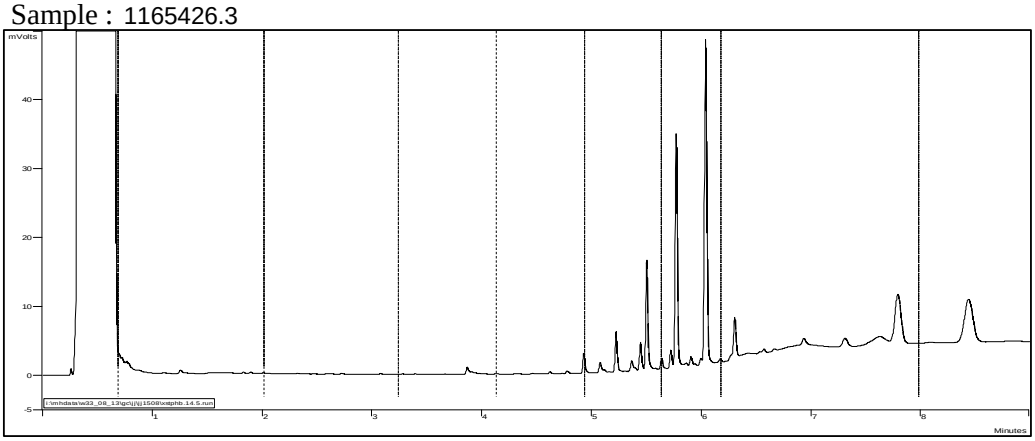
Sample : 1165426.1



Sample : 1165426.2

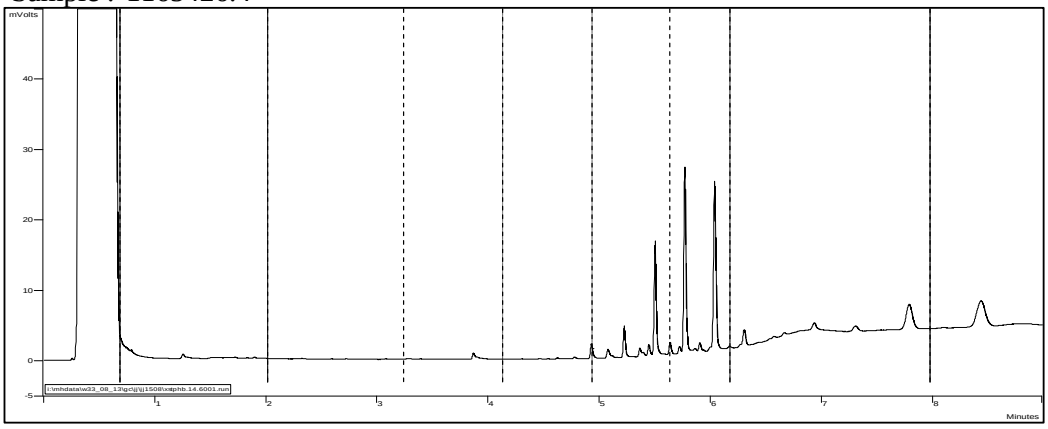


Sample : 1165426.3



C7 C10 C15 C20 C25 C30 C34 C44

Sample : 1165426.4



C7 C10 C15 C20 C25 C30 C34 C44