AB Lime Limited Landfill Resource Consent Application

Landfill Gas Technical Memo

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AB Lime Limited

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Important note about this report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for landfill management to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime Limited (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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Executive Summary

AB Lime Limited propose to increase the operations of their existing landfill, which will change the status of the activities for a number of resource consents. This technical memo summarises the landfill gas management of the landfill and investigates the impact of increasing waste acceptance on landfill gas management.

The application for resource consent is prepared by Jacobs New Zealand Limited (Jacobs) on behalf of AB Lime Limited in support of an application for the expanded operation of the AB Lime Landfill, located at 10-20 Kings Bend, Winton. The purpose of this technical memo for landfill gas management is to assist in this application for resource consent and provide technical input into the Assessment of Effects on the Environment (AEE).

The landfill gas operations at the AB Lime landfill comprise an active landfill gas extraction system that has been designed and operated in accordance with the NZ landfill guidelines (WasteMINZ, 2018).

In 2009 a landfill gas principal flare was installed, and the flare meets the requirements of the consent conditions as listed in Air Discharge Permit No. 201351.

The annual compliance report from Environment Southland shows that the landfill has been compliant with the air discharge consent conditions except in the period 2017/2018 when there was a significant non-compliance noted with the landfill gas flare temperature (Nov 2017). Additional landfill gas extraction wells were installed, and the flare temperature criteria was compliant for the remainder of the 2017/2018 period (see Table 1 in Section 3).

The 2018/2019 annual compliance report also mentions a significant non-compliance with the air discharge consent. It appears that the non-compliance is related to odour issues, and since odour management is part of the air discharge consent, it is possible that the non-compliance may be related to, for example, odorous waste arriving at the landfill and not being buried quickly and covered with a capping layer. Equally the odour issues may have resulted from landfill gas discharges at, for example, the working face. We note that the Environment Southland "FULL COMPLIANCE OBSERVATION LISTING" does not report any non-compliance issues against the air discharge permit.

Landfill gas monitoring has been carried out in general accordance with the Air Discharge Permit consent and does not exceed the criteria set in the consent conditions.

Whilst the landfill surface gas emission monitoring meets the consent criteria, it does not meet the Air Quality NES criteria. An amendment to an existing consent condition to reflect the Air Quality NES landfill surface gas emission criteria has therefore been proposed (refer to section 9 of the main AEE document).

Since the landfill started accepting waste in 2004 an Independent Peer Reviewer has reviewed the design, construction, operation, maintenance and monitoring of the landfill to assess if the work is undertaken by appropriately qualified personnel and in accordance with good practice. The Independent Peer Reviewer's role covers landfill gas management and includes at least one site inspection per year. The Environment Southland annual compliance reports references the peer reviews and grade them as "full compliance" except in year 2016/2017 when there was a low risk of non-compliance, see Table 1 in Section 3.

In 2014 AB Lime engaged the services of Dr Rissmann to assess the gas emissions from the surface of the landfill, quantify the efficiency of the active gas extraction system and better understand the landfill gas generation, transport and biological attenuation at the landfill. Dr Rissmann concluded that the landfill has a relatively low methane output and high methane oxidation rates.

An updated landfill gas generation model has been prepared as part of this application. The updated model estimates the volume of landfill gas generated in the future which allows AB Lime for the early planning of a second principal flare (if required, since in January 2019 AB Lime was granted a variation to the existing air discharge consent permit AUTH-205862-01-V, to use landfill gas as a supplementary source in the coal-fired dryers of the limeworks operations).

A new Landfill Gas Management Plan has been developed as part of this application to provide the landfill procedures on how to manage the potential effects related to landfill gas. Management plans are a commonly and widely accepted method utilised in landfill management and allow an adaptive management approach so continuous improvement and refinement to each management plan can occur as best practice procedures evolve.

1. Purpose of this report

The purpose of this report is to assess whether existing landfill gas management associated with the operation of the AB Lime landfill will be changed due to the proposed change to incoming waste quantities. It is proposed that the current upper limit of 100,000 tonnes/annum is revised such that there is no limitation on the tonnage of waste that may be received. Removal of the limit means that although the overall area of the landfill will not be altered, the rate at which the landfill is exhausted over time may be accelerated.

This document sets out the current landfill gas management environment and analyses to what extent there will be a need for changes to the landfill gas management due to the removal of an upper limit for waste acceptance at the AB Lime landfill.

2. Description of the existing landfill gas management environment

Current activities on site include the operation of a landfill, a limestone quarry and processing of limestone and fertiliser.

For the purposes of this report, the following terminology and associated definitions will be used:

- **Existing** – the current on-site arrangements;
- **Consented** – the design, operation and management approach envisaged throughout the lifespan of the site that has been consented;
- **Future** – the nature of activities and effects anticipated as a result of removing the existing 100,000 tonne per annum limitation on waste that can be accepted at the site; and
- **Landfill Gas (LFG)** – the production of landfill gas due to the placement of waste in the landfill.

2.1 Landfill Gas Generation & Composition

Landfill gas (LFG) occurs as a result of microbial decomposition of biodegradable material within a landfill, including, food scraps, garden waste, paper, wood and cardboard.

Under anaerobic conditions biological activity within the landfill produces a mixture of methane (45%-60%), carbon dioxide (40%-60%), and trace gases including nitrogen, oxygen, ammonia, sulphides, hydrogen, carbon monoxide and non-methane organic compounds (NMOCs).

Methane is a colourless and odourless gas, which is explosive in concentrations ranging from 5% and 15% in air and flammable above 15% concentration. Carbon dioxide is also a colourless and odourless gas but is non-combustible. Both are considered to be "greenhouse" gases, contributing to global warming. Trace gases within landfill gas are those that give the gas its characteristic odour.

2.2 Landfill Gas Control

The current objectives of landfill gas management at the AB Lime landfill follows those identified in the New Zealand good practice landfill guidelines; such as the Technical Guidelines for Disposal to Land prepared by WasteMINZ (2018). The site's landfill gas control objectives are to:

- Reduce the short and long term hazards associated with landfill gas (which is flammable, explosive and an asphyxiant gas);
- Minimise odour nuisance associated with landfill gas (due to the organic contaminants it contains); and
- Minimise greenhouse gas emissions.

2.3 Landfill Gas Collection & Extraction System Design

The current design objectives of the landfill gas management system at the AB Lime landfill follow those listed in the WasteMINZ Guidelines (2018) to:

- Minimise the risk to human health and safety;
- Minimise the potential impact on air quality and the uncontrolled emissions of greenhouse gases to atmosphere;
- Minimise the ingress of air into the landfill and thereby minimise the risk of fires;
- Minimise the potential for landfill gas migration into services and buildings within the site boundary;
- Minimise the potential for landfill gas migration beyond the site boundary;
- Effectively control gas emissions; and

- Minimise the damage to soils and vegetation within restored landfill areas.

The currently consented landfill gas system is described in:

- The Landfill Gas Design Report- Phase 1 Area (2004), Available on request
- The Design Report- Landfill Gas Stage 1 Permanent Flare (2009), available on request.

The 2004 and 2009 landfill gas design reports show that the design of the landfill gas collection and extraction system focussed on the:

- Removal of landfill gas from within the landfill via vertical and horizontal gas extraction wells;
- Transport of landfill gas in aboveground pipes to a permanent landfill gas principal flare;
- Treatment of landfill gas in a permanent landfill gas principal flare; and
- Removal of landfill condensate from the aboveground pipework.

2.4 Treatment of Landfill Gas: Permanent Landfill Gas Principal Flare Design

The treatment of landfill gas at the landfill follows the principles of the WasteMINZ Guidelines (2018) through treatment via a permanent landfill gas principal flare. AB Lime installed a principal landfill gas flare approximately 50 m south-west of the landfill in 2009. The location of the gas flare is shown on the site plan contained in Attachment **1.** In the period 2004 to 2009 a temporary candle-stick flare was used because there was insufficient waste and landfill capping could not be installed to efficiently operate a principal flare.

Design details of the principal flare including aboveground pipework (gas header pipes) are contained in Attachment **2** The principal flare has been operating since 2009 and has been designed to operate up to 1000 m^3/hour.

In early 2016, major work was undertaken on the gas extraction system as the principal flare operated under low flow rates with low methane and elevated oxygen concentrations in the landfill gas. The completed work included:

- Replacement of gas knockout pots with release valves;
- Lowering and sealing of wellheads; and
- Installation of a non-return valve on one of the extraction wells due to an incident of preferential flow out of the wellfield.

2.5 Landfill Gas Generation Modelling

2.5.1 2004 Modelling of Volume of Landfill Gas Generation

The 2004 landfill gas design report provides information about the modelling of volume of landfill gas generation. The use of modelling to predict the volume of landfill gas generated is in accordance with the WasteMINZ Guidelines (2018). The model used in the 2004 report is based on a first order decay (Scholl Canyon Equation) developed by the US Environmental Protection Agency. The LFG Emissions Model (version 2) was used.

The 2004 landfill gas modelling assumptions and salient points are as follows:

- The landfill operates for a 35 year period from the initial placement of waste in 2004 (which is the length of the resource consents obtained), although it was noted in the 2004 report that the landfill may operate for a longer period.
- A total of 60,000 tonnes per annum of waste is received. This is total waste and includes inorganic and organic material. Only the organic component of the waste will decompose to generate LFG. Based on the Ministry for the Environment's Waste Data report (1997) approximately 70% of the waste has the

potential to decompose and generate LFG. The estimation was run for 42,000 tonnes per annum of LFG producing waste. This estimate assumes that greenwaste is included in the material landfilled.

- The potential methane generation capacity of the waste (Lo) of 170 m^3 per tonne has been used and is the NSPS default value for the model.
- For the first five years of operation as there will be only intermediate capping provided resulting in a lower landfill collection efficiency and a higher evaporation rate from the landfill. For years 2004-2009 a collection efficiency of 55% and a moisture content (k) value of 0.1 to reflect the slightly drier conditions in the landfill have been used in the estimation.
- From 2010 when it is assumed some final cap will be in place and there will be full leachate recirculation through the landfill the gas collection efficiency has been increased to 75% and k value to 0.15 to better reflect the higher moisture content in the landfill.
- A 50/50 mixture of CO_2 and methane is used in the estimation. In reality methane generation may vary from 30-65% and is very dependent on the types of waste being placed and the conditions of the landfill.
- The peak volume of landfill gas generation of around 2000 m^3/hr occurs in 2038, i.e. shortly before the end of the 35 year consent period. Assuming that 75% of the peak gas generation can be collected, the peak gas flow rate to the principal flare would be 1500 m^3/hr.

The principal flare design capacity is 1000 m^3/hr, so it was always envisaged that a second principal flare (or other forms of gas utilisation such as gas-to-energy or gas-as-fuel) would be required at some stage in the future.

2.5.2 Actual Gas Extraction Rate as Measured at the Principal Flare

In February 2020, the actual gas extraction rate was 100 m^3/hr, as measured at the principal flare inlet. The 100 m^3/hr collected gas rate is significantly less than the predicted landfill gas extraction rate of 1200 m^3/hr (in year 2020) based on the 2004 modelling.

The likely reasons for the relatively low landfill gas collection rate are discussed in Section 4.1.

2.5.3 Landfill Surface Emission Survey 2014

In 2014 AB Lime commissioned Dr. Clint Rissmann from E3 Scientific Ltd to conduct a landfill emission survey to better understand the gross emissions of methane from the landfill. A copy of the draft E3 Scientific Report is available on request. The survey comprised 810 gas flux measurements across the site (around 15,000 m^2) and an additional 72 subsurface gas compositions were made across 16 parts of the landfill.

The main conclusions of the report were reported as follows:

- The gas composition within the landfill is around 65% methane and 35% CO_2 which is outside the typical range used in landfill gas generation modelling. The enrichment of methane is probably due to the abundance of lime within the landfill (e.g. daily cover) which enhances the removal of slightly acidic CO_2. Enhanced removal of CO_2 is responsible for the slight over concentration of methane;
- Flux survey emissions averaged a daily methane output of 0.4 plus $\pm$ 0.2 ton per day;
- The majority of the landfill methane output is associated with 11 small hotspots with a combined total area of 500 m^2;
- Instantaneous flux measurements indicate a whole-of-site methane oxidation rate of around 85%. This is 8.5 times higher than the default value recommended by the IPCC. The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change;

- It is likely that the entrainment of atmospheric oxygen under suction of the landfill gas system is a key driver of enhancing methane oxidation. In addition, Dr Rissmann believes that the relatively low compaction rates at AB Lime together with the greater surface area of the waste pile also play an important role in the deeper penetration of atmospheric gases into the waste pile;
- Flare gas data indicates a high degree with atmospheric entrainment consistent with:
  i. Significant leaks within the wells or reticulation system, and
  ii. Stressing of the waste pile due to over extraction (excess oxygen and nitrogen in extracted gas). Best practice guidelines for landfill flaring recommends maintaining volumetric oxygen concentration at <2%; and
- Although untested, it is likely that poorly sealed well heads are significant emission sources. Specifically, the poor seal between well head lids and concrete casing and the gravel galleries that provide a preferential pathway for landfill gas migration. Methane emissions remain elevated around well heads within the finished cells.

The above summary of the E3 Scientific report provides context as to why the landfill gas extraction rate at the landfill has been relatively low (refer to section 2.4).

2.6 Extraction Wells Design

The design of the extraction wells at the landfill follows the general recommendations presented in the WasteMINZ Guidelines (2018), such as well spacing, wellhead features, well depth, perforated pipe of well, well pipe materials and minimising air ingress near the well head.

The extraction well design is presented in the Design Report- Landfill Gas Stage 1 Permanent Flare (2009), available on request. These extraction wells are:

- Located in an approximately 50 m grid across the landfill;
- Installed in an approximately 1000 mm concrete manhole riser, with gravel aggregate between the 150 mm diameter extraction well and the manhole riser;
- The concrete manhole riser is progressively lifted and the 150 mm pipework extended as the refuse is being placed and compacted around the manhole riser; and
- Lateral gas collection pipes are connected to the main vertical gas extraction well for improved landfill gas collection.

In the 2013 to 2019 period, additional vertical landfill gas extraction wells were installed to improve the rate of landfill gas extraction from the landfill. These works can be summarised as follows:

- Two 150 mm diameter gas extraction wells were installed in 600 mm diameter boreholes in 2013. A description of the 150 mm diameter well design is presented in Attachment ;
- Three 100 mm diameter gas extraction wells were installed in 600 mm diameter boreholes in 2017. The 100 mm diameter wells are also referred to as 'shallow wells'. A description of the 100 mm diameter well design is presented in Attachment **3**; and
- Ten 100 mm diameter gas extraction well were installed in 600 mm diameter boreholes in 2019. A description of the 100 mm diameter well design is presented in Attachment **4**.

A site plan showing the locations of the 150 mm diameter and 100 mm diameter vertical gas extraction wells is presented in Attachment .

2.7 Gas Migration Probe Design

The design of the gas migration probes at the landfill follows the general recommendations presented in the WasteMINZ Guidelines (2018) in terms of probe depth and material type. In October 2003, seven landfill gas monitoring probes were installed.

The gas probes comprised 50 mm diameter uPVC pipes installed in 100 mm diameter boreholes with gravel between the 50 mm pipe and 100 mm diameter borehole. The depth of the boreholes ranges from 5 to 22 m below ground level.

A site plan showing the gas probe locations and the gas probe construction details are contained in Attachment **5.**

2.8 Monitoring of Landfill Gas

The landfill gas monitoring at the landfill is carried out in general accordance with the recommendations presented in the WasteMINZ Guidelines (2018) in relation to the types of gases to monitor, flow rate monitoring, frequency of monitoring and setting of trigger levels.

The effectiveness of the landfill gas system is carried out by monitoring of the following:

- Principal gas composition and flow rate;
- Vertical gas extraction well gas composition and flow rate;
- Landfill surface gas emissions; and
- Landfill gas probes outside the landfill footprint for migration of landfill gas.

AB Lime regularly provides Environment Southland with annual reports of the required landfill gas monitoring under the resource consent conditions.

3. The effectiveness of current landfill gas management arrangements in managing effects

Since the creation of the landfill in 2004 AB Lime Ltd have collected landfill gas monitoring data associated with the overall operations of the landfill. The landfill gas monitoring data is collected pursuant to the requirements of the current Air Discharge Permit, Consent No. 201351, as discussed in the Landfill Gas Management Plan.

Environment Southland compliance monitoring information has been used to determine whether the site currently complies with the existing air discharge consent (and limits within that consent). Environment Southland compliance monitoring reports from 2012/13 to 2018/19 have been viewed and are summarised in **Table 1** below.

We note that this excludes odour compliance. An odour compliance assessment has been carried out in the Air Quality section of the application.

Table 1 Environment Southland Compliance grading summary for AB Lime Air Discharge Permit – note compliance grade method changes over time

Year	Environment Southland Compliance Report Comments	Compliance Grade (see key for changes)
2018/19	Landfill gas collection has increased with a number of additional gas wells drilled. The gas flare burning temperature has consistently been compliant with consent limits.	Moderate to technical issues
	In the compliance report category "Other Consent Performance" the following comment was made: A peer review inspection was completed in April 2019 with consulting engineer John Cocks, Environment Southland and AB Lime. The peer review concluded that the landfill was generally being operated in accordance with the consents and good practice.	Full compliance
2017/18	Ongoing issues were reported with the gas flare temperatures up until November 2017. Additional gas wells were drilled, and temperatures were compliant for the remainder of the 2017/2018 period. Environment Southland noted that not all data for the 2018/2018 period had been reviewed at the time of writing the compliance report and that this included the annual air discharge report.	Moderate to technical issues
	In the compliance report category "Other Consent Performance" the following comment was made: A peer review inspection was completed in April 2018 with consulting engineer John Cocks, Environment Southland and AB Lime. No major design or construction matters required review in the 2017/2018 period. Four new gas wells were installed in accordance with best practice and no issues were raised by the peer reviewer.	Full compliance
2016/17	Although the air discharge report is not included in this summary, ongoing issues were reported with regard to the gas flare operation, i.e. low methane, low flow and non-compliance minimum combustion temperatures. Major work was completed during the 2016/2017 period, and this issue will continue to be worked through with a variety of stakeholders.	Low risk non-compliance
	A peer review inspection was completed in April 2017 with AECOM Consulting Services Ltd. Minor issues were identified, and an action plan was subsequently submitted by AB Lime Ltd. Area 14 of the landfill was signed off for use in 2017.	Low risk non-compliance

Year	Environment Southland Compliance Report Comments	Compliance Grade (see key for changes)
2015/16	AB Lime was compliant with all standards set out in its resource consents for discharges to land, air and water, with minor issues noted to the timeliness of reporting. Peer review was conducted in March 2016 with no major issues identified.	Moderate to technical issue
2014/15	One incident was reported to Environment Southland by AB Lime in August 2014 relating to water vapour in fresh gas. An automatic release valve was added to the system to rectify the issue and it was rectified in a timely manner. Peer review was conducted in March 2015 with no major issues identified. Area 13 stage 2 (the new landfill cell) has been signed off. The peer review performance summary report identified no major issues with the operation of the landfill, with minor issues noted relating to timeliness of reporting.	Good to excellent
2013/14	AB Lime was fully compliant with all standards set out in its resource consents for discharges to land, air and water, with minor issues noted relating to timeliness of reporting. Peer review was conducted in March 2014 with no major issues identified. Area 13 is partially lined and is expected to be fully operational within the next few months. A leachate recirculation system is now being trialled with promising results being observed.	Good to excellent
2012/13	AB Lime was fully compliant with all standards set out in its resource consents for discharges to land, air and water, with minor issues noted relating to timeliness of reporting A peer review was conducted in May 2013 with no major issues identified. Weather conditions have led to a delay in lining of Area 13, but it is expected that this will be operational within the next few months.	Good to excellent

Key:

Grading (2014/15 onwards)	Compliance Grade (2014/15 onwards)
	FULL COMPLIANCE – Compliance with all relevant consent conditions, plan rules, regulations and national environmental standards.
	LOW RISK NON-COMPLIANCE - Compliance with most of the relevant consent conditions, plan rules, regulations and national environmental standards. Non-compliance carries a low risk of adverse environmental effects or is technical in nature (e.g. failure to submit a monitoring report).
	MODERATE NON-COMPLIANCE - Non-compliance with some of the relevant consent conditions, plan rules, regulations and national environmental standards. The non-compliance was deemed to have had some environmental consequences and/or there is a moderate risk of adverse environmental effects or there was a frequent recurrence of low risk or technical non-compliance.
	SIGNIFICANT NON-COMPLIANCE - Non-compliance with many of the relevant consent conditions, plan rules, regulations and national environmental standards where there were significant environmental consequences and/or a high risk of adverse environmental effects.
Grading (pre 2014/15)	**Compliance Grade (pre 2014/15)**
	Good to excellent: Consent holder has excellent communication with Environment Southland; they have contingency measures in place; reports supplied on time and compliant; minor to no exceedances with no environmental impact.
	Moderate to technical issues: Consent holder reports late; has minor exceedances over period of time; moderate exceedances with minor impact on the environment.
	Significant non-compliance: Consent holder has exceedances with measurable impact on the environment; reports not supplied; negligent or intentional non-compliance.

4. The expected changes to landfill gas management resulting from a removal of a tonnage limit for waste acceptance

Discharge permit AUTh-201346-V3 consents the activity of discharging 100,000 tonnes of solid waste per annum onto or into land. Consent is now sought to alter the activity to remove the upper threshold for waste acceptance, so that the landfill can accept waste in a wide array of circumstances.

Fundamentally, the following aspects of the landfill are not expected to change as a result of removal of this limit:

- The landfill footprint (the consented landfill footprint is 37.15 ha) and thus area requiring final capping will not change; and
- The total volume of landfill gas generated (as the consented void volume has not changed).

The possible changes to landfill gas management resulting from a removal of a tonnage limit for waste acceptance quantities would relate to:

- The requirement for an updated landfill gas generation model to estimate the volume of landfill gas that will be produced with an increase in a waste acceptance rate (refer to section 4.2);
- The requirement to comply with the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (refer to section 4.3);
- An increase in the frequency of installing landfill gas extraction wells;
- The requirement for additional gas treatment (e.g. an additional principal flare) if the gas flow rate to the current flare exceeds the flare's maximum design gas flow rate of 1000 m^3/hr;
- An increase in uncontrolled landfill gas emissions through the working face if the size of the working face cannot be managed; and
- An increase in uncontrolled landfill gas emissions through the oversteep slopes if the existing capping on the oversteep slopes cannot be improved.

4.1 Likely Reasons for Low Landfill Gas Flow Rate at the Principal Flare

Section 2.5.2 described that the current measured landfill gas flow rate into the principal flare is significantly lower than the predicted flow rate from the modelling carried out in the 2002 AEE.

It is considered that there are several reasons for the low landfill gas generation at the landfill, including:

- Loss of landfill gas through the relatively large working face;
- Loss of landfill gas through the landfill surface on oversteep slopes at the landfill. It is assumed that these oversteep slopes do not have an appropriate cover/cap to minimise landfill gas emissions, since these slopes are typically 1(v):2(h) and it's reasonable to assume that normal compaction equipment cannot safely and effectively construct a low permeability capping layer on these slopes (refer to the proposed Landfill Gas Management Plan);
- Loss of landfill gas through cracks in the permanently and temporary capped areas of the site;
- Insufficient capping near extraction wells, enabling a relatively low suction/extraction to be applied to the well in order to minimise the risk of oxygen infiltration through the landfill cap into the gas control system;
- Landfill gas leakage at gas extraction wellhead, e.g. leaking valves, sampling ports;
- Landfill gas leakage in aboveground landfill gas header pipework;
- Methane oxidation through the landfill cap (see Section 2.5.3);
- Elevated levels of leachate and/or perched leachate with the landfill;

- Dissolved landfill gas in leachate; and
- Not enough gas extraction wells installed.

The Landfill Gas Management Plan and Landfill Leachate Management Plan provide procedures and good operating practices, with the overall aim to increase the landfill gas capture at the landfill.

4.2 Updated Landfill Gas Generation Model (2020)

The updated landfill gas generation model estimates the future volume of gas generated by the landfill. The updated landfill gas generation model has been carried out in general accordance with the WasteMINZ Guidelines (2018), similar to that discussed in Section 2.5.1. The model used was LandGEM version 3.02.

The updated landfill gas generation model makes the following assumptions:

a) Three model runs were carried out for three maximum annual refuse acceptance rates:

   1) 100,000 tonnes/year

   2) 200,000 tonnes/year

   3) 300,000 tonnes/year

   We note that the 2004 model used 60,000 tonnes/year.

b) Actual historic placement rates and waste composition data were used for the years 2004 to 2018.

c) That 43% of the refuse is putrescible or biodegradable, based on a combination of:

   1) A 2018 report by Waste Not Consulting Limited, on behalf of WasteNet Southland, into the waste composition of the Southland Regional Landfill (i.e. AB Lime Landfill).

   2) Adding the estimated 3% of other organic waste, such as biosolids, to the Waste Not Consulting Limited organic content.

   3) Hence the landfill total organic content has been estimated at around 43%. Attachment **6** shows the reasoning behind the 43% estimate.

d) L_o or potential of methane generation per ton of waste of 100 m^3/hr, compared to the 2004 report value of 170 m^3/hr;

e) With k or moisture content of landfill of 0.05 for years 2004 to 2009 and 0.1 from 2009 onwards since limited leachate recirculation has been used. The 2004 report used a k value of 0.15.

f) A gas collection efficiency of 10% in years 2004 to 2009 (when the landfill was operating without a principal flare) and 30% from 2009 to 2020. With these gas collection efficiency estimates the model has been calibrated to the volume of LFG being collected of 100 m^3/hr, as this is what is actually measured at the principal flare in Feb 2020.

g) From 2021 onwards the gas collection efficiency has been increases to 75%, based on the assumption that a combination of the following measures will be carried out:

   i. Improved cover and capping procedures, as described in the Landfill Operations Management Plan;

   ii. A reduced working face area, as described in the Landfill Operations Management Plan;

   iii. Minimising gas emissions through the existing oversteep slopes through appropriate capping of these slopes, as described in the Landfill Operations Management Plan;

   iv. Increased gas flow rates from gas extraction wells through improved operation and maintenance of the leachate collection pipework. It is envisaged that this will reduce the potential for storing excess leachate within the landfill that may interfere the gas extraction well, such as ‘flooding’ parts of the perforated section of the gas extraction well, (refer to the Landfill Leachate Management Plan);

v. Timely repair of leakage of landfill gas losses in cracks that may exist in the landfill capping, around the base of the wellheads, within the wellhead valves and monitoring ports, and in aboveground gas transmission/header pipework to the principal flare;

vi. Improved compaction efficiency of the waste, reducing the air-voids within the waste;

vii. Reduce the distance between the vertical landfill gas extraction wells;

viii. Continue to use horizontal collectors connected to the vertical gas extraction wells; and

ix. High rates of methane oxidation within the landfill and through the landfill capping system.

a) A 40/60 mixture of CO_2 and methane is used in the estimation. In reality methane generation may vary from 30-65% and is very dependent on the types of waste being placed and the conditions of the landfill.

The updated landfill gas generation model is contained in Attachment **7**.

4.3 Air Quality NES and the Control of Greenhouse Gases

The Resource Management (National Environmental Standards for Air Quality) Regulations 2004 aim to set a guaranteed minimum level of health protection for all New Zealanders. Ambient air quality standards are covered in the Air Quality section of the AEE.

Regulations 25 to 27 of the Air Quality NES provides guidance on the control of greenhouse gas emissions at landfills.

4.3.1 Regulation 25- Application of Regulations 26 and 27

National Environmental Standards	Section	Comment
S 25 Application of regulations 26 and 27	(1) Regulations 26 and 27 apply to a landfill if— (a) the landfill— (i) has a total capacity of not less than 1 million tonnes; and (ii) contains not less than 200 000 tonnes of waste; and (iii) is or is likely to be accepting waste; and (b) the waste in or to be included in the landfill is likely to consist of 5% or more (by weight) of matter that is putrescible or biodegradable. (2) However, regulations 26 and 27 do not apply to a landfill until 8 October 2007 if the landfill— (a)has a total capacity of not less than 1 million tonnes of waste; and	The landfill installed and used the principal flare when it had accepted around 250,000 tonnes in 2009. It therefore complies with Air Quality NES Regulation 25(1).

National Environmental Standards	Section	Comment
	(b) on 8 October 2004— (i) contains not less than 200 000 tonnes of waste; and (ii) is accepting waste; and (c) does not operate a gas collection system. (3) Regulations 26 and 27 do not apply to a cleanfill.	
S 26 Control of gas	(1) No person may allow the discharge of gas to air from a landfill. (2) Subclause (1) does not apply if the landfill has a system for the collection of gas from the landfill— (a) that is designed and operated to ensure that any discharge of gas from the surface of the landfill does not exceed 5 000 parts of methane per million parts of air; and (b) in which the gas is— (i) flared in accordance with regulation 27; or (ii) used as a fuel or for generating electricity.	AB Lime landfill has a system for the collection of gas. Air discharge permit 201351 condition 19(b) states that the concentration of methane measured at the surface of the landfill areas with intermediate of final cover shall not exceed 5.0% by volume. As part of this application it is proposed that condition 19(b) is amended to reflect the criteria of Air Quality NES Regulation 26(2)(a), i.e. that the 5.0% methane concentration in consent condition 19(b) is changed to 0.5% methane. This is presented in Section 9 of the proposed consent conditions in the main AEE document. S 26(2)(b) is discussed under s 27.
S 27 Flaring of gas	(1) If gas collected at a landfill is destroyed by flaring,— (a) the system for the principal flare or flares must— (i) comply with the requirements in subclause (2); or (ii) achieve at least the same effect as the system in subclause (2); and (b) the system for the backup flare must—	The design of the principal flare has been discussed in Section 2.3 and complies with the design criteria of Regulations 27(1)(a) and 27(2). The annual monitoring reports prepared by AB Lime and submitted to Environment Southland described when the flare is operating and therefore complies with Regulation 27(3). The backup flare is discussed in Section 4.3.2

National Environmental Standards	Section	Comment
	(i) comply with the requirements in subclause (3); or (ii) achieve at least the same effect as the system in subclause (3). (2) The system for a principal flare must— (a) have a flame arrestor; and (b) have an automatic backflow prevention device, or an equivalent device, between the principal flare and the landfill; and (c) have an automatic isolation system that ensures that, if the flame is lost, no significant discharge of unburnt gas from the flare occurs; and (d) have a continuous automatic ignition system; and (e) have a design that achieves a minimum flue gas retention time of 0.5 seconds; and (f) be designed and operated so that gas is burned at a temperature of at least 750°C; and (g) have a permanent temperature indicator; and (h) have adequate sampling ports to enable emission testing to be undertaken; and (i) provide for safe access to sampling ports while any emission tests are being undertaken. (3) The system for a backup flare must have— (a) a flame arrestor; and (b) an automatic backflow prevention device, or an equivalent device, between the backup flare and the landfill; and (c) an automatic isolation system that ensures that, if the flame is lost, no significant discharge of unburnt gas from the flare occurs; and	The potential use of the gas as a fuel is discussed in Section 4.3.3

National Environmental Standards	Section	Comment
	(d) a continuous automatic ignition system. (4) A principal flare must be operated at all times unless it has malfunctioned or is shut down for maintenance. (5) A backup flare must be operated if, and only if, a principal flare is not operating.	

4.3.2 Backup Flare

The landfill currently does not have a backup flare; however, AB Lime is committed to installing a backup flare by 30 June 2020.

The backup flare:

- Will comprises a Solar Spark Passive Vent Flare, model CF-10 or similar 'candle-stick' flare;
- has an operating range between 5 -140 Standard Cubic Feet per Minute (SCFM), i.e. 8 – 240 m^3/hr. Therefore, the CF-10 has sufficient capacity to deal with the current 100 m^3/hr flow rate (measured at the principal flare in May 2020);
- will be modified with blower arrangement so that the CF-10 flare can actively extract landfill gas from the landfill (as opposed to act as a passive landfill gas flare);
- will be installed near the existing principal flare;
- will have a flame arrestor;
- will have an automatic backflow prevention device, or an equivalent device, between the CF-10 flare and the landfill;
- will have an automatic isolation system that ensures that, if the flame is lost, no significant discharge of unburnt gas from the flare occurs; and
- will have a continuous automatic ignition system.

4.3.3 Use of Landfill Gas as a Fuel

On 15 January 2019 AB Lime were granted a variation to their existing air discharge consent for their quarry operations, Discharge Permit AUTH-205862-01-V1. The variation included the use of landfill gas as a supplementary fuel source to coal which is the fuel used to fire the limestone dryers of the limeworks operations. The application was previously consented to use only coal as a fuel source.

If the landfill gas is used as a supplementary fuel then the gas will be burned at around 850 ^{0}C and be in the kiln (limestone dryers) for at least 0.5 seconds as the kiln is 20 m long (see Attachment **8**, **item 5-g**).

If the landfill gas is treated in the kiln, then the principal flare would constitute the backup flare (when the kilns are operating). However, as the kilns are not operating continuously the CF-10 flare will still be used as a 'default' backup flare (see Section 4.3.2) Attachment 7.

5. The effects of the changes of a removal of an upper limit of waste acceptance on landfill gas management

AB Lime current have an air discharge permit, consent no. 201351, that allows the discharge of contaminants to air from a landfill. In order to effectively manage potential effects relating to the above consented activities and additional effects that may incur due to an increase in waste acceptance, specific management plans have been constructed to address these issues.

Management plans are a commonly and widely accepted method utilised in landfill management and allow an adaptive management approach so continuously improvement and refinement to each management plan can occur as best practice procedures evolve.

In particular the Landfill Gas Management Plan, Landfill Operations Management Plan and Landfill Leachate Management Plan provide the landfill procedures on how to manage the potential affects related landfill gas.

Section 9 of the main AEE identifies the current conditions of consent for AUTH-201351 and identifies any changes to /compliance with current conditions due to increased waste quantities and proposed change to condition.

6. Conclusion

The landfill gas operations at the AB Lime landfill comprise an active landfill gas extraction system that has been designed and operated in accordance with the NZ landfill guidelines (WasteMINZ, 2018).

In 2009 a landfill gas principal flare was installed, and the flare meets the requirements of the consent conditions as listed in Air Discharge Permit No. 201351.

The annual compliance report from Environment Southland shows that the landfill has been compliant with the air discharge consent conditions except in the period 2017/2018 when there was a significant non-compliance noted with the landfill gas flare temperature (Nov 2017). Additional landfill gas extraction wells were installed, and the flare temperature criteria was compliant for the remainder of the 2017/2018 period (see **Table 1** in Section 3).

The 2018/2019 annual compliance report also mentions a significant non-compliance with the air discharge consent. It appears that the non-compliance is related to odour issues, and since odour management is part of the air discharge consent, it is possible that the non-compliance may be related to, for example, to odorous waste arriving at the landfill and not being buried quickly and covered with a capping layer. Equally the odour issues may have resulted from landfill gas discharges at, for example, the working face. We note that the Environment Southland "FULL COMPLIANCE OBSERVATION LISTING" does not report any non-compliance issues against the air discharge permit.

Landfill gas monitoring has been carried out in general accordance with the Air Discharge Permit consent and does not exceed the criteria set in the consent conditions.

Whilst the landfill surface gas emission monitoring meets the consent criteria, it does not meet the Air Quality NES criteria. An amendment to an existing consent condition to reflect the Air Quality NES landfill surface gas emission criteria has therefore been proposed (refer to section 9 of the main AEE document).

Since the landfill started accepting waste in 2004 an Independent Peer Reviewer has reviewed the design, construction, operation, maintenance and monitoring of the landfill to assess if the work is undertaken by appropriately qualified personnel and in accordance with good practice. The Independent Peer Reviewer's role covers landfill gas management and includes at least one site inspection per year. The Environment Southland annual compliance reports references the peer reviews and grade them as "full compliance" except in year 2016/2017 when there was a low risk of non-compliance, see **Table 1 i**n Section 3.

In 2014 AB Lime engaged the services of Dr Rissmann to assess the gas emissions from the surface of the landfill, quantify the efficiency of the active gas extraction system and better understand the landfill gas generation, transport and biological attenuation at the landfill. Dr Rissmann concluded that the landfill has a relatively low methane output and high methane oxidation rates (see Section 2.5.3).

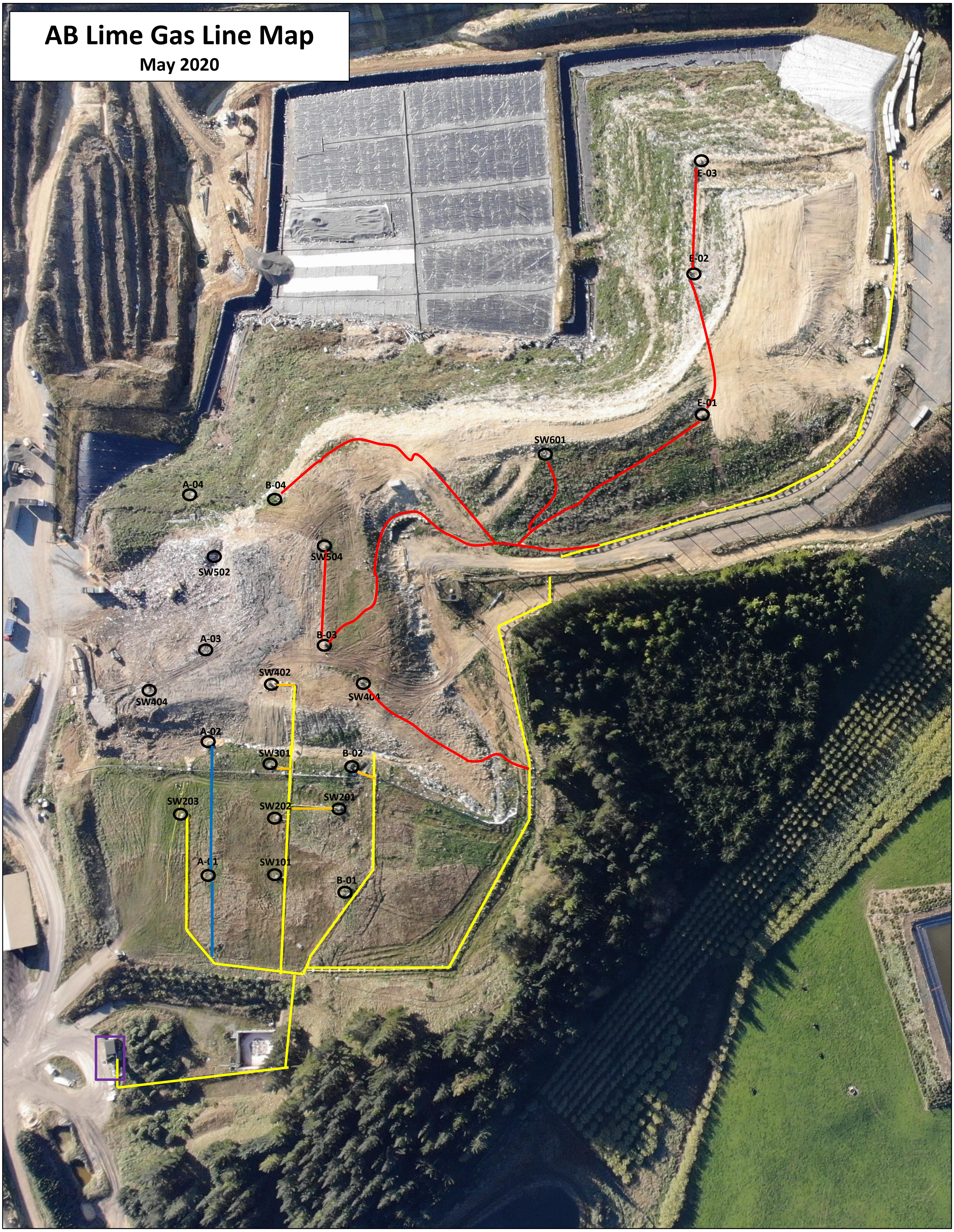
An updated landfill gas generation model has been prepared as part of this application (refer to Attachment **7**). The updated model estimates the volume of landfill gas generated in the future which allows AB Lime for the early planning of a second principal flare (if required, since in January 2019 AB Lime was granted a variation to the existing air discharge consent permit AUTH-205862-01-V, to use landfill gas as a supplementary source in the coal-fired dryers of the limeworks operations).

A new Landfill Gas Management Plan has been developed as part of this application to provide the landfill procedures on how to manage the potential effects related to landfill gas. Management plans are a commonly and widely accepted method utilised in landfill management and allow an adaptive management approach so continuous improvement and refinement to each management plan can occur as best practice procedures evolve.

Attachment 1. Site Plan- Location of Permanent Gas Flare

AB Lime Gas Line Map

May 2020



Legend

- Above Ground Main Gas Line (200mm)
- Below Ground active gas line
- Temporary 65mm gas lines
- Smaller pipe connections off main line to well
- Gas Well Head
- Flare

Attachment 2. Gas Well Installation Specification (2013)

External Memo

To	Steve Smith	Date	4 October 2013
From	Leah King	Project No	AE03541.17
Copy	Charlie Watts, Richard Greenwood, Walter Starke		
Subject	Gas Well Installation Specification		

The following memorandum provides the specification for drilling and installing two boreholes through landfill waste to retrospectively install two gas extraction wells.

1. Location

Figure 1 shows the locations of the proposed gas wells. The holes shall be set out by the Contractor and the positions agreed upon by AB Lime (approximate coordinates are outlined in the table below). The holes must be located within 2m of the co-ordinates shown on the map to ensure they do not intersect special waste such as asbestos or contaminated soil.

Table 1 – Gas well coordinates

Gas well	Easting	Northing
LFG201	2152908.82	5443018.27
LFG202	2152953.53	5442991.26

2. Drilling

2.1 General drilling practices

The following general drilling techniques and practices shall be adopted:

a) Measure and calculate drillhole depth relative to ground level.
b) Adopt a drilling technique to ensure that drill rods are centralised within the drill hole.
c) Ensure that all equipment and components are maintained in a good, clean, lubricated condition, and otherwise maintained according to the manufacturers' instructions.

Should the Contractor fail to ensure that drilling is undertaken as specified or instructed in the Scope of Works, then the Contractor may be required to re-drill part or the entire hole at the Contractor's cost.

2.1.1 Methods

The method used for Exploratory Holes shall be wash drilling (600 mm diameter) for the purposes of installing a gas well (150 mm solid and slotted uPVC or HDPE pipe). No sampling is required though a drillers log should be kept.

2.1.2 Casing and drill rods

Casing shall be used to stabilise caving ground and advanced after each core run, where necessary. It is expected casing will be required as drilling will be carried out throughout landfill waste.

2.1.3 Flushing medium and lubricants

The flushing medium shall normally be clean water. However, with agreement of the AB Lime non-toxic drilling muds, additives, or air/foams may be used. The Contractor shall ensure that all proposed foams are either biodegradable or water soluble.

The Contractor shall use only non-hydrocarbon based lubricants for drilling equipment joints, i.e. sunflower oil or similar.

2.1.4 Arisings

Arrangements should be made for the disposal of all surplus materials arising from the boreholes prior to completion of work. It is assumed that the arisings will be placed in an active cell at the AB Lime Landfill rather than taken off site.

2.1.5 Depth of holes

Drillholes are being carried out for the purpose of installing gas extraction wells. Drillholes should be drilled to the depths outlined in Table 2.

Table 2 – Depth of gas well

Gas well	Ground level (mAMSL)	Depth of hole (m)	Depth of hole (mAMSL)
LFG201	119.7	31.0	88.7
LFG202	123.4	30.0	93.4

2.2 Water supply

There is a water supply on site however this is not in the vicinity of drilling locations. Therefore the contractor will require a water truck to enable a consent supply of water or water supply. AB Lime have confirmed that water can be provided on site for both boreholes.

3. Gas Well Installation

3.1.1 Materials

The materials used in the well construction and gas collection system shall be suitable for the service and resistant to corrosion. They are to be installed in accordance with current New Zealand Standards or Codes of Practice. PVC or HDPE are recommended.

3.1.2 Installation

Consideration should be given to the settlement of the pipework when designing wellheads and pipework. Guidance suggests that typically the maximum well depth is limited to 75% of total landfill depth to avoid puncturing the liner. Slip couplings should be used to minimise damage to the well.

The 150 mm diameter uPVC or HDPE pipe should be centred in the 600 mm diameter hole and allow for the placement of gravel backfill. The 150 mm diameter pipe must have an end-cap.

Each well pipe must have perforations or holes drilled at designated locations as follows:

a) Four perforations with a diameter of 12 mm will be located in a horizontal row around the pipe at intervals of 90 degrees.

b) The horizontal spacing between each row of holes will be 100 mm to 200 mm.

Each well pipe will include perforations along the lower two-thirds of the pipe. There shall be no perforations in the top one-third of the pipe or top 6 m of the pipe, which is the lesser.

The gravel backfill shall have a diameter in the range of 20 mm to 75 mm. The gravel backfill shall be placed to within 2m of the surface. On top of the gravel layer there shall be a 2 m thick layer of wetted bentonite. This bentonite clay layer should be of permeability equal to the existing cover material. Please see Appendix B sketch for details.

When backfilling the borehole with gravel the borehole casing should be removed slowly so the hole does not collapse around the uPVC or HDPE pipe.

3.2 Reporting

The Contractor shall maintain a Daily Site Log Book. The Daily Site Log Book shall also be used to record all verbal instructions requested at that particular drilling rig.

During the progress of the Works, the Contractor shall submit one copy of all its daily site records and driller's logs relevant to a particular Exploratory Location. These records are to be submitted not more than five working days after completion of all work. The type of form for daily site records shall be agreed with the Engineer. As a minimum the Daily Site Log Book shall include:

1) Contractor’s name, Contract number, Geotechnical Investigation title, inclination/orientation of drillholes, and drillhole numbers.
2) Rig type, number, operator, hours worked, and method(s) of drilling.
3) Date of operation and weather conditions.
4) Details of lengths of casing and levels of changes of casing size.
5) Details of any leachate inflows or water losses noted.
6) Details of any delay and standing time, giving reasons.

4. Health and Safety

The contractor shall comply with all relevant New Zealand safety legislation. It is recommended that best practice guidance is followed in ‘Guidelines for the safe investigation by drilling of landfills and contaminated land’ from ‘Site Investigation in Construction Series’ by the Site Investigation Steering Group, 1993.

4.1 Health and Safety Planning

The health and safety plan shall be submitted to AB Lime prior to commencement of works and include details of all of the following:

- hazards workers may be exposed to while working
- hazards workers may create while working which could harm others or the environment
- how these hazards may be minimised, isolated, or eliminated
- emergency procedures
- incident and near miss investigation procedures
- the location of first aid facilities, fire extinguishers, equipment emergency stop buttons and safety equipment
- the method by which the Contractor shall inform employees and others on the site of contents of the health and safety plan
- how records will be kept of site inductions, risk assessments, toolbox talks etc.

All personnel working on the site must be given an induction on the contents of the safety plan. This information must be kept on site and available at all times when staff and visitors are on site.

4.2 Health and safety on site

The contractor shall take all practical steps to make the site and working environment safe and must abide by the existing landfill health and safety protocols. Ensure that all those working on or visiting the site are aware of the rules governing site safety, are properly supervised and not unnecessarily exposed to hazards. The following should apply on site:

- The site should be designated as a no smoking area.
- If the borehole has not been completed by the end of drillers shift the hole should be covered by a suitable plate so that it cannot be accessed by other workers on site. At the beginning of the next shift the rig should not be started until the plate has been carefully removed and the borehole monitored for gases.

4.3 Plant and equipment

It is recommended that:

- All plant and equipment must comply with current NZ safety legislation.
- Spark arrestors and automatic air intake shutdown valves should be provided on all plant and equipment operating on or near landfill sites.

4.3.1 Recognition and treatment of hazards

- All personnel working on the site should be aware of the type of waste that is being drilled through and the types of diseases associated with landfills such as leptospirosis (Weil's disease) and tetanus.
- All plant and equipment should be cleaned within a designated cleaning zone using steam, hot water or a high-pressure water cleaning system whenever leaving the site or a contaminated area and at completion of installation of landfill gas wells.
- Exposure to potential hazards where the contaminants are not yet identified should be limited to the minimum practicable. Should unknown or suspicious contaminants be encountered (i.e. discharge of gases or unusual arisings, drilling operations should be stopped immediately until an environmental specialist can inspect, monitor and determine what the contaminant is and whether a hazard exists.

AB Lime may, acting on reasonable grounds, suspend any identified hazardous activities and proceed to eliminate, isolate or minimise them in order to comply with the Act.

Attachments

Appendix A – Gas well layout plan

Appendix B – Gas well sketch

Yours sincerely

Leah King
Engineering Geologist
Phone: 03 940 4908
Email: LAKing@globalskm.com

NOTES

1. ALL LEVELS PROVIDED ARE APPROXIMATE ONLY AND MAY CHANGE WITH FURTHER INVESTIGATION. LEVELS WERE FOUND BY USING CONTOUR HEIGHT AT POINT A.

LEGEND

- LANDFILL FOOTPRINT
- WASTES
- WASTES POLY INTERSECT
- GAS WELL
- WASTE INTERSECTION POINTS
- POINT A

GAS WELL CO-ORDINATES			
GAS WELL	NORTHING	EASTING	LEVELS (m)
POINT A	5442902.46	2152848.27	87.000
LFG201	5443018.27	2152908.82	119.700
LFG202	5442991.26	2152953.53	123.400

APPROVAL ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
A	30.08.13	RM	JRR		ISSUED FOR INFORMATION

DRAWING NUMBER	REFERENCE DRAWING TITLE

Sinclair Knight Merz
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CLIENT: AB LIME LTD
PROJECT: AB LIME LANDFILL SOUTHLAND

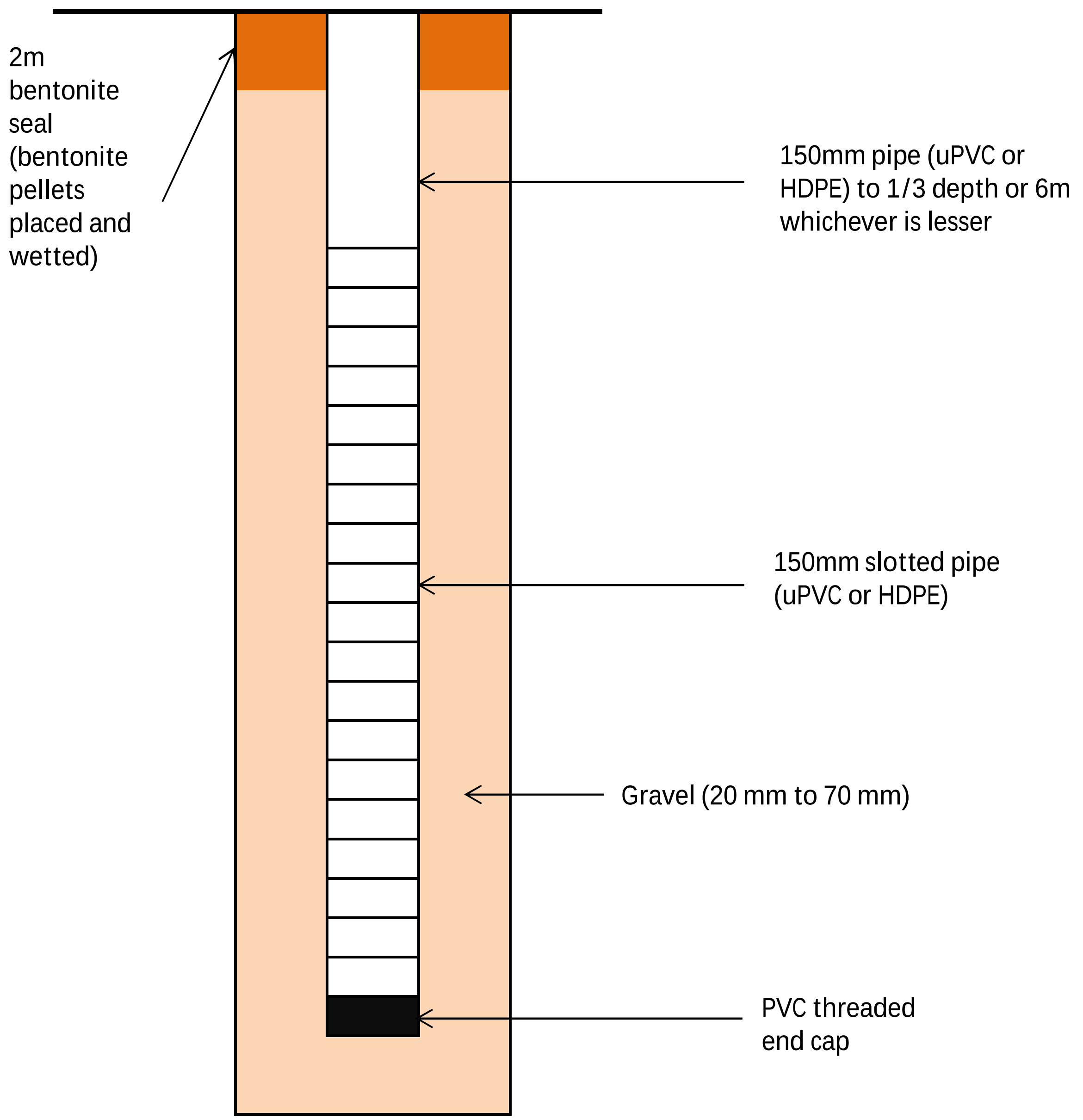
DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DMB	MF	LAB	RBG
DESIGNED: LAB/GER	DESIGN REVIEW: WS	DATE 07.09.12	DATE 13.09.12

TITLE: AB LIME LANDFILL
GAS WELL LAYOUT PLAN
SEPTEMBER 2013

SCALE: 1:1000 (A1)
DRAWING No: AE03541.17-ECC-DG-0202
REV: A

A1

DATE: 2/10/2013 4:15:52 PM LOGIN NAME: MARTIN, MERCI (SKM)
LOCATION: I:\AENVA\Projects\AE03541\Deliverables\Drawings\Geotech\AE03541.17-ECC-DG-0202.dwg



Client:	AB Lime	Job No:	AE03541
Project:	AB Lime Landfill	Date:	30-Sep-13
	WP17 - LFG Wells	Scale:	NA
Title:	Appendix B - Gas well installation	By:	Jon Rabey
SKM		Figure:	-

Attachment 3. Gas Well Design (2017)

Memorandum

Level 2, Wynn Williams Building
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Subject	**Gas Well Map for Future Cells - Well Design**	**Project Name**	AB Lime
Attention	Fiona Smith	**Project No.**	IZ000400
From	Louise Wilson		
Date	31 August 2017		
Copies to			

1. Introduction

AB Lime requires a gas well map to be prepared for Areas 13, 14 and future cells. Relevant landfill gas management guidelines and design parameters have been researched to inform the creation of a site specific well map.

As there are no specific New Zealand requirements for well spacing, well diameter and the installation method (progressive construction during filling or retrospective drilling), this research has been undertaken to inform best practices and understand the most suitable design for AB Lime.

1.1 Recent Gas Well Design Advice

During recent discussions, Jacobs noted that the following parameters should be followed for well installation on site (wells LFG201 and LFG202):

- For borehole diameter of 400mm and well diameter of 100mm, a well spacing of 40m is suitable.
- For borehole diameter of 600mm and well diameter of 150mm, a well spacing of 50m is suitable.

2. Well Design

2.1 New Zealand Guidelines

The Technical Guidelines for Disposal to Land report (WasteMINZ, April 2016) was reviewed to inform the most suitable gas well specification and installation techniques for use in future cells at AB Lime landfill (**Table 1**).

Table 1: Summary of relevant gas well specifications from Technical Guidelines for Disposal to Land report (WasteMINZ, April 2016)

Item	Details	Comments
Well map design	Primary considerations are: • Radius of influence (ROI) and spacing • Phasing of landfill development	ROI heavily influenced by nature of waste and vacuum pressure applied

Item	Details	Comments
	• Landfill geometry	
Well spacing	50 to 70m	Influencing factors include: • Well diameter (and subsequent ROI) • Waste compaction • Vacuum pressure
Well locations	≤ 30m from edge of waste mass	
Well depths	• Series of deep wells in the body of the waste mass • Series of shallow wells around the perimeter	Base of each well should be at least 5m above base of landfill
Construction material	HDPE	• Resistant to chemical attack • Maintains strength when buried • Flexible to accommodate settlement
Extraction vacuum	>10 millibar needed for large* diameter wells in an area where there is a competent cap	Current vacuum pressure of AB Lime landfill wells is 20 millibar * note that 'large' is not quantified by a specific diameter range

2.2 International Guidelines and National Examples

A summary of well design aspects including borehole diameter, well depth and spacing based on international landfill guidance and local examples is provided in **Table 2**.

Table 2: Landfill gas well design research summary

Well Design Aspect	EPA Landfill Collection Systems, Appendix E	World Bank Guidance Fact Sheet: Landfill Gas Collection, Flaring and Energy Recovery Design	Landfill-gas.com	Rosedale Landfill, Auckland (Aftercare Plan)	Ryman Abbots Way landfill (now closed)**	Greenmount Landfill, Auckland (now closed)
Borehole	≥ 600mm	300 to 1000mm in diameter*	325mm	Unknown	400-600mm	400-600mm
Pipe diameter	Not provided	Not provided	Not provided	Unknown	100mm	100mm

Well Design Aspect	EPA Landfill Collection Systems, Appendix E	World Bank Guidance Fact Sheet: Landfill Gas Collection, Flaring and Energy Recovery Design	Landfill-gas.com	Rosedale Landfill, Auckland (Aftercare Plan)	Ryman Abbots Way landfill (now closed)**	Greenmount Landfill, Auckland (now closed)
Well hole and pipe depth:	75% of waste thickness or distance from landfill surface to top of water table (whichever is less).	75% of the waste thickness (but maintaining not less than 5m distance between base of the pipe and the landfill liner system.	To base of landfill, without penetrating liner.	Unknown	Unknown	Unknown
Well spacing	175 feet (53m) Note: spacing must be < 2 times the ROI apart	No guidance.	50m	50m	25 – 50m	60m

Notes:
* >600mm preferred due to increase gas collection potential

** Ryman Abbots Way closed landfill now has a retirement village developed on top of the landfill.

3. Installation Methods

Wells A1-1, A1-2, B1-1 and B1-2 were installed using progressive construction techniques. AB Lime are currently installing wells LFG0201 and LFG0202 by way of retrospective drilling. It is understood that both methods have had challenges and that AB Lime would like to obtain recommendations for the future installation methods used.

Considerations for progressive versus retrospective installation of active gas wells and suitability for AB Lime are presented in **Table 3**.

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Table 3: Considerations for progressive versus retrospective installation of active gas wells and suitability for AB Lime

	Progressive Installation	AB Lime Considerations	Retrospective Installation	AB Lime Considerations
Factors influencing well placement (WasteMINZ April 2016 report)	**Access for waste placement:** The wells are typically developed in parallel with the waste placement and need to be suitably placed and spaced to enable waste placement.	Can be managed on site.	**Location of any special or liquid wastes:** The wells are located to ensure, as far as practicable, that they do not pass through localised areas of special wastes or liquid waste which might affect well performance.	Possibility of Al dross waste deposited within cells in future.
	Proximity to the tipping area: To reduce the potential for odour issues, the wells need to be sited as close as possible to the tipping area; however, if an individual well is too close to an open area, then there will be a tendency to draw in air and the vacuum applied at the well will need to be adjusted accordingly.	Can be managed on site.	**Irregular base formation information:** For older sites there is often limited information of the exact base formation of the landfill. Care must be taken not to compromise the liner system when drilling gas wells, with wells being carefully positioned and targeted to depths at least 5 m above the base liner level.	Base levels of landfill cells are well documented. Not considered to be an issue.
	Capping on platforms and side slopes: The permeability of a temporary soil cap on platforms and side slopes not currently receiving waste would permit air ingress if high vacuum pressures were applied to an extraction well. Thus	Need to adjust vacuum pressure accordingly and consider well spacing. However, due to current data for gas generation on site (recording limited methane generation), unlikely to require	**Depth constraints:** Typically the maximum depth a well can be retrospectively drilled into an existing waste mass is in the order of 30 m, which may not be the full depth of the waste column. For deep landfills, consideration should be given to	Predicted waste depths will be greater than 30m in future cells (as shown by drawing 3541-CV-052 Pre and Post Settlement Final Landfill Heights).

	during operation of the landfill only relatively low vacuums can be applied to a number of wells thus reducing the collection efficiency. This may necessitate closer well spacing.	additional wells to mitigate this risk.	whether well installation should be a combination of retrospective drilling and progressive installation.	
Issues	Working around the well head with heavy machinery during filling and not causing damage.	This has been a challenge in the past.	Significant drilling costs (>$40k per well) and challenges finding suitable drilling equipment and companies who are willing to undertake the work.	Challenges with being able to drill well to suitable diameter (600mm with 150mm pipe) to allow required radius of influence.
Recommendation	Preferred method, especially for deep wells in central area of cells. Consider this a better 'future proofing' approach, as costs will be known during construction of the wells and AB Lime do not need to engage specialist contractors.	Provides confidence that gas will be collected, especially in deepest areas of the future landfill. Can plan around areas of special/hazardous waste. Can install onsite without need to engage drilling contractor, so will not incur large contractor fees upon completion of filling. Progressive installation reduces the risk profile for AB Lime.	Least preferred method for deep wells in central area of cells. May be suitable method for shallower wells around perimeter (if <15-20m deep). Consider that there are safety in design risks involved in retrospective drilling, including risks to human health and financial risks that would not be present during progressive installation.	Challenges with engaging contractors, price of drilling and achieving drilling depth while keeping drill hole open and stable. Also requires knowledge of exact locations of special and hazardous wastes and their likely settlement profiles to avoid drilling through.

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4. Recommendations

Based on the researched guidance and our understanding of the site, the following design parameters are recommended:

Aspect	Details
Borehole diameter	600mm
Well diameter	150mm This is recommended so as to be consistent with the current well design, and to allow a greater ROI. Greater ROI is beneficial due to greater waste compaction that is likely to occur with advances in machinery in the future.
Well spacing	50m
Well depths	Wells to be installed to variable depths in central areas of cells. Depths likely to be between 25 to 70m deep as per current predicted final landfill height (pre settlement), and the basal depth of each well is calculated at 75% of pre settlement waste thickness (no less than 5m above landfill liner). This is to allow settlement of waste and 'downdrag' of well without compromising the liner. Wells to be installed to shallower depths around perimeter where waste depths are less (likely <30m depth).
Installation method	Progressive installation – due to difficulties in retrospectively drilling to required depths in future cells. Possibility that retrospective drilling may be suitable for shallow wells around the perimeter of the landfill (based on preference by AB Lime).
Considerations	Locations of special waste types such as Aluminium dross.

Attachment 4. 100 mm Diameter Landfill Gas Extraction Well Design (2019)

Memorandum

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Subject	**100mm Diameter Landfill Gas Extraction Wells Specification Update**	**Project Name**	AB Lime Cell 3 Design
Attention	Fiona Smith	**Project No.**	IZ000400
From	Louise Wilson		
Date	16 January 2019		
Copies to	**John Cocks**		

1. Installation of 100mm diameter landfill gas extraction wells

AB Lime plan to install up to 13 100mm diameter wells in the currently capped, southernmost area of the landfill, as well as within capped areas of Areas 10 and 12. The proposed layout is shown in the drawing included in **Appendix A** (IZ000400-LFG-NG-DRG-0001). These new wells are being installed in addition to the 'main' wells, which have been set out in an approximately 50m grid across the landfill and will be installed through a combination of retrospective drilling and progressive installation.

1.1 Proposed well depths

The maximum depths to which each well can be safely drilled without risk of penetrating the liner was calculated and is provided in the cross sections included in **Appendix A** (IZ000400-LFG-NG-DSN-0001 to 0003). This is based on the following:

- The depth calculations for the areas not currently capped are the same as those used for the main wells; installation to a maximum depth of ≤75% of the waste thickness (but maintaining not less than 5m distance between base of the well pipe and the landfill liner system), as per World Bank guidance referenced in Jacobs' Gas Well Map for Future Cells – Well Design Memo dated 31 August 2017 (IZ000400-0008-NG-MEM-0001).
- As landfilling in the southernmost area and Areas 10 and 12 was completed and capped a number of years ago, some settlement will have already taken place. This means retrospectively drilled wells can be installed to greater depths than those in parts of the landfill that have not yet been capped. It is considered that wells can be drilled to within 3m of the landfill liner in this southernmost area.

Jacobs understands that the primary objective of installing additional wells is increase the efficiency of landfill gas capture. Therefore, drilling the wells as deep as is reasonably practical (based on drilling equipment) and safe (so as not to puncture the base liner, taking into account likely future settlement) is recommended.

As a general rule, good practice in vertical gas extraction well design would favour a greater number of extraction points rather than larger individual extractions points, justifying the retrospective drilling and installation of these additional, 100mm diameter gas wells.

1.2 Main well parameters

Jacobs provided advice to AB Lime on 16 June 2017 regarding gas well diameters for the main wells. This was based on a review of the New Zealand Technical Guidance for Disposal to Land (April 2016) and international literature. We note that the New Zealand Technical Guidance for Disposal to Land have since been updated and finalised (August 2018), and this memorandum has been prepared with reference to the finalised document, which states that:

- Minimum criteria for well spacing is 50-70m.
- Wells should be placed no greater than 30m from the edge of the waste mass.

The advice email sent to AB Lime on 16 June 2017 is presented in **Appendix B**. A summary of the advice provided is as follows.

- Well diameter of 600mm and pipe diameter of 150mm is recommended to provide a sufficient radius of influence for main wells.
- Well spacing of approximately 50m is required.

The original well design specification drawing, prepared by SKM in 2013 and updated in 2018, is presented in **Appendix C**.

1.3 100mm diameter well parameters

AB Lime have requested to reduce the pipe diameter to 100mm for the 13 additional wells, while retaining the well diameter of 600mm. A 100mm pipe diameter is considered to suitable for the following reasons:

- Well spacings will be <50m (approximately 15-30m) as they are being installed in between the main wells and are therefore in accordance with the Technical Guidelines.
- The radius of influence permitted by a 100mm pipe diameter is anticipated to be sufficient based on the proposed well spacings.
- Well stability during drilling would be maintained by a 600mm well diameter. However, it is noted that this is a relatively large well diameter and it is possible to reduce this to a minimum of 250mm if AB Lime wish. The only exception is in areas where there is actual or potential for perched leachate, a diameter of 600mm is recommended. This larger diameter would aid in draining perched leachate to lower levels within the landfill, thereby increasing the potential for landfill gas extraction from ‘middle’ depth parts of the landfill that were previously covered in perched leachate).
- A 2m thick bentonite seal at the surface is recommended (as per the previously issued specification presented in **Appendix C**. An unslotted pipe length of 3m below the bentonite layer is recommended to minimise the risk of air ingress from the ground surface (through possible imperfections/cracks in the landfill cap near the well head). The unslotted pipe length is relatively short (3m), with the objective of capturing landfill gas that may be present in the upper parts of the refuse (below and in close proximity to the landfill cap), which in turn minimises the risk of oxidation of methane in the cap.
- Note: perched leachate can be a problem where daily cover is not removed and the daily cover is relatively impermeable, e.g. clay and silty type soils, if gravel or sands are used as daily cover than the daily cover should be permeable enough so as not to create perched leachate.

The wells have been designed and must be installed in accordance with the Technical Guidelines for Disposal to Land (August 2018) Appendix B.3, i.e. well riser structure, wellhead, pipeline, condensate management and the prevention of air ingress.

An updated well design specification drawing is presented in **Appendix D**.

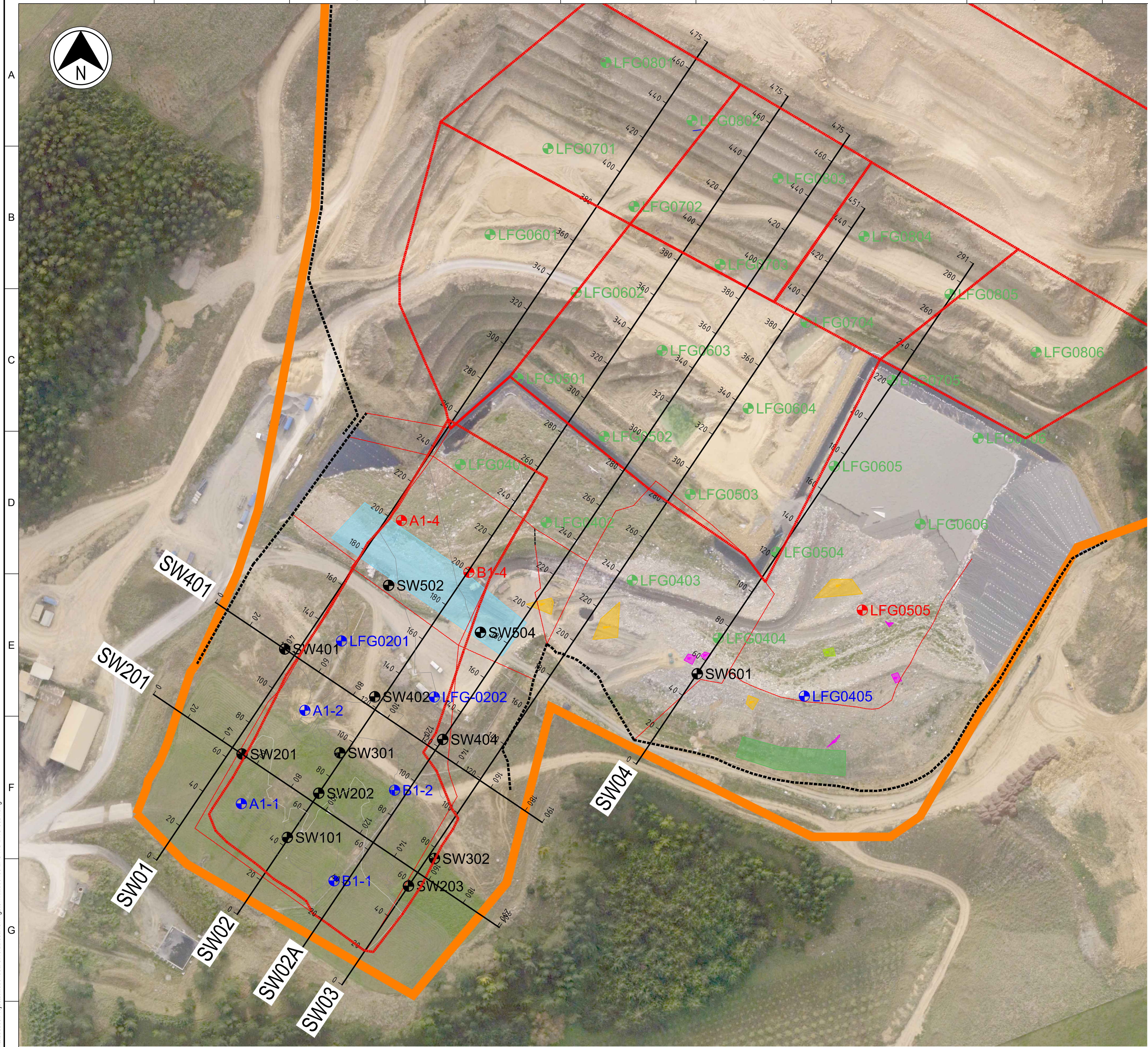
2. As-built documentation

It is recommended that As-built documentation of existing landfill gas extraction wells is compiled and saved on file. This should include:

- An updated version of the well map drawing (IZ000400-LFG-NG-DRG-0001) showing actual installation locations, as these may differ from proposed locations.
- Photographs of retrospective drilling being undertaken.

Memo prepared by:	Louise Wilson	
Reviewed by:	Walter Starke	16/01/2019
Approved by:	Louise Wilson, on behalf of Jason Harvey-Wills	16/01/2019

Appendix A – Gas well location drawing and cross sections



GAS WELL SET-OUT DATA

WELL SITE	NORTHING (m)	EASTING (m)	CAPPED AS BUILT RL (m)	DESIGN CAP RL (m)*	LANDFILL BASE RL (m)	WASTE DEPTH (m)	MAX. WELL DEPTH (m)	LANDFILL LINER TO WELL BASE (m)
SW101	2152882.71	5442923.50	93.13		75.05	18.08	15.08	3.00
SW201	2152860.88	5442963.69	94.25		75.25	19.00	16.00	3.00
SW202	2152897.83	5442944.79	95.82		75.60	20.23	17.23	3.00
SW203	2152924.86	5442930.97	93.63		76.29	17.34	14.34	3.00
SW301	2152907.98	5442964.28	98.30		75.79	22.51	19.51	3.00
SW302	2152954.62	5442935.01	94.28		76.86	17.41	14.41	3.00
SW401	2152881.43	5443014.34		103.41	79.92	23.49	20.49	3.00
SW402	2152924.85	5442991.31		106.38	77.18	29.20	26.20	3.00
SW404	2152957.60	5442970.76		103.29	77.94	25.35	22.35	3.00
SW502	2152931.52	5443045.07		108.80	77.36	31.44*	23.58	7.86
SW504	2152975.80	5443022.34		111.44	79.05	32.39*	27.39	5.00
SW601	2153080.33	5443002.41		108.21	83.29	24.92*	18.69	6.23

* HEIGHTS LISTED ARE PRE-SETTLEMENT

NOTES

1. CO-ORDINATES ARE IN RELATION TO NZMG.
2. ECO-N HAS NOT BEEN DISPOSED OF IN AREA BENEATH SW504 (AS CONFIRMED BY AB LIME).
3. DRAWING TO BE VIEWED IN CONJUNCTION WITH DRAWINGS IZ000400-LFG-NG-DSN-0001 TO 0003.
4. Ø100mm WELLS TO BE CONSTRUCTED IN ACCORDANCE WITH SPECIFICATION IZ000400-OA-NG-DDE-0002 CONTAINED WITHIN DOCUMENT IZ000400-LFG-NG-MEM-0001-Rev 1 DATED 16/01/19

LEGEND

AREA 14 - 20 BASE
ANCHOR TRENCH
EXISTING LANDFILL
LANDFILL FOOTPRINT

WELL PROPOSED (Ø100mm)
WELL EXISTING
WELL PROPOSED
WELL IN PROGRESS

HAZARDOUS WASTE

ASBESTOS
METH. CONTAMINATED
DUNNAGE TIMBER
TAHA
ECO-N

CONSTRUCTION ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
1	17/01/19	DMB	WS	LDW	ISSUED FOR CONSTRUCTION
0	15/11/18	DMB	WS	LDW	ISSUED FOR CLIENT REVIEW

DRAWING NUMBER	REFERENCE DRAWING TITLE

AB LIME

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CLIENT AB LIME LTD
PROJECT LANDFILL
LANDFILL GAS EXTRACTION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DMB	LDW	WS	LDW
DESIGNED LDW	DESIGN REVIEW WS	DATE 16/01/19	DATE 16/01/09

TITLE
LANDFILL GAS EXTRACTION
Ø100mm WELL SITE LAYOUT
PLAN

SCALE 1:1000 (A1)
DRAWING No IZ000400-LFG-NG-DRG-0001
REV 1

A1

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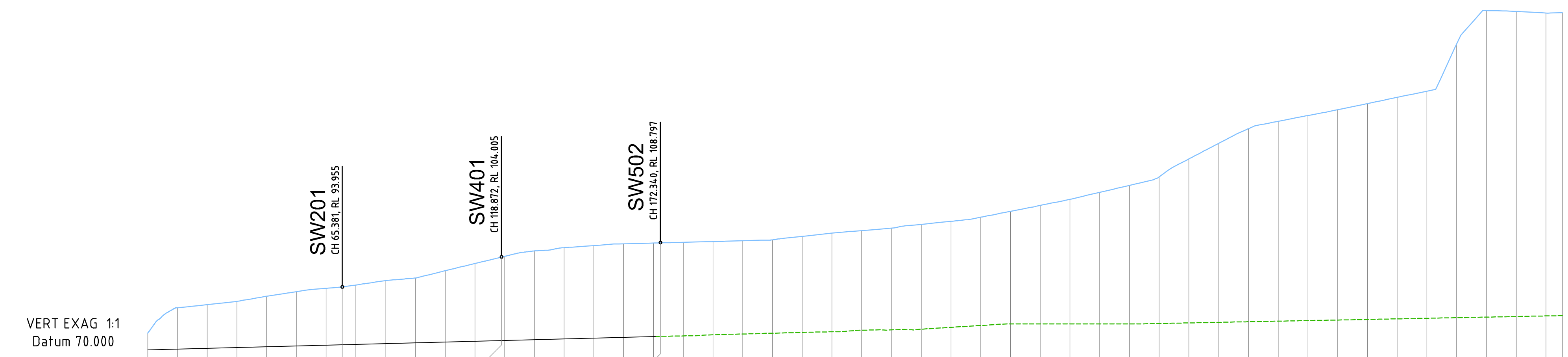

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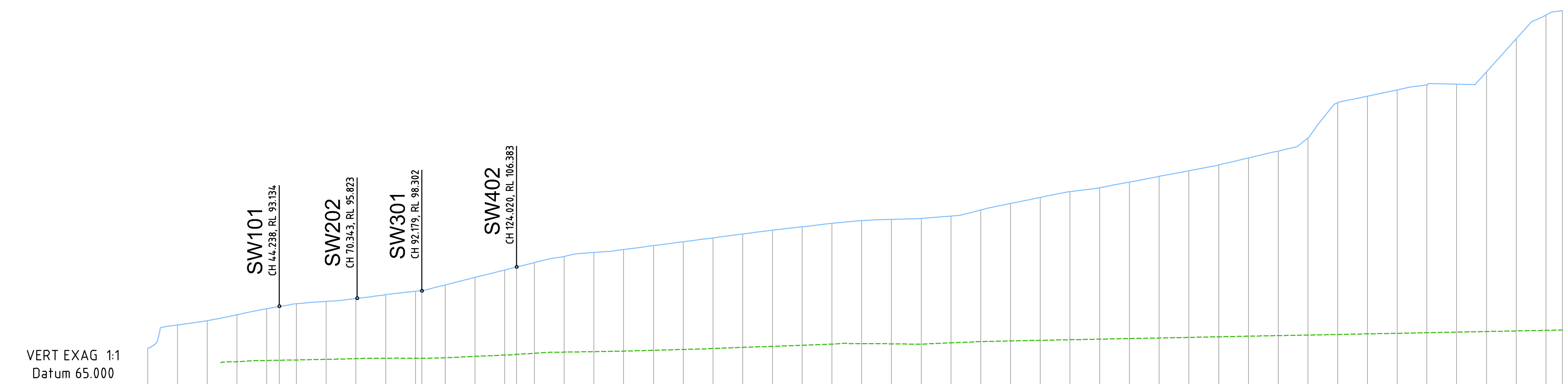
20.000	88.032		
30.000	89.146		
40.000	90.869		
50.000	92.405		
60.000	93.530		
70.000	94.645		
80.000	96.102		
90.000	96.985		
100.000	99.412		
110.000	101.848		
120.000	104.254		
130.000	106.082		
140.000	107.176		
150.000	107.888		
160.000	108.464		
170.000	108.729		
170.654		77.355	
180.000	108.973	77.548	31.425
190.000	109.218	77.924	31.294
200.000	109.487	78.196	31.291
210.000	109.774	78.458	31.316
220.000	110.942	78.721	32.222
230.000	112.018	78.938	33.080
240.000	112.917	79.447	33.470
250.000	113.704	79.576	34.128
260.000	115.005	79.781	35.224
270.000	115.990	80.434	35.556
280.000	117.397	81.053	36.344
290.000	119.351	81.600	37.751
300.000	121.333	81.600	39.733
310.000	123.392	81.600	41.792
320.000	125.732	81.600	44.132
330.000	128.071	81.600	46.471
340.000	130.937	81.716	49.221
350.000	136.977	81.912	55.065
360.000	142.189	82.108	60.081
370.000	147.129	82.304	64.825
380.000	149.588	82.500	67.089
390.000	151.517	82.694	68.824
400.000	153.453	82.885	70.567
410.000	155.534	83.077	72.457
420.000	157.643	83.272	74.371
430.000	159.692	83.469	76.223
440.000	175.546	83.666	91.880
450.000	186.766	83.863	102.903
460.000	186.468	84.060	102.408
470.000	185.924	84.257	101.667
475.495	186.023	84.366	101.658

Max Well Depth (m)	16.00	20.49	23.58
Landfill Liner To Well Base (m)	3.00	3.00	7.86

CL-SW01 LONG SECTION



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30.000	90.292	74.555	15.738
40.000	92.353	74.981	17.372
50.000	94.039	75.133	18.906
60.000	94.817	75.353	19.465
70.000	95.753	75.585	20.168
80.000	97.045	75.702	21.343
90.000	98.205	75.723	22.482
100.000	100.339	75.889	24.450
110.000	102.838	76.364	26.474
120.000	105.338	76.797	28.541
130.000	107.837	77.387	30.450
140.000	109.895	77.783	32.112
150.000	111.232	77.941	33.291
160.000	112.216	78.108	34.108
170.000	113.523	78.397	35.127
180.000	114.831	78.676	36.154
190.000	116.138	78.976	37.162
200.000	117.445	79.349	38.096
210.000	118.674	79.714	38.960
220.000	119.856	80.079	39.777
230.000	121.017	80.447	40.570
240.000	121.903	80.600	41.303
250.000	122.344	80.548	41.796
260.000	122.657	80.464	42.193
270.000	123.445	80.894	42.551
280.000	125.489	81.299	44.190
290.000	127.662	81.529	46.133
300.000	129.699	81.739	47.960
310.000	131.664	81.936	49.728
320.000	132.974	82.134	50.841
330.000	134.867	82.331	52.536
340.000	136.760	82.528	54.233
350.000	138.653	82.724	55.930
360.000	140.587	82.920	57.667
370.000	142.950	83.116	59.835
380.000	145.242	83.312	61.931
390.000	149.592	83.508	66.084
400.000	161.500	83.704	77.796
410.000	163.710	83.900	79.809
420.000	165.805	84.097	81.708
430.000	167.500	84.294	83.206
440.000	167.707	84.491	83.215
450.000	171.815	84.690	87.125
460.000	182.947	84.890	98.056
470.000	190.912	85.090	105.822
475.495	192.389	85.202	107.187

Max Well Depth (m)	15.08	17.23	19.51	26.20
Landfill Liner To Well Base (m)	3.00	3.00	3.00	3.00

CL-SW02 LONG SECTION

CONSTRUCTION ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
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0	15/11/18	DMB	WS	LDW	ISSUED FOR CLIENT REVIEW

DRAWING NUMBER	REFERENCE DRAWING TITLE

Level 2, Carlaw Park
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Fax: +64 9 928 5501
Web: www.jacobs.com

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PROJECT LANDFILL
LANDFILL GAS EXTRACTION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DMB	LDW	WS	LDW
DESIGNED	DESIGN REVIEW	DATE 16/01/19	DATE 16/01/19
LDW	WS		

TITLE
LANDFILL GAS EXTRACTION
Ø100mm WELL SITE LAYOUT
PROFILE - SHEET 1

SCALE	DRAWING No	REV
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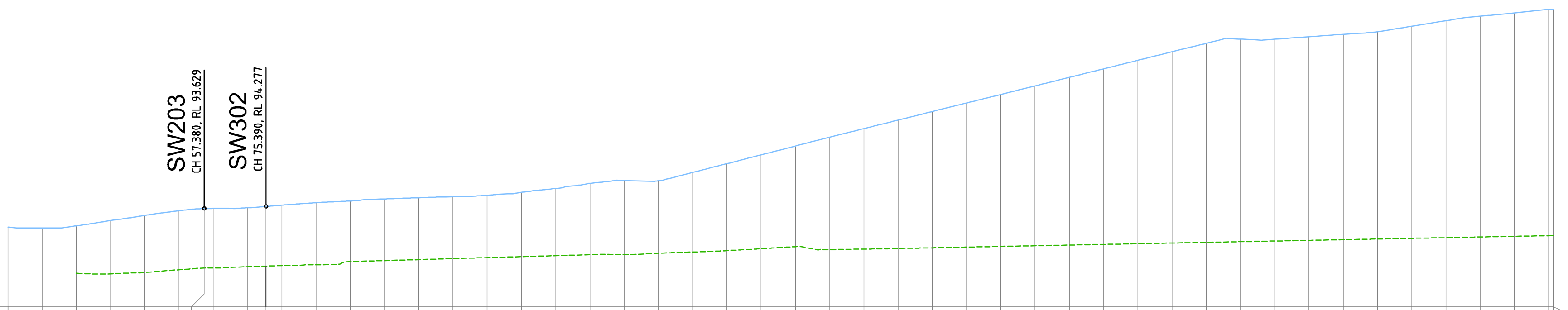
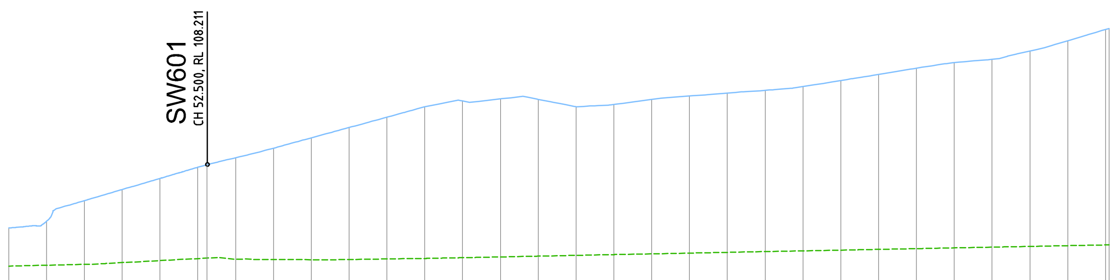


VERT EXAG 1:1
Datum 65.000

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
0.000					
10.000	88.000				
20.000	88.620	74.818	13.802		
30.000	90.162	74.612	15.550		
40.000	91.680	75.020	16.660		
50.000	93.050	75.786	17.263		
(SW203 CH 57.380)				14.34	3.00
60.000	93.717	76.336	17.381		
70.000	93.916	76.676	17.239		
(SW302 CH 75.390)				14.41	3.00
80.000	94.656	77.015	17.641		
90.000	95.387	77.249	18.138		
100.000	95.881	78.186	17.695		
110.000	96.486	78.471	18.014		
120.000	96.840	78.757	18.083		
130.000	97.141	79.042	18.099		
140.000	97.564	79.328	18.237		
150.000	98.441	79.613	18.828		
160.000	99.500	79.898	19.602		
170.000	101.045	80.184	20.861		
180.000	101.885	80.197	21.688		
190.000	101.795	80.593	21.202		
200.000	104.218	80.968	23.250		
210.000	106.793	81.374	25.419		
220.000	109.372	81.942	27.429		
230.000	111.957	82.531	29.425		
240.000	114.526	81.661	32.865		
250.000	117.035	81.828	35.207		
260.000	119.530	82.002	37.528		
270.000	122.025	82.191	39.834		
280.000	124.520	82.392	42.128		
290.000	127.015	82.607	44.408		
300.000	129.510	82.807	46.703		
310.000	132.005	83.004	49.001		
320.000	134.500	83.201	51.299		
330.000	136.996	83.398	53.598		
340.000	139.488	83.595	55.893		
350.000	141.957	83.792	58.165		
360.000	143.194	83.989	59.205		
370.000	143.149	84.186	58.963		
380.000	143.882	84.383	59.499		
390.000	144.589	84.580	60.009		
400.000	145.342	84.777	60.565		
410.000	146.939	84.974	61.965		
420.000	148.567	85.171	63.396		
430.000	149.862	85.368	64.494		
440.000	150.824	85.565	65.259		
450.000	151.903	85.764	66.139		
451.296	151.888	85.790	66.098		

CL-SW03 LONG SECTION



VERT EXAG 1:1
Datum 75.000

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
10.000	93.218	81.554	11.664		
20.000	98.681	81.782	16.899		
30.000	101.624	82.243	19.382		
40.000	104.568	82.789	21.778		
50.000	107.511	83.319	24.193		
(SW601 CH 52.500)				18.69	6.23
60.000	110.040	83.143	26.897		
70.000	112.580	83.073	29.507		
80.000	115.317	83.021	32.296		
90.000	118.055	83.068	34.987		
100.000	120.793	83.227	37.566		
110.000	123.523	83.355	40.168		
120.000	125.094	83.553	41.542		
130.000	125.628	83.752	41.876		
140.000	125.524	83.962	41.562		
150.000	123.584	84.172	39.412		
160.000	124.148	84.376	39.772		
170.000	125.522	84.574	40.948		
180.000	126.433	84.771	41.662		
190.000	127.181	84.968	42.213		
200.000	127.911	85.165	42.746		
210.000	128.907	85.362	43.545		
220.000	130.501	85.559	44.942		
230.000	132.133	85.757	46.376		
240.000	133.765	85.956	47.808		
250.000	135.279	86.155	49.125		
260.000	136.123	86.351	49.772		
270.000	138.328	86.547	51.781		
280.000	141.048	86.739	54.308		
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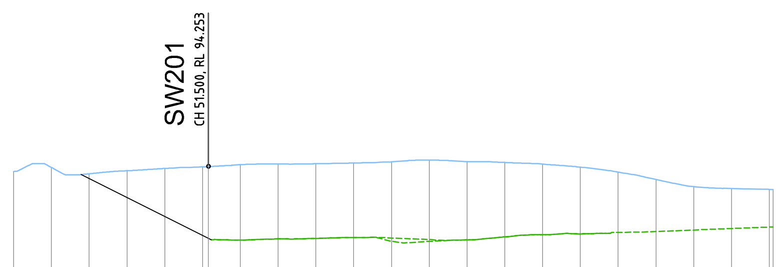
CL-SW04 LONG SECTION



VERT EXAG 1:1
Datum 65.000

CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
0.000					
10.000	93.975				
20.000	92.313				
30.000	93.109				
40.000	93.719				
50.000	94.138				
(SW201 CH 51.500)				16.00	3.00
60.000	94.746	74.746	20.000		
70.000	94.889	75.073	19.816		
80.000	94.964	75.209	19.755		
90.000	95.153	75.446	19.707		
100.000	95.468	74.464	21.004		
110.000	95.937	74.417	21.520		
120.000	95.498	74.817	20.681		
130.000	95.301	75.612	19.689		
140.000	94.871	76.179	18.692		
150.000	94.069	76.412	17.657		
158.172		76.679			
160.000	92.772				
170.000	90.799				
180.000	88.912				
190.000	88.396				
200.000	88.183				
201.016	88.134				

CL-SW201 LONG SECTION

CONSTRUCTION ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
1	16/01/19	DMB	WS	LDW	ISSUED FOR CONSTRUCTION
0	15/11/18	DMB	WS	LDW	ISSUED FOR CLIENT REVIEW

DRAWING NUMBER	REFERENCE DRAWING TITLE

Level 2, Carlaw Park
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AUCKLAND 1010
NEW ZEALAND
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Fax: +64 9 928 5501
Web: www.jacobs.com

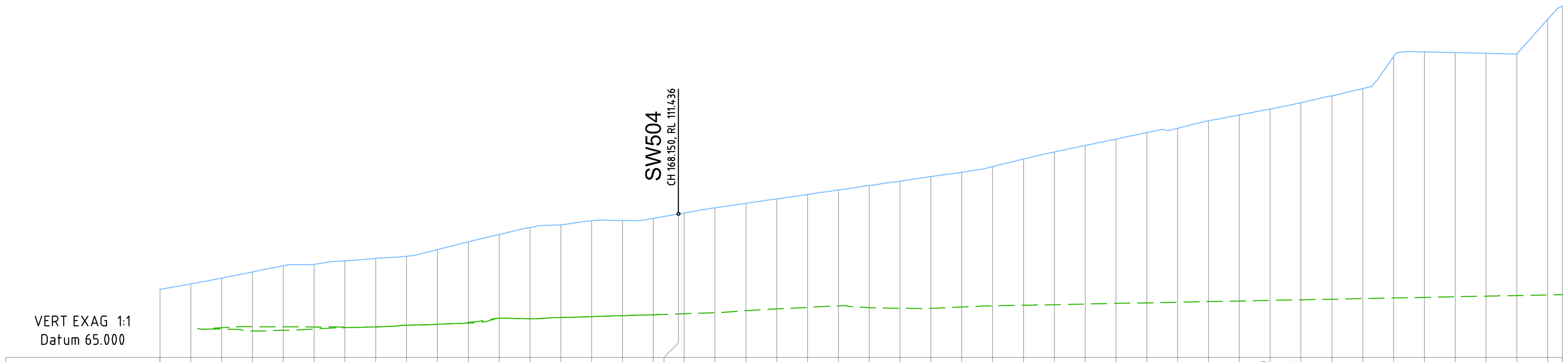
CLIENT AB LIME LTD
PROJECT LANDFILL
LANDFILL GAS EXTRACTION

DRAWN DMB | DRAWING CHECK LDW | REVIEWED WS DATE 16/01/19 | APPROVED LDW DATE 16/01/19
DESIGNED LDW | DESIGN REVIEW WS

TITLE
LANDFILL GAS EXTRACTION
Ø100mm WELL SITE LAYOUT
PROFILE - SHEET 2

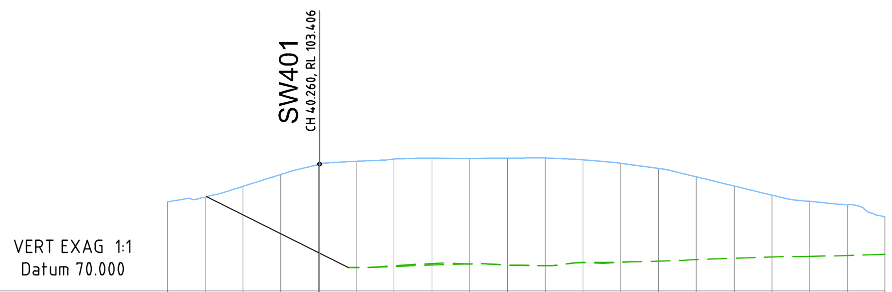
SCALE 1:1000 (A1) | DRAWING No IZ000400-LFG-NG-DSN-0002 | REV 1

A1



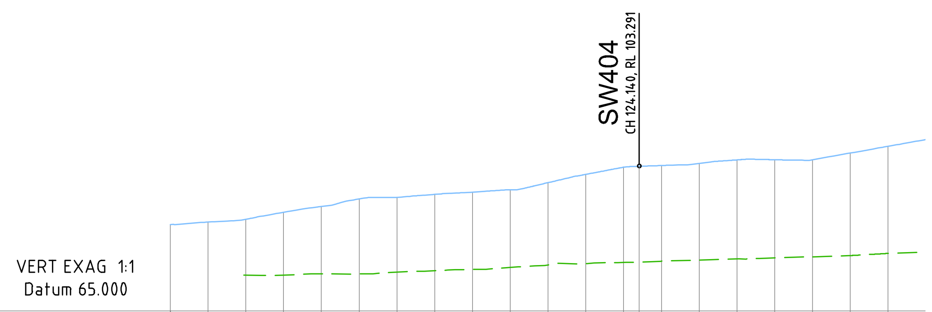
CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
0.000					
10.000	88.774				
20.000	90.639	74.547	16.091		
30.000	92.678	74.914	17.764		
40.000	94.638	74.826	19.812		
50.000	95.066	74.800	20.266		
60.000	96.258	74.760	21.498		
70.000	97.030	74.831	22.200		
80.000	97.734	75.413	22.321		
90.000	99.911	75.715	24.196		
100.000	102.415	76.295	26.120		
110.000	104.810	77.616	27.194		
120.000	107.064	77.511	29.552		
130.000	107.905	77.886	30.020		
140.000	109.273	78.185	31.088		
150.000	109.327	78.484	30.843		
160.000	110.003	78.784	31.219	27.39	5.00
170.000	111.735	79.111	32.624		
180.000	113.445	79.450	33.995		
190.000	114.887	80.131	34.756		
200.000	116.329	80.651	35.678		
210.000	117.771	81.170	36.601		
220.000	119.212	81.689	37.523		
230.000	120.654	81.084	39.571		
240.000	122.096	80.877	41.219		
250.000	123.538	80.914	42.624		
260.000	124.980	81.294	43.685		
270.000	126.798	81.659	45.139		
280.000	129.236	81.857	47.379		
290.000	131.548	82.057	49.491		
300.000	133.635	82.254	51.381		
310.000	135.723	82.451	53.272		
320.000	137.810	82.648	55.162		
330.000	139.211	82.845	56.366		
340.000	141.645	83.043	58.602		
350.000	143.537	83.239	60.298		
360.000	145.440	83.435	62.005		
370.000	147.488	83.631	63.857		
380.000	149.737	83.827	65.909		
390.000	152.050	84.024	68.026		
400.000	162.482	84.220	78.261		
410.000	163.979	84.417	79.562		
420.000	163.742	84.614	79.128		
430.000	163.506	84.815	78.691		
440.000	163.378	85.017	78.362		
450.000	174.510	85.219	89.291		
454.674	178.781	85.312	93.469		

CL-5 LONG SECTION



CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
0.000					
10.000	94.752				
20.000	97.585				
30.000	100.710				
40.000	103.345			20.49	3.00
50.000	104.213	76.134	28.079		
60.000	104.766	76.621	28.145		
70.000	105.008	77.208	27.800		
80.000	104.962	77.120	27.841		
90.000	105.036	76.815	28.221		
100.000	105.089	76.670	28.419		
110.000	104.595	77.420	27.175		
120.000	103.684	77.562	26.122		
123.462		77.682			
130.000	102.322				
140.000	100.100				
150.000	97.677				
160.000	95.255				
170.000	93.617				
180.000	92.707				
189.924	89.522				

CL-SW401 LONG SECTION



CHAINAGE	DESIGN LEVELS	EXISTING LEVELS	DEPTH	Max Well Depth (m)	Landfill Liner To Well Base (m)
0.000					
10.000	88.516				
20.000	89.244	74.431	14.813		
30.000	91.126	74.467	16.658		
40.000	92.640	74.814	17.826		
50.000	94.631	74.771	19.860		
60.000	95.047	75.221	19.825		
70.000	95.864	75.637	20.227		
80.000	96.458	75.945	20.513		
90.000	97.045	76.513	20.532		
100.000	98.949	77.112	21.837		
110.000	101.156	77.479	23.677		
112.158					
120.000	103.053	77.816	25.238	22.35	3.00
130.000	103.494	78.139	25.356		
140.000	104.035	78.455	25.581		
150.000	104.981	78.740	26.241		
160.000	105.024	79.012	26.012		
170.000	105.019	79.318	25.702		
180.000	106.803	79.634	27.169		
190.000	108.587	80.212	28.375		
200.000	110.371	80.569	29.802		

CL-SW02A LONG SECTION

CONSTRUCTION ISSUE

REV	DATE	DRAWN	REV'D	APP'D	REVISION
1	16/01/19	DMB	WS	LDW	ISSUED FOR CONSTRUCTION
0	15/11/18	DMB	WS	LDW	ISSUED FOR CLIENT REVIEW

DRAWING NUMBER	REFERENCE DRAWING TITLE

JACOBS
Level 2, Carlaw Park
12-16 Nicholls Lane, Parnell
AUCKLAND 1010
NEW ZEALAND
Tel: +64 9 928 5500
Fax: +64 9 928 5501
Web: www.jacobs.com

CLIENT AB LIME LTD
PROJECT LANDFILL
LANDFILL GAS EXTRACTION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DMB	LDW	WS	LDW
DESIGNED LDW	DESIGN REVIEW WS	DATE 16/01/19	DATE 16/01/19

TITLE
LANDFILL GAS EXTRACTION Ø100mm WELL SITE LAYOUT PROFILE - SHEET 3

SCALE 1:1000 (A1) | DRAWING No IZ000400-LFG-NG-DSN-0003 | REV 1

A1

DATE: 16/01/2019 3:13:28 PM LOGIN NAME: BROOKLAND, DAVID M
LOCATION: C:\Users\dbrookland\Documents\Jacobs Projects\IZ000400\Deliverables\Drawings\Civil\IZ000400-LFG-NG-DRG-0001.dwg

Appendix B – Main wells design advice email from Jacobs to AB Lime

Wilson, Louise

From: Moody, Louise
Sent: Friday, 16 June 2017 4:51 PM
To: Fiona Smith
Subject: RE: Gas well diameters

Hi Fiona

No problem at all, you have a great weekend too!

Louise

From: Fiona Smith [mailto:FSmith@ablime.co.nz]
Sent: Friday, 16 June 2017 4:35 PM
To: Moody, Louise
Subject: RE: Gas well diameters

Thanks for this Louise. It all make sense to me.

I will talk this through with Steve and SouthDrill .

Appreciate this – will talk next week. Enjoy your weekend!
Cheers
Fiona

From: Moody, Louise [mailto:Louise.Moody@jacobs.com]
Sent: Friday, 16 June 2017 3:36 p.m.
To: Fiona Smith
Subject: Gas well diameters

Hi Fiona

In response to your query regarding the possibility of reducing the diameter of the gas well drill holes from 600mm, and reducing the pipe diameter from 150mm, we have undertaken some research and reviewed the original SKM designs. We note the following:

- The purpose of the diameter of 600mm and pipe of 150mm is to provide sufficient draw of gas.
- Narrower wells may make for more challenging/slow draw of gas.
- A reduction in well diameter will reduce the 'radius of influence', meaning that an increased number of wells may be necessary to adequately extract the gas.
- New Zealand Technical Guidance for Disposal to Land (April 2016) does not provide a directive around the diameter of LFG extraction wells, so we have also reviewed international guidelines and relevant articles. One guideline advises that well diameter should be no less than 600mm, and pipe diameter no less than 75mm.
- The NZ Technical Guidance states the following:
  - For deep wells, the stability of the open bore during construction is of prime importance. Larger bores are more stable in construction than small bore wells, and the construction of the well can be undertaken without damage to the well structure. For this reason, a large bore size is typically adopted for deep wells. This large diameter also permits a larger radius of influence and will induce a greater gas flow.
- Walter has experience with historical landfill sites where the diameter was approximately 400mm and a borehole spacing of 60m. However, he notes that the compaction level at historical landfills is likely to be significantly less than at AB Lime, where modern compaction equipment leads to lower waste permeability. Therefore, our current designs show borehole spacing of 50-55m.

Based on this preliminary research and our experience, we advise that based on suction of 20 bar (as per your email of Monday 12 June) we consider that a reduction in **well diameter to 400mm** and **pipe diameter of 100mm** would likely provide sufficient gas extraction, *however* this would reduce the radius of influence such that we consider the **well spacing would need to be reduced to 40m**.

We also note that this would need to be approved by the peer reviewer.

Please let us know if you would like us to undertake further review and discussion with AECOM to assess the best way forward for wells LFG201 and LFG202.

Cheers,

Louise Moody | Jacobs | Environmental Consultant and Acting Section Lead | Environment Spatial Planning and Water, Christchurch | +64 3 940 4912 | 021 210 4984 | Louise.Moody@jacobs.com | www.jacobs.com

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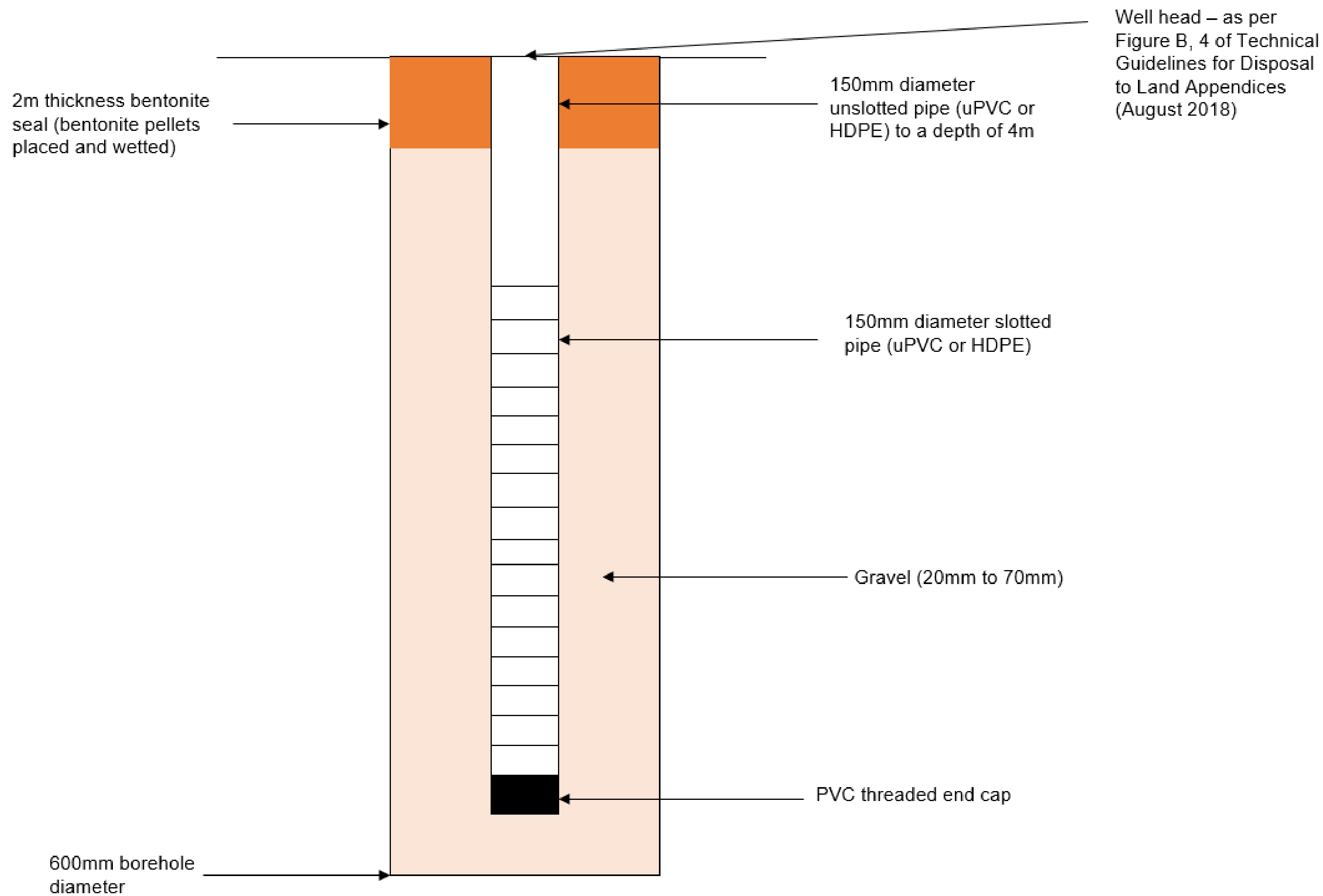
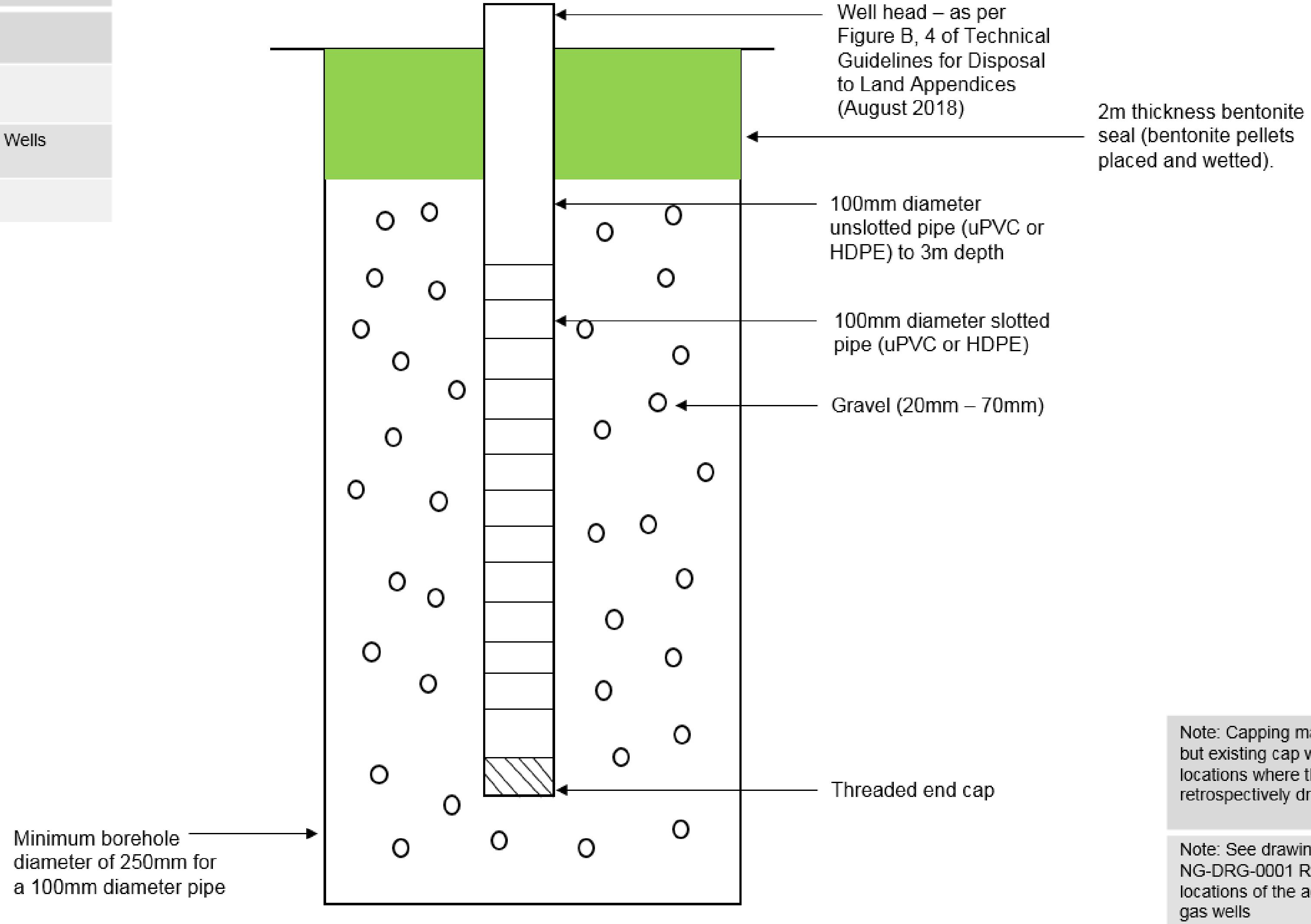
Appendix C – Updated original (2013) well specification drawing for main wells


Well head – as per Figure B, 4 of Technical Guidelines for Disposal to Land Appendices (August 2018)
2m thickness bentonite seal (bentonite pellets placed and wetted)
150mm diameter unslotted pipe (uPVC or HDPE) to a depth of 4m
150mm diameter slotted pipe (uPVC or HDPE)
Gravel (20mm to 70mm)
PVC threaded end cap
600mm borehole diameter

Appendix D – Updated well specification drawing for 100mm diameter landfill gas extraction wells

Project	AB Lime Cell 3 Design
Project No.	IZ000400
Work Package	A.P4.EV.LFG
Task	100mm Diameter Wells Specification
Element	Well Design



Note: Capping material not shown in drawing but existing cap will be in place in the locations where the wells will be retrospectively drilled

Note: See drawing number IZ000400-LFG-NG-DRG-0001 Rev 1 for the proposed locations of the additional 100mm dia. landfill gas wells

Attachment 5. Landfill Gas Migration Probe- Site Location Plan & Construction Details (2003)

NOTES

1. THE HORIZOTNAL COORDINATE SYSTEM FOR THE SITE IS NEW ZEALAND MAP GRID 1949.
2. THE LATEST SURVEY FOR THE SITE WAS PERFORMED BY DRONE SURVEY, FLOWN ON 12/03/2020.

CONSENT ISSUE

REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

AB LIME

Jacobs
Level 2, Wynn Williams Building
47 Hereford Street
CHRISTCHURCH CENTRAL 8013
NEW ZEALAND
Tel: +64 3 940 4900
Fax: +64 3 940 4901
Web: www.jacobs.com

CLIENT: AB LIME LTD.
PROJECT: LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
NBL	KJ	CW	VP
DESIGNED	DESIGN REVIEW	DATE 29.05.20	DATE 29.05.20
LJ	CW		

TITLE: GROUNDWATER, STORMWATER & GAS BOREHOLE LOCATIONS PLAN

SCALE: AS SHOWN
DRAWING No: IZ000400-1000-NG-DRG-1008
REV: A
A1

DATE: 29/05/2020 12:17:57 PM NAME: KIM, JOHN

SINCLAIR KNIGHT MERZ

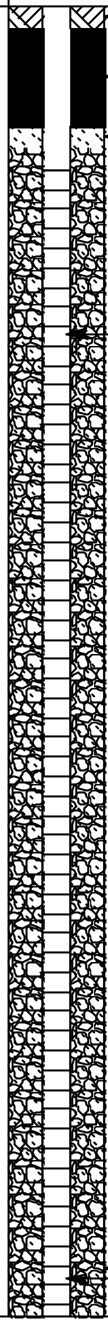
BOREHOLE LFG1

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	99.89 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	100.68 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5443082.8 N 2152830.9	**Sampling Method:**	Core

Depth (mBGL)	Graphic Log	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
0.00–2.30		SILT - Light brown clayey SILT, sl. sandy, occ. yellow brown fine to coarse angular limestone gravels, mod. plastic, firm, moist [COLLUVIUM]. - 1.98 m core loss from 0 to 2.83 m.		
1			98.9	
2			97.9	
2.30–4.70		LIMESTONE - Yellow brown biosparite LIMESTONE, sl. weathered to mod. weathered, very weak to mod. strong, very thin to thinly bedded with interbedded thin (<0.34 m) soft orange brown non-plastic clayey silt horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION]. - 0.91 m core loss from 2.83 to 4.66 m. - silt horizons at 2.49 (0.34 m), 2.87 (0.09 m), 3.61 (0.14 m) and 4.56 (0.13 m). - fractures at 3.01 (0.12 m) and 3.19 m (0.14 m).		
3			96.9	
4			95.9	
4.70–8.40		LIMESTONE - Greenish grey biosparite LIMESTONE, mod. weathered, very weak to mod. strong, massive, skeletal fragments, trace black specks, occ. brown staining [FOREST HILL FORMATION]. - gradually becoming browner in colour. - 0.83 m core recovery from 7.46 to 8.83 m.		
5			94.9	
6			93.9	
7			92.9	
8			91.9	
8.40–		LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, thinly to medium bedded with interbedded thin (<0.04 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION]. - soft horizons at 8.63, 8.71, 8.91 and 9.46 m. - fractures at 8.71 (0.11 m), 9.15 (0.15 m), 9.49 (0.08 m) and 10.23 m (0.06 m). Occ. black specks in fracture at 10.23 m. - 0.54 m core recovery between 10.32 and 11.32 m. - soft horizon at 11.52, 11.66, 12.29 (0.12 m thick), 12.56 and 12.65 m.		
9			90.9	
10			89.9	
11			88.9	

Piezometer Construction Details



DRILLING DETAILS	
Drilled Depth:	25.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	12/07/03
Date Borehole Completed:	14/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SKMHYDRO_1 GW&GAS.GPJ SKM2.GDT 02/10/03

SINCLAIR KNIGHT MERZ

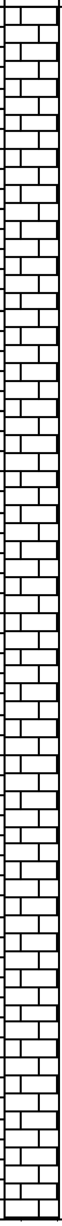
BOREHOLE LFG1

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	99.89 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	100.68 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5443082.8 N 2152830.9	**Sampling Method:**	Core

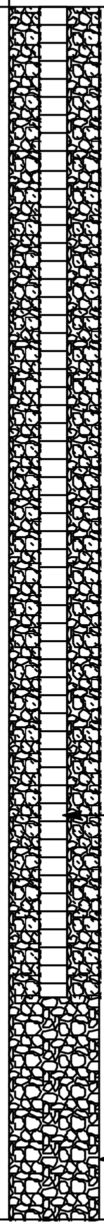
Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)
	- fractures at 11.74, 12.17 (0.03 m), and 12.26 m (0.03 m).	
13	- fractures at 13.72 (0.04 m), 13.77 (0.08 m), 14.79 (0.08 m), 15.00 (0.10 m) and 15.30 m (0.08 m). Reddish brown staining & occ. black specks in cracks.	86.9
14		85.9
	- soft horizons at 14.7 and 15.86 m.	
15		84.9
16	- fractures at 15.92 (0.05 m), 16.07 (0.03 m), 16.35 (0.03 m), 16.67 (0.06 m), 17.82 (0.09 m), 18.76 (0.06 m), 19.95 (0.19 m), 18.60 (0.05 m), 21.72 (0.02 m) and 22.25 m (0.02 m). Reddish brown staining in fractures at 15.92, 16.67 and 18.60 m.	83.9
	- greenish grey staining at 16.38 (0.04 m) and 16.74 m (0.07 m).	
17		82.9
	- soft horizons at 17.43, 17.55, 18.87, 20.91, 21.72, 22.25, 22.92, 23.17, 23.35 m. Reddish brown staining in soft horizon at 23.17 m.	
18		81.9
19		80.9
20		79.9
21		78.9
22		77.9
23		76.9

Graphic Log



Groundwater Level: ∇ (approx. 16.5 m)

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	25.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	12/07/03
Date Borehole Completed:	14/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

BOREHOLE LFG1

SINCLAIR KNIGHT MERZ

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	99.89 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	100.68 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5443082.8 N 2152830.9	**Sampling Method:**	Core

Depth (mBGL)	Graphic Log	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level	Piezometer Construction Details
25		EOH @ 25.0 m (target depth reached).	74.9		
26			73.9		
27			72.9		
28			71.9		
29			70.9		
30			69.9		
31			68.9		
32			67.9		
33			66.9		
34			65.9		
35			64.9		

DRILLING DETAILS

Drilled Depth:	25.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	12/07/03
Date Borehole Completed:	14/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SINCLAIR KNIGHT MERZ

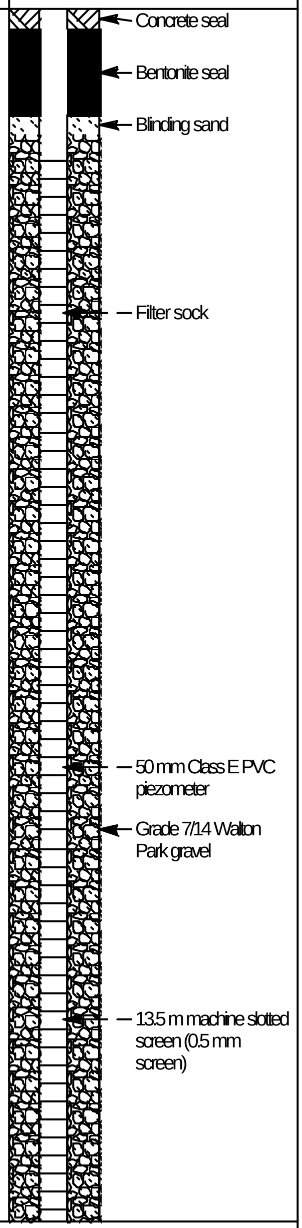
BOREHOLE LFG2

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	88.38 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	89.13 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442962.3 N 2152789.7	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
	TOPSOIL - Brown clayey SILT, mod. plastic, firm, moist, trace reddish brown limonite inclusions [TOPSOIL].		
	SILT - Orange brown clayey SILT, mod. plastic, firm, moist, trace brown limonite inclusions [ALLUVIUM].		
1		87.4	
2		86.4	
	- 1.42 m core loss from 0 to 2.68 m.		
3	- soft horizon at 2.85 m.	85.4	
	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, very thin to thinly bedded with interbedded thin (<0.08 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION].		
4		84.4	
	- soft horizons at 3.10, 3.28, 3.83, 4.01, 4.18, 4.50, 4.61, 4.89, 5.03 and 5.21 m.		
	- fractures at 3.88 (0.07 m), 5.38 (0.10 m), 5.78 m. Orange brown staining in cracks.		
5	- increase in black specks from 4.52 to 4.60 m.	83.4	
6		82.4	
	- soft horizons at 6.62, 6.72, 6.79, 7.01, 7.45, 7.73, 7.98 and 8.34 m.		
7		81.4	
	- greenish grey staining at 7.26 (0.08 m) and 7.48 m (0.03 m).		
8		80.4	
	- fractures at 8.68 (0.20 m) and 9.24 (0.12 m).		∇
9	- increased black specks from 8.92 to 8.98 m.	79.4	
	- soft horizons at 9.20, 9.36, 10.20, 10.40 and 10.95 m.		
10		78.4	
11		77.4	

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	15.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	10/07/03
Date Borehole Completed:	11/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SINCLAIR KNIGHT MERZ

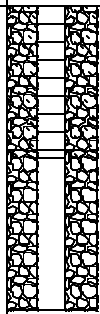
BOREHOLE LFG2

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	88.38 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	89.13 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442962.3 N 2152789.7	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)
	- soft horizons at 12.35, 12.66 and 13.26 m.	
	- fracture at 12.71 m (0.18 m). Orange brown staining & occ. black specks in crack.	
13		75.4
14	LIMESTONE - Greenish grey biomicrite LIMESTONE, mod. weathered, very weak, massive, skeletal fragments, trace black specks, occ. orange brown streaks [FOREST HILL FORMATION].	74.4
	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, medium bedded with interbedded thin (<0.06 m) soft horizons, skeletal fragments, trace black specks [FOREST HILL FORMATION].	
15		73.4
	- soft horizons at 14.18 and 14.63 m.	
	EOH @ 15.0 m (target depth reached).	
16		72.4
17		71.4
18		70.4
19		69.4
20		68.4
21		67.4
22		66.4
23		65.4

Column headings: Graphic Log; Groundwater Level; Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	15.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	10/07/03
Date Borehole Completed:	11/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SINCLAIR KNIGHT MERZ

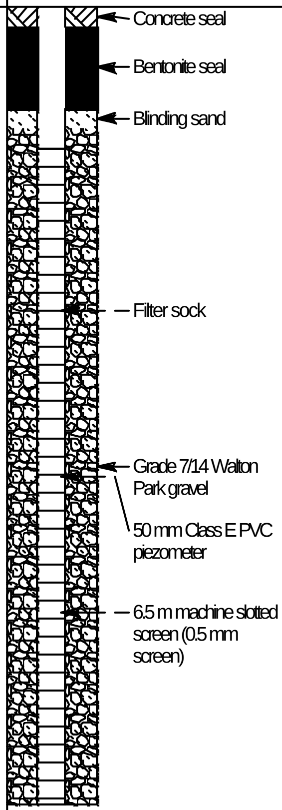
BOREHOLE LFG3

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	81.92 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	82.75 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442867.2 N 2152764.8	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
0	FILL - Greyish brown clayey SILT, occ. yellow brown and grey medium to coarse angular gravels (limestone chips and basaltic gravels) [FILL].		
1		80.9	
	- greyish brown silt matrix washed away during drilling.		
	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, thin to medium bedded with interbedded thin (<0.08 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION].		
2		79.9	
3	- fractures at 1.72 (0.10 m), 1.85 (0.07 m), 2.01 (0.14 m), 2.29 (0.16 m), 2.62 (0.08 m) and 3.00 m (0.08 m). Reddish brown staining and occ. black pyrite specks in cracks.	78.9	
	- soft horizons at 2.45, 2.61, 3.08, 3.65, 3.87, 4.18, 4.38, 4.50 and 4.66 m.		
	- 1.65 m core loss from 0 to 2.85 m.		
4		77.9	
5		76.9	
6		75.9	∇
	- soft horizons at 6.36, 6.55, 6.65, 6.75, 6.93, 7.03, 7.22 and 7.31 m.		
7	- fracture at 6.85 m (0.37 m). Black staining in crack.	74.9	
8	EOH @ 8.05 m (target depth reached).	73.9	
9		72.9	
10		71.9	
11		70.9	

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	7.90 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	10/07/03
Date Borehole Completed:	10/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (1 hr).

The stratification lines represent approximate boundaries. The transition may be gradual.

SINCLAIR KNIGHT MERZ

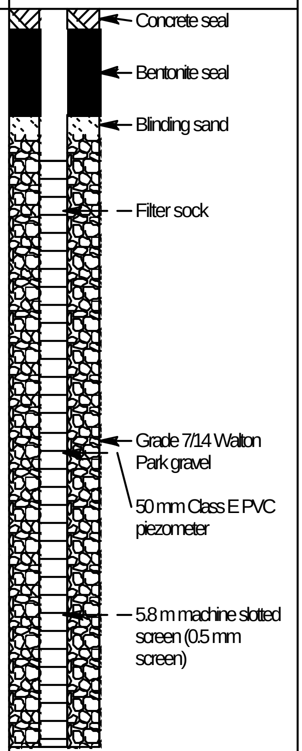
Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

BOREHOLE LFG4

Project:	AB Lime Borehole Installation	**Ground Elevation:**	73.16 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	73.88 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442765.9 N 2152808.0	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
0–0.2	TOPSOIL - Brown clayey SILT, moist, firm, mod. plastic, rootlets [TOPSOIL].		
0.2–1.25	SILT - Light brown clayey SILT, firm, plastic, moist, occ. brown limonite nodules, occ. reddish brown staining [ALLUVIUM]. - soft.		
1		72.2	
1.25–6.3	SILT - Light grey clayey SILT, firm, mod. plastic to plastic, moist, occ. brown limonite nodules, occ. orange brown streaks [ALLUVIUM]. - 0.85 m core loss from 0 to 2.98 m. - soft from 1.65 to 2.08 m. - black staining from 1.83 to 3.28 m. - loss of core from 2.08 m.		
2		71.2	
3		70.2	
4	- decrease in orange brown staining.	69.2	
5		68.2	∇ (approx. 5.3)
6	- loss of core from 4.26 m.	67.2	
6.3–7.3	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, thin to thinly bedded with interbedded thin (<0.05 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION]. - soft horizons at 6.46, 6.58, 6.80, 6.88 and 7.03 m. - fracture at 6.95 (0.10 m). Reddish brown staining in crack. EOH @ 7.30 m (target depth reached).		
7		66.2	
8		65.2	
9		64.2	
10		63.2	
11		62.2	

Piezometer Construction Details



DRILLING DETAILS	
Drilled Depth:	7.30 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	09/07/03
Date Borehole Completed:	09/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

BOREHOLE LFG5

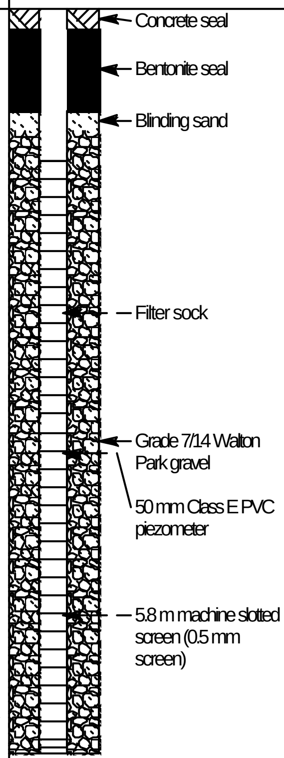
SINCLAIR KNIGHT MERZ

Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	75.65 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	76.47 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442791.9 N 2152906.9	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
0	SILT - Light brown clayey SILT, moist, firm to stiff, plastic, trace brown limonite nodules [ALLUVIUM].		
1	- orange brown and pale grey silty inclusions.	74.7	
	SILT - Orange brown clayey SILT, moist, firm to stiff, non-plastic, trace brown limonite nodules and light grey silty inclusions [ALLUVIUM].		
2	- 2.39 to 2.46 m, increase in limonitic nodules. - reddish brown streaks.	73.7	
3		72.7	
4	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, medium bedded with interbedded thin (<0.02 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION].	71.7	
5	- soft horizons at 4.36 and 5.06 m. - fractures at 4.45 (0.07 m), 4.65 (0.07 m) and 5.94 m (0.04 m). Reddish brown staining in cracks.	70.7	
6	LIMESTONE - Light greenish grey biomicrite LIMESTONE, unweathered to sl. weathered, weak to mod. strong, massive, skeletal fragments, trace black specks, occ. orange brown staining [FOREST HILL FORMATION].	69.7	
7	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, medium bedded, skeletal fragments, trace black specks [FOREST HILL FORMATION]. - horizontal tight and smooth undulating fracture with reddish brown staining.	68.7	∇
8	EOH @ 7.36 m (target depth reached).	67.7	
9		66.7	
10		65.7	
11		64.7	

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	7.36 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	07/07/03
Date Borehole Completed:	08/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (15 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SKMHYDRO_1 GW&GAS.GPJ SKM2.GDT 02/10/03

SINCLAIR KNIGHT MERZ

BOREHOLE LFG6

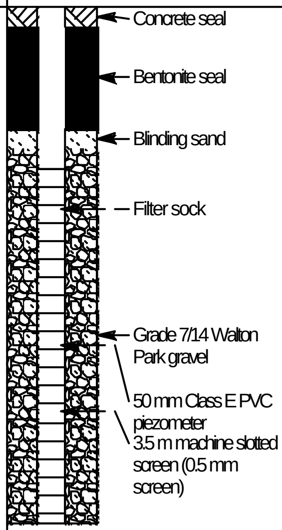
Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	73.38 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	74.16 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442821.1 N 2153001.7	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)	Groundwater Level
0 – 0.4	TOPSOIL - Brown clayey SILT, moist, firm, non-plastic, trace black limonite inclusions, rootlets [TOPSOIL].		
0.4 – 0.8	SILT - Greyish brown clayey SILT, firm, moist, mod. plastic, occ. black limonite inclusions, occ. reddish brown streaks [ALLUVIUM].		
0.8 – 4.0	SILT - Orange brown clayey SILT, firm, moist, non-plastic, occ. black limonite inclusions, occ. reddish brown staining [ALLUVIUM].		
3	- decrease in black limonite inclusions, mod. plastic.		
4.0 – 5.1	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, very thin to thinly bedded with interbedded thin (<0.02 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION].		▽ (approx. 4.0 m)
	- fractures at 4.32 (0.21 m) and 4.67 m (0.12 m). Orange staining in crack at 4.32 m.		
	- soft horizons at 4.53 and 4.65 m.		
	- 3.83 m lost core from 2.88 to 5.10 m.		
	EOH @ 5.10 m (target depth reached).		

Depth scale (mBGL) / Elevation (mAMSL): 1 / 72.4; 2 / 71.4; 3 / 70.4; 4 / 69.4; 5 / 68.4; 6 / 67.4; 7 / 66.4; 8 / 65.4; 9 / 64.4; 10 / 63.4; 11 / 62.4

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	5.10 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	06/07/03
Date Borehole Completed:	07/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (15 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SKMHYDRO_1 GW&GAS.GPJ SKM2.GDT 02/10/03

SINCLAIR KNIGHT MERZ

BOREHOLE LFG7

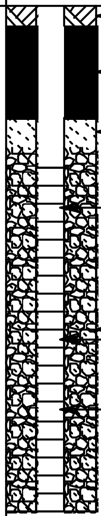
Sinclair Knight Merz Ltd.
25 Teed St, Newmarket
Auckland, New Zealand
Phone: +64 9 913 8900
Fax: +64 9 913 8901

Project:	AB Lime Borehole Installation	**Ground Elevation:**	76.00 mAMSL
Job Number:	AE02098.11	**Top of Casing Elev.:**	76.71 mAMSL
Location:	AB Lime Ltd, Winton, SOUTHLAND	**Drilling Method:**	HQ Core
Coordinates:	E 5442855.2 N 2153089.1	**Sampling Method:**	Core

Depth (mBGL)	LITHOLOGICAL DESCRIPTION	Elevation (mAMSL)
0.0	TOPSOIL - Brown clayey SILT, wet, non-plastic, very soft, rootlets [TOPSOIL].	76.0
	SILT - Orange brown clayey SILT, moist, mod. plastic, firm to stiff, trace reddish brown streaks, trace brown limonitic inclusions [ALLUVIUM].	
1		75.0
	- increase in reddish brown streaks and brown limonite inclusions.	
2		74.0
	SILT - Greenish brown clayey SILT, moist, soft, non-plastic, trace brown limonite inclusions [ALLUVIUM].	
	LIMESTONE - Yellow brown biosparite LIMESTONE, unweathered to sl. weathered, mod. strong to strong, very thin to thinly bedded with interbedded thin (<0.07 m) soft horizons, skeletal fragments, trace black specks, occ. near vertical tight and undulating smooth fractures [FOREST HILL FORMATION].	
3		73.0
	- soft horizons at 2.38, 2.45, 2.97, 3.15, 3.53, 3.74, 3.94, 4.21 and 4.55 m.	
4	- fractures at 2.85 (0.10 m), 3.04 (0.11 m) and 4.07 m (0.14 m). Reddish brown staining in cracks.	72.0
	- 0.4 m core loss from 1.85 to 3.0 m.	
5	EOH @ 5.0 m (target depth reached).	71.0
6		70.0
7		69.0
8		68.0
9		67.0
10		66.0
11		65.0

Groundwater Level: ∇ at approx. 73.0 mAMSL

Piezometer Construction Details



DRILLING DETAILS

Drilled Depth:	5.00 mBGL
Bore Diameter:	HQ 96.0 mm
Date Borehole Started:	06/07/03
Date Borehole Completed:	06/07/03
Logged By:	D Jones
Drilling Company:	Webster Drilling & Exploration Ltd

COMMENTS

Bore developed by air surging until water was clear (45 min).

The stratification lines represent approximate boundaries. The transition may be gradual.

SKMHYDRO_1 GW&GAS.GPJ SKM2.GDT 02/10/03

Attachment 6. Estimate of Organic Content in Incoming Waste for Landfill Gas Generation Modelling

Estimate of organics content in incoming waste stream for landfill gas generation modelling

Site: AB Lime Landfill

By: Walter Starke, Jacobs New Zealand Limited

Date: May 2020

1) Introduction

Landfill gas is generated from the organic component of the incoming waste stream.

The organic component of the incoming waste stream is used in the Landfill Gas Generation Model presented in Appendix J of the Landfill Gas Assessment of Environmental Effects report.

This document estimates the organic content of the incoming waste stream based on:

- The data reported by Waste Not Consulting Limited, on behalf of WasteNet Southland, into the waste composition of the Southland Regional Landfill, i.e. the AB Lime Landfill.
- The biosolids content accepted at the AB Lime Landfill, based on correspondence between AB Lime Ltd and Jacobs.

2) Waste Not Consulting Limited report dated 2018.

- Waste Not Consulting Limited, on behalf of WasteNet Southland, prepared a report into the waste composition of the Southland Regional Landfill in 2018.
- A copy of the summary pages of the 2018 report has been attached.
- A screen-shot of the summary page is presented below.

Table ES1- Primary composition of waste to landfill from Southland region - 12 April 2017 - 11 April 2018

Southland region - Waste to landfill April 2017-April 2018	% of total	Tonnes per annum
Paper	11.0%	5,336 T/annum
Plastics	14.1%	6,819 T/annum
Organics	29.2%	14,110 T/annum
Ferrous metals	2.6%	1,237 T/annum
Non-ferrous metals	0.7%	336 T/annum
Glass	4.5%	2,187 T/annum
Textiles	5.9%	2,869 T/annum
Sanitary paper	6.7%	3,232 T/annum
Rubble	3.7%	1,776 T/annum
Timber	6.5%	3,143 T/annum
Rubber	0.6%	282 T/annum
Potentially hazardous	14.5%	7,025 T/annum
TOTAL	**100.0%**	**48,351 T/annum**

APPENDIX I

3) Estimate of Table ES-1 of organics contributing to the Landfill Gas Generation Model

Using Table ES-1 the following items and percentages have been used for the Landfill Gas Generation Model:

a) Paper: 5.5%, i.e. ½ of the 11% report in Table ES-1, based on a relatively low percentage of paper noted at the working face (pers. com. Fiona Smith and Walter Starke, May 2020), and assuming that on average ½ the 'paper' takes a very long time to decompose in the landfill.
b) Organics: 29.2%
c) Sanitary paper: 3.4%, i.e. ½ of the 6.7% reported in Table ES-1, assuming that on average ½ the sanitary paper items take a very long time to decompose in the landfill.
d) Timber; 2%, i.e. around 1/3 of the 6.5% reported in Table ES-1, assuming that the majority of timber takes a very long time to decompose in the landfill.

Therefor the total 'organics' content contributing to the landfill gas generation model from Table ES-1 is estimated at around 40.1%.

4) The biosolids content accepted at the AB Lime Landfill

The biosolids accepted at AB Lime are estimated at around 3%, see attached communication between Fiona Smith (AB Lime Ltd) and Walter Starke (Jacobs).

5) Total estimate of organic content for landfill gas generation modelling

The total estimate of organic content for landfill gas generation modelling is estimated as 43%, being a combination of:

- 40.1% (see item 3)
- 3% (see item 4)

Conclusion: The landfill gas generation model will assume that 43% of incoming waste is organic.

WasteNot Consulting

Composition of Solid Waste in Southland Region - 2018

Prepared for WasteNet Southland:

Gore District Council,
Invercargill City Council
Southland District Council

April 2018

Document quality control

Version	Date	Written by	Distributed to
Final 1.0	March 2020	BM	DP - ICC
Draft 0.2	July 2018	BM	DP - ICC
Draft 0.1	May 2018	BM	-

Contact Details

WasteNet Councils

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Contents

Executive Summary

In 2007 and 2011, WasteNet Southland commissioned Waste Not Consulting to undertake surveys of the composition of waste disposed of at the major disposal facilities in the region. In 2018, to provide updated composition information for the Councils' next waste assessment and waste management and minimisation plan, WasteNet again commissioned Waste Not Consulting to undertake surveys of waste composition in the region.

The project included visual surveys of the composition of waste being disposed of at Invercargill transfer station and Southland Regional Landfill. A simpler form of survey was undertaken by transfer station staff at Gore refuse transfer station and three facilities in Southland District. The data from the surveys was combined with weighbridge records and other information from the WasteNet Councils to calculate the composition and quantity of waste being disposed of to landfill from the region.

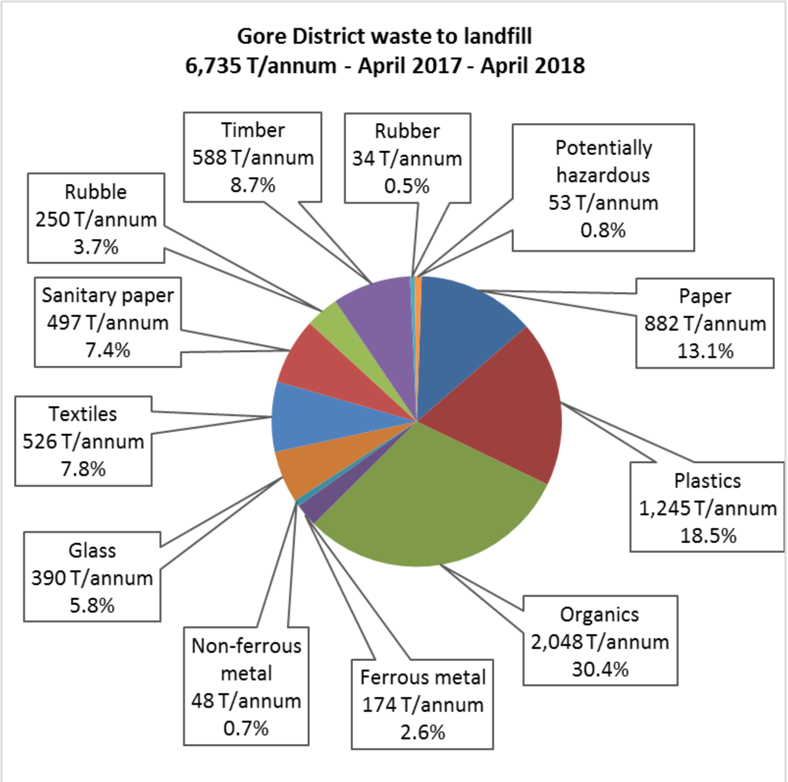
In the period 12 April 2017 to 11 April 2018, 48,351 tonnes of waste from Southland region were disposed of at Southland Regional Landfill (SRL). The composition of the waste in April-June 2018, when the surveys took place, is shown in the table below. The table shows the twelve primary categories of waste; the surveys used 25 classifications in total. These results have been extrapolated to an annual basis in the table, although it is recognised that this does not take seasonal variations in waste composition into account.

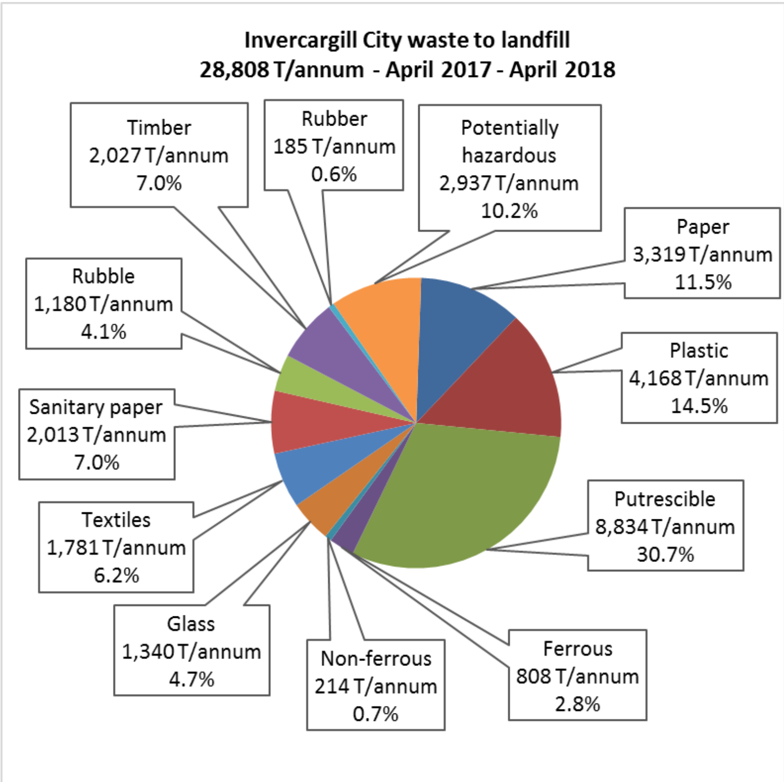
Table ES1- Primary composition of waste to landfill from Southland region - 12 April 2017 - 11 April 2018

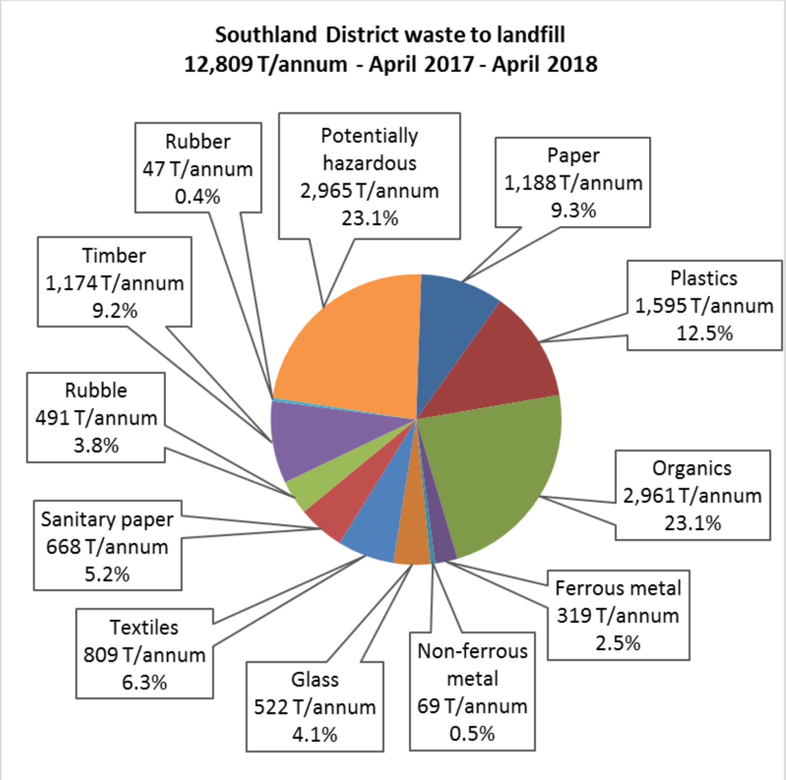
Southland region - Waste to landfill April 2017-April 2018	% of total	Tonnes per annum
Paper	11.0%	5,336 T/annum
Plastics	14.1%	6,819 T/annum
Organics	29.2%	14,110 T/annum
Ferrous metals	2.6%	1,237 T/annum
Non-ferrous metals	0.7%	336 T/annum
Glass	4.5%	2,187 T/annum
Textiles	5.9%	2,869 T/annum
Sanitary paper	6.7%	3,232 T/annum
Rubble	3.7%	1,776 T/annum
Timber	6.5%	3,143 T/annum
Rubber	0.6%	282 T/annum
Potentially hazardous	14.5%	7,025 T/annum
TOTAL	**100.0%**	**48,351 T/annum**

Organic materials, which included kitchen waste and greenwaste, was the largest component of the waste stream during the survey period, comprising 29.2% of the total. The survey took place in autumn, which is associated with a low rate of vegetative growth. It is likely the quantity of greenwaste would have been greater at other times of the year. It is also noted that the surveys took place from April to June, which is, generally, a period of below-average waste generation. Generally, waste disposal is lowest in the winter months, rising towards an annual peak in early summer.

The waste streams from the three areas are shown separately in the following three graphs.







The major difference in the composition of the three waste streams is in the proportion of potentially hazardous materials. Twenty-three percent of waste from Southland District is potentially hazardous (62% of which is contaminated oyster farming material) while less than 1% of waste from Gore District is potentially hazardous.

It is noted that while the tonnages of potentially hazardous materials are reliable, having primarily been taken directly from weighbridge records at Southland Regional Landfill, the proportions of the other materials are based on relatively short surveys and are, as a result, less reliable.

Starke, Walter

From: Fiona Smith <fsmith@ablime.co.nz>
Sent: Tuesday, 12 May 2020 2:13 PM
To: Starke, Walter
Cc: Jensen, Katrina; Watts, Charlie; Steve Smith
Subject: [EXTERNAL] AB Lime Landfill - Organic Content as discussed at todays meeting
Attachments: Final 1.0 Southland WasteNet SWAP 2018.pdf

Hi Walter,

The 2018 SWAP analysis (attached) is only the Southern Waste assessment for Wastenet councils. In addition to this, there is municipal waste and special wastes from out of region.
I have itemised these out in brief and allocated some assumed organic percentages.
This brings up the organic total for the landfill to approx. 33%

Thanks
Fiona

12 April to 11 April 2018 - same date range used by Wastenet for 2018 SWAP analysis

Waste Source	Total Tonnage	% Organic	Organic Tonnage	
Wastenet Tonnages incl. Special Wastes	48,439.87	29%	14,144.44	
Out of Region Municipal	2,340.56	29%	683.44	Assume same as Southland Municipal (29.2% organic)
Out of Region Specials - soil/gravels	2,204.26	3%	66.13	Assume top soil/gravels OM 3%
Biosolids - Queenstown	3,665.93	100%	3,655.93	Assume Biosolids are 100% organic
Total	56,650.62	32.7	18,549.94	

Fiona Smith
Environment and H&S Manager

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PO Box 102, Winton, NZ.
Ph: 03 236 7577 | Fax: 03 236 0775 | Mobile: 027 243 8755
Email: fsmith@ablime.co.nz
Website: www.ablime.co.nz.

Attachment 7. Updated Landfill Gas Generation Model (2020)

Predicted Landfill Gas and Methane Generation for 100,000 tonnes per annum of waste(k= 0.05 and 0.1)

Year	Total Landfill gas (m3/year)	Total Landfill gas (m^3/hour)	Collection Efficiency (%)	Landfill gas collected (m^3/hour)	Methane collected (m^3/hour)	Methane(m3/year) as per model	k
2005	118282	14	10	1	1	70969	0.05
2006	331851	38	10	4	2	199110	0.05
2007	547059	62	10	6	4	328235	0.05
2008	786286	90	10	9	5	471772	0.05
2009	984493	112	10	11	7	590696	0.05
2010	2018693	230	30	69	41	1211216	0.1
2011	2229819	255	30	76	46	1337891	0.1
2012	2424152	277	30	83	50	1454491	0.1
2013	2611735	298	30	89	54	1567041	0.1
2014	2692019	307	30	92	55	1615212	0.1
2015	2763627	315	30	95	57	1658176	0.1
2016	2899369	331	30	99	60	1739621	0.1
2017	2969624	339	30	102	61	1781774	0.1
2018	3054887	349	30	105	63	1832932	0.1
2019	3190424	364	30	109	66	1914254	0.1
2020	3308756	378	30	113	68	1985253	0.1
2021	3415827	390	75	292	175	2049496	0.1
2022	3776182	431	75	323	194	2265709	0.1
2023	4102245	468	75	351	211	2461347	0.1
2024	4397279	502	75	376	226	2638367	0.1
2025	4664237	532	75	399	240	2798542	0.1
2026	4905790	560	75	420	252	2943474	0.1
2027	5124357	585	75	439	263	3074614	0.1
2028	5322124	608	75	456	273	3193274	0.1
2029	5501071	628	75	471	283	3300643	0.1
2030	5662989	646	75	485	291	3397793	0.1
2031	5809499	663	75	497	298	3485699	0.1
2032	5942066	678	75	509	305	3565240	0.1
2033	6062018	692	75	519	311	3637211	0.1
2034	6170555	704	75	528	317	3702333	0.1
2035	6268763	716	75	537	322	3761258	0.1
2036	6357625	726	75	544	327	3814575	0.1
2037	6438032	735	75	551	331	3862819	0.1
2038	6510786	743	75	557	334	3906472	0.1
2039	6576617	751	75	563	338	3945970	0.1
2040	6636183	758	75	568	341	3981710	0.1
2041	6690081	764	75	573	344	4014049	0.1
2042	6738850	769	75	577	346	4043310	0.1
2043	6782978	774	75	581	348	4069787	0.1
2044	6822906	779	75	584	350	4093744	0.1
2045	6859035	783	75	587	352	4115421	0.1
2046	6891726	787	75	590	354	4135035	0.1
2047	6921306	790	75	593	356	4152783	0.1
2048	6948070	793	75	595	357	4168842	0.1
2049	6972288	796	75	597	358	4183373	0.1
2050	6994201	798	75	599	359	4196521	0.1
2051	7014029	801	75	601	360	4208418	0.1
2052	7031970	803	75	602	361	4219182	0.1
2053	7048204	805	75	603	362	4228922	0.1
2054	7062893	806	75	605	363	4237736	0.1
2055	7076184	808	75	606	364	4245710	0.1

Predicted Landfill Gas and Methane Generation for 200,000 tonnes per annum of waste(k= 0.05 and 0.1)

Year	Total Landfill gas (m3/year)	Total Landfill gas (m^3/hour)	Collection Efficiency (%)	Landfill gas collected (m^3/hour)	Methane collected (m^3/hour)	Methane(m3/ year) as per model	k
2005	118282	14	10	1	1	70969	0.05
2006	331851	38	10	4	2	199110	0.05
2007	547059	62	10	6	4	328235	0.05
2008	786286	90	10	9	5	471772	0.05
2009	984493	112	10	11	7	590696	0.05
2010	2018693	230	30	69	41	1211216	0.1
2011	2229819	255	30	76	46	1337891	0.1
2012	2424152	277	30	83	50	1454491	0.1
2013	2611735	298	30	89	54	1567041	0.1
2014	2692019	307	30	92	55	1615212	0.1
2015	2763627	315	30	95	57	1658176	0.1
2016	2899369	331	30	99	60	1739621	0.1
2017	2969624	339	30	102	61	1781774	0.1
2018	3054887	349	30	105	63	1832932	0.1
2019	3190424	364	30	109	66	1914254	0.1
2020	3308756	378	30	113	68	1985253	0.1
2021	3415827	390	75	292	175	2049496	0.1
2022	4461596	509	75	382	229	2676958	0.1
2023	5407848	617	75	463	278	3244709	0.1
2024	6264051	715	75	536	322	3758431	0.1
2025	7038776	804	75	603	362	4223266	0.1
2026	7739777	884	75	663	398	4643866	0.1
2027	8374068	956	75	717	430	5024441	0.1
2028	8947998	1021	75	766	460	5368799	0.1
2029	9467312	1081	75	811	486	5680387	0.1
2030	9937207	1134	75	851	510	5962324	0.1
2031	10362385	1183	75	887	532	6217431	0.1
2032	10747102	1227	75	920	552	6448261	0.1
2033	11095208	1267	75	950	570	6657125	0.1
2034	11410188	1303	75	977	586	6846113	0.1
2035	11695193	1335	75	1001	601	7017116	0.1
2036	11953077	1365	75	1023	614	7171846	0.1
2037	12186420	1391	75	1043	626	7311852	0.1
2038	12397557	1415	75	1061	637	7438534	0.1
2039	12588602	1437	75	1078	647	7553161	0.1
2040	12761466	1457	75	1093	656	7656880	0.1
2041	12917880	1475	75	1106	664	7750728	0.1
2042	13059410	1491	75	1118	671	7835646	0.1
2043	13187471	1505	75	1129	677	7912483	0.1
2044	13303346	1519	75	1139	683	7982007	0.1
2045	13408193	1531	75	1148	689	8044916	0.1
2046	13503063	1541	75	1156	694	8101838	0.1
2047	13588905	1551	75	1163	698	8153343	0.1
2048	13666578	1560	75	1170	702	8199947	0.1
2049	13736860	1568	75	1176	706	8242116	0.1
2050	13800453	1575	75	1182	709	8280272	0.1
2051	13857995	1582	75	1186	712	8314797	0.1
2052	13910061	1588	75	1191	715	8346036	0.1
2053	13957172	1593	75	1195	717	8374303	0.1
2054	13999800	1598	75	1199	719	8399880	0.1
2055	14038371	1603	75	1202	721	8423022	0.1

Predicted Landfill Gas and Methane Generation for 300,000 tonnes per annum of waste(k= 0.05 and 0.1)

Year	Total Landfill gas (m3/year)	Total Landfill gas (m^3/hour)	Collection Efficiency (%)	Landfill gas collected (m^3/hour)	Methane collected (m^3/hour)	Methane(m3 /year) as per model	k
2005	118282	14	10	1	1	70969	0.05
2006	331851	38	10	4	2	199110	0.05
2007	547059	62	10	6	4	328235	0.05
2008	786286	90	10	9	5	471772	0.05
2009	984493	112	10	11	7	590696	0.05
2010	2018693	230	30	69	41	1211216	0.1
2011	2229819	255	30	76	46	1337891	0.1
2012	2424152	277	30	83	50	1454491	0.1
2013	2611735	298	30	89	54	1567041	0.1
2014	2692019	307	30	92	55	1615212	0.1
2015	2763627	315	30	95	57	1658176	0.1
2016	2899369	331	30	99	60	1739621	0.1
2017	2969624	339	30	102	61	1781774	0.1
2018	3054887	349	30	105	63	1832932	0.1
2019	3190424	364	30	109	66	1914254	0.1
2020	3308756	378	30	113	68	1985253	0.1
2021	3415827	390	75	292	175	2049496	0.1
2022	5147011	588	75	441	264	3088206	0.1
2023	6713450	766	75	575	345	4028070	0.1
2024	8130824	928	75	696	418	4878494	0.1
2025	9413316	1075	75	806	484	5647990	0.1
2026	10573763	1207	75	905	543	6344258	0.1
2027	11623779	1327	75	995	597	6974267	0.1
2028	12573873	1435	75	1077	646	7544324	0.1
2029	13433553	1534	75	1150	690	8060132	0.1
2030	14211424	1622	75	1217	730	8526854	0.1
2031	14915271	1703	75	1277	766	8949162	0.1
2032	15552138	1775	75	1332	799	9331283	0.1
2033	16128399	1841	75	1381	829	9677039	0.1
2034	16649821	1901	75	1425	855	9989893	0.1
2035	17121624	1955	75	1466	880	10272974	0.1
2036	17548528	2003	75	1502	901	10529117	0.1
2037	17934808	2047	75	1536	921	10760885	0.1
2038	18284328	2087	75	1565	939	10970597	0.1
2039	18600586	2123	75	1593	956	11160352	0.1
2040	18886749	2156	75	1617	970	11332049	0.1
2041	19145680	2186	75	1639	984	11487408	0.1
2042	19379970	2212	75	1659	996	11627982	0.1
2043	19591964	2237	75	1677	1006	11755179	0.1
2044	19783785	2258	75	1694	1016	11870271	0.1
2045	19957352	2278	75	1709	1025	11974411	0.1
2046	20114401	2296	75	1722	1033	12068641	0.1
2047	20256505	2312	75	1734	1041	12153903	0.1
2048	20385086	2327	75	1745	1047	12231052	0.1
2049	20501431	2340	75	1755	1053	12300859	0.1
2050	20606705	2352	75	1764	1059	12364023	0.1
2051	20701960	2363	75	1772	1063	12421176	0.1
2052	20788151	2373	75	1780	1068	12472890	0.1
2053	20866139	2382	75	1786	1072	12519684	0.1
2054	20936706	2390	75	1793	1076	12562024	0.1
2055	21000558	2397	75	1798	1079	12600335	0.1

2004 Modelling

1. Placement rate of 60,000 tonnes per annum with first placemetn 2004
2. 2005 - 2009 a k value of 0.1 used as leachate recirculation not in place
3. 2010 to 2039 k value of 0.15 used
4. Landfill operated for 35 year conentt period
5. 50/50 ration of methane and CO2

2009 Modelling

1. for 2004 to 2007 actual placemetn rates used, from 2008 to 2039 60,000 tonnes per annum used
2. 70% of waste placed assumed to be organinc
3 Lo valume of 170 m3 per tonne
4. 2004 -2009 a collection effciency of 55% and k value of 0.1
5 2010 to 2039 a collectio efficiency of 75% and k value of 0.15
6. 50/50 mixture of CO2 and methane
7. Ran model for 0.1 k value first then again for 0.15 for all years. Selcted 2005 to 2009 results for 0.1 and 50% removal and then from 2010 at 0.15 and 70 %

2020 Modelling

Run 2

3. Max placement rate from 2020 is 300,000 tonnes per annum
4. 35 year consent period to 2055
5. Placement rates 2004 to 2019 as per data supplied by AB Lime
6. 52 % organics to 2013 and 43 % organics since 2013
7. k0.05 for first 5 years then .1
8. Methane /CO2 ratio 60/40
9. From 2021 up to total of 300,000 tonnes per annum which of organics is 105,000 tonnes/yr
10 Lo of 100 m3/tonne
11. 2004 -2009 a collection effciency of 10% and k value of 0.05
12. 2010 to 2020 a collection efficiency of 30%
13. 2021 to 2055 a collection efficiency of 75%

Run 3

From 2020 at 100,000 tonnes placement per annum

Run 4

From 2020 at 200,000 tonnes placement per annum

Year	Placement tonnes	% Organics	Tonnes organic in model
2004	27,914.09	52	14515
2005	51,762.75	52	26917
2006	54,607.80	52	28396
2007	62,753.19	52	32632
2008	55,825.95	52	29029
2009	49,572.60	52	25778
2010	48,647.91	52	25297
2011	49,045.95	52	25504
2012	50,462.73	52	26241
2013	47,974.00	43	20629
2014	47,823.20	43	20564
2015	58,173.30	43	25015
2016	50,505.10	43	21717
2017	53,670.53	43	23078
2018	61,560.00	43	26471

Attachment 8. Air Discharge Permit AUTH 205862-01- Variation- Additional Notes

Consent Change (Variation) or Cancellation of Consent Conditions Application

TO ALLOW THE USE THE COMBINATION OF LANDFILL GAS (LFG) AND COAL AS A DUAL FUEL SYSTEM IN THE LIMESTONE KILN DRYERS AT AB LIME LIMITED

Additional Notes for:

3. What is the Consent number(s) you wish to change/cancel the conditions of?

AUTH:205862-01

4. List of Condition/s number/s and give details of the proposed changes/cancellation.

Condition 1:

Changes to this condition have come about due to:

- *The purchase of a Surface Miner lime excavation at the AB Lime Quarry has eliminated the need to quarry at night and produces a quieter, less dusty excavation process. It operates a quicker excavation rate and the proposed change reflects this.*
- *The need to reflect a more accurate amount of lime that is dried per hour due to a more uniform product coming from the surface miner being quicker to dry.*
- *The inclusion of being able to utilise the Landfill Gas produced onsite as part of a dual fuel system in the rotary lime dryers.*

Condition 1 currently reads:

1. The discharge to air shall only be contaminates from the following processes:
- *The quarrying of limestone using excavators at a rate of up to 200 tonnes per hour;*
- *The operation of two coal-fired rotary lime dryers with a combined drying rate of approximately 100 tonnes per hour of crushed limestone;*
- *Crushing and screening of limestone*
- *Blending, transporting and storage of lime and fertiliser products; and*
- *Associated on-site processes*

Proposed Changes:

1. The discharge to air shall only be contaminates from the following processes:
- *The quarrying of limestone using excavators and a surface miner at a rate of up to ~~200~~ 500 tonnes per hour;*
- *The operation of two ~~coal-fired~~ coal and /or landfill gas fired rotary lime dryers with a combined drying rate of approximately ~~100~~ 120 tonnes per hour of crushed limestone;*
- *Crushing and screening of limestone*
- *Blending, transporting and storage of lime and fertiliser products; and*
- *Associated on-site processes*

Change to Subheading:

Change sub heading between conditions 2 and 3 to Coal and /or Landfill Gas fired Lime Dryers

Other consent Conditions:

Other consent conditions are not affected by the inclusion of Landfill Gas as a fuel in the Lime Dryers

NOTE: Other Consents held by AB Lime that address the use of Landfill Gas

*AB Lime already has an Air Discharge Permit (**A071-010; 201351**) that addresses the use of an 'other utilisation system' for Landfill Gas (condition 18), that would include kiln dryers, that has conditions (18a – 18f) that cover the requirements of system setup, monitoring, and environmental protection. It is felt that it is not necessary to repeat these conditions in the Quarry Discharge Permit.*

5. **Describe any adverse effects that may results from the proposed change/cancellation to the condition/s. You must include an Assessment of Environmental Effects as outlined in the Fourth Schedule of the RMA 1991. The extent of detail required should be relative to the scale and significance of the potential adverse effects the activity may have on the receiving environment.**

a) if it's likely that the activity will result in any significant adverse effect on the environment, a description of any possible alternative locations or methods for undertaking the activity;

No significant adverse effects on the environment

b) an assessment of the actual or potential effect on the environment of the activity;

There are no additional effects on the environment.

- *There is a reduction in time spent in rock excavation, resulting in less noise and dust*
- *Consents to allow the operation of coal fired kiln dryers and the operation of a Landfill Gas Flare have already been granted to AB Lime Limited.*

c) if the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment that are likely to arise from such use;

Any Risks to the Environment:

- *None in regard to the use of the Surface Miner*
- *LFG is a hazardous substance*
- *There is very little risk to the environment of any additional fugitive emissions of LFG from the AB Lime site associated with the use of LFG as a Dual Fuel at the Kiln Dyers.*
- *Due to the installation of two isolation systems and associated non-return valves, it will not be possible to discharge unburned landfill gas at the Mill.*
- *The 300mm PE pipe from the Flare to the Mill will run underground (minimum 900mm depth) and will be encased in a 450mm concrete pipe to protect it from damage from traffic.*
- *100mm and 80mm stainless Steel pipe work and fittings will be used above ground*
- *A gauze mesh and knockout pot to filter and capture any condensate from the LFG will be installed prior to use as a fuel*

d) if the activity includes the discharge of any contaminant, a description of—

  i. the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and
  ii. any possible alternative methods of discharge, including discharge into any other receiving environment;

<u>Nature of the Discharge:</u>

- *Combustion gases will be emitted from the burning of Landfill Gas. The main products of combustion from utilisation of landfill gas are carbon dioxide and water. Other trace contaminants are carbon monoxide, nitrogen oxides, sulphur dioxide, hydrogen chloride and particulate matter.*
- *Coal combustion gases will also continue to be discharged from the lime drying kilns as the Landfill Gas will be used as a supplementary fuel, not a complete replacement.*
- *Products of combustion from landfill gas combustion will be minor and will results in ground level concentrations down wind that are considerably lower than the relevant ambient air quality criteria to protect health*
- *Controls will be in place to prevent discharge of unburned gas*
- *The receiving environments will have minimal adverse effects as the site already discharges coal combustion and LFG combustion exhausts.*

<u>Nature of the Discharge:</u>

- *Alternative discharge is through the destruction of LFG at the Gas Flare*

e) a description of the mitigation measures (safeguards and contingency plans where relevant) to be undertaken to help or prevent or reduce the actual or potential effect;

<u>Controls to prevent discharge unburned gas are included in the start-up and shut down process:</u>

- *Start and Stop controls will be available at the point of control i.e. at the Flare and at the Mill*
- *The Flare will operate as normal until the Mill starts up*
- *A continuous automatic LPG Pilot Burner ignition system will start combustion at the kiln dryer with coal dust and LFG will come online once temperatures reach 800 degrees Celsius.*
- *Isolation points prior to entry of the mill and at the connection to the main landfill gas line by the flare. Isolation points include flame arrestors and backflow prevention.*
- *If the Kiln dryers stop operating (end of shift, mill stopped for maintenance, fault etc.) the LFG will be automatically diverted to the Gas Flare for destruction.*
- *When the kiln dryers are not in operation, LFG will be destructed at the existing flare*

f) identification of the persons affected by the activity, any consultation undertaken, and any response to the views of any persons consulted;

There are no persons affected by the inclusion of using landfill gas as a dual fuel source in the drying kilns. The closest residential neighbour to the drying kilns are located 400 m to the NW and objectionable effects of utilisation of LFG is unlikely. The site already uses 100% coal-fired kilns and flares LFG 24 hours a day.

g) if the scale and significance of the activity's effects are such that monitoring is required, a description of how and by whom the effects will be monitored if the activity is approved;

<u>Person responsible for monitoring:</u>
Monitoring of the Dual Fuel System will be undertaken by a suitably experienced or qualified staff member. This additional monitoring will be included as part of the existing site monitoring program.

<u>What needs to be monitored and how?</u>

- *Monitoring of gas composition (methane %, carbon dioxide % and oxygen %) is already at the point of gas extraction from the landfill and prior to current destruction at the gas flare. Composition monitoring will continue when the gas is diverted to the drying kilns.*
- *The operational temperature of the drying kiln is already recorded and the average temperature recorded in the drying chambers is 850 degrees Celsius. This is well above the Landfill Air Discharge Permit (A071-0101: 201351(18)(e)) requirement for a minimum combustion temperature of 750 degrees Celsius for the enclosed flare or other utilisation system.*
- *A permanent kiln temperature display already exists in the Mill control room. This is also logged as part of the mill data files*
- *Residence time of the LFG in the kiln dryer will be at least 0.5 seconds due to the 20m length of the kiln dryer.*
- *Emissions testing of the gas flare will be completed by AECOM. Emissions testing from the kiln dryer/s will be completed annually to coincide with the gas flare testing. Sampling ports have been designed into the Dual Fuel system and will be located at the exhaust pipe of the kiln dryers. The exhaust pipe port will be easily accessed via an existing landing. Stack Emissions will also be included in the annual testing.*

Additional matters:

a) an assessment of the activity against any relevant provisions of any relevant objectives, policies, or rules;

The use of a surface miner for quarrying rock does not infringe on any relevant objective, policies or rules that could be found in relation to this activity.

The use of Landfill Gas in dryers is a common use for this fuel and does not infringe on any relevant objective, policies or rules that could be found in relation to this activity

b) any information specified to be included in the application in accordance with the relevant regional plan;

Environment Southland Air Quality Plan – Stage 2 will address industrial and commercial discharge to air, however this has not yet been published.

c) any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects;

There are some positive Environmental impacts for utilising the methane from Landfill Gas as an energy source:

- *<u>Direct Green House Gas Reductions:</u> During its operational lifetime, an LFG energy project will capture an estimated 60 to 90 percent of the methane created by a landfill, depending on system design and effectiveness. The methane captured is converted to water and carbon dioxide when the gas is burned to produce heat.*

- *<u>Indirect Green House Gas Reductions</u>: Producing energy from LFG displaces the use of non-renewable resources (such as coal) that would be needed to produce the same amount of* *energy. This displacement avoids Green House Gas emissions from fossil fuel combustion by an end user facility or power plant*

d) any physical effect on the locality, including any landscape and visual effects;

None

e) any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity;

None

f) any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations;

None

g) any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants;

Exhaust from the Lime Dryers moves through a scrubber system to remove any particulate matter before final remaining contaminants are discharged to air, along with water vapour.

h) any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations.

None

Prepared by Fiona Smith

AB Lime Environment Manager
01 November 2018

AB Lime Limited Landfill Resource Consent Application

Landfill Air Quality Technical Memo

Landfill Air Quality Technical Memo | 1

29 May 2020

AB Lime Limited

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AB Lime Limited Landfill Resource Consent Application

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Project Manager:	Katrina Jensen
Author:	Donovan van Kekem of NZ Air
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Contents

Attachment 1. CALPUFF and CALMET Modelling Inputs

Executive Summary

AB Lime Limited propose to increase the operations of their existing landfill, which will change the status of the activities for a number of resource consents. At the core of this proposal is the removal of the 100,000 tonnes per year limit to allow the AB Lime landfill to take a varying degree of waste depending on the needs of the wider region, as well as providing the ability to accept waste for crisis and emergency response scenarios. The assessment of effects for the resource consent application is based on managing the effects of operations at the landfill at all levels of activity.

This technical memo summarises the current management, systems and processes for air quality and investigates the impact of removing the limit of waste acceptance on air quality on this resource consent application.

The application for resource consent is prepared by NZ Air on behalf of AB Lime Limited in support of an application for the expanded operation of the ABL Landfill, located at 10-20 Kings Bend Winton. The purpose of this technical memo for discharges to air is to assist in this application for resource consent and provide technical input into the Assessment of Effects on the Environment (AEE).

A Landfill Air Quality Management Plan supplements this technical memo and provides a toolbox of mitigation measures that can avoid, manage, reduce and mitigate air quality adverse effects that also reflects best practice methodology. The implementation of this management plan framework will provide a net improvement in current operations, even with a removal of a tonnage limit. Proposed monitoring improvements in the Landfill Air Quality Management Plan provide three levels of odour mitigation, depending on the severity of expected adverse effects. This tiered approach provides for a high level of detail in site odour management and will prevent offensive and objectionable effects at the nearest sensitive receptors. This substantive improvement is designed to eliminate historical off-site odour complaints.

The working face area is recommended to reduce to 1000 m² under the Landfill Operations Management Plan and will result in a substantial reduction in the potential for odour emissions at the site. The steepness of internal waste slopes is recommended to reduce to 1(v):3(h) under the Landfill Operations Management Plan and temporary cover and permanent capping are recommended to improve under the Landfill Operations Management Plan and will reduce odour nuisance at the site.

Notably, coal consumption as a power source for the lime kilns is set to reduce by utilising landfill gas to power the kilns. This has a significant impact on net emissions for the site and decreases the site's impact on ambient air standards. The air dispersion modelling assessment has predicted that this will result in at least a 65% reduction in peak off-site SO_2 concentrations, as well as a reduction in other products of combustion related to coal burning.

The acceptance of certain streams of hazardous waste such as aluminium dross, methamphetamine and asbestos are already consented. The potential for pollutants from these waste streams will remain low because of the infrequent acceptance rates, as well as the management procedures in place for special waste acceptance identified in the Landfill Operations Management Plan and the Landfill Air Quality Management Plan.

Existing controls have been effective in controlling dust emissions from the site and are expected to continue. Further mitigation measures have been implemented under the Landfill Air Quality Management Plan to add another layer of certainty that adverse off-site effects will not occur.

Overall, this technical memo concludes that that the proposed operation of the AB Lime landfill will reduce current off-site effects on ambient air quality. Peak off-site air quality effects are predicted to be well below the relevant ambient air quality criteria.

1. Overview of Site Activities

An overview of the site and existing landfill operations is covered under Section 2 of the main AEE proposal.

1.1 Status of the activity within the relevant Regional and District Plans

AB Lime Limited currently holds two air discharge consents for its current activities:

- Limeworks air discharge consent – AUTH-205862-01; and
- Landfill air discharge consent – AUTH-201351

As a part of the proposed increase in the waste acceptance rate, AB Lime is seeking a replacement air discharge consent for the landfill (replacing AUTH-201351). It is proposed that the existing limeworks air discharge consent will be amended to reduce the consented sulphur dioxide (SO_2) discharge limit from 10 kg/hr to 6 kg/hr. This voluntary reduction in the discharge limit is based on measured and calculated discharge rates from the operation of the kilns being well below the current consented 10 kg/hr limit. In addition, the proposed use of landfill gas (LFG) to reduce the site's coal consumption rates will also reduce total SO_2 emissions from the kilns. This voluntary reduction in the SO_2 mass emission rate is predicted to eliminate the potential for an exceedance of the New Zealand ambient air quality standards and guidelines for SO_2.

The overall status of the application for the air discharge consent is for a discretionary activity as defined in the Southland Regional Air Plan. The following activities form part of this proposal on-site and are discretionary under the following Rules in the Regional Air plan:

- Rule 5.5.2(2)(c) – Discharge of landfill gas contaminants to air;
- Rule 5.5.2(18) – Discharge of contaminants to air from refuse activities; and
- Rule 5.5.6 – The use of masking agents to disguise odour.

A full list of activities to be consented is provided in Section 1.3 of the main AEE document. Also, a full planning assessment of the regulatory framework is included in Section 7 of the AEE.

2. Description of Existing Environment for Air Quality Management

2.1 Identification of Sensitive Receptors

AB Lime's quarry and landfill are well separated from neighbouring properties/off-site dwellings. Figure 1 illustrates the location of off-site dwellings relative to the site. Green markers indicate dwellings owned by AB Lime, and yellow markers are the nearest dwellings not owned by AB Lime. The nearest dwelling not owned by AB Lime (R4) is approximately 1,240 m from the landfill operations. Neighbouring dwellings are primarily situated west – south of the site, and land northwest – south east is sparsely populated. As such, winds blowing from the north, northeast and east have the highest potential to generate off-site air quality effects.

A desktop study was undertaken to identify discrete receptors deemed sensitive to changes in air quality as a result of discharges from the landfill. The nearest potentially affected sensitive receptors are marked in Figure 1 (yellow markers) and are summarised in Table 1.

In the context of the assessment contained in this report, the term 'sensitive receptor' is defined as a location where a sensitive activity occurs. Sensitive activity means an activity undertaken at a place or in an area where a person or persons are present and have a reasonable expectation that their enjoyment of the amenity values of that place or area will not be materially impaired by the effects of a discharge of odour, dust or smoke; and may include places where people gather for recreation, education, worship, culture or similar purposes, or where they reside, including outdoor living areas.

Table 1 Location of Nearest Receptors

Receptor ID	Receptor Type	Approximate distance from current landfill operations (m)	Direction Relative to the Site
R1	ABL Owned Rural Dwelling	690	West
R2	ABL Owned Rural Dwelling	890	Southwest
R3	ABL Owned Rural Dwelling	1,000	Southwest
R4	Rural Dwelling	1,300	South
R5	Rural Dwelling	1,800	Southwest
R6	Rural Dwelling	1,900	Southwest
R7	Rural Dwelling	1,800	Southwest
R8	ABL Owned Rural Dwelling	500	South
R9	Rural Dwelling	1,600	West
R10	Rural Dwelling	1,800	West
R11	Rural Dwelling	1,600	Southwest
R12	Rural Dwelling	1,600	South

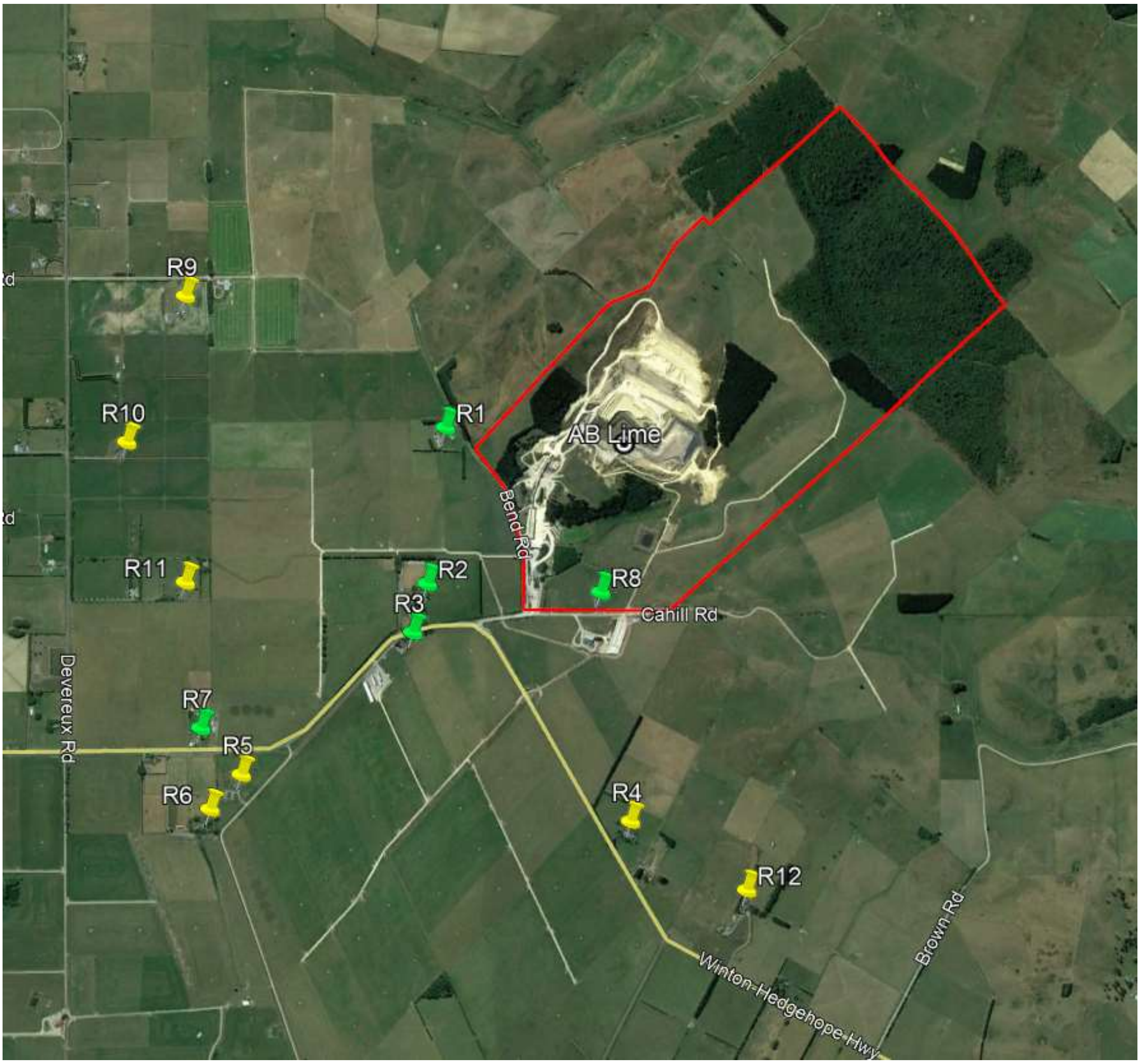


Figure 1 - Neighbouring Receptors - as of April 2020

As shown in Figure 1 AB Lime also owns a large amount of the land surrounding the site. The land parcel to the north of the site is unoccupied and currently used for agricultural purposes.

The Landfill Air Quality Management Plan (attached as Appendix U to the main AEE document) is focussed on limiting the potential for adverse air quality effects at neighbouring dwellings. The proposed control measures will also limit the potential for adverse air quality effects at unoccupied land and adjacent public roads.

Table 4 in the Ministry for Environment Good Practice Guide for Assessing and Managing Odour – 2016[1] (MfE odour GPG), reproduced below, describes the sensitivity of receiving environments to odour impacts. Note that there is a similar table in the MfE GPG for dust.

[1] Ministry for the Environment. 2016. *Good Practice Guide for Assessing and Managing Odour*. Wellington: Ministry for the Environment.

Table 4: Types of land use and the general sensitivity of the receiving environment

Land use	Rating	Reasons for sensitivity
Hospitals, schools, childcare facilities, rest homes, marae	High	People of high sensitivity (including children, the sick and the elderly) are exposed, and/or People are likely to be exposed continuously (up to 24 hours, seven days a week).
Residential	High	People of high sensitivity (including children and the elderly) are exposed. People expect a high level of amenity in their home and immediate environs (ie, curtilage). People may be present all times of the day and night, both indoors and outdoors. Visitors to the area are unfamiliar with any discharges and are more likely to be adversely affected (which can cause embarrassment to residents and raise awareness of the problem).
Open space recreational	Moderate to high	These areas are used for outdoor activities and exercise, in circumstances where people tend to be more aware of the air quality. People of all ages and sensitivity can be present.
Tourist, cultural, conservation	High	These areas may have high environmental values, so adverse effects are unlikely to be tolerated.
Commercial, retail, business	Moderate to high	These areas have a similar population density to residential areas as people of all ages and sensitivity can use them. Commercial activities may also be sensitive to other uses (eg, food preparation affected by volatile organic compounds emissions from paint manufacture). There can be embarrassment factors for businesses with clients on their premises. Note: Need to consider the time of day, nature of activity, and likelihood of exposure (people are typically present less than 24 hours per day).

Land use	Rating	Reasons for sensitivity
Rural residential/ countryside living	Moderate to high	Population density is lower than in residential areas, so the opportunity to be adversely affected is lower. However, people of high sensitivity can still be exposed at all times of the day and night. Often people move into these areas for a healthier lifestyle and can be particularly sensitive to amenity issues or perceived health risks.
Rural	Low for rural activities; moderate or high for other activities	A low population density means there is a decreased risk of people being adversely affected. People living in and visiting rural areas generally have a high tolerance for rural activities and their associated effects. Although these people can be desensitised to rural activities, they may still be sensitive to other types of activities (eg, industrial activities).
Heavy industrial	Low	Adverse amenity effects tend to be tolerated, as long as the effects are not severe. Many sources discharge into air, so there is often a mix of effects. People who occupy these areas tend to be adult and in good physical condition, so are more likely to tolerate adverse effects, particularly if the source is associated with their employment. Note: Need to consider the time of day, nature of activity, and likelihood of exposure (people are typically present less than 24 hours per day).
Light industrial	Moderate	These areas tend to be a mix of small industrial premises and commercial/retail/food activities. Some activities are incompatible with air quality impacts (such as food manufacturers not wanting odours from paint spraying), while others will discharge to air. Note: Need to consider the time of day, nature of activity, and likelihood of exposure (people are typically present less than 24 hours per day).
Public roads	Low	Roads users will typically be exposed to adverse effects from air discharges for only short periods of time.

The rural zoned land adjacent to the site would be considered to have a 'moderate to high' sensitivity (as defined in the MfE GPGs) to odour and dust discharged from the landfill operations. The adjacent public roads would have a 'low' sensitivity, due to the infrequent and short duration of exposure on these roads.

Odours such as those discharged from landfill operations are primarily 'fresh waste' type smells from the tip face, and 'sulphur/'rotten egg' type odour from the landfill gas. These are considered offensive at rural dwellings, even at low levels. Therefore, these dwellings are considered to have a 'high' sensitivity to odours discharged from the landfill as defined in the MfE Odour GPG.

2.2 Meteorology

AB Lime has weather data collected from two weather stations, one adjacent to current/historic operations, and another on the AB Lime dairy farm due south of the landfill site (see Figure 2).

Figure 2 Location of AB Lime weather stations

Predominantly winds measured on the site weather station blow from the west and the south (see windrose in Figure 3). These winds blow air discharges from the site towards predominantly unoccupied land.

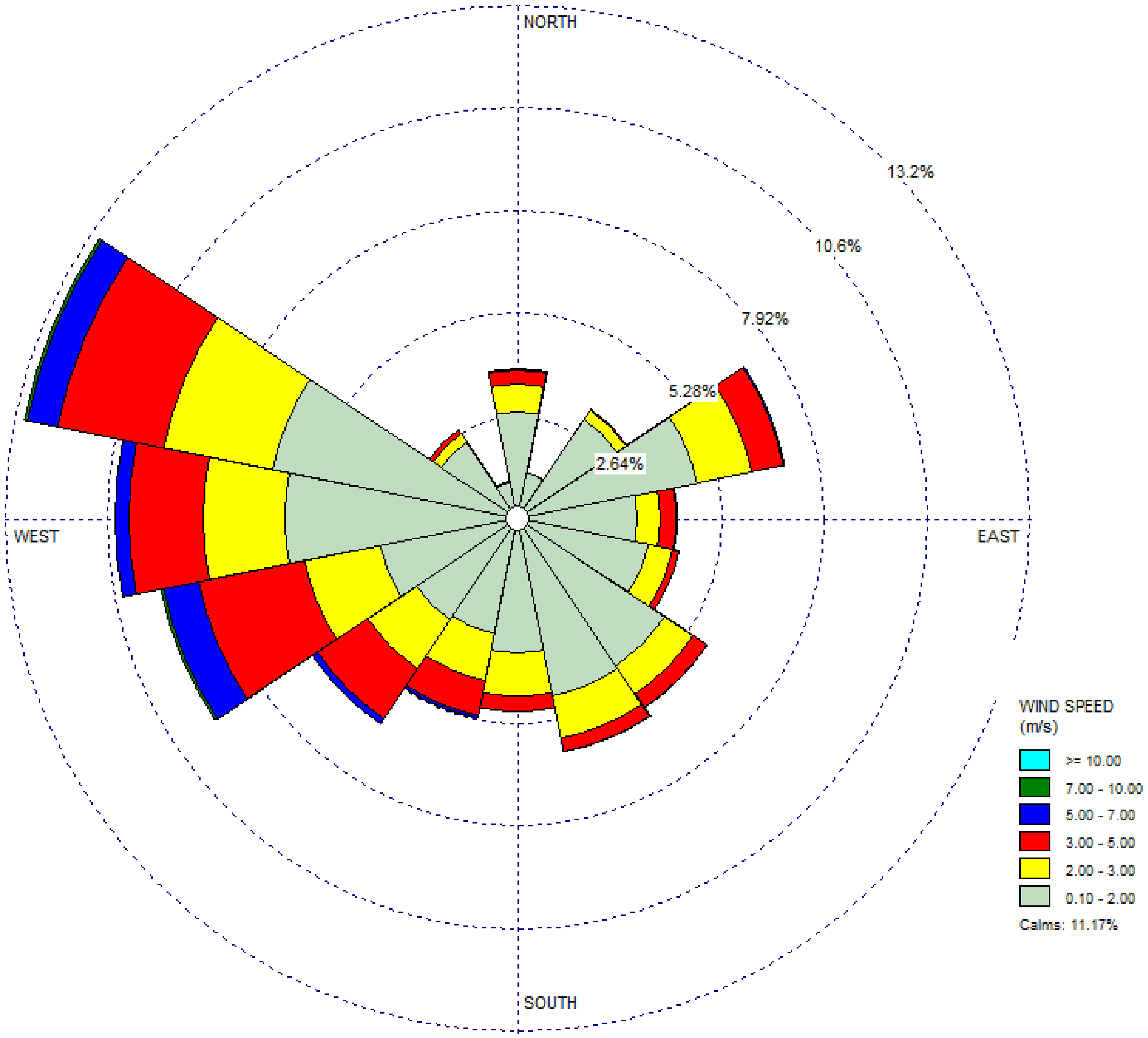


Figure 3 On-site Weather Station Windrose 2012 - 2014

Winds from the north – east (which would blow emissions from the site towards the nearest off-site dwellings) occur much less frequently.

It is noted that this on-site weather data is collected from a weather station that is approximately 3 m above ground level (installed on a short mast on top of a shipping container, see Figure 4). As a result of the short mast and its proximity to large trees (approximately 60 m to the west), the wind conditions may not be fully representative of the broader conditions across the whole site. The wind speeds will be lower as a result of the height above ground level (wind speeds increase with height above ground level as a result of reduced effects of surface roughness). This higher proportion of low wind speeds is apparent in the windrose presented in Figure 3.

Despite these limitations, the windrose provides a good representation of the wind conditions at the landfill emission points.

Figure 4 On-site Weather Station

AB Lime have a backup weather station located on the dairy farm just south of the site. Data collected from this station from April 2019 – April 2020 has been collated. A windrose of this data is presented in Figure 5.

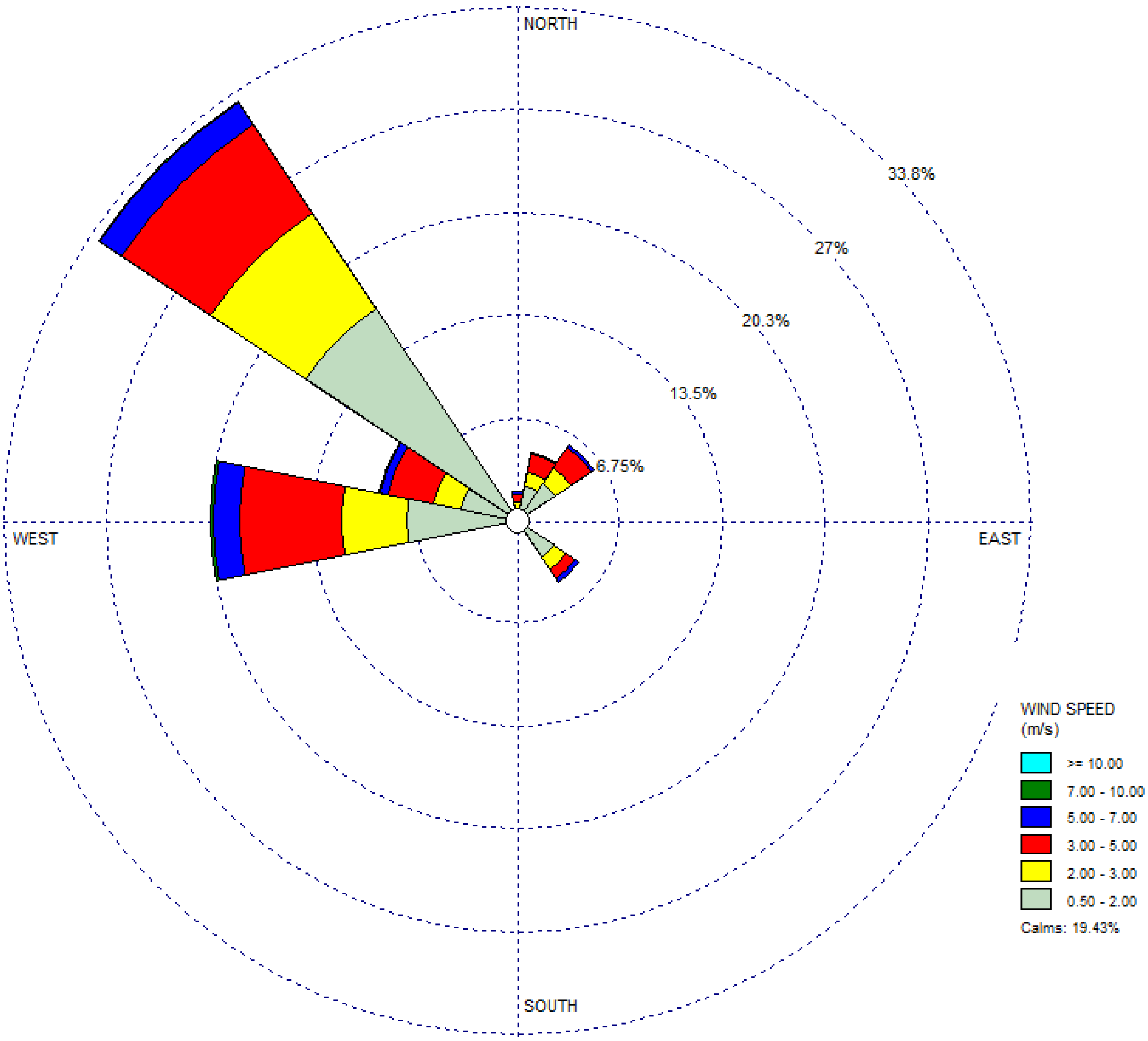


Figure 5 AB Lime Dairy Farm Weather Station Windrose – April 2019 – April 2020

This weather station records wind direction data in 16 cardinal directions. This weather station has not recorded any winds coming from the following cardinal directions – ENE, E, ESE, S, SW, and NNW. As it is very unlikely that no wind directions from these directions occurred over a whole year, this data is considered by the Applicant to be less reliable.

This weather station is also installed on the top of a shipping container with a height above ground level of approximately 3 m (see Figure 6). Therefore, the windspeeds recorded at this site are likely to be proportionally lower than that from a standard weather station with a 10 m mast. This weather station is located in a more open environment (as compared with the on-site weather station) but still has some structures which are likely influence the wind data recorded (see equipment platform southeast of the weather station in Figure 6).

Figure 6 AB Lime Dairy Farm Weather Station

There is very little publicly available meteorological data available in the broader region. Historic observations (daily at 9am) are available for a weather station in Winton, however given that these provide a very limited snapshot in time they bear little relevance to this assessment. The nearest weather station with good quality continuous data is the Invercargill Aero weather station (located at the Invercargill airport). This weather station is approximately 31 km south of the AB Lime site. A windrose for data collected at this site between 2010 and 2012 (inclusive) is presented in Figure 7.

Given the distance of this weather station from the AB Lime site and its coastal location, the wind patterns are unlikely to be very representative of those at the site. However, the data is presented for comparative purposes.

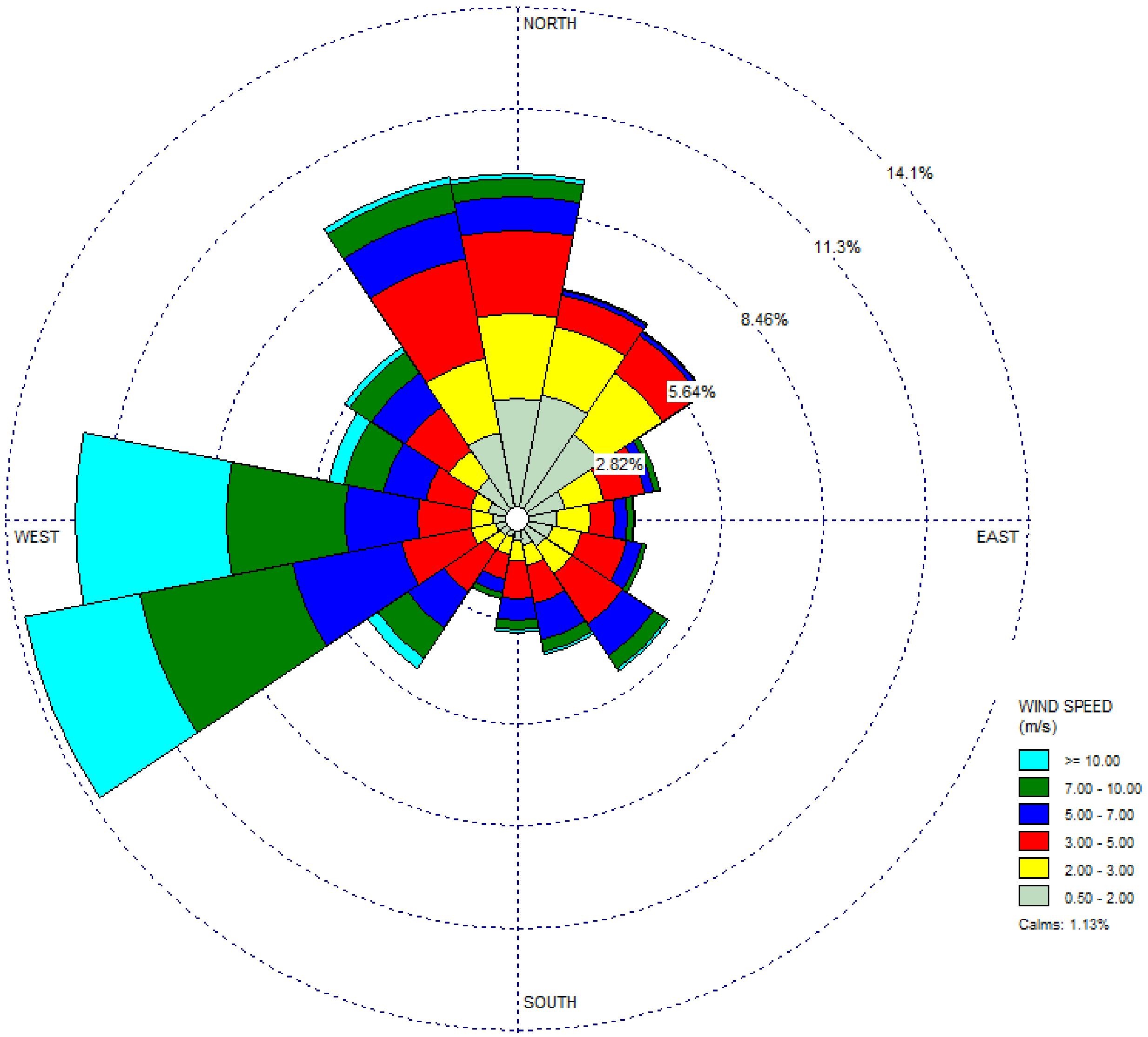


Figure 7 Invercargill Aero Windrose 2010 -2012

2.3 Topography

Historic odour complaints have occurred down valley (southeast – south) from the landfill during cold air drainage conditions. The local topography dictates the flow of air during these cold air drainage effects. Cold air drainage effects occur as the land cools overnight. As the land cools, the air above the ground surface also cools. Cold air is denser than warm air and therefore flows down slope following the decreasing elevation of the local topography (similar to how water flows over the land). This effect is particularly pronounced in valleys. Anabatic (up valley) and katabatic (down valley) air flows dominate mesoscale meteorology where the primary influence of air movement is land heating cooling effects, generally during low windspeed conditions.

The site is situated in a semi-circular valley on the side of a hill (see Figure 8). As the land cools overnight, the cold air drains down this valley towards the closest neighbouring receptors (see blue arrows on Figure 8). Due to this local topography and the cold air drainage directionality, during poor air dispersion conditions (low wind speeds, low temperature inversion layers, early mornings/late evenings), there is a much higher potential for adverse off-site air quality effects.

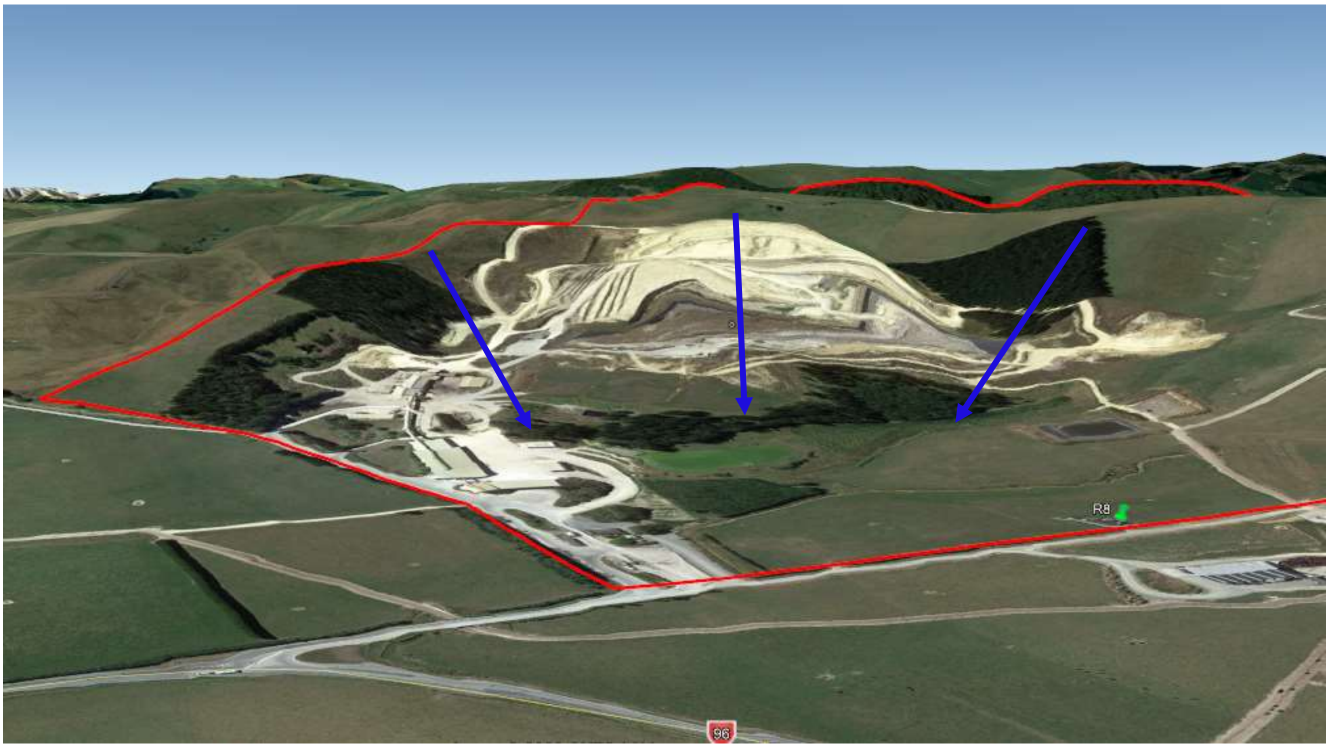


Figure 8 Topography – cold air drainage

2.4 Ambient Air Quality

The current ambient air quality is likely to be influenced by currently consented discharges to air from AB Lime's existing operations.

2.4.1 Odour

In a rural environment such as that surrounding the current AB Lime landfill, normal rural odours such as those from sheep and beef farming, silage, irrigation of effluent, application of fertiliser and other rural activities are expected and form the accepted existing environment for rural residents.

AB Lime operates a dairy farm due south of the landfill site. The milking sheds, effluent treatment plant, and silage storage pit associate with this farm are located within 100 m of the landfill's southern boundary. A similar dairy milking operation and associated silage storage pit exists approximately 800 m southwest of receptor R6. These dairy farm operations have the potential to generate odours which can be similar to some of the odour generated from the site. The treatment of dairy effluent in the washdown water, for example, can release hydrogen sulphide (**H_2S**). H_2S is an odorous gas which is also produced from landfill activities. Similarly, if the feed in silage pits is left for too long it can begin to decompose anaerobically which results in odour which could be considered similar to odour that may be associated with anaerobic decomposition of organic material in the landfill.

There is a potential that amalgamation could occur as a result of odours from the landfill mixing with the adjacent dairy farm operations (particularly at R4 where these activities are directly in line with one another).

2.4.1.1 Odour complaint analysis

There are 69[2] complaints recorded between November 2004 and March 2020 in AB Lime's complaint register. Of these 69 complaints, 65 are related to odour. Of these 65 odour complaints identified in AB Lime's register, 51 were not investigated by way of a site visit from Environment Southland. A total of 4 complaints have resulted in enforcement action. The complaint register includes both complaints that were phoned in directly to AB Lime and complaints that came through Environment Southland (ES). Three of the complaints have been related to rubbish and one is related to dust (the dust complaint was related to very early operations in 2004).

AB Lime's complaint register records information about the complaint and subsequent investigations. Table 2, Table 3 and Table 4 contain a summary of various aspects of the complaint record.

Table 2 presents a summary of complaint investigation outcomes, both from AB Lime's internal investigations and ES investigations. A large percentage of the odour complaints were not investigated by ES (78%). This is generally a result of:

- The complaint being made directly to AB Lime with AB Lime reporting the complaint to ES at a later time;
- The complainant declining the offer for ES to attend and investigate the complaint; or
- ES not attending for some other reason.

Of the 13 occasions when ES are recorded as visiting the site, on 9 occasions odour was detected beyond the boundary of the site by ES. Of these nine, only 4 incidents were recorded as being offensive or objectionable and resulted in enforcement action.

All of the complaints, bar one, are recorded as being investigated by AB Lime. Of these investigations 20% of the investigations confirmed odour off-site and 13% are recorded as possible odour off-site. For the remainder, AB Lime could not find/detect off-site odour associated with the complaint.

Table 2 Odour Investigation Summary

Investigation Outcome	Count
ES did not visit	51
Investigated by ES - odour detected offsite	9
Investigated by ES - no odour detected off-site	4
Investigated by ES – odour detected which resulted in enforcement action	4
Investigated by AB Lime - odour observed by AB Lime	13
Investigated by AB Lime - no odour observed	43
Investigated by AB Lime – possible odour off-site	8

Overall, only a small number of these complaints have resulted in independently confirmed adverse off-site effects. It is noted that as many complaints were anonymous, were not able to be investigated immediately due to delays in receiving the complaint, and/or were reported by the complainant as occurring for a brief period of time, it is possible that detectable odour has been present off-site more frequently, but was not able to be validated by an external party.

[2] Note that some of the complaint records relate to a series of complaints at or about the same date

Figure 9 summarises the location of complaints received (where known). In Figure 9 the red markers indicate the approximate location of the complaint and the number of complaints that have occurred from that location. Approximately 40% of the complaints have been received from unknown locations or anonymous complainants.

Figure 9 Location of Complaints

Figure 9 shows that primarily the complaints (where the location is known) occur from the closest dwellings not owned by AB Lime. Note that the 13 recorded complaints at the R13 location occurred prior to 2011 before AB Lime acquired this property. These complaints all occur down valley of the site where cold air drainage effects are likely to carry odour generated on the site towards these dwellings.

There are three complaints recorded from approximate locations beyond ~2 km from the active working area at the landfill. ES investigated the complaint near the intersection of Bennet and Gap Roads and could detect odour at this location. The other two complaints were not verified by either AB Lime or ES.

Based on an analysis of the AB Lime complaint record, the likely source of the odour has been determined (see Table 3). Where sufficient information is available; NZ Air has categorised the likely source of the odour based on the odour character detected and results of investigations made by AB Lime. The source of the odour has been categorised as unknown for 38% of the complaints. Note that where no alternate information is available, most complaints received after hours have been assumed to be landfill gas, as in most cases daily cover is in place and it is unlikely that odour from the waste placed in proceeding day(s) is the source of the odour.

Table 3 Complaints by Likely Source (Odour Complaints Only)

Likely source of odour	Count
Landfill gas	18
Fresh waste	8
Excavation into landfill	4
Movement of waste	3
Special waste	5
Unknown	25
Other	2
Total	**65**

Based on this analysis it is likely that the primary source of historic odour complaints (where known/estimated) from the site are associated with landfill gas emissions from the site. Approximately 50% of the likely sources relate to on-site waste handling and processing activities. In response to these incidents AB Lime modified site practices to limit off-site odour nuisance effects.

Table 4 presents the time of day where complaints were made. The majority of complaints have occurred in the early morning or late evening. Nearly all of these complaints have been correlated to periods of calm or light wind speeds. AB Lime have identified meteorological conditions where complaints are more likely to occur, and these include early morning inversion layer conditions and low wind speeds. It is likely that air movement during these calm conditions will be dominated by cold air drainage effects and as such air will drain down valley towards the nearest complainant properties. The immediate terrain surrounding the on-site weather station (see Figure 10) will involve cold air drainage from the west/southwest, the wind direction recorded on-site during a number of complaints was from these directions. After draining past the weather station, the air will change direction and flow down the broader valley towards neighbouring receptors. This explains the variance between recorded on-site wind conditions and the location of the complaint relative to the site.

Table 4 Complaints by Time of Day (Odour Complaints Only)

Time of day	Count
Morning	20
Evening	26
Midday	3

Time of day	Count
Afternoon	3
Unknown	13
Total	**65**

Figure 10 Terrain near on-site weather station

2.4.2 Dust

In a rural environment such as that surrounding the AB Lime landfill there are a number of sources of nuisance dust that are considered normal in this location. These include unsealed roads, tilling paddocks, fertiliser spreading, dust emissions from exposed paddocks, and other horticultural or rural activities.

The consented AB Lime quarry and landfill both form part of the existing environment. AB Lime has industry standard dust mitigation measures on its site and as such is not a major contributor to nuisance dust emissions in the local environment. This is backed up by the absence of dust related complaints from site activities.

The landfill operations will be a smaller contributor to overall dust emissions from site activities primarily due to the smaller scale of fine material handling activities and shorter unsealed haul roads.

Overall, it is expected that there will be some nuisance dust present in the surrounding environment but at a level that is normal/expected in a rural environment such as that surrounding the site.

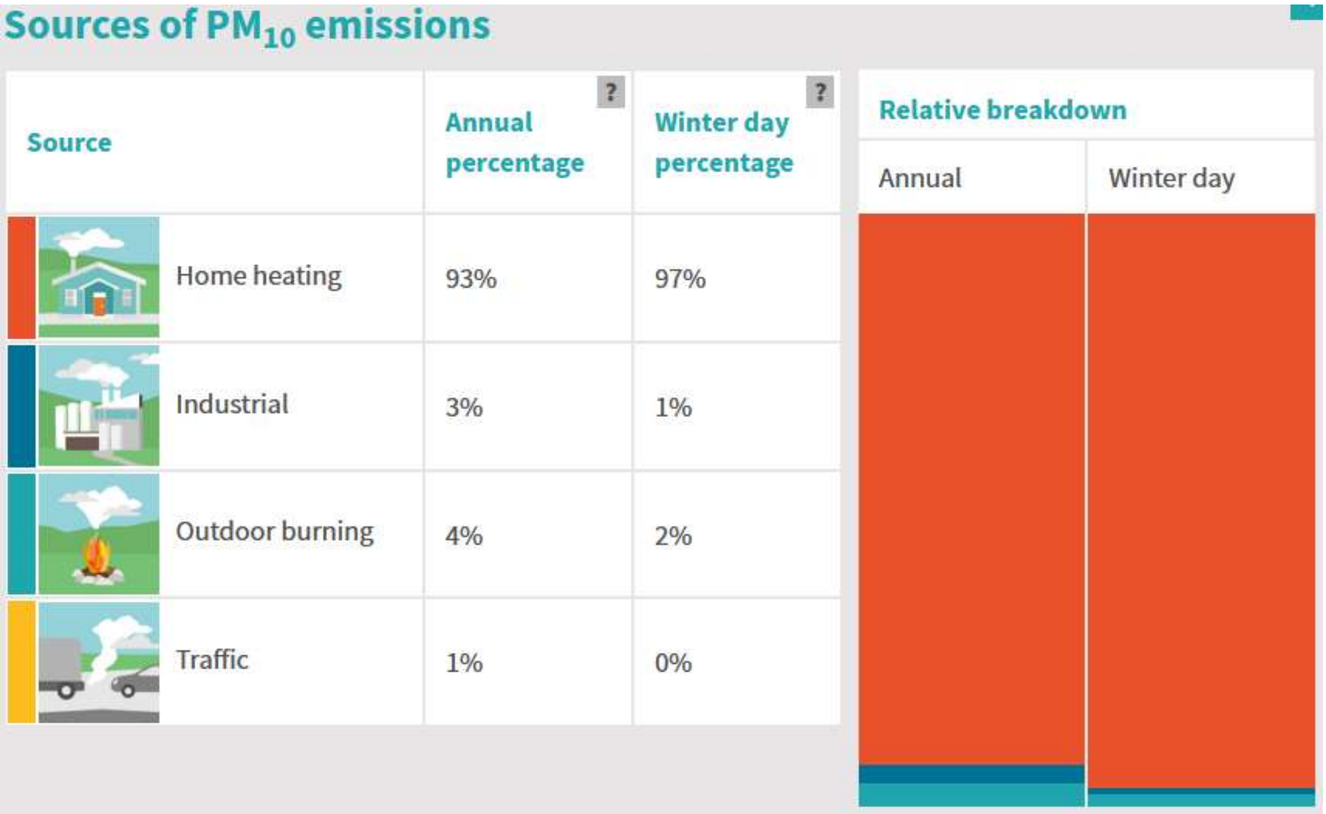
2.4.3 Products of combustion

The surrounding area is characterised by a low density of housing, relatively low traffic volumes and a general lack of other industrial combustion sources. It is therefore expected that any contribution to off-site ambient concentrations of products of combustion (carbon monoxide (**CO**), sulphur dioxide (**SO_2**), particulate matter less than 10 microns in diameter (**PM_{10}**), and nitrogen dioxide (**NO_2**)) from these sources will be low.

The consented landfill gas flare and coal fired lime kilns are therefore likely to be the principal source of SO_2 emissions in the surrounding environment. Nearly all of the sulphur in the coal and H_2S in the landfill gas will be converted to SO_2 during combustion in the lime kilns/landfill gas flare. Likewise, PM_{10}, NO_2 and CO will be emitted from these combustion sources. It is important to note that the current AB Lime quarry and landfill are legally established and its associated discharges to air are currently permitted under the current air discharge consents. These discharges therefore form part of the existing/receiving environment and it is important to note that these consents have another 18 years before their expiry.

The nearest township to the site is Winton. Winton is a small township with a population of approximately 2,100 people. ES has been monitoring PM_{10} in Winton since 2013, and records show that exceedances of the National Environmental Standard for PM_{10} occurred once in 2016 and once in 2017 in Winton.

Figure 11 demonstrates that the principal source of PM_{10} in Winton is emissions from home heating. The land immediately surrounding the AB Lime site is sparsely populated, with a much lower density of homes which are likely to use fires for home heating. Therefore, it is anticipated that ambient PM_{10} and $PM_{2.5}$ concentrations will not be as high as those in the Winton township.



Sources of PM_{10} emissions

Source	Annual percentage	Winter day percentage
Home heating	93%	97%
Industrial	3%	1%
Outdoor burning	4%	2%
Traffic	1%	0%

Figure 11 Winton PM10 Breakdown[3]

ES has been monitoring $PM_{2.5}$ in Winton since May 2019. Last winter the monthly average peaked at 8.6 µg/m^3 in July 2019. The limited amount of $PM_{2.5}$ monitoring to date is within the applicable national environmental standards and guidelines.

The AB Lime site is not within a gazetted airshed. The nearest gazetted airshed is in Invercargill, approximately 29 km to the south of the site.

To be conservative, off-site background concentrations of PM_{10} and NO_2 have been estimated using the NZTA background air quality estimator[4]. Background concentrations of CO have been conservatively estimated using the default background values in the Ministry for the Environment's (MfE) Good Practice Guide (GPG) on Assessing Emissions to Air from Industry[5]. The background concentrations used are presented in Table 5. Note that it has been assumed that the background concentrations of SO_2 are negligible given the lack of any SO_2 discharge sources in the surrounding environment.

[3] Source LAWA: https://www.lawa.org.nz/explore-data/southland-region/air-quality/winton/

[4] https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/tools/air-quality-map/

[5] Ministry for the Environment Good Practice Guide for Assessing Discharges to Air from Industry, 2016

Table 5 Background Ambient Air Quality

Pollutant	Averaging Period	Background Concentration (µg/m^3)
NO_2	1-hr	37
	24-hr	23
PM_{10}	24-hr	21
	Annual	10*
CO	1-hr	5,000
	8-hr	2,000

*The NZTA estimator does not contain an PM_{10} annual average, therefore NZ Air have conservatively estimated this value based on other rural background concentrations.

3. Overview of Site Activities

A detailed description of the site activities is included in Section 3 of the main AEE document. However, the following provides a brief overview of the site activities to provide context to this assessment:

a) Vehicles transporting refuse, cover and/or construction material to and from the site do not enter the site prior to 7.45 am or leave after 6.15 pm on any day;

b) Other landfilling operations (such as placing cover, maintenance etc.) are undertaken during operating days between 7.00 am and 6.15 pm;

c) Gates are locked after hours;

d) Access to the site for waste disposal is permitted Monday to Saturday: 8 am to 6 pm

e) Hours may be shortened over the winter period (May to October);

f) Waste is only delivered to the site in vehicles dedicated specifically for the transport of solid waste, and which have been given prior authorisation to access the site by AB Lime. All landfill users and waste carriers are required to complete a formal application form for waste acceptance and sign a Landfill Users access agreement to authorise landfill loads/users and document waste acceptance. The landfill is not open to the general public for the disposal of waste. The types of waste that are able to be accepted at the AB Lime landfill include:

    - Domestic;
    - Industrial;
    - Commercial;
    - Clean fill;
    - Medical waste only in accordance with NZS 4304:2002 "Health Care Waste Management";
    - Asbestos in accordance with the Health and Safety in Employment (Asbestos) Regulations 2016;
    - Methamphetamine contaminated household wastes that have an average contamination of below 100ug/100cm^2;
    - Difficult wastes that require special handling e.g. Cess pit sludge, offal, bulky items in minor quantities; and
    - Acceptable Aluminium Dross Waste

g) Waste streams defined as 'Special Waste' include:

    - Putrescible waste from commercial or industrial sources, such as produce, fish or animal waste; sludge, septage, mud trap and grease trap waste; odorous green waste and woody waste;
    - Asbestos-containing waste;
    - Medical waste – in accordance with "Healthcare Waste Management" standards;
    - Methamphetamine contaminated furnishings;
    - Treated Hazardous waste that meets that Hazardous Waste criteria.
    - Aluminium dross; and
    - Emergency waste required to be disposed of by the Ministry for Primary Industries (MPI) under special permit.

h) Discretionary waste becomes acceptable waste with the issue of a special permit and is covered in more detail under the Landfill Operations Management Plan;

i) Over the last 16 years the average annual waste acceptance rate has slowly increased (based on the trend line in Figure 12) and the landfill is currently accepting approximately 60,000 tonnes per annum;

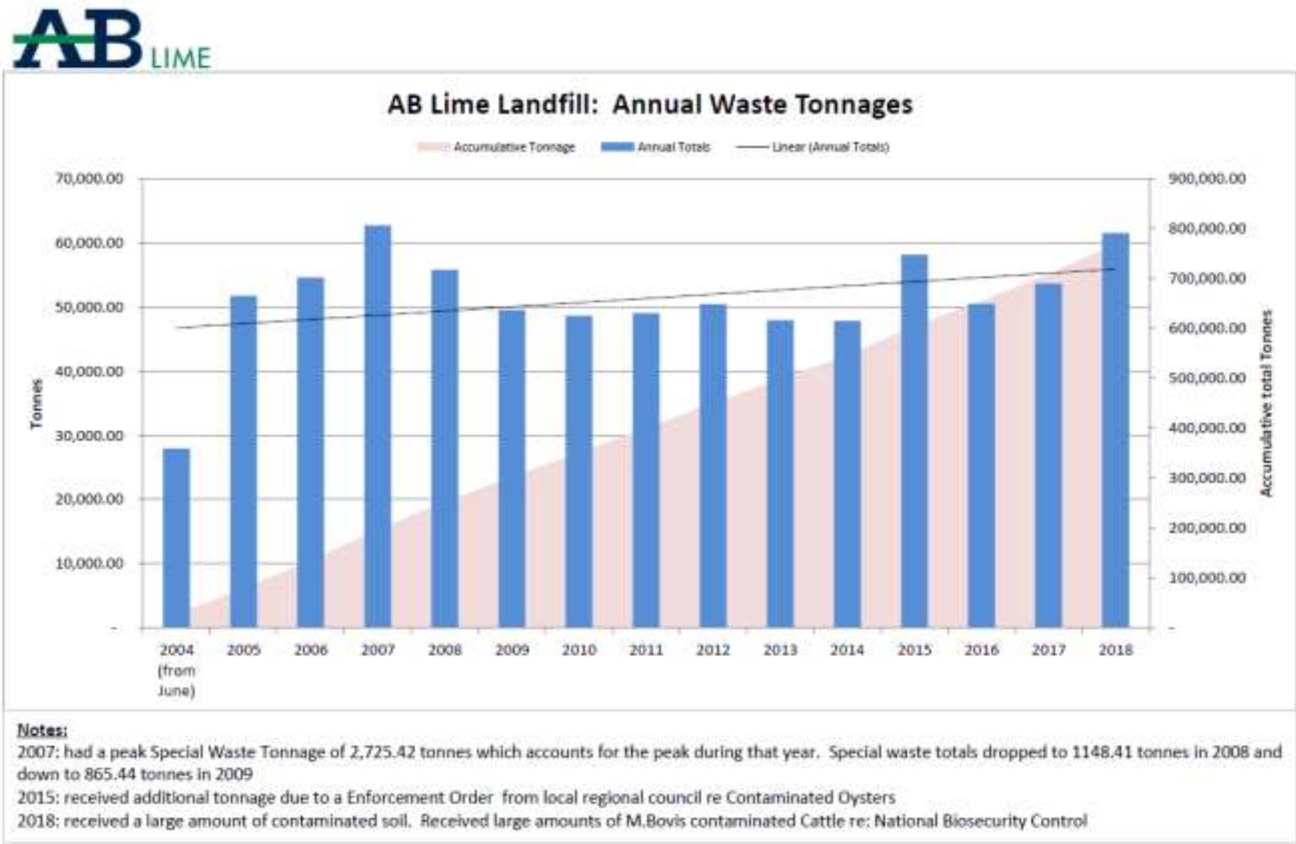


Figure 12 Annual Waste Acceptance Rates

It is acknowledged that this waste acceptance rate is well below the currently consented 100,000 tonnes per annum. However, AB Lime is seeking to remove the existing 100,000 tonnes per annum limit to allow for an elevated increase in waste acceptance rates to occur with future operations or community needs. As such, increased air quality management and mitigation is proposed as a part of this application.

j) The following speed limits apply to the landfill site:

- Sealed roads - 30 km/hr
- Unsealed roads - 15 km/hr

k) Entry to the site is via Bend Road (via Cahill Road and the Winton-Hedgehope Highway/State Highway 96). All vehicles entering the site and transporting waste are required to stop and register at the weighbridge.

The weighbridge operator instructs all transporters to adhere to the directions of the Pointsman at the working face. The Pointsman:

- Directs vehicles/transporters of waste to the appropriate location to offload;
- Instructs the vehicles to reverse to the offloading area where it is safe to do so, and discharge their load; and
- Visually inspects loads as they are offloaded to ensure compliance with Waste Acceptance Criteria.

The landfill is designed to be sequentially filled in a series of areas, i.e. cells. As of April 2020, fifteen (15) Areas have been filled as shown on drawing IZ000400-1000-NG-DRG-1012. The future filling programme for Areas 15 onwards is shown on drawing IZ000400-1000-NG-DRG-1012.

l) The working face, also known as the open face or operating face, is the area where the waste is spread and compacted. The area of the working face, i.e. exposed refuse, is kept to a practical minimum having consideration to the quantity of waste entering the site, maintenance of optimum compaction and health & safety requirements.

m) A bulldozer is used to spread the waste at the open area of the working face in 300 mm to 500 mm thick layers. A refuse compactor is then used to compact the waste layer to target refuse density of 0.8 tonnes/m^3.

n) At the end of each working day the waste is covered by a daily cover layer. Daily cover is generally to be replaced by intermediate cover in any area of an active cell where a new covering lift of waste is not planned within the next seven days, although the precise timeframe may vary according to prevailing conditions. Daily cover is broken up before filling continues to aid the movement of leachate and gas within the landfill.

o) Intermediate cover has the same objectives as daily cover, i.e. to control nuisances such as litter, odour and vermin, but in addition, intermediate cover should reduce the infiltration of rainfall, help prevent the escape of leachate and landfill gas, and be functional over a prolonged period of time (e.g. weeks or months). Where odour control is an issue and/or active landfill gas extraction is warranted, the intermediate cover may need to be replaced by a temporary capping.

p) Finally, permanent capping is placed over the landfill cell. The landfill permanent cap seals the underlying landfill waste to minimise infiltration of surface water, which would generate more leachate, and to prevent discharge of landfill gas to the atmosphere in an uncontrolled manner.

Table 6 provides a summary of the cover and capping proposed at the AB Lime landfill.

Table 6 Summary of Cover and Capping Types for the AB Lime Landfill, Thickness and Material Type

Cover/Capping Type	**When used**	**Material type (typical) and thickness**
Daily cover	Each day	150 mm minimum thick soil
Intermediate cover	>7 days	300 mm minimum thick low permeability soil
Temporary capping	>3 months	600 mm minimum thick low permeability soil
Permanent capping	As required	See consent conditions

q) Landfill gas that is generated in the waste mass is collected by a series of landfill gas wells. This gas is piped to a landfill gas flare and combusted at temperatures in excess of 750 ºC;

r) Leachate drains by gravity from the collection systems in the landfill to a concrete leachate storage tank. There is an aerator in this leachate storage tank which facilitates aerobic conditions in the leachate. From this storage tank the leachate is pumped into tankers and transported off-site for disposal (currently at a local wastewater treatment plant);

s) All vehicles which enter the active landfilling area are required to exit the site via the wheel wash;

NB refer to Section 4.1.2 of the main AEE document for an overview of the landfill capacity and lifespan.

4. Existing and Proposed Discharges to Air

The landfill currently discharges air pollutants to air in accordance with their existing resource consents. Future proposed operations on the site will continue to discharge pollutants to air. With appropriate management techniques identified throughout this technical memo and the Landfill Air Quality Management Plan a removal of the current limit for waste acceptance should not result in any additional air pollutants (see Section 8):

- Odour;
- Dust;
- Landfill gas (consists primarily of methane (**CH_4**), carbon dioxide (**CO_2**) and trace amounts of hydrogen sulphide (**H_2S**));
- Products of combustion including:
  - Nitrogen Dioxide (**NO_2**);
  - Carbon Monoxide (**CO**);
  - Particulate matter with a particle diameter of less than 10 µm (**PM_{10}**); and
  - Sulphur Dioxide (**SO_2**).

There is also a minimal potential for discharges of the following to air, although it is noted that it is very unlikely that there will be any increase in the potential for discharges to air of these pollutants, as these waste streams are currently consented:

- Airborne pathogens from medical waste;
- Methamphetamine and toxic volatile organic compounds (**VOCs**) such as: acetone, benzene, isopropanol, from meth contaminated waste;
- Airborne asbestos fibres; and
- Toxic fumes and dust from aluminium dross.

4.1 Health Effects

The MfE Ambient Air Quality Guideline report provides a good summary of potential health effects from the inhalation of products of combustion, and these are summarised below.

4.1.1 Carbon Monoxide

*"When inhaled, CO combines with haemoglobin (**Hb**), the blood's oxygen-carrying protein, to form COHb. In this state the Hb is unable to carry oxygen (**O_2**). It takes about 4 to 12 hours for CO concentrations in the blood to reach equilibrium with the CO concentration in air, so any fluctuations in the ambient CO concentrations are only slowly reflected in the COHb levels in humans. High exposures to CO can cause acute poisoning, with coma and collapse occurring at COHb levels of over 40%. Ambient exposures to CO are several orders of magnitude lower than those associated with acute poisoning. However, some exposures in urban settings have been shown to adversely affect the heart, brain and central nervous system. Adverse cardiovascular effects of CO inhalation include decreased O_2 uptake and decreased work capacity. Those with angina may suffer decreased exercise capacity at onset of angina, and increased duration of angina. Adverse neurobehavioral effects of CO include a decrease in vigilance, visual perception, manual dexterity, ability to learn and perform complex sensorimotor tasks in healthy individuals, and reduced birth weight in non-smoking mothers."*

4.1.2 PM_{10} and $PM_{2.5}$

"The major health effects from airborne particles are:

- *increased mortality aggravation of existing respiratory and cardiovascular disease;*
- *hospital admissions and emergency department visits;*
- *school absences;*
- *lost work days; and*
- *restricted activity days.*

People most susceptible to the effects of particles include the elderly; those with existing respiratory disease such as asthma, chronic obstructive pulmonary disease and bronchitis; those with cardiovascular disease; those with infections such as pneumonia; and children. The results of epidemiological studies have provided no evidence for the existence of a threshold value below which no adverse health effects are observed."

4.1.3 Nitrogen Dioxide

"Exposure to NO_2 has been shown to cause reversible effects on lung function and airway responsiveness. It may also increase reactivity to natural allergens. Inhalation of NO_2 by children increases their risk of respiratory infection and may lead to poorer lung function in later life. Recent epidemiological studies have shown an association between ambient NO_2 exposure and increases in daily mortality and hospital admissions for respiratory disease. NO_2 has also been shown to potentiate the effects of exposure to other known irritants, such as ozone and respirable particles. There is some evidence that acute exposure to NO_2 may cause an increase in airway responsiveness in asthmatic individuals. This response has been observed only at relatively low NO_2 concentrations, mostly in the range of 400–600 µg/m^3. However, the findings of both clinical and epidemiological studies do not provide any clear quantitative conclusions about the health effects of short-term exposures to NO_2. The adverse health effects at low levels of NO_2 remain equivocal, with conflicting patterns of results obtained in both controlled exposure studies and in epidemiological studies. The contribution of NO_2 as one of a mixture of pollutants in the ambient environment has yet to be clearly defined."

4.1.4 Sulphur Dioxide

"Sulphur dioxide (SO_2) is a potent respiratory irritant when inhaled. Asthmatics are particularly susceptible. SO_2 acts directly on the upper airways (nose, throat, trachea and major bronchi), producing rapid responses within minutes. It achieves maximum effect in 10 to 15 minutes, particularly in individuals with significant airway reactivity, such as asthmatics and those suffering similar bronchospastic conditions. The symptoms of SO_2 inhalation may include wheezing, chest tightness, shortness of breath or coughing, which are related to reductions in ventilatory capacity (for example, reduction in forced expiratory volume in one second, or FEV_1), and increased specific airway resistance. If exposure occurs during exercise, the observed response may be accentuated because of an increased breathing rate associated with exercise. A wide range of sensitivity is evident in both healthy individuals and more susceptible people, such as asthmatics, the latter being the most sensitive to irritants."

4.1.5 Hydrogen Sulphide

"H_2S is a colourless gas with a distinctive odour at low concentrations. Humans detect it at levels of 0.2–2.0 µg/m^3, depending on its purity. This is the odour threshold, which is defined as the concentration at which 50% of a group of people can detect an odour. At about three to four times this concentration range it smells like rotten eggs. H_2S causes nuisance effects because of its unpleasant odour at concentrations well below those that cause health effects. Continuous exposure to H_2S reduces sensitivity to it.

In acute exposures H_2S acts on the nervous system to cause a range of symptoms characterised as H_2S intoxication. At levels above 15 mg/m^3 it causes eye irritation, and above 70 mg/m^3 it causes permanent eye damage. Above 225 mg/m^{3}it paralyses olfactory perception so that the odour is no longer a warning signal of the gas's presence. At concentrations above 400 ug/m^{3}there is a risk of pulmonary oedema, and above 750 mg/m^3 it over-stimulates *the central nervous system, causing rapid breathing, cessation of breathing, convulsions, and unconsciousness. At 1400 mg/m^3 it is lethal.*

Adverse effects have been observed in occupationally exposed populations at an average concentration of 1.5–3.0 mg/m^3. Symptoms include restlessness, lack of vigour, and frequent illness. In occupationally exposed groups, at levels of 30 mg/m^3 or more 70% complained of fatigue, headache, irritability, poor memory, anxiety, dizziness and eye irritation."

4.2 Comparison

AB Lime currently holds two air discharge consents for its current activities:

- Limeworks air discharge consent – AUTH-205862-01; and
- Landfill air discharge consent – AUTH-201351

The limeworks air discharge consent permits the discharge of dust to air from the quarry operations. It also permits the discharge of products of combustion to air from two coal (or LFG) fired lime drying kilns. It is not proposed that any changes will be made to the consented quarry activities or its air discharge consent. Therefore, the air discharges associated with these consented site activities will not change.

The proposed changed/new landfill air discharge consent conditions are presented in Section 7 of the main AEE document for this proposal. The primary change to the proposed processes and associated discharges to air is the removal of the 100,000 t/yr limit on waste acceptance rates. With the removal of this limit, AB Lime will have the capacity to accept a larger amount of waste.

With an increased rate of waste acceptance, the amount of waste transported to and handled on-site in any given time period may increase. The landfill cells will fill up faster and the surface area of the covered/capped waste mass will progress faster than it was predicted to under the current consent conditions.

It is important to note that it is unlikely that the landfill will be completely filled within the duration of this consented (requested 35 year term). A further air discharge consent is likely to be required in the future that will be based on the potential effects at that time. Landfills are designed to accept large volumes of waste (as this is the most economically viable option) and continue to discharge air contaminants (primarily LFG) long after the void is completely filled as a result of decomposition of the waste mass over time.

With this increased rate of waste acceptance the following additional discharges to air <u>may</u> occur:

- A higher mass emission of 'fresh waste' odour from the increased transport of waste to site and handling of waste at the tip face;
- A higher rate of fugitive LFG emissions through the capping and open faces;
- A higher production rate of LFG and associated flaring from the larger landfill mass (as compared with the predicted filling and capping rate under the existing consent). As a result of this increase in the volume of gas being flared, there will be an increase in combustion products from the flaring operation;
- An increase in odour emissions (and potential minimal emissions of toxic air pollutants) from the larger volumes/increased rates of special waste acceptance and disposal; and
- An increase in nuisance dust emissions for increased traffic movements and material handling (primarily cover and capping materials) rates.

However, AB Lime is proposing to <u>reduce</u> off-site air quality impacts from current consented operations as a result of the following mitigation measures and consent condition changes:

- A reduction in the size of the open working area and open faces from historic operations to 1,000 m^2. This reduction in open faces and open working area will substantially reduce the amount of fugitive LFG releases from the working face. It will also reduce the amount of odorous leachate produced from the landfill due to a reduction in rainfall ingress into the waste mass.

- Improved waste placement procedures and cell design (as outlined in in the Landfill Operations Management Technical Memo).

- Improvement of the landfill gas extraction system to improve the percentage of LFG collected from the existing and future waste mass.;

- An improved, Landfill Air Quality Management Plan with staged management procedures designed to provide a proactive response to actual and potential effects at the boundary, such that effects at the nearest sensitive receptors are minimised/eliminated;

- Despite the fact that more LFG will be produced and will need to be disposed of via high temperature combustion, AB Lime will off-set the potential for increased emissions of combustion products from the site by reducing the consented SO_2 mass emission rates (in the limeworks air discharge consent). This reduction will be supported, in part, by using LFG to fuel the lime drying kilns such that the site's coal consumption rates are lowered. This will result in a net reduction in potential peak off-site concentrations of controlled pollutants (SO_2, PM_{10}, NO_2 and CO).

In this way AB Lime proposes to provide a net decrease in off-site ambient air quality effects as compared with the current consented activities, improving the local air quality.

5. Assessment Criteria

5.1 Odour

The main potential discharge to air from the proposed AB Lime landfill operations is nuisance odour. The odour rules, policies and objectives in the Southland Regional Air Plan (**SRAP**) refer to the 'offensive or objectionable' threshold for nuisance beyond the boundary of the activity. Therefore, for the purpose of this assessment, the assessment criteria for odour discharges is considered to be the 'offensive or objectionable' threshold.

A method for assessing 'offensive or objectionable' odour involves undertaking an assessment using the FIDOL (Frequency, Intensity, Duration, Offensiveness and Location) factors, which is a technique commonly used throughout New Zealand.

The FIDOL criteria for assessing offensive and objectionable nuisance odour is described in Section 2.4 of the MfE odour GPG. Table 3 of the MfE odour GPG (reproduced below) provides a description of these FIDOL factors.

Table 3: Description of the FIDOL factors

Frequency	How often an individual is exposed to the odour.
Intensity	The strength of the odour.
Duration	The length of exposure.
Offensiveness/character	The character relates to the 'hedonic tone' of the odour, which may be pleasant, neutral or unpleasant.
Location	The type of land use and nature of human activities in the vicinity of an odour source.

The MfE odour GPG also contains a list of recommended assessment tools (in Table A2.2 – reproduced below) for preparing an assessment of effects for modifying discharges of odour to air from an existing facility. NZ Air has used a number of the relevant tools in this assessment.

Table A2.2: Selecting odour assessment tools for preparing or evaluating resource consents for proposed modifications to existing industrial or trade activity

Assessment tool	Priority based on effects		Comments
	Chronic	Acute	
Community consultation	High	–	Periodic meetings with community representatives from community associations. Look for anecdotal evidence of community feeling about odour effects.
	–	High	Assess how the proposed changes will affect plant performance.
Complaint records	High	–	Complaints that have been validated by an enforcement officer should be clearly identified. Complaints may also be substantiated (verified) based on wind direction or process records, or as simply registered but not confirmed. Assess how proposed changes might assist in reducing the level of complaint.
	–	High	Have any complaints been attributed to acute events? Assess how proposed changes will affect plant performance.
Industry/council experience	High	High	Experiences of the industry or regional council with other similar discharges.
Odour annoyance survey	High	Not applicable	Urban and semi-urban areas. Assess against per cent annoyed criterion. Assess how the proposed changes will reduce level of annoyance.
Meteorology and terrain assessment	High	High	Use to assess the potential for downwind adverse effects as a result of poor dispersion around terrain features, or in particular meteorological conditions.
Review emission control system(s)	Moderate	Low	Look for compliance with best practicable option (BPO), or industry codes of practice. Assess how proposed changes will affect plant performance.
Odour diaries	Moderate	Not applicable	Isolated areas with low population densities. Assess the frequency, duration, and strength of odour impact events and associated experiences over six months, or a longer time period if necessary, to encompass a specific season. Assess how the proposed changes will reduce level of annoyance.
Review of odour management plan and contingency procedures, risk assessment	Not applicable	High	What is the level of acceptable risk for uncontrolled odour discharges? Consider high-probability/low-impact events, and low probability/high-impact events. Is BPO being used? Assess how the proposed changes will affect plant performance.

5.2 Products of Combustion

The LFG flare and lime dryer kilns will continue to discharge products of combustion to air.

5.2.1 Sources of Air Quality Assessment Criteria

The Ministry for the Environment's Good Practice Guide on Assessing Emissions to Air from Industry[6] recommends an order of priority when reviewing air quality assessment criteria. This order of priority is as follows:

- Ministry for the Environment, Resource Management (National Environmental Standards for Air Quality) Regulations, 2004 (**NES**)[7];
- Ministry for the Environment, Ambient Air Quality Guidelines (2002 update) (**AAQG**)[8];
- Regional Air Quality Targets (**RAQT**); and,
- World Health Organisation Air Quality Guideline (**WHO AQG**) Global Update 2005[9].

5.2.2 National Environmental Standards

The MfE promulgated the NES as regulations under the Resource Management Act (**RMA**) on 6 September 2004. These regulations are based on the potential for health effects. These health effects are described in the MfE New Zealand AAQG. The NES applies standards to five air pollutants, being PM_{10}, CO, NO_2, SO_2, and ozone (**O_3**).

The NES also places restrictions on landfill gas emissions and flaring (Regulations 25 – 27). AB Lime's compliance with these regulations is assessed in the Landfill Gas Technical Memo. Compliance with these Regulations is achieved in part by the proposed use of LFG produced on-site as a fuel in the lime drying kilns.

Table 7 presents the NES ambient air quality assessment criteria relevant to this assessment.

Table 7 Ambient Air Quality Standards Applicable to Regulation 13 of the NESAQ

Contaminant	Threshold Concentration	Number of exceedances allowed
Carbon monoxide	10 milligrams per cubic metre expressed as a running 8-hour mean	1 in a 12-month period
Nitrogen dioxide	200 micrograms per cubic metre expressed as a 1-hour mean	9 in a 12-month period
Ozone	150 micrograms per cubic metre expressed as a 1-hour mean	None
PM_{10}	50 micrograms per cubic metre expressed as a 24-hour mean	1 in a 12-month period
Sulphur Dioxide	350 micrograms per cubic metre expressed as a 1-hour mean 570 micrograms per cubic metre expressed as a 1 -hour mean	None

In addition to the standards above, Regulation 17 of the NES states:

"A consent authority must decline an application for a resource consent (the proposed consent*) to discharge PM_{10} if the discharge to be expressly allowed by the consent would be likely, at any time, to increase the*

[6] Ministry for the Environment Good Practice Guide for Assessing Discharges to Air from Industry, 2016
[7] Ministry for the Environment, Resource Management (National Environmental Standards for Air Quality), Regulations 2004
[8] Ministry for the Environment, Ambient Air Quality Guidelines (2002 update)
[9] Air quality Guidelines for Europe Second Edition, 2000

concentration of PM_{10} (calculated as a 24-hour mean under Schedule 1) by more than 2.5 micrograms per cubic metre in any part of a polluted airshed other than the site on which the consent would be exercised."

The AB Lime site is not within a polluted airshed, and for this reason NZ Air has not assessed the potential increase in PM_{10} concentrations against the NES Regulation 17 requirements.

5.2.3 Ambient Air Quality Guidelines

The AAQG were published by the MfE in 2002 following a comprehensive review of international and national research. The AAQG criteria provide the minimum requirements that ambient air quality should meet in order to protect human health and the environment.

AAQG levels for pollutants and averaging periods not superseded by the NES are still relevant and should be considered as part of any assessment. The AAQG criteria set for the protection of human-health are presented in Table 8.

Table 8 Ambient Air Quality Guidelines Relevant to Assessment

Pollutant	Threshold Concentration ($\mu g/m^3$)	Averaging Period
NO_2	100	24-hr
SO_2	350 120	1-hr 24-hr
CO	30,000	1-hr
PM_{10}	20	Annual

5.2.4 Regional Air Quality Targets

Policy 4.3.1 in the SRAP contains a copy of the historic MfE 1994 guidelines (now superseded by the 2002 guidelines). Given that these are outdated guidelines, little weighting has been applied to these in this assessment.

6. Current and Proposed Mitigation Measures

As a part of this application a comprehensive landfill air quality management plan (**LAQMP**) has been developed. This management plan is attached as Appendix U to the main AEE document and contains a detailed description of the proposed mitigation measures for potential discharges to air from the landfill operations.

To provide for a high level of air discharge control from the landfill operation, the LAQMP includes a staged mitigation approach. This provides for multiple factors of safety. Mitigation/management procedures are broken down to three levels (**Level 1**, **Level 2**, and **Level 3**). It is expected that Level 1 mitigation will be sufficient to mitigate the potential for off-site air quality effects during normal operating conditions. However, should Level 1 mitigation be insufficient to control air discharges from the source/activity, then Level 2 mitigation will be applied. If Level 1 and Level 2 controls are still not controlling air discharges from the site, Level 3 mitigation will be applied. Level 3 mitigation is a final resort and in many instances involves ceasing the emitting activity. This staged mitigation approach will ensure that the air discharges are controlled to a point that the site activities are not causing an adverse effect at dwellings or sensitive locations beyond the boundary of the site.

Note that in many cases not all the Level 2 or Level 3 mitigation measures will need to be applied when boundary monitoring/off-site feedback triggers the requirement to increase the level of mitigation. The mitigation measures are intended to be a tool box of available mitigation measures to be applied at the site management's discretion, dependant on the severity of the actual or potential effect.

The trigger points which mandate the requirement to increase the mitigation/management practices to a higher level are based on boundary and off-site monitoring results and/or community/Council feedback. Where one of the following occurs AB Lime is to consider increasing mitigation to the next level:

- Boundary nuisance odour or dust assessments indicate that there is detectable odour at the boundary of the site or observable dust crossing the boundary of the site;
- An adverse/observable nuisance odour/dust or toxic air quality effect is observed by an on-site staff member/contractor;
- Boundary H_2S sensors exceed the trigger points in **Section 10** of the LAQMP;
- An odour or dust observation has been called in from a neighbouring resident (as a part of the community engagement process);
- An air quality complaint has been made to the Regional Council or AB Lime has been called in from a neighbouring resident; or
- A Regional Council enforcement officer has observed nuisance odour or dust beyond the boundary of the site.

Ultimately the Landfill Air Quality Management Plan structure is aimed at mitigating adverse effects and provides a buffer before an off-site non-compliance occurs.

This level of air quality management is considered to be consistent with good practise air quality control for New Zealand landfill operations.

The Section below focuses on the proposed improvements to mitigation measures which will be implemented on-site. The same structure has been adopted for ease of referencing.

6.1 Odour

Nuisance odours generated from the landfill operations may cause offensive or objectionable effects beyond the boundary of the site if not managed carefully.

Based on current operations (as of April 2020) approximately 50% of the waste received on-site is organic waste. Organic waste has the potential to decompose and this decomposition process often releases offensive odours. Odour at the tip face and waste compaction zones is usually of a 'rotten cabbage' type odour. Site staff working in this environment will often become desensitised to the odour and therefore are less likely to notice odours associated with normal operations.

Currently, (as of April 2020) approximately 20% of the waste accepted at the landfill is 'special waste' which generally consists of highly odorous waste (Biosolids, animal hides, sump waste, dead animals, etc). Odour from these products is generally very offensive and as such a high level of odour mitigation is required for these products.

In short, the landfill receives waste that ranges from no odour emission potential to very odorous waste that is highly offensive.

Odour is also emitted from as a result of the anaerobic decomposition of the waste within the landfill. The principal odorous gas that is emitted from this process is H_2S which has a characteristic 'rotten egg' like smell. H_2S can be emitted from waste received at the tip face which has already begun to decompose anaerobically, from waste which is decomposing within the landfill cells (H_2S is often present in high concentrations in the LFG), and from the leachate. The control and management of H_2S emissions from a landfill is critical in managing off-site odour nuisance.

Essentially, landfill operations are inherently odorous and it is not possible to completely remove all odour emission from a landfill. Therefore, the control measures are critical to ensuring that nuisance effects do not occur beyond the boundary of the site.

6.1.1 Potential Odour Sources

The activities/processes which occur/will occur at the AB Lime landfill that have the potential to generate odour include:

- Transport of waste onto the site;
- Waste deposition, handling, and compaction at the tip face;
- Special waste handling;
- Landfill gas;
- Leachate collection and processing;
- Fugitive emissions from daily cover or final capping;
- Hazardous waste handling; and
- Combustion gases.

6.1.2 Site wide odour mitigation

Much of the current standard site operating procedures involve odour control aspects. However as is evidenced in the analysis of complaints (see Section 2.4.1.1), current control measures have at times failed to prevent offensive or objectionable odour beyond the boundary. Therefore, AB Lime propose to substantially increase the level of site-wide and activity specific odour mitigation.

Key additional site-wide odour mitigation measures include:

- Undertaking regular boundary odour observations during meteorological conditions which could result in odours on-site traveling towards the nearest off-site neighbours;

- Utilising automated alarms on the weather station data to provide real time alerts to site staff in the instance that meteorological conditions could blow emissions from the site towards the nearest neighbouring receptors. Utilising these alerts to better manage higher risk odour discharge activities on-site;
- Undertaking real time H_2S monitoring at the site boundary, between the landfill and the nearest off-site residences; and
- Limiting the tip face and exposed waste area to 1,000 m^2.

6.1.3 Transport of waste to site

Odour and/or dust can be discharged to air during the transport of waste to the site.

Much of the current controls with respect to odour controls from this source have been effective in the past. There are no recorded complaints which relate directly to waste transport to the site. Nonetheless, AB Lime are proposing a higher level of control for this activity than is currently employed on-site. Essentially all Level 2 and Level 3 controls are additional to current site mitigation and controls.

6.1.4 Waste deposition, handling and compaction at the tip face

The tip face is a key odour emission point at the site. During operational hours odour is emitted constantly in varying degrees from this emission point.

Waste spreading and compaction disturbs the waste profile and can result in elevated odour emissions from odorous waste. It can also enlarge the odour plume resulting in a higher potential for off-site effects.

6.1.4.1 Mitigation

Most of the Level 1 mitigation measures in Table 6 of the LAQMP are consistent with current site management practices. Additional Level 1 controls to that currently adopted on-site include:

- The size limit on the tip face.
- The separate tripping bay for odorous waste that is not special waste.
- Using staff as 'odour spotters' at the tip face.
- Increased LFG extraction in and around the tip face.

All Level 2 and Level 3 controls are additional to that currently adopted on-site.

6.1.5 Special Waste

Special Wastes are wastes that come in on permit and generally classified as Special Waste/Difficult Waste/Discretionary**.** These wastes include putrescible waste from commercial or industrial sources, such as produce, fish or animal waste; sludge, septage, mud trap and grease trap waste; odorous green waste and woody waste. Treated Hazardous waste also becomes acceptable if it meets that Hazardous Waste criteria identified in the Landfill Operations Management Plan. Discretionary waste becomes acceptable waste with the issue of a Special Permit.

Hazardous waste streams that are consented to be received by AB Lime are discussed in Section 6.2.

Special waste must be deposited in the landfill in accordance with the conditions and protocols outlined in the Landfill Operations Management Plan.

6.1.5.1 Mitigation

Special waste deliveries and disposal has been recorded as being a contributing factor to off-site complaints in the past. As such additional mitigation is proposed for this activity. Critical to the success of these controls will be the boundary odour observations and H_2S monitoring.

Most of the special waste Level 1 mitigation measures in Table 6 of the AQMP are consistent with current site management practices. Additional Level 1 controls to that currently adopted on-site include:

- Limiting the time any excavation into capped or covered existing waste mass is exposed for.
- There is to be no compacting or spreading of special waste after deposition into the designated pit.
- Prioritising intermediate cover of special waste deposition areas.

All Level 2 and Level 3 controls are additional to that currently adopted on-site.

6.1.6 Leachate

Odour emissions from the leachate are most associated with the anaerobic state of the leachate when it drains out of the waste mass. The anaerobic decomposition of the organic material in the water results in the evolution of odorous gases, primarily H_2S.

Leachate drains by gravity from the collection systems in the landfill to the concrete leachate storage tank.

The tank is sized for average flows after 35 years of waste filling and for peak flow in the early phases of the landfill. The leachate tank has a capacity of $675m^3$. The leachate tank has an aerator to maintain aerobic conditions within the leachate, reducing odours associated with any further anaerobic decomposition.

For transport off-site, leachate is pumped from a sump in the concrete tank to a tanker loading point. The tanker loading bay has a drain back to the leachate tank.

At times, leachate may be recirculated into the landfill to make use of the absorptive capacity of the waste and enhance microbial degradation. The re-injection system is designed to allow leachate to be pumped from the leachate tank directly to the landfill. Primarily the leachate will be tankered off-site.

Dissolved oxygen (**DO**) levels are monitored continually within the leachate tank to ensure that oxygen levels are sufficient to avoid odours.

6.1.6.1 Mitigation

Most of the leachate Level 1 mitigation measures in Table 6 of the LAQMP are new. Historically the leachate tank was not identified as a major source of odour from the site, however, in consultation with external experts, AB Lime identified this tank and the associated leachate handling activities to be a source of odour emissions from the site. Recently an aerator was installed along with a dissolved oxygen (**DO**) meter. This has reduced the potential for odour emissions from this source.

The proposed continuous monitoring of DO and H_2S at the leachate tank and the associated alarms will aid early identification of the potential for odour emissions from this source and provide a much higher level of odour mitigation than that historically undertaken at the site.

All Level 2 and Level 3 controls are also additional to that currently adopted on-site.

6.1.7 Capping

A full description of the landfill cover/capping design and process is included in the Landfill Operations Management Plan.

Currently inspections of the cap are carried out at least once every week and following significant storm events. The inspections check for:

- Vegetation die-off;
- Cracking of the cap surface;
- Subsidence and erosion;
- Leachate breakout through the cap; and
- Waste protruding through the cap.

Any defects that are noticed are remedied immediately and a report of the inspection and actions taken are forwarded to Environment Southland within two months of each inspection, or as agreed with Environment Southland.

It is generally accepted that wastes can be expected to settle up to 15-20%. Differential settlement of the waste over time may result in cracking of the cap and issues with drainage. This may result in escape of LFG to the atmosphere

If settlement of the cap is severe and results in cracking of the clay liner then the topsoil and knaprock protection will be removed (scrape from the surface and temporarily stockpiled). The clay layer will be either:

1) Be excavated, reworked, and compacted back into place, or
2) If cracking is well defined, cracks should be locally filled with bentonite pellets

If the daily cover, intermediate cover, or final capping does not remain airtight then odour and/or landfill gas can be released from the waste mass below.

6.1.7.1 Mitigation

Existing cap inspection and reporting as is required by the existing consent conditions and the NESAQ Regulations will continue. However, as an additional Level 1 control a portable gas detector will be used to identify any H_2S leaks/emission points.

Historically after hours complaints have been attributed to insufficient daily cover at the end of the day. The methodology for applying and breaking up daily cover is revised from that currently implemented. The thickness and methodology for applying daily cover at the end of day has been updated.

There are specific capping/cover investigation procedures proposed for when H_2S that is detected at the boundary by the boundary monitors. This monitoring and investigation procedure is additional to current site practices.

Once again Level 2 and Level 3 controls are additional to that currently adopted on-site.

6.2 Hazardous Waste Handling

As discussed earlier, the hazardous waste streams that are consented to be received by AB Lime include:

- Medical waste – in accordance with "Healthcare Waste Management" standards;
- Asbestos – In accordance with NZ Health and Safety at Work (Asbestos) Regulations 2016;
- Methamphetamine contaminated furnishings; and
- Aluminium dross.

A very small amount of this waste is accepted on-site. Historically any air discharges associated with this waste disposal have not resulted in adverse off-site effects. However, AB Lime is updating its documented material specific management procedures for handling and disposing of these hazardous waste streams. These updated procedures are included in the Landfill Operations Management Plan. These procedures also include strict controls such that any emissions to air of hazardous or toxic air pollutants are mitigated sufficiently to ensure worker safety, and the even lower risk of off-site effects (which are very limited due to the very large separation distances between the waste disposal area and the nearest off-site receptors).

Overall, AB Lime is in the process of improving the management and mitigation measures associated with this waste stream and even if larger volumes of this waste are to be received in the future, these management practices will be sufficient to mitigate any potential off-site air quality effects.

6.3 Emergency Waste Acceptance

In the instance of a local, regional or national biosecurity emergency or natural disaster, as a Class A Landfill, AB Lime may be required by the regulatory authorities to accept a substantial volume of solid waste and/or biosecurity waste over a relatively short period of time.

Due to the organic nature of some of these wastes, their acceptance at the landfill site is likely to cause a heightened loss of amenity or nuisance associated with odour given the volume of material that is involved. Historically these crisis waste acceptance events (M. Bovis, MPI events, etc) have resulted in nuisance off-site odour effects and enforcement action. While some of these effects arose out of extraordinary circumstances, AB Lime is committed to developing procedures to manage future instances where such deposition may occur.

From recent experiences with large volumes of extraordinary waste, including from the M. Bovis and Escheria events, AB Lime has been able to identify that applying their standard practices to the handling and management of this waste receival was not as effective at reducing off-site odour effects. As a result, a number of factors contributed to odour problems, some of which were beyond the control of AB Lime. These included:

- Accepting large volumes of waste over a short period of time;
- Not requiring (or being able to require) waste deliveries to be pre-treated prior to arriving on-site;
- Accepting deceased animals which have not had their stomachs slit; and
- Not placing sufficient cover on the crisis waste pits, etc.

In the future AB Lime is seeking to limit the receival of such waste streams, but when directed by a Government Agency, AB Lime may need to accept emergency waste.

To ensure that off-site nuisance odour effects do not occur during these events, and applying the learnings from prior events,, a special procedure for the acceptance and management of such waste streams has been developed and is included in the Landfill Operations Management Plan. Furthermore, proposed consent conditions under Section 9 of the main AEE document outline how emergency waste is to be handled moving forward.

To control potential odour emissions from the receival and disposal of crisis waste, the existing odour mitigation measures and controls for acceptance of highly odorous waste described in Section 4 of the LAQMP are to be applied, along with a number of additional controls (see Section 6 of the LAQMP). These additional controls are specifically designed to prevent odour emissions which have occurred in previous crisis waste acceptance events.

6.4 Combustion Emissions

As discussed in Section 5.2, combustion emissions contain toxic air pollutants that are hazardous to human health and are therefore regulated by national environmental standards.

Products of combustion (CO, PM_{10}, NO_2 and SO_2) are emitted from the following sources on-site:

- Motor vehicle exhausts;
- The landfill gas flare;
- Portable temporary candlestick LFG flares; and
- The coal fired lime kilns (covered in a separate air discharge consent)

There are a limited number of site vehicles and delivery trucks on-site at any one time, and as such exhaust emissions from these vehicles are minimal contributors to discharges of controlled pollutants from the site.

6.4.1 Mitigation

The major proposed change in mitigation proposed for these emissions is to use the LFG produced on-site to replace a portion of the coal use in the lime drying kilns. This will result in a more efficient use of the energy produced on-site and reduce overall emissions of products of combustion to air, particularly SO_2 emissions

The primary method for reducing the concentration of toxic products of combustion from the site is to ensure that the combustion equipment is well tuned and operating as intended such that efficient combustion is occurring. Inefficient combustion results in higher emission rates of controlled pollutants.

The Landfill Gas Management Plan contains a full description of the LFG flare operations and associated mitigation and controls. There are also consent conditions which require the LFG flare to be operated in a manner that the products of combustion are limited to a practical minimum.

All of the current site mitigation measures to limit combustion emissions will be retained. These are described in Section 7 of the LAQMP. Additional contingence measures are also described in Section 7 of the LAQMP.

6.5 Dust

Consent conditions 9-14 of AUTH-201351 relate to dust discharges from the site, and include the requirement that AB Lime ensures the there is no offensive of objectionable dust discharged beyond the boundary of the site.

6.5.1 Emissions Sources

The main sources of nuisance dust emission at the landfill are:

- Disturbance of surface fines on access roads as a result of traffic movements;
- Earthworks and material handling activities - such as the placement of cover material during dry periods;
- Filling and compaction of dusty waste;
- Fugitive dust emissions from exposed surfaces;
- Material being tracked off-site onto Cahill Road by vehicle movements; and
- Dust from material stockpiles.

6.5.2 Factors Influencing Dust Generation

The major factors that influence dust emissions from surfaces are:

- Wind speeds across the site; increased pickup of dust from exposed surfaces occurs at windspeeds above 7 m/s;
- The percentage of fine particles in the material;
- Moisture content of the material;
- The area of exposed surfaces;
- Disturbances such as vehicle movements, materials handling activities, etc; and
- The height of the dust source above the surrounding ground level.

The separation distances between the primary dust generating activities and the site boundary are generally greater than 300 m. The main access road is sealed for a length of approximately 400 m reducing the potential for material to be tracked off-site. The nearest unsealed road is ~400 m from the nearest public road.

Given these large separation distances and the presence of mature planting mostly surrounding the operations, there is a limited potential for off-site nuisance dust effects. However, to ensure that the site remains compliant with its consent requirements a number of industry standard dust mitigation measures are currently applied on-site. These include:

- On-site vehicle speed limits;
- A sealed site accessway;
- A wheel wash at the site exit;
- Procedures for limiting the handling and disturbance of dusty waste;
- Use of a water truck on-site to keep site haul roads damp; and
- Grassing stockpiles that are not being used for more than 2 months.

Additional mitigation measures are outlined in Section 8 of the LAQMP. These include:

- Regular road maintenance;
- Using water at the tip face to wet down dusty loads;
- Limiting the drop height of material handling activities;
- Limiting the size of potentially dusty stockpiles; and
- Controlling dust emissions from exposed surfaces.

All Level 2 contingency dust emission mitigation measures are additional to that already conducted on-site.

6.6 Maintenance

To ensure continued effective operation of all critical air discharge control equipment and plant on-site, this equipment will be checked and maintained in accordance with the manufacturer’s guidance and site procedures.

This includes:

- Daily pre-start checks are to be made on all site vehicles and the water cart. Vehicles are to be regularly serviced in accordance with the manufacturer’s service and maintenance requirements;

- The fence line odour suppressant system and the portable odour fogging unit are to be checked/maintained at least monthly for correct and efficient operation;
- The on-site weather station and associated automatic alarm system is to be audited and calibrated annually;
- The boundary and onsite H_2S sensors are to be bump tested monthly and calibrated in accordance with the manufacturer's requirements;
- The landfill gas meter is to be bump tested at least monthly and calibrated in accordance with the manufacturer's requirements;
- The methane Flame Ionisation Detector (**FID**) is to be audited and calibrated in accordance with the manufacturer's requirements;
- The landfill gas flare(s) are to be maintained and monitored in accordance with the procedures outlined in the Landfill Gas Management Plan; and
- The leachate tank aerator is to be monitored and maintained in accordance with the requirements in the Landfill Leachate Management Plan.

6.7 Monitoring

6.7.1 LFG Monitoring

Careful management and monitoring of the landfill gas system is required to minimise the potential for objectionable odours and the risk of explosion, combustion, asphyxiation, underground fires or vegetation damage within the landfill and beyond the site boundary.

Current consent conditions 20 – 24 of air discharge permit AUTH-201351 related to LFG monitoring requirements. The LFG monitoring procedures are outlined in the Landfill Gas Management Plan.

Additional LFG monitoring frequencies and procedures are outlined in Section 4.6 of the LAQMP above.

6.7.2 Leachate Tank Monitoring

Current consent condition 26 of AUTH-201351 relates to monitoring requirements for the leachate tank DO levels. The leachate monitoring process is described in the Landfill Leachate Management Plan.

6.7.3 Site Weather Conditions

Current consent condition 26 of AUTH-201351 relates to the required weather monitoring on-site.

Currently AB Lime has a weather station located relatively central to the site. A backup station is located on the adjacent AB Lime dairy farm (down valley of the farm).

Site weather conditions including rainfall, wind velocity and direction, barometric pressure and temperature are to continue to be monitored continuously (at least once every hour). The information will be used to assist investigations and response to any odour complaints and interpretation of gas monitoring results.

The onsite weather station is to remain located in an area central to the site where the observations are representative of the site wind conditions. The height of the mast is should be no less than 6 m above ground level, but ideally 10 m above ground level. The monitoring station is to not to be situated next to large structures or trees which would influence local airflows.

The weather station is to log measured parameters continuously. The weather station is proposed to be connected to an automated alarm system that triggers an on-site flashing light and email/text message alerts to inform site staff of wind directions from the north, northeast and east (winds blowing from 0 - 90 degrees azimuth).

6.7.4 Boundary Odour Observations

Boundary odour observations are to be made once a week during winds blowing from the north, northeast and east (winds blowing from 0 - 90 degrees azimuth), or during still cold air drainage conditions. Where practicable these odour observations are to be made during the first occurrence of these meteorological conditions during the working week. Where these meteorological conditions do not occur during the week, downwind odour observations are optional.

The monitoring frequency is to be increased if offensive odour emitted from the landfill is detected at the site boundary or an off-site complaint/observation is received as described in Sections 4 and 11 of the LAQMP.

The methodology for undertaking the boundary odour monitoring is explained in the LAQMP attached as Appendix U to the main AEE document.

6.7.5 H_2S boundary monitoring

At least two low range continuous datalogging H_2S monitors are proposed to be installed along the south western boundary of the site (for example, one at the site office and one near R8). The continuous monitors will have a minimum H_2S detection limit of 10 ppb (i.e. an OdaLog Low Range H_2S Logger or similar).

Data from these two monitors is to be logged and automated alarms are to be set at 20 ppb (0.02 ppm) such that additional mitigation measures discussed in the LAQMP can be implemented.

The monitors are to be installed as close to ground level as possible (without being at risk of flooding), as H_2S is heavier than air.

Where required, the low range H_2S sensor can be used in ‘survey mode’ to scan upwind and detect the source(s) of the H_2S emissions where an alarm has occurred.

6.8 Complaints

Current consent condition 27 of air discharge permit AUTH-201351 relates to AB Lime’s requirement to record, investigate, and respond to complaints. It is proposed that the following procedure will be adopted by AB Lime to record and respond to any air quality complaints. This methodology is also included in the LAQMP.

6.8.1 Receiving complaints

The process for managing complaints is detailed in the Environmental Management Plan. The following sections provide additional details when the complaints relate to air quality..

6.8.2 Response to complaints

The Environmental Manager will contact the complaint by telephone, or if this is not possible by sending a letter on the same day as the complaint is received. To validate and investigate the source of the complaint undertake the following as appropriate:

- Correlate complaint with weather conditions;
- For a dust complaint, undertake off-site and on-site observations to determine the location and extent of the dust plume. Work upwind to identify the source(s) of the dust emissions;

- For an odour complaint, undertake odour scout survey to ascertain the extent, intensity, and character of the odour plume. Start at the area where the complaint was received and work upwind to identify the source of the odour. Where appropriate utilise an OdaLog low range H_2S sensor (or similar) to identify any measurable concentrations of H_2S within the plume/at the source;
- Check and record current tipping operations;
- Check and record any odorous/dusty load history (type, age, number, disposal method, timing);
- Check daily, intermediate and final cover;
- Check gas collection systems and flare for proper operation;
- Check leachate tank aerator unit for proper operation;
- Check leachate tank H_2S sensor readings; and
- Record all odour scout and investigation observations in the AB Lime incident response forms.

If the cause of the complaint is identifiable, measures that have to/will be put in place to avoid a recurrence will be implemented and records provided to external parties as required. If there is uncertainty as to the nature or cause of the complaint the Environmental Manager will seek clarification. A meeting may be required to discuss the complaint and if required will be arranged as soon as is practicable.

All complaints will be responded to in writing, although in some cases this may be after clarification.

Copies of the written responses will be filed in the complaints register.

All complaints will be reported to Environment Southland as soon as practicable.

6.8.3 Validated complaints

Should investigation of odour/dust complaints indicate that discharges from the landfill are causing objectionable or offensive effect beyond the boundary, site staff are to instigate Level 2 or Level 3 mitigation measures for the source of the emission.

AB Lime may offer the complainant(s) and any other concerned neighbouring residents the opportunity to participate in an odour diary program. The design of the odour diary programme shall be in accordance with recognised good practice.

An odour diary record sheet is to be provided to all participants. The odour diary program is to continue for a minimum period of three weeks (pending participant approval). Contact details of the Environmental Manager are to be supplied to the participants of the odour diary program such that direct feedback can be provided to AB Lime if and when landfill odour is detected beyond the boundary of the site. This feedback can be used by AB Lime to further investigate odour sources on-site and implement additional controls where required.

Where appropriate, AB Lime shall notify Environment Southland of the odour diary program and provide a summary of the results on request.

6.8.4 Ongoing complaints

If a complainant is dissatisfied with a response to a complaint, every reasonable attempt is to be made to find a satisfactory solution. If all reasonable measures are rejected, the complainant will be referred to Environment Southland and Southland District Council. Details of the measures offered will be sent to the regulatory authority at the same time as being offered to the complainant or if offered verbally as soon afterwards as is practical.

In the instance of ongoing validated complaints, AB Lime is to offer to set up a community liaison group. Neighbouring property owners and a representative member of Environment Southland are to be invited to participate in the community liaison meetings. The frequency of meeting, location and time are to be agreed at the first meeting.

The purpose of the community liaison group is to discuss matters relevant to the landfill operation including, but not limited to:

a) Community participants to share any observations/concerns that they may have about AB Lime's operations;

b) Environment Southland to share any response to concerns/reports, investigation results, and/or independent monitoring that it has undertaken;

c) AB Lime to share results of any investigations into odour/dust emission sources on-site;

d) Concerns and aspects of potential non-compliance and ways of alleviating them, particularly in respect of odour;

e) To consider and recommend changes to the Landfill Air Quality Management Plan where there is repeated validated off-site odour or dust nuisance effects; and

f) Consideration of any mitigation or enhancements proposed by the consent holder over the life of the consent.

6.8.5 Access to complaints register

The register of complaints will be provided to Environment Southland annually and be available for inspection by Environment Southland and Southland District Council at all reasonable times.

7. Air dispersion modelling

7.1 Modelling Methodology

NZ Air has undertaken a conservative quantitative air dispersion modelling assessment to assess the potential worst case ambient air quality impacts beyond the boundary of the site. The proposed landfill gas combustion emissions, including cumulative impacts associated with the operation of the on-site lime kilns, have been modelled. The results of the modelling have been compared against the relevant ambient air quality standards (discussed in Section 5.2).

The lime kilns operate based on product demand, which is seasonal. Currently the kilns do not operate from June – August. In the operational months (September – May) the average weekly run is 63 hours per week (about 38% of the time). The coal burn rates are also variable as the kilns do not always operate at peak capacity (varying from less than 10 kg/hr through to just under the 2,800 kg/hr consent limit). However, during peak production periods, the kilns can run 24 hours a day and burn just under the consented peak burn rate of 2,800 kg/hr. NZ Air has modelled a worst case scenario of the kilns operating 24/7, which is particularly conservative for the predicted peak longer term average concentrations of the pollutants modelled.

Currently AB Lime has a maximum consented SO_2 discharge rate from its lime kilns of 10 kg/hr. However, calculated SO_2 mass discharge rates from recent kiln operations have peaked at under 5 kg/hr[10]. As a part of this consent application AB Lime is applying to reduce the consented maximum SO_2 discharge rate to 6 kg/hr. In addition to this reduction in the consented maximum SO_2 discharge rate, AB Lime is proposing to use all the available LFG as fuel for the kilns (when the kilns are operational). This will replace a portion of the coal burnt as outlined in each modelling scenario below.

Jacobs' landfill gas specialists have modelled three landfill gas generation scenarios to represent; the currently consented, expected, and upper bound LFG production rates that could occur under each landfill operating scenario (refer to the Landfill Gas Technical Memo). The peak LFG production rates which would occur in year 2055 (final year of the proposed consent duration) under each scenario are as follows:

1) The current consented landfill with a waste acceptance rate of 100,000 t/yr occurring until 2055: **606 m^3/hr**
2) The landfill operated with a waste acceptance rate of 200,000 t/yr occurring until 2055: **1,202 m^3/hr**
3) The landfill operated with a waste acceptance rate of 300,000 t/yr occurring until 2055: **1,798 m^3/hr**

Based on these LFG production rates and AB Lime's proposed amendments to site operations and the Quarry air discharge consent, three air dispersion modelling Scenarios have been modelled:

1) Air Dispersion Modelling **Scenario 1**

This represents the current consented peak off-site effects associated with emissions from the flare and lime kilns. This modelling scenario is based on:

- The kilns burn the currently consented maximum coal consumption rate of 2,800 kg/hr and a SO_2 emission rate of 10 kg/hr. Kiln operation is assumed to occur 24/7. *(NB this SO_2 emission rate of 10kg/hr is taken from current limeworks consent AUTH-205861-01-V1. This consent is to be varied as part of this proposal to reduce this emission rate.)*

[10] AB Lime 2018 Annual Lime works Air Discharge Report

- The existing landfill gas flare burning 606 kg/hr of LFG 24/7. This burn rate is based on the peak LFG gas production rate modelled under the 100,000 t/year model scenario in the Landfill Gas Technical Memo.
- It has been assumed that the H_2S concentration in the LFG is 90 ppm, based on current measured peak H_2S concentrations in the LFG. The H_2S production in the waste mass is influenced by the waste composition. It is assumed that the future waste composition will not be dissimilar to that received to date and therefore this concentration of H_2S in the LFG collected is considered appropriate.
- The landfill gas flare converts 100% of the sulphur in the H_2S to SO_2.
- PM_{10}, CO and NOx emission rates from the flare emissions are based on the emission factors published in Table 2.4-4 of Chapter 2.4 of the USEPA AP42 emission factors[11].
- PM_{10}, CO and NOx emission rates from the coal combustion emissions are based on the emission factors published in Chapter 1.7 of the USEPA AP42 emission factors[12].

2) Air Dispersion Modelling **Scenario 2**

This represents the expected future peak off-site effects associated with emissions from the flare and lime kilns when the available LFG is used to partially fuel the kiln operation. Note that when the kilns are not operating all of the LFG produced on-site will be burnt in the flare (or potentially through the kiln burners with emissions bypassing the kilns themselves). As the pollutant mass emission rates from the combustion of the LFG are a small fraction of those from the coal combustion, when only LFG is being burnt the peak off-site effects will be much lower than those presented in Table 13.

This modelling scenario is based on:

- All of the available peak LFG produced by the landfill (1,202 kg/hr in the 200,000 t/year waste acceptance model) is burnt in the kilns.
- A maximum coal burning rate of 1,598 kg/hr in the kilns (57% of the consented peak, reduced to reflect the energy provided from the LFG combustion). It has been assumed that there is 60% methane content in the LFG (based on the Landfill Gas Technical Memo) It is also assumed that the energy provided by the combustion of 1 m^3 of LFG is approximately the same as burning 1 kg of coal (this is based on the calorific value of the LFG compared with the current calorific value of coal currently burnt in the kilns).
- Due to the reduced coal consumption the mass emission rate of the SO_2 discharged from the coal combustion is 57% of the proposed 6 kg/hr cap (i.e. max of 3.42 kg/hr). *(NB this SO_2 emission rate of 6kg/hr is proposed for the variation of AUTH-205861-01-V1 as part of this proposal to reduce this emission rate.)*
- Kiln operation is assumed to occur 24/7. This is a worst case scenario, as when the kilns are not operating combustion emissions from the site will be limited to LFG combustion only (which has much lower mass emission rates).
- As above, the LFG burnt in the kilns contains 90 ppm H_2S and the kiln burners convert 100% of the sulphur in the H_2S to SO_2. 50% of the SO_2 produced during the combustion of the LFG is scrubber out in the lime kiln and associated wet scrubber before being discharged out the stack.

[11] https://www3.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf
[12] https://www3.epa.gov/ttn/chief/ap42/ch01/final/c01s07.pdf

3) Air Dispersion Modelling **Scenario 3**

This represents the upper bound future peak off-site effects associated with emissions from the flare and lime kilns. This modelling scenario is based on:

- As above, except the LFG production rate is higher (1,798 m^3/hr), and therefore even less coal is burnt in the kilns.

PM_{10}, CO and NOx emissions were not modelled for Scenarios 2 and 3 as all of the Scenario 1 results were below the relevant ambient air quality criteria and the reduced coal burning rates in Scenarios 2 and 3 will result in a proportion decrease on off-site effects.

NZ Air has gathered the required modelling input information in conjunction with ABL and Jacobs to conduct air dispersion modelling and assess the potential increase in ground level concentrations of the pollutants listed in Table 7 and Table 8 above.

7.2 Model selection

NZ Air has used the air dispersion model CALPUFF in the assessment. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model which simulates the effects of time and space varying meteorological conditions on pollution transport, transformation, and removal. It includes algorithms for sub grid scale effects and longer range effects.

The dispersion of the pollutants will be influenced by building wake effects and local terrain. Peak off-site concentrations are predicted relatively close to the emission points (within 1 km). Therefore, a simpler Gaussian Plume model could have been used. However, it is considered that the use of CALPUFF is also appropriate as it will incorporate the local terrain and three dimensional weather patterns in the absence of observed data.

7.3 Modelling Inputs

The CALPUFF modelling inputs used for each modelling Scenario are presented in Table 9.

Table 9 Modelling Inputs

Modelling Inputs								
Source	**Stack Height**	**Exit Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temp (ºC)**	**SO_2 Emission Rate (g/s)**	**NOx Emission Rate (g/s)**	**PM_{10} Emission Rate (g/s)**	**CO Emission Rate (g/s)**
Scenario 1								
Kiln Stack 1	9	0.8	11.1	100	1.389	2.450	0.097	0.082
Kiln Stack 2	9	0.8	11.1	100	1.389	2.450	0.097	0.082
Flare	7	0.154	20	1000	0.0348	0.066	1.212	0.027
Scenario 2								
Kiln Stack 1	9	0.8	11.1	100	0.497	[redacted]	[redacted]	[redacted]
Kiln Stack 2	9	0.8	11.1	100	0.497	[redacted]	[redacted]	[redacted]
Flare	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Scenario 3								
Kiln Stack 1	9	0.8	11.1	100	0.330	[redacted]	[redacted]	[redacted]
Kiln Stack 2	9	0.8	11.1	100	0.330	[redacted]	[redacted]	[redacted]
Flare	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

7.3.1 Nitrogen Dioxide Estimation

Off-site NO_2 concentrations were estimated by utilising the 'NO_2 proxy method' as described in the MfE Good Practice Guide for Assessing Air Discharges from Industry[13]. NZ Air has conservatively assumed that 10% NOx is discharged is NO_2 and then added the modelled concentration to the default combined NO_2 with ozone values in Table A3.1 of the Industry GPG (1 hour average of 95 µg/m^3 and a 24 hour average of 75 µg/m^3).

7.4 Meteorological Data

NZ Air has used a one year (2019) meteorological data file representative of the project site generated in MM5 (5th-generation Mesoscale Model). MM5 is a prognostic meteorology model developed by Pennsylvania State University and the U.S. National Centre for Atmospheric Research. The model is a limited-area, non-hydrostatic, terrain-following sigma coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation.

[13] Ministry for the Environment. 2016. *Good Practice Guide for Assessing Discharges to Air from Industry.* Wellington: Ministry for the Environment.

MM5 was used to develop a 50 x 50 km three-dimensional meteorological data set with a 4 km grid size for CALMET. This prognostic data was then input into CALMET and run to generate a 3D meteorological data set over the ABL site, with terrain and land use features incorporated.

In the preparation of the meteorological data for the CALPUFF model, there is no recent, local, publicly available, meteorological data which is representative of the site. As discussed earlier the closest weather station with high quality data is in Invercargill (31 km South of the site).

The on-site weather station broke in early 2019 and therefore insufficient data from this station is available to be incorporated into the model. Likewise, data from the dairy farm weather station is only available from April onwards in 2019, and furthermore as discussed above the wind direction data in this dataset is questionable. For these reasons AB Lime's measured weather data could not be incorporated into the CALMET modelling. Therefore, NZ Air has used prognostic data only in the CALMET modelling.

A wind rose from the centre of the site has been extracted from CALMET and is presented in Figure 13.

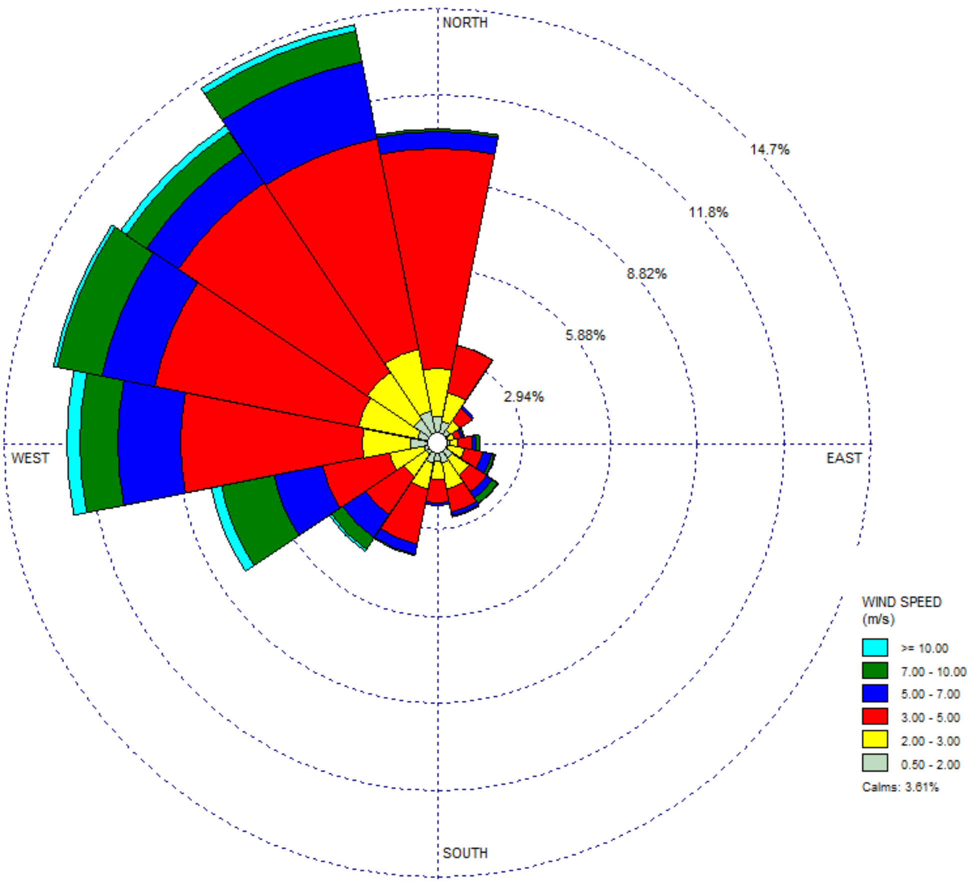


Figure 13 CALMET Windrose Over the Site 2019

CALMET was run primarily utilising default settings. The parameters used in the CALMET modelling are summarised in Table 10.

Table 10 Parameters used in CALMET for this Project

CALMET	
Input	**Parameter**
Model version	8.6.1
Mode	Prognostic data for surface and upper air data
Grid size	6 x 6 km
Grid Spacing (m)	200 m.
Year(s) of analysis	2019
Centre of grid	UTM 297679.61 m East (E), 4888150.42South (S), zone 59 south
Number of Vertical cells	10
TERRAD	0.5 km

7.5 Terrain

The wind flows predicted by the CALMET model appear to be influenced by the local terrain in a realistic manner. See Figure 14 for an example of the terrain effects on wind flows.

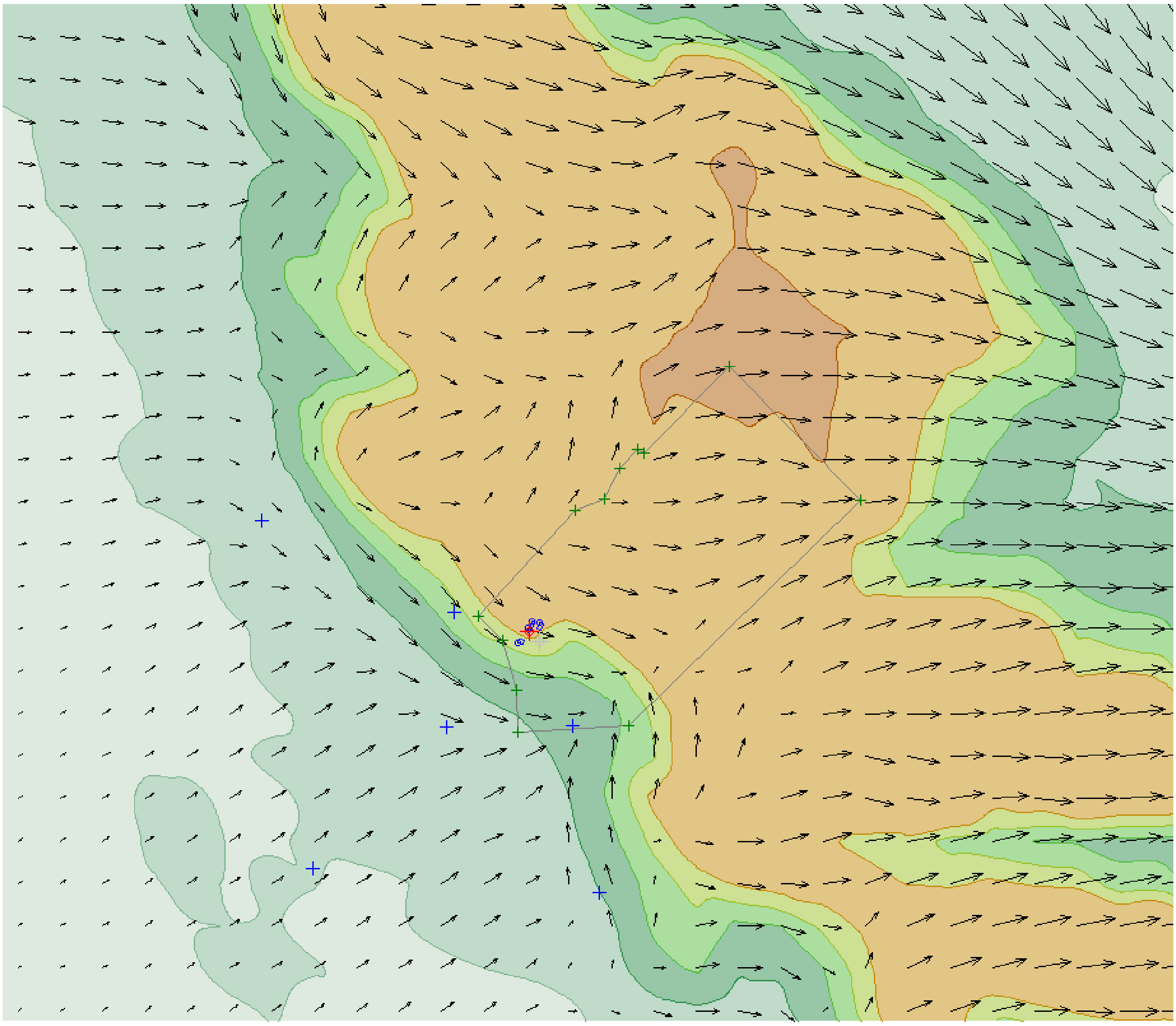


Figure 14 Wind Flows Following Terrain Features

7.6 Building Wake Effects

It is generally accepted that building downwash or wake effects can occur when the stack or discharge point is not greater than 2.5 times the height of a building or structure within 5L of the stack (L is the lesser of building height or projected building width). Building wake effects are turbulent zones around the edges and in the lee of a building which can drag a plume emitted from a point discharge down closer to ground level than would usually occur in the absence of said building or structure.

The kiln stacks are below the ridgeline of adjacent buildings. For this reason, adjacent buildings have been incorporated into the model and CALPUFF's Building Profile Input Program (**BPIP**) was used to calculate the building wake effects on the emissions.

Figure 15 provides a representation of the building profiles used in the modelling.

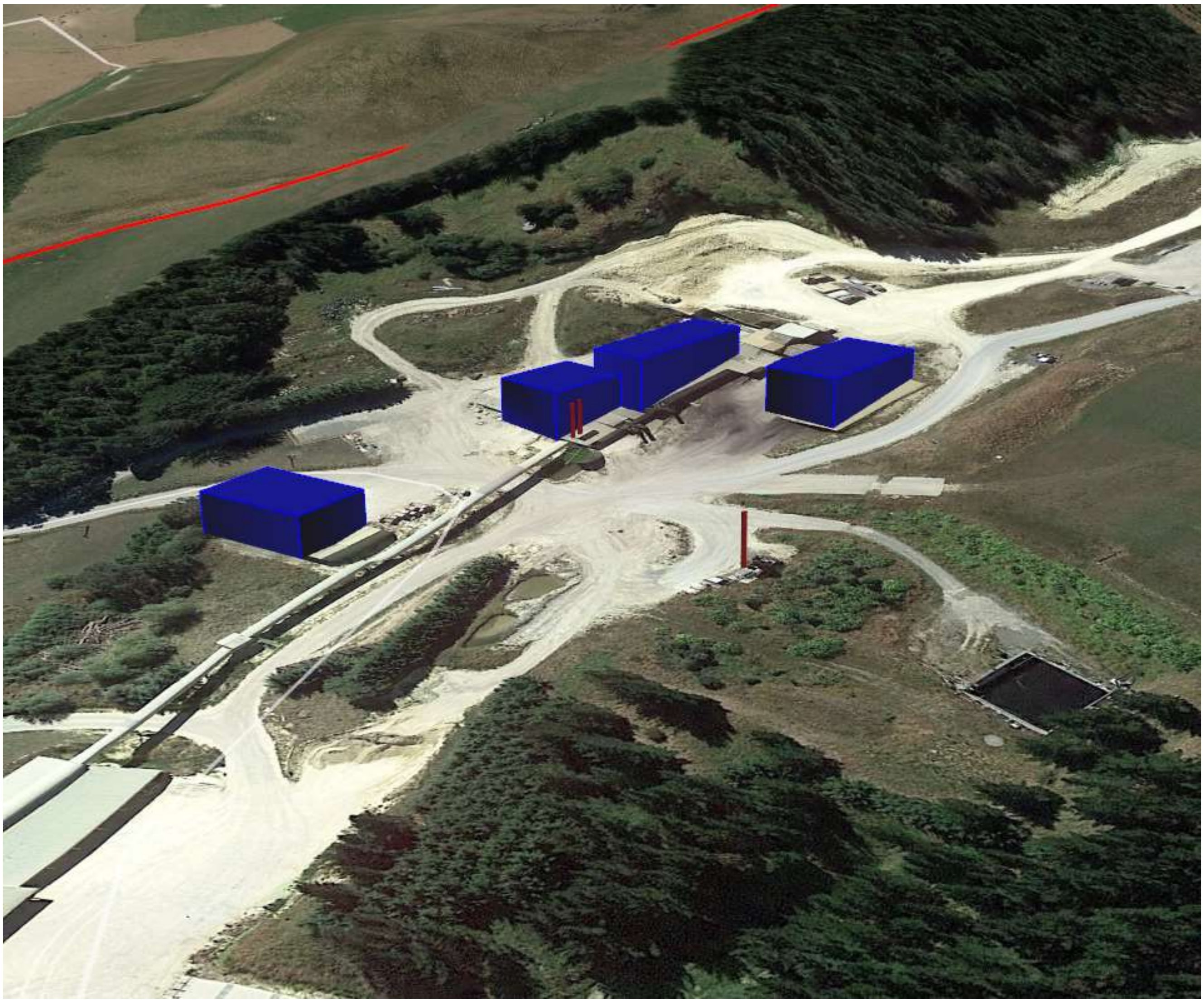


Figure 15 Building Profiles

7.7 CALPUFF

CALPUFF was used to model the dispersion of the pollutants. The CALPUFF modelling inputs are summarised in Table 11.

Table 11 Parameters Used in CALPUFF for this Project

CALPUFF	
Input	**Parameter**
Model version	8.6.1
Receptor Grid	Nested 50 m grid spacing within 500 m 100 m grid spacing within 1 km 200 m grid spacing within 2.5 km

CALPUFF	
Input	**Parameter**
Grid size	5 km x 5 km
Year(s) of analysis	2019
Time step	3600 s
Stack tip down wash	Yes
MDISP	2
MPDF	Yes

Discrete receptors were used to assess peak concentrations at the nearest five sensitive receptors in any given direction (R1, R2, R4, R5 and R9) identified in Figure 1.

The full CALMET and CALPUFF modelling inputs are included in Attachment 1**.**

7.8 Modelling Results

7.8.1 Scenario 1 – Existing consented operation

The predicted peak off-site Scenario 1 modelled concentrations are presented in Table 12.

Table 12 Scenario 1 Modelling Results

	PM_{10} µg/m^3		NO_2 µg/m3		SO_2 µg/m^3 *		CO µg/m^3	
Averaging period	**24 hour**	**Annual**	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**8 hour**
Max beyond site boundary	8	0.22	132	93	420	205	195	148
R9	1	0.01	98	76	31	13	14	8
R1	3	0.05	109	82	157	83	73	52
R2	0	0.00	97	75	18	4	8	4
R5	0	0.00	97	76	17	6	8	2
R4	0	0.05	98	76	38	10	18	12
Background	21	10					5000	2000
Max plus background	29	10	132	93	420	205	5195	2148
Criteria	**50**	**20**	**200**	**100**	**350**	**120**	**30000**	**10000**

The peak consented emission scenario results in an exceedance of the off-site both the 1 hour and 24 hour SO_2 ambient air quality criteria. This exceedance is the result of the sulphur discharge rate remaining at the currently consented rate of 10kg/hr. As noted above, this discharge rate is being reduced to 6 kg/hr as part of this proposal.

Figure 16 presents a contour plot of the SO_2 1 hour 99%ile average ground level concentrations. Figure 17 presents a contour plot of the SO_2 24-hour average ground level concentrations.

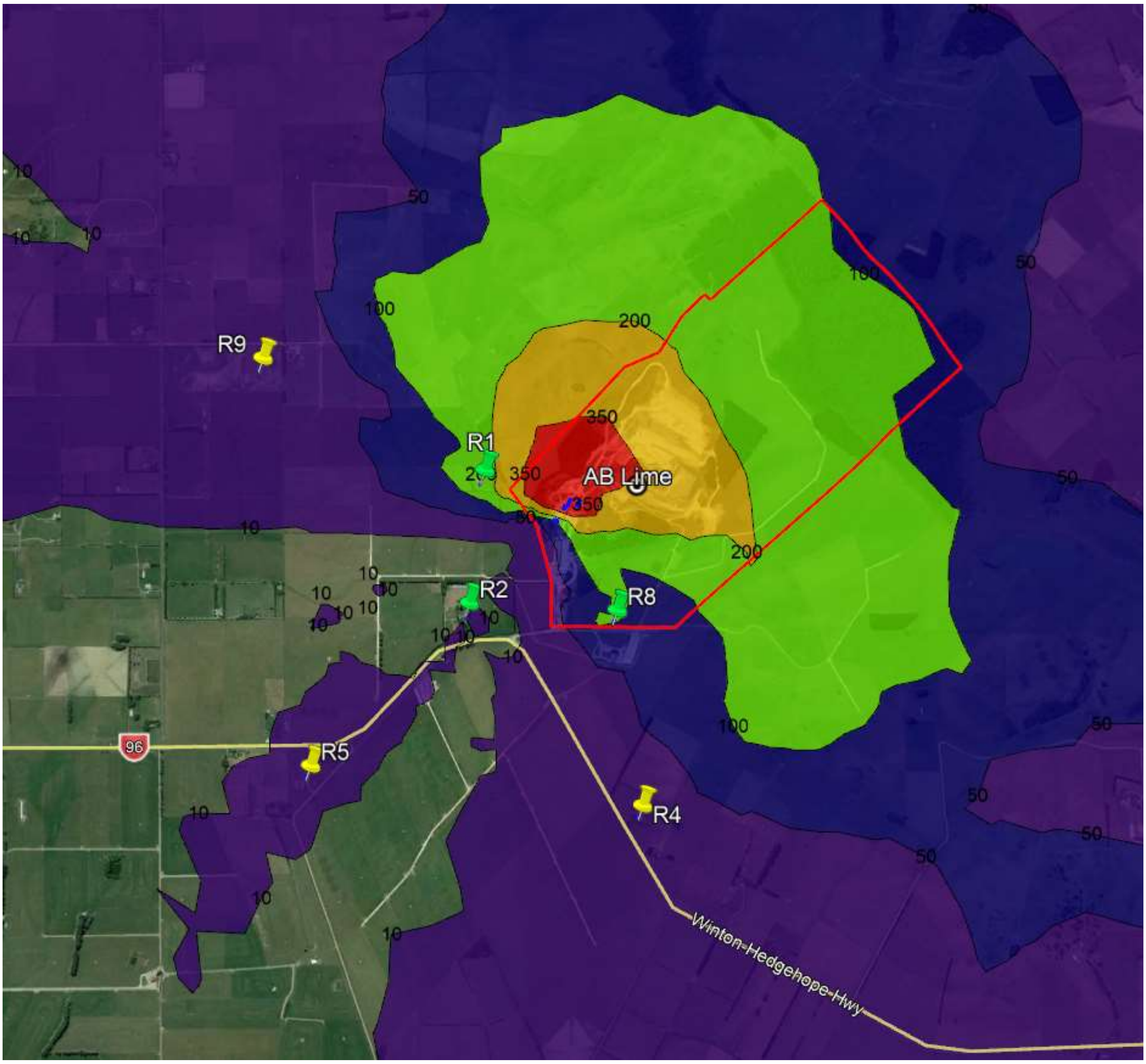


Figure 16 Scenario 1 Predicted SO_2 1 hour 99.9%ile average concentrations (μg/m^3)

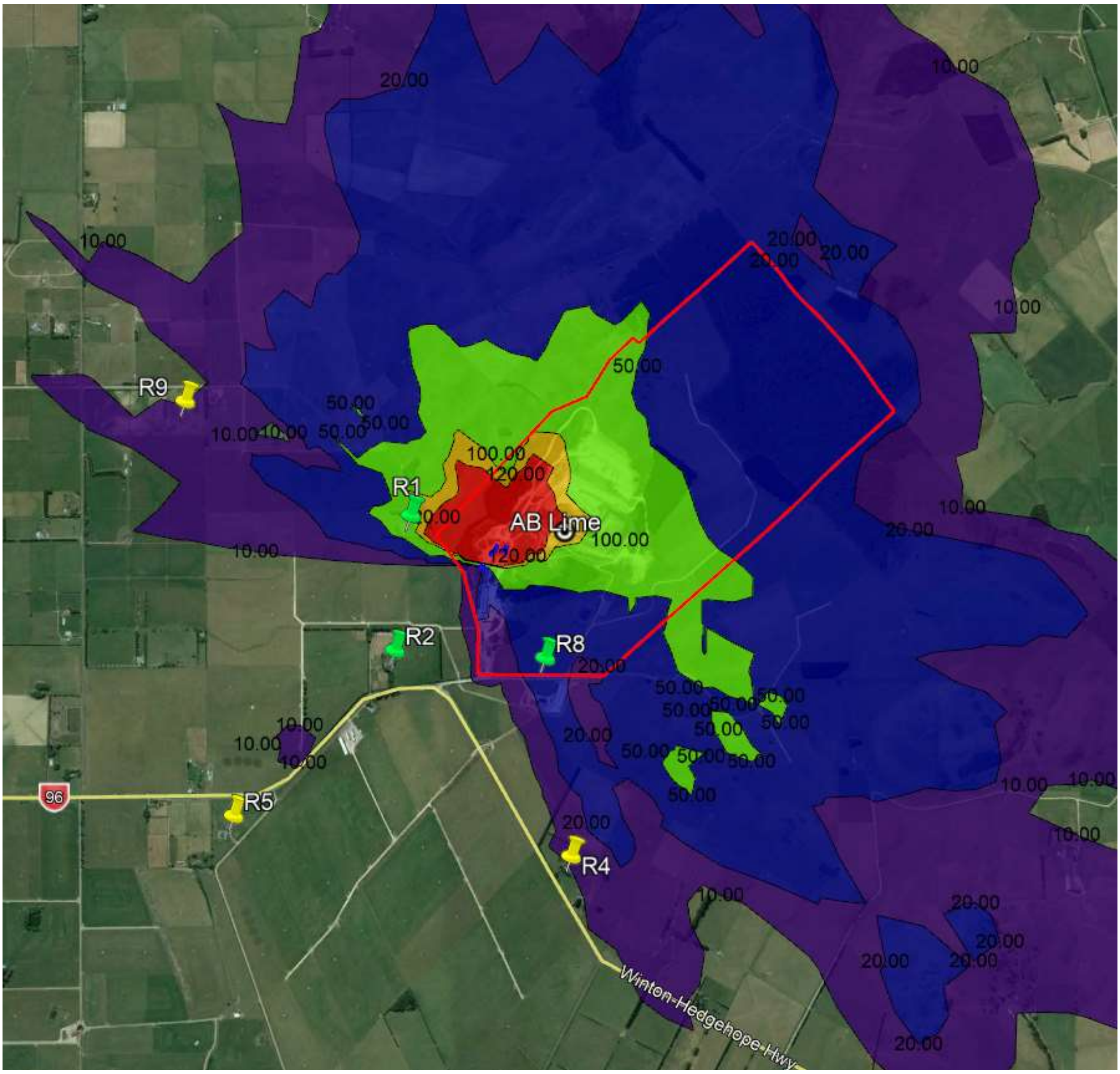


Figure 17 Scenario 1 Predicted SO_2 24-hour average concentrations (µg/m^3)

7.8.2 Scenario 2 – Based on 200,000 t/year waste acceptance and LFG to kilns

The predicted peak off-site Scenario 2 modelled concentrations are presented in Table 13.

Table 13 Scenario 2 Modelling Results

	SO_2 µg/m^3 *	
Averaging period	**1 hour 99.9%ile**	**24 hour**
Max beyond site boundary	150	70
R9	11	5
R1	56	29
R2	7	1
R5	6	2
R4	13	4
Background		
Max plus background	150	70
Criteria	**350**	**120**

The peak Scenario 2 emission scenario (waste acceptance rate 200,000 t/y and LFG burnt in kilns) results in off-site concentrations below SO_2 ambient air quality criteria. This is expected given the lower coal usage rates and lower peak sulphur emission rates from the coal consumption.

These Scenario 2 results, which represent the expected off-site effects resulting from the proposed landfill operations, present a substantial improvement in off-site ambient air quality effects.

Figure 18 presents a contour plot of the Scenario 2 SO_2 1 hour 99%ile average ground level concentrations. Figure 19 presents a contour plot of the Scenario 2 SO_2 24-hour average ground level concentrations.

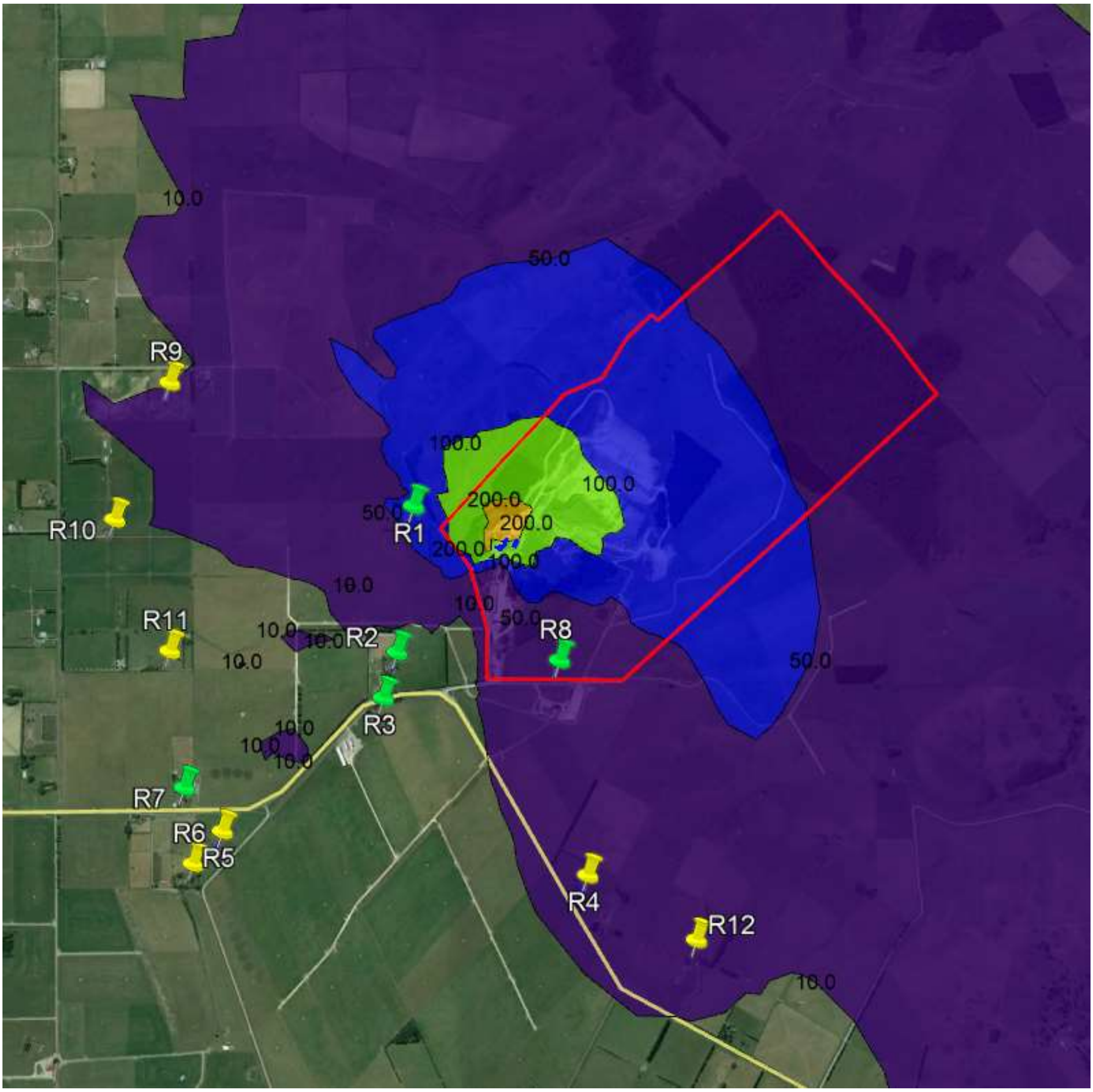


Figure 18 Scenario 2 Predicted SO_2 1 hour 99.9%ile average concentrations (μg/m^3)

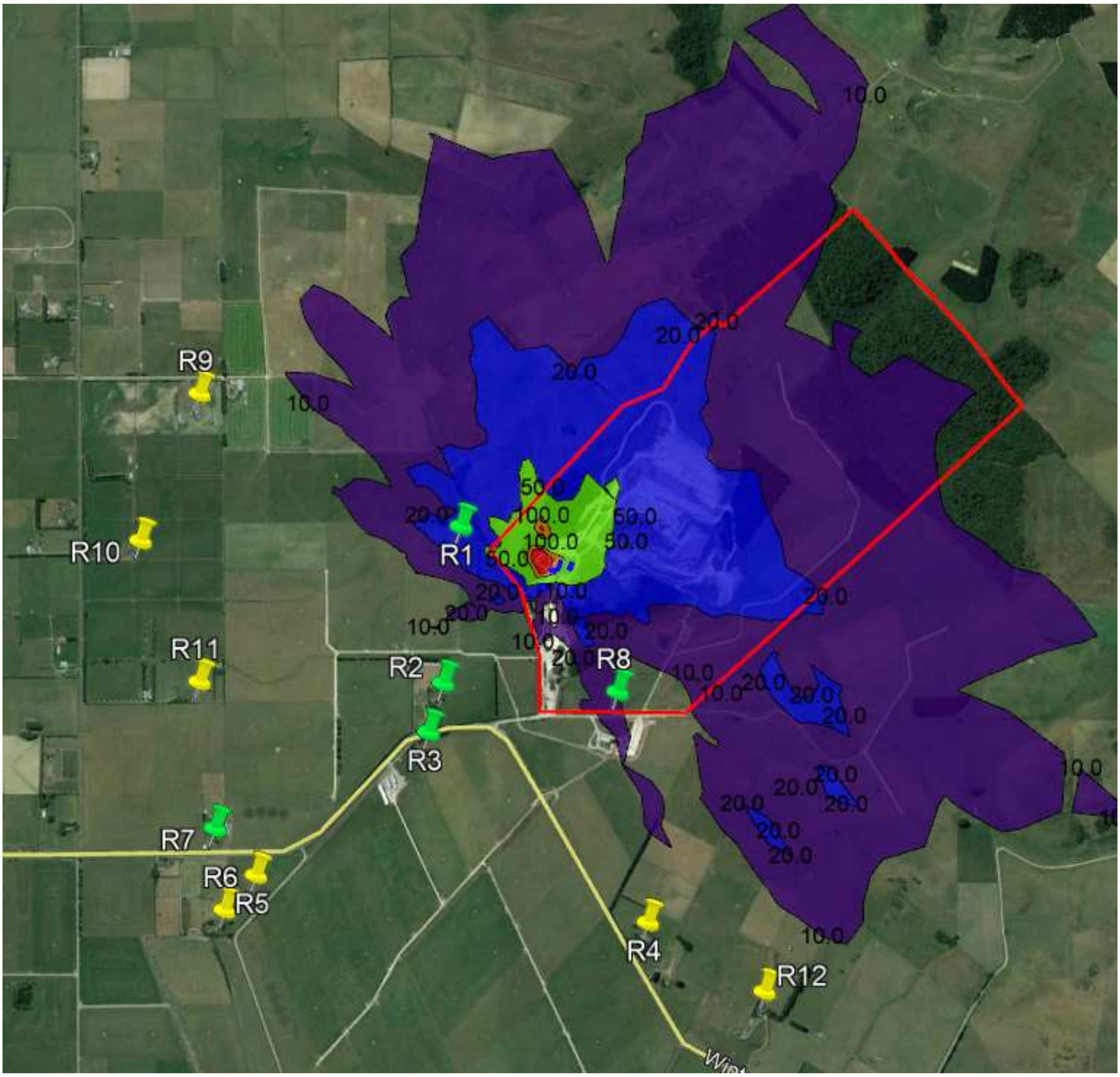


Figure 19 Scenario 2 Predicted SO_2 24-hour average concentrations (µg/m^3)

7.8.3 Scenario 3 – Based on 300,000 t/year waste acceptance and LFG to kilns

The predicted peak off-site Scenario 3 modelled concentrations are presented in Table 14.

Table 14 Scenario 3 Modelling Results

	SO_2 µg/m³ *	
Averaging period	**1 hour 99.9%ile**	**24 hour**
Max beyond site boundary	100	46
R9	7	3
R1	37	20
R2	4	1
R5	4	1
R4	9	2
Background		
Max plus background	100	46
Criteria	**350**	**120**

The peak Scenario 3 emission scenario (waste acceptance rate 300,000 t/y and LFG burnt in kilns) results in an even bigger reduction in off-site concentrations of SO_2. This is expected as even more coal is being replaced with LFG, as LFG combustion has a lower SO_2 emission rate compared with coal there is a net improvement in off-site effects.

7.8.4 Reduction in off-site effects

The reduction in predicted peak off-site modelled SO_2 concentrations associated with Scenario 2 and Scenario 3, is presented in Table 15 and Table 16.

Table 15 Scenario 2 reduction of peak off-site SO_2 concentrations

Scenario 2	Reduction µg/m³		Percent reduction		Results as a percentage of the SO_2 criteria	
Averaging period	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**24 hour**
Max beyond site boundary	-270	-135	-64%	-66%	43%	58%
R9	-20	-9	-65%	-65%	3%	4%
R1	-101	-54	-64%	-65%	16%	25%
R2	-12	-2	-64%	-64%	2%	1%
R5	-11	-4	-65%	-65%	2%	2%
R4	-25	-7	-65%	-65%	4%	3%

Table 16 Scenario 3 reduction of peak off-site SO_2 concentrations

Scenario 3	Reduction µg/m^3		Percent reduction		Results as a percentage of the SO_2 criteria	
Averaging period	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**24 hour**	**1 hour 99.9%ile**	**24 hour**
Max beyond site boundary	-320	-159	-76%	-77%	28%	39%
R9	-24	-10	-77%	-77%	2%	3%
R1	-120	-64	-76%	-77%	11%	16%
R2	-14	-3	-76%	-76%	1%	1%
R5	-13	-4	-77%	-77%	1%	1%
R4	-29	-8	-77%	-77%	3%	2%

The proposed changes in site combustion operations will result in a substantial reduction in peak off-site effects. The reduced peak off-site SO_2 concentrations are predicted to be well below the ambient air quality criteria, less than 60% of the criteria for Scenario 2 and less than 40% of the criteria for Scenario 3.

7.9 Current Level of Off-site Effects

7.9.1 Odour

As discussed in the analysis of odour complaints in Section 2.4.1.1, there has been incidences in the past where odour emissions from AB Lime have resulted in adverse off-site odour effects.

Whilst odour complaints are relatively infrequent, any offensive or objectionable effect beyond the boundary is not acceptable. As a result of enforcement action, community engagement, and odour investigations, AB Lime have identified sources of odour and put in mitigation to minimise off-site effects.

Furthermore, AB Lime is committed to improving the current level of off-site odour effects. As such a very comprehensive odour management procedure is being adopted in the proposed LAQMP attached.

7.9.2 Dust

Only one complaint was received with regards to dust emissions from the site. This occurred very early in the site development (2004), and the source was identified and emissions were controlled.

Other than this one complaint there have been no dust related complaints or concerns raised by neighbouring receptors. The current level of off-site nuisance dust effects is considered to be very low.

7.9.3 Combustion Emissions

The Scenario 1 modelling results presented in Section 7.8 indicate that if AB Lime were to run the combustion plant at its peak capacity 24/7 the peak off-site concentrations of SO_2 could exceed the health based New Zealand ambient air quality criteria. Consequently, the SO_2 discharge rate is being reduced in limeworks consent AUTH-205861-01-V1 from 10kg/hr to 6kg/hr.

However, the current site operations and associated emissions are well below that which have been modelled. The current peak LFG combustion in the flare is approximately 120 m^3/hr , which is much lower than the modelled peak capture and combustion rate which could occur in the future (2055), 606 m^3/hr.

Furthermore, the current calculated peak SO_2 emission rates are estimated to be approximately 4.5 kg/hr, which is much less than the modelled 10 kg/hr. Additionally, the kilns do not operate 24/7 and therefore the modelling results are likely to have overpredicted the current off-site effects (particularly the 24 hour average results).

AB Lime are presently the largest industrial type activity in the vicinity and as such are a major contributor to the current ambient SO_2 concentrations in the local environment. As identified in this assessment, while the ambient SO_2 concentrations are somewhat elevated, it is important to note that they are below the relevant ambient air quality criteria. Transitioning the site to running the lime kilns from landfill gas will reduce the SO_2 concentrations.

7.10 Assessment of Potential Effects from Expanded Operation

7.10.1 Published Separation Distances for Landfill Operations

The concentration of air pollutants in the air rapidly decreases with distance from any given emission source. Therefore, the separation distance between an emission point and the nearest sensitive receptor is one of the most important factors in the potential for adverse air quality effects.

There are a number or publications which provide guidance for recommended separation or buffer distances between industrial air emissions and the nearest sensitive receiving environments. These guidance documents are designed to be used as a guide for siting industrial activities relative to sensitive land uses. Where sensitive activities are outside these separation distances it is not anticipated that there will be adverse air quality effects.

Recommended separation distances from a landfill footprint include:

South Australian EPA[14] – **500 m**

EPA Victoria[15] – **500 m**

The Auckland Unitary Plan[16] – **1,000 m**

The nearest sensitive receptor, not owned by AB Lime, is R4, which is approximately 1,100 m from the landfill footprint. Receptors R1 and R8, owned by AB Lime are within 500 m of the landfill footprint.

7.10.2 Experience at Other Landfills

Odour complaints have occurred at other landfills of a similar design to AB Lime. Recorded odour complaints associated with the Redvale landfill[17], north of Auckland, primarily come from receptors within 1,000 m of the landfill[18]. Redvale landfill is also a lime quarry which is being backfilled with municipal waste. Redvale can receive up to 400,000 tonnes of waste per annum. A limited number of odour complaints have occurred at distances up to 1,500 m from the landfill. Complaints that occur at greater distances from the site occur during cold calm conditions at night time or in the early morning. This is consistent with AB Lime's historic complaint record. AB Lime has identified that these meteorological conditions are more likely to result in off-site odour complaints, and is proposing to increase odour mitigation measures to prevent odour effects during these conditions.

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14 www.epa.sa.gov.au/xstd_files/Waste/Guideline/guide_landfill.pdf

15 https://www.epa.vic.gov.au/about-epa/publications/788-3

16 https://unitaryplan.aucklandcouncil.govt.nz/Images/Auckland%20Unitary%20Plan%20Operative/Chapter%20E%20Auckland-wide/1.%20Natural%20Resources/E14%20Air%20quality.pdf

17 http://www.tba.co.nz/pdf_papers/FS08_Redvale.pdf

18 https://www.aucklandcouncil.govt.nz/ResourceConsentDocuments/20BUN60339589AirDischarge.pdf

There have also been odour complaints at the Levin Landfill[19]. Complaints have occurred primarily from a residential receptor approximately 400 m from the landfill activities. This receptor is down gradient from the landfill operations and complaints generally occur early in the morning or late in the evening, where cold air drainage effects are more prevalent. A number of off-site H_2S monitoring programs were undertaken to ascertain better, less subjective, data about potential nuisance odour occurrences. These monitoring programs confirmed the complaint patterns. An external consultant has recommended mitigation measures for this landfill which include; better daily cover and capping of the waste mass, weather monitoring, restricting activities during certain weather conditions, boundary air quality monitoring, instigating community engagement to reduce delays in complaint response, and installing an aerator in the leachate pond. These mitigation measures are consistent with those proposed for the AB Lime landfill operations.

Independent reviews were conducted into the Spicer Landfill in Porirua[20] odour emissions. This landfill also has a number of residential dwellings within 400 m of the landfill footprint and down gradient from the landfill. The independent reviews investigated the correlation between receiving biosolids from a local wastewater treatment plant and odour complaints. Recommended mitigation measures to avoid future odour emissions/complaints included better management of biosolid waste, a higher solids content of the biosolid waste prior to delivery to the site, and odour monitoring at the site boundary. Historic odour complaints have occurred when AB Lime has received odorous special waste (i.e. M. Bovis cattle), AB Lime is proposing to improve the management of special waste handling and disposal. This includes requiring clients to pre-treat the waste prior to delivery to site. This is consistent with the recommendations and procedures adopted at the Spicer Landfill.

Despite the AB Lime landfill being located a further distance from sensitive receivers that the above examples, similar mitigation measures are proposed. These measures were considered industry good practice by a range of air quality experts. Utilising similar methods at the AB Lime site, even when the closest receptors are more distant, is considered to be appropriate.

7.10.3 Odour

To assess the potential odour effects from the proposed expanded AB Lime landfill, NZ Air has utilised a number of the assessment tools recommended in the MfE Odour GPG (see Section 5.1). The odour assessment criteria is the ‘offensive or objectionable’ threshold. Whether or not an odour has an offensive or objectionable effect is determined via an assessment of the FIDOL factors, discussed earlier. Odour effects can be acute (infrequent, high intensity) or chronic (frequent, low intensity).

Odour complaints and ES enforcement action records indicate that there have been both acute and chronic effects from the historic operation of the AB Lime landfill. Acute effects observed by ES have been observed relatively close to the site and have resulted in enforcement action. The complaint records indicate that there have been chronic effects, infrequent low intensity odour, primarily detected at a limited number of dwellings at distance from the site.

Despite the fact that AB Lime is proposing to increase the waste acceptance rate, it is proposing a much-improved odour management structure for the site such that these acute and chronic effects can be minimised or removed completely. Overall, AB Lime propose to implement industry standard odour mitigation measures such that there is a substantial improvement in the ambient off-site odour levels, particularly at the nearest off-site sensitive receptors.

[19] http://www.horizons.govt.nz/HRC/media/Media/Consent/56273040_Doug-Boddy-evidence_(v1)_1.PDF. http://www.horizons.govt.nz/HRC/media/Media/Consent/Levin-Landfill-Odour-Assessment_Report-FINAL.pdf

[20] Beca Ltd report: Spicer Landfill Odour Report, December 2015.

7.10.3.1 FIDOL Assessment

Whilst the FIDOL assessment below is focused on off-site sensitive receptors (dwellings), it is acknowledged that adverse odour effects can occur on unoccupied land or public spaces, such as public roads. Crucially, the potential for offensive or objectionable odour effects to occur at these locations is much lower due to the reduced frequency and duration that any one receptor may spend in these environments. The likelihood that a neighbour or member of the public is in one of these locations at the same time that meteorological conditions and site activities result in acute offensive odour beyond the boundary is low.

The mitigation measures proposed for the site are aimed at preventing any odour beyond the boundary of the site. It is anticipated that the level of odour mitigation proposed will not only be effective at eliminating adverse odour effects at neighbouring dwellings, but also at neighbouring unoccupied land or public spaces.

7.10.3.1.1 Frequency

Based on an analysis of the odour complaint record, the frequency at which offensive odour is observed off-site is low. Between 2005 and 2019 the average number of odour complaints per year is 4.2, the range is from 0 complaints to a maximum of 16 complaints in any one year (see Figure 20). The peak in complaints in 2018 was related to AB Lime being required to take a large volume of M. Bovis infected deceased cattle, and as discussed above, in instances such as this, odour issues are not necessarily within the control of the consent holder.

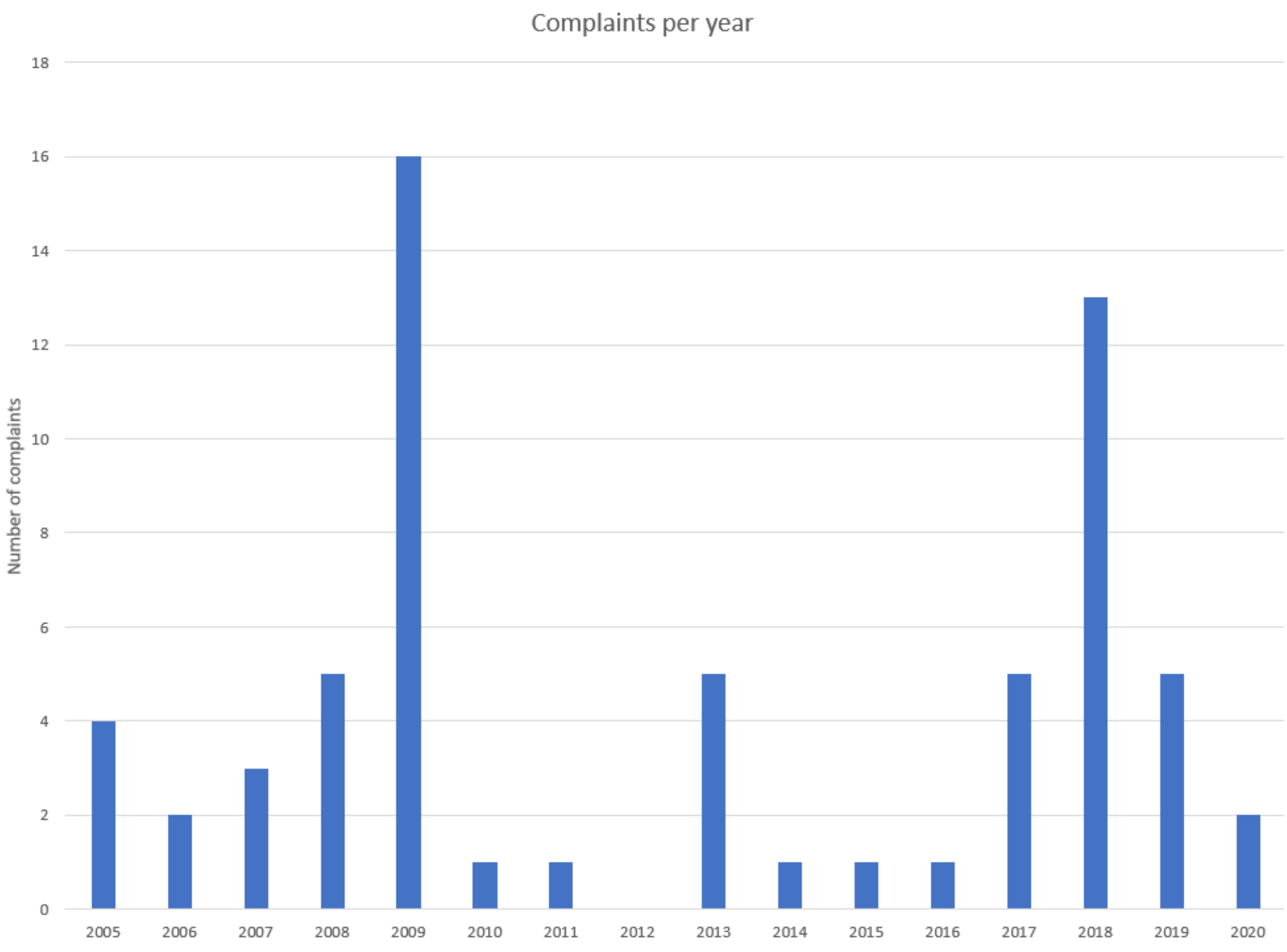

Figure 20 Odour complaints per year

Based on the on-site weather data (2012 – 2014), there is also a limited amount of time that the wind blows towards any one given receptor. Table 17 contains the approximate amount of time winds will blow towards any one of the sensitive receptors not owned by AB Lime, identified in Section 2.1. Note that there is a large proportion (17%) of light wind or calms (winds below 0.2 m/s) recorded in this dataset. As described above, during these calm conditions it is likely that there will be a higher percentage of winds flowing towards down valley receptors.

Table 17 Approximate Percentage Time Wind Blows Towards a Receptor

Receptor	% of time wind blowing towards
R9	11%
R10	8%
R11	8%
R5	7%
R6	7%
R4	4%
R12	4%

53% of the time wind blows towards mostly uninhabited land.

Whilst it is likely that some level of odour will be discharged from the landfill at all times, the mitigation measures proposed are designed to limit the number of sources discharging at any one time, and the volume of and intensity of odour discharged from the site. With the substantial separation distances that AB Lime has between its landfill footprint and the nearest sensitive receptors not owned by AB Lime, it is expected that this proposed reduction in cumulative odour emissions from the site will substantially reduce the frequency of observable odour beyond the boundary of the site from historic operations.

The frequency that Level 1, Level 2, and Level 3 controls fail to contain odour emissions beyond the boundary of the site and the meteorological conditions are such that odour could carry from the site to one of the nearest sensitive receptors is considered to be very low.

7.10.3.1.2 Intensity

The perceived intensity of odour is directly related to the concentration of the odour in the air. Due to dispersion and mixing of an odour plume the higher the separation distance between the emission point and the receptor, the lower the odour concentration, and therefore the lower the intensity. Odour concentrations generally decrease exponentially with distance from the source. As the nearest sensitive receptor not owned by AB Lime is over 1 km away from the landfill footprint, which is outside the conservative separation/buffer distance guidance discussed in Section 7.10.1, it is likely that the intensity of any odour observed at these locations will be low.

As discussed in Section 6 AB Lime are proposing significant improvements to their on-site management of the site, including the odour management procedures. Particular attention has been paid to the primary odour emission points. These include; a big reduction in the size of the open working face, improved capping, improved LFG capture, additional controls for receiving and disposing of highly odorous special waste, a reduction in leachate production and improved management of leachate, etc. These improvements will reduce the concentration and volume/mass of odour emissions at the source of the emission. This will consequently result in a substantive decrease in off-site odour concentrations and hence a decrease in the perceived odour intensity.

7.10.3.1.3 Duration

The complaint record often describes short lived off-site odour events. Often when a complaint has been investigated by AB Lime or Environment Southland the odour is no longer present, or intermittent. Therefore, the duration of current observable odour events appears to be short.

Intermittent short duration odour events are often observed when odour producing activities on-site are variable, or the specific meteorological conditions (wind speed, wind direction, stability class, etc) which result in the observations occur for short periods of time. These short duration low intensity odour effects often occur on the edge of an odour plume.

As discussed already, it is proposed that there will be a net decrease in odour being discharged from the site, despite the proposed increase in waste acceptance rates. Furthermore, the proposed boundary H_2S and odour scout monitoring will act as an early warning system for detectable odour beyond the boundary of the site. This will trigger additional on-site odour control measures such that odour can no longer be detected at the boundary. As such, it is anticipated that any odour detected beyond the boundary of the site will be for a short duration.

The duration of experiencing any odour effects for road users is expected to be short. Public users of Cahill Road, Bend Road and State Highway 96 are transient in nature and unlikely to experience any prolonged periods of odour. Furthermore, the consent holder owns the majority of land parcels that would utilise Cahill and Bend Road.

7.10.3.1.4 Offensiveness

The character of the odour that is discharged from the landfill differs depending on its source. Odour from landfill gas or anaerobic decomposition is often characterised as a 'sulphurous/rotten egg' type odour due to the high concentrations of H_2S in the gas. Odour from fresh waste can vary, but some have described it as a 'rotten cabbage' like odour. Odours from some of the special waste streams that are received by AB Lime are also variable dependant on the product being received, but many are highly offensive. For example, deceased animals, biosolids, animal skins, sump waste, etc often have a strong, very offensive odour, at the source.

The offensiveness of an odour is often described as its hedonic tone. There are different scales used for hedonic tone. In the UK Guidance on Odour Management[21] a +5 to -5 scale is used. Positive scores are associated with pleasant odours, whereas negative scores are associated with unpleasant odours. Figure 21 is an example scale from the UK guidance.

The MfE odour GPG uses a similar hedonic tone scale but from -4 (extremely unpleasant) to +4 (extremely pleasant).

[21] Environment Agency for England and Wales. 2002. "*Integrated Pollution Prevention and Control (IPPC) Draft Horizontal Guidance for Odour, Part 1 Regulation and Permitting*"

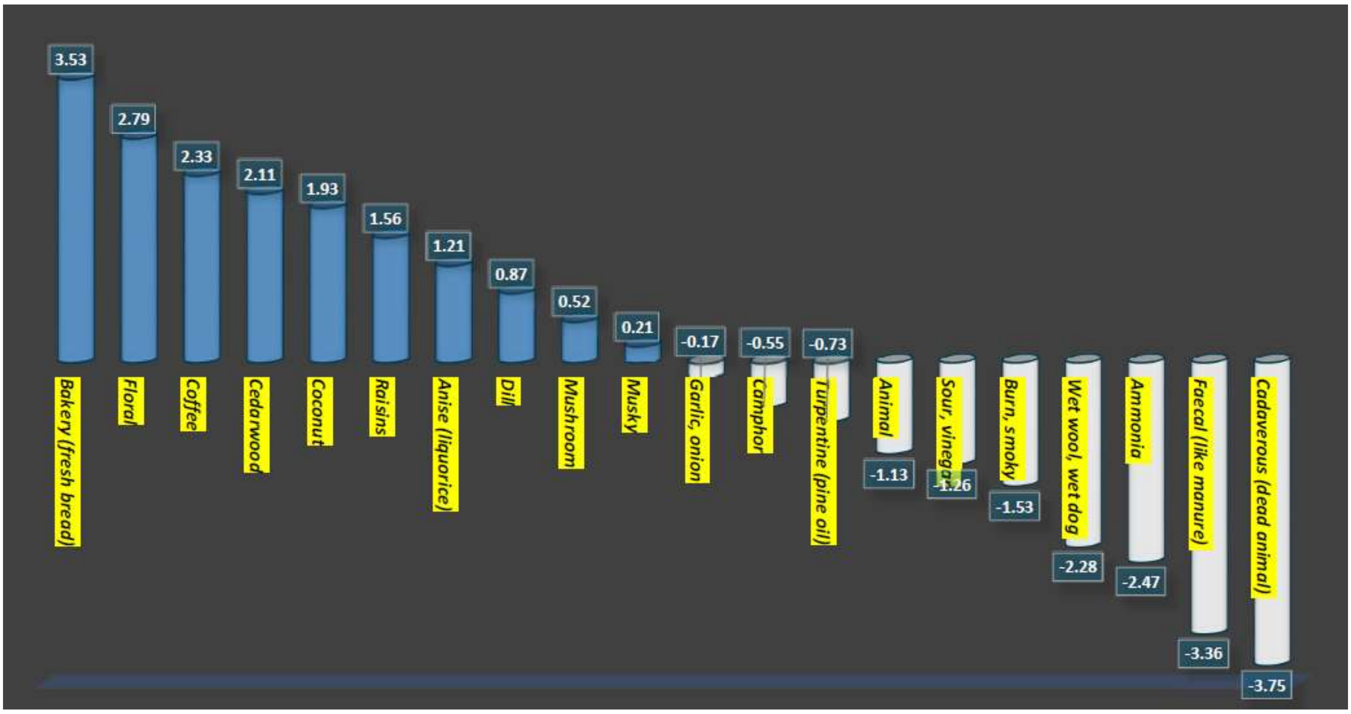

Figure 21 Hedonic Tone Scale

On this scale, high intensity odour produced at the source of on-site activities will have a highly negative hedonic tone. However, lower intensity odours, such as that from fresh waste will have a less offensive hedonic tone and could be scored as -1 to -2 on the above scale.

Often, odours which are considered offensive at higher concentration or intensity, can be considered far less offensive or even acceptable at lower intensities. As the odour management plan for the AB Lime landfill is designed to prevent odour being detectable at the boundary it is anticipated that, at most, the concentration of odour at the nearest sensitive receptors will be low to negligible. At these low concentrations the offensiveness of any odour detected is likely to be much lower than that at the source.

Therefore, the potential for 'offensive' odour beyond the boundary of the site is low.

7.10.3.1.5 Location

The location of the existing landfill is considered appropriate. It is well separated from neighbouring sensitive receptors and AB Lime own much of the surrounding land. This limits the potential for off-site adverse odour effects.

To increase the waste acceptance rate at the existing landfill is considered a much better solution than building another landfill at a greenfield site.

7.10.4 Dust

As discussed earlier, dust emissions from the site have not historically resulted in off-site effects. Current dust mitigation measures on the site are effective at limiting dust emission beyond the boundary of the site. Potential dust emissions from site activities are dominated by the quarry activities, primarily due to the higher fine material handling activities associated with the quarry operations.

Whilst the waste acceptance rate is proposed to be increased, this will equate to a relatively small increase in potential dust emissions from the site. There is the potential for an increase in dust emissions from; the higher number of truck movements on internal unsealed roads, increased material handling activities associated with capping/daily cover, and a small potential of increased receival rates of dusty waste (historically a very small proportion of the waste received is dusty).

Notwithstanding the above, AB Lime are proposing a higher level of dust mitigation with contingency measures (Level 2 controls) on-site, such that the potential for nuisance dust effects beyond the boundary of the site are further limited.

As above, there are published recommended separation distances from quarry air discharges. For the purpose of providing perspective, the following documented separation distances are appropriate for the quarry activities, and would be very conservative for the landfill activities:

- Auckland Council recommends a separation distance of **200 m** from a dwelling (it's a controlled activity to establish a quarry within 200 m of a dwelling in the Auckland Unitary Plan).
- The Victoria Environmental Protection Agency (Vic EPA) recommends a separation distance of **250 m** for a quarry which does not involve blasting[22].
- The South Australia EPA recommends a separation distance of **300 m** for extractive industries with no blasting[23].

Given the very large separation distance between the site activities and the nearest off-site receptors, well in excess of these conservative separation distances, it is anticipated that there is a very low potential for off-site nuisance dust effects resulting from the proposed site activities.

7.10.5 Combustion Emissions

The air dispersion modelling assessment in Section 7 above demonstrates that the conservatively predicted peak off-site concentrations of products of combustion from the site will all be below the relevant ambient air quality criteria. In the likely waste acceptance rate scenario (Scenario 2), the predicted peak off-site SO_2 concentrations are 43% and 58% of the 1 hour and 24 hour ambient air quality criteria, respectively. Note that it is unlikely that these peak off-site concentrations will actually occur due to the conservatism in the modelling approach. The primary contributor to off-site SO_2 concentrations is the coal burning in the kilns. Given the seasonality in the kiln operation, the actual coal consumption rates will infrequently occur at peak modelled burn rates. Therefore, the likelihood that the kilns are operating at the peak emission rates modelled during the worst case dispersion conditions is low. As such the actual off-site peak concentrations are likely to be lower than that presented in the results Tables.

Peak off-site concentrations of PM_{10}, NO_2 and CO are predicted to be low. Potential effects on the surrounding ambient air quality are dominated by potential peak off-site SO_2 concentrations. The current consented peak SO_2 emissions from the site would result in an exceedance of both the 1 hour and 24 hour ambient air quality criteria.

AB Lime are proposing to reduce the consented mass discharge limit of SO_2 from the kilns, this in conjunction with partial replacement of coal consumption by using the available LFG as fuel in the kilns will result in a net reduction in peak off-site effects.

As such there will be an improvement in the surrounding ambient air quality associated with the proposed expanded operations at the landfill.

[22] Victoria EPA, 2013: 'Recommended separation distances for industrial residual air emissions' Publication number 1518
[23] South Australia EPA, 2007: 'Guidelines for separation distances'

7.10.6 Other Toxic/Hazardous Emissions

Whilst the AB Lime landfill is consented to take a number of hazardous waste streams (described in Section 6.2) this occurs infrequently and at a small scale.

Over the lifetime of the landfill, limited amounts of the following consented toxic/hazardous waste have been disposed of in the landfill:

- asbestos containing waste;
- medical waste;
- methamphetamine contaminated furnishings; and
- aluminium dross.

Given that no new asbestos containing products are allowed to be made, imported, or used in New Zealand it is anticipated that the amount and rate of disposal of this waste stream will decrease over time.

The other waste streams above have only been disposed of as a one off event when AB Lime has been required to accept these wastes by the relevant regulatory authority. It is unlikely that any substantive disposal of these other waste streams will occur in the future, although this cannot be discounted as it depends of circumstances beyond AB Lime's control.

Notwithstanding the above, AB Lime have specific management procedures in place for the handling and disposal of these hazardous waste streams. These procedures are primarily focused on protecting site staff such that they are not exposed to toxic concentrations of potential airborne emissions from these substances. As a result of these management practices, concentrations of any air emissions from the handling and disposal of these waste streams should be well below the relevant workplace exposure criteria. Given the large separation distances between the landfill footprint and the nearest site boundary (200 – 1,000 m), the dispersion of any toxic air pollutants emitted from these activities will result in negligible concentrations of these pollutants at the boundary of the site.

8. Conclusion

Despite the proposed increase in waste acceptance rates at the AB Lime Landfill it is predicted that off-site effects on the surrounding ambient air quality will reduce, as compared with the current effects.

The predicted reduction in odour effects will occur as a result in the improved management and mitigation measures on-site. The Landfill Operations Management Plan and Landfill Air Quality Management Plan have been updated to reflect industry best practice methodology. This presents an improvement in current operations. In particular, the large reduction in the open working face area will result a substantial reduction in the potential for odour emissions from the site.

The proposed boundary monitoring will trigger the proposed three stage odour mitigation process. This procedure provides for a high level of contingency in the site odour management which is designed to limit observable odour at the boundary of the site and hence prevent offensive or objectionable effects at neighbouring receptors. This substantive improvement in odour management is designed to eliminate historical off-site odour complaints.

Although there is a small potential for an increase in dust emissions from the proposed increased waste acceptance rate, existing controls have been effective at controlling dust emissions from the site and are expected to be effective at controlling and additional emissions. However, to provide for a higher level of certainty that adverse off-site effects will not occur, additional contingency measures are proposed (Level 2 mitigation measures in Section 8 of the LAQMP).

AB Lime are proposing to reduce coal consumption rates on-site by utilising the LFG produced by the waste mass to fuel the lime drying kilns. This has a twofold benefit to AB Lime, it decreases the site's running costs and decreases the site's impact on the environment. The air dispersion modelling assessment has predicted that this will result in at least a 65% reduction in peak off-site SO_2 concentrations. It is predicted that there will be a similar decrease in other products of combustion due to the fact that LFG is a cleaner burning fuel than coal.

Whilst there is a low potential for discharges of hazardous air pollutants from the handling and disposal of specific hazardous waste streams on-site, this occurs very infrequently and at a small scale. Due to the existing management practices and the small scale of these potential discharges it is predicted that potential effects from these activities will be negligible at the site boundary and off-site receptors.

Overall, this assessment concludes that the proposed operation of the AB Lime landfill will reduce current off-site effects on ambient air quality. Peak off-site effects are predicted to be well below the relevant ambient air quality criteria.

Attachment 1. CALPUFF and CALMET Modelling Inputs

CALPUFF Parameters

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	**Description**	**Value**
PUFLST	CALPUFF output list file (CALPUFF.LST)	CALPUFF.LST
CONDAT	CALPUFF output concentration file (CONC.DAT)	CONC.DAT
DFDAT	CALPUFF output dry deposition flux file (DFLX.DAT)	DFLX.DAT
WFDAT	CALPUFF output wet deposition flux file (WFLX.DAT)	WFLX.DAT
LCFILES	Lower case file names (T = lower case, F = upper case)	F
NMETDOM	Number of CALMET.DAT domains	1
NMETDAT	Number of CALMET.DAT input files	12
NPTDAT	Number of PTEMARB.DAT input files	0
NARDAT	Number of BAEMARB.DAT input files	0
NVOLDAT	Number of VOLEMARB.DAT input files	0
NFLDAT	Number of FLEMARB.DAT input files	0
NRDDAT	Number of RDEMARB.DAT input files	0
NLNDAT	Number of LNEMARB.DAT input files	0
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-01-01-00-0000-2019-01-31-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-01-31-00-0000-2019-03-03-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-03-03-00-0000-2019-04-02-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-04-02-00-0000-2019-05-03-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-05-03-00-0000-2019-06-02-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-06-02-00-0000-2019-07-02-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-07-02-00-0000-2019-08-02-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-08-02-00-0000-2019-09-01-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-09-01-00-0000-2019-10-02-00-0000.DAT

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	**Description**	**Value**
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-10-02-00-0000-2019-11-01-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-11-01-00-0000-2019-12-02-00-0000.DAT
METDAT	CALMET gridded meteorological data file (CALMET.DAT)	CALMET_2019-12-02-00-0000-2020-01-01-00-0000.DAT

INPUT GROUP: 1 -- General Run Control Parameters		
Parameter	**Description**	**Value**
METRUN	Run all periods in met data file? (0 = no, 1 = yes)	0
IBYR	Starting year	2019
IBMO	Starting month	1
IBDY	Starting day	1
IBHR	Starting hour	0
IBMIN	Starting minute	0
IBSEC	Starting second	0
IEYR	Ending year	2020
IEMO	Ending month	1
IEDY	Ending day	1
IEHR	Ending hour	0
IEMIN	Ending minute	0
IESEC	Ending second	0
ABTZ	Base time zone	UTC+1200
NSECDT	Length of modeling time-step (seconds)	3600
NSPEC	Number of chemical species modeled	1
NSE	Number of chemical species to be emitted	1
ITEST	Stop run after SETUP phase (1 = stop, 2 = run)	2
MRESTART	Control option to read and/or write model restart data	0
NRESPD	Number of periods in restart output cycle	0
METFM	Meteorological data format (1 = CALMET, 2 = ISC, 3 = AUSPLUME, 4 = CTDM, 5 = AERMET)	1
MPRFFM	Meteorological profile data format (1 = CTDM, 2 = AERMET)	1
AVET	Averaging time (minutes)	60
PGTIME	PG Averaging time (minutes)	60
IOUTU	Output units for binary output files (1 = mass, 2 = odour, 3 = radiation)	1

INPUT GROUP: 2 -- Technical Options		
Parameter	**Description**	**Value**

INPUT GROUP: 2 -- Technical Options		
Parameter	**Description**	**Value**
MGAUSS	Near field vertical distribution (0 = uniform, 1 = Gaussian)	1
MCTADJ	Terrain adjustment method (0 = none, 1 = ISC-type, 2 = CALPUFF-type, 3 = partial plume path)	3
MCTSG	Model subgrid-scale complex terrain? (0 = no, 1 = yes)	0
MSLUG	Near-field puffs modeled as elongated slugs? (0 = no, 1 = yes)	0
MTRANS	Model transitional plume rise? (0 = no, 1 = yes)	1
MTIP	Apply stack tip downwash to point sources? (0 = no, 1 = yes)	1
MRISE	Plume rise module for point sources (1 = Briggs, 2 = numerical)	1
MTIP_FL	Apply stack tip downwash to flare sources? (0 = no, 1 = yes)	0
MRISE_FL	Plume rise module for flare sources (1 = Briggs, 2 = numerical)	2
MBDW	Building downwash method (1 = ISC, 2 = PRIME)	2
MSHEAR	Treat vertical wind shear? (0 = no, 1 = yes)	0
MSPLIT	Puff splitting allowed? (0 = no, 1 = yes)	0
MCHEM	Chemical transformation method (0 = not modeled, 1 = MESOPUFF II, 2 = User-specified, 3 = RIVAD/ARM3, 4 = MESOPUFF II for OH, 5 = half-life, 6 = RIVAD w/ISORROPIA, 7 = RIVAD w/ISORROPIA CalTech SOA)	0
MAQCHEM	Model aqueous phase transformation? (0 = no, 1 = yes)	0
MLWC	Liquid water content flag	1
MWET	Model wet removal? (0 = no, 1 = yes)	0
MDRY	Model dry deposition? (0 = no, 1 = yes)	0
MTILT	Model gravitational settling (plume tilt)? (0 = no, 1 = yes)	0
MDISP	Dispersion coefficient calculation method (1= PROFILE.DAT, 2 = Internally, 3 = PG/MP, 4 = MESOPUFF II, 5 = CTDM)	2
MTURBVW	Turbulence characterization method (only if MDISP = 1 or 5)	3
MDISP2	Missing dispersion coefficients method (only if MDISP = 1 or 5)	3
MTAULY	Sigma-y Lagrangian timescale method	0
MTAUADV	Advective-decay timescale for turbulence (seconds)	0
MCTURB	Turbulence method (1 = CALPUFF, 2 = AERMOD)	1
MROUGH	PG sigma-y and sigma-z surface roughness adjustment? (0 = no, 1 = yes)	0
MPARTL	Model partial plume penetration for point sources? (0 = no, 1 = yes)	1
MPARTLBA	Model partial plume penetration for buoyant area sources? (0 = no, 1 = yes)	0
MTINV	Strength of temperature inversion provided in PROFILE.DAT? (0 = no - compute from default gradients, 1 = yes)	0
MPDF	PDF used for dispersion under convective conditions? (0 = no, 1 = yes)	1
MSGTIBL	Sub-grid TIBL module for shoreline? (0 = no, 1 = yes)	0
MBCON	Boundary conditions modeled? (0 = no, 1 = use BCON.DAT, 2 = use CONC.DAT)	0
MSOURCE	Save individual source contributions? (0 = no, 1 = yes)	0
MFOG	Enable FOG model output? (0 = no, 1 = yes - PLUME mode, 2 = yes - RECEPTOR mode)	0
MREG	Regulatory checks (0 = no checks, 1 = USE PA LRT checks)	0

INPUT GROUP: 3 -- Species List		
Parameter	**Description**	**Value**
CSPEC	Species included in model run	SO2

INPUT GROUP: 4 -- Map Projection and Grid Control Parameters		
Parameter	**Description**	**Value**
PMAP	Map projection system	UTM
FEAST	False easting at projection origin (km)	0.0
FNORTH	False northing at projection origin (km)	0.0
IUTMZN	UTM zone (1 to 60)	59
UTMHEM	Hemisphere (N = northern, S = southern)	S
RLAT0	Latitude of projection origin (decimal degrees)	0.00N
RLON0	Longitude of projection origin (decimal degrees)	0.00E
XLAT1	1st standard parallel latitude (decimal degrees)	30S
XLAT2	2nd standard parallel latitude (decimal degrees)	60S
DATUM	Datum-region for the coordinates	WGS-84
NX	Meteorological grid - number of X grid cells	30
NY	Meteorological grid - number of Y grid cells	30
NZ	Meteorological grid - number of vertical layers	10
DGRIDKM	Meteorological grid spacing (km)	0.2
ZFACE	Meteorological grid - vertical cell face heights (m)	0.0, 20.0, 40.0, 80.0, 160.0, 320.0, 640.0, 1200.0, 2000.0, 3000.0, 4000.0
XORIGKM	Meteorological grid - X coordinate for SW corner (km)	294.6796
YORIGKM	Meteorological grid - Y coordinate for SW corner (km)	4885.1506
IBCOMP	Computational grid - X index of lower left corner	1
JBCOMP	Computational grid - Y index of lower left corner	1
IECOMP	Computational grid - X index of upper right corner	30
JECOMP	Computational grid - Y index of upper right corner	30
LSAMP	Use sampling grid (gridded receptors) (T = true, F = false)	F
IBSAMP	Sampling grid - X index of lower left corner	1
JBSAMP	Sampling grid - Y index of lower left corner	1
IESAMP	Sampling grid - X index of upper right corner	2
JESAMP	Sampling grid - Y index of upper right corner	2
MESHDN	Sampling grid - nesting factor	1

INPUT GROUP: 5 -- Output Options		
Parameter	**Description**	**Value**
ICON	Output concentrations to CONC.DAT? (0 = no, 1 = yes)	1
IDRY	Output dry deposition fluxes to DFLX.DAT? (0 = no, 1 = yes)	0
IWET	Output wet deposition fluxes to WFLX.DAT? (0 = no, 1 = yes)	0

INPUT GROUP: 5 -- Output Options		
Parameter	**Description**	**Value**
IT2D	Output 2D temperature data? (0 = no, 1 = yes)	0
IRHO	Output 2D density data? (0 = no, 1 = yes)	0
IVIS	Output relative humidity data? (0 = no, 1 = yes)	0
LCOMPRS	Use data compression in output file (T = true, F = false)	T
IQAPLOT	Create QA output files suitable for plotting? (0 = no, 1 = yes)	1
IPFTRAK	Output puff tracking data? (0 = no, 1 = yes use timestep, 2 = yes use sampling step)	0
IMFLX	Output mass flux across specific boundaries? (0 = no, 1 = yes)	0
IMBAL	Output mass balance for each species? (0 = no, 1 = yes)	0
INRISE	Output plume rise data? (0 = no, 1 = yes)	0
ICPRT	Print concentrations? (0 = no, 1 = yes)	0
IDPRT	Print dry deposition fluxes? (0 = no, 1 = yes)	0
IWPRT	Print wet deposition fluxes? (0 = no, 1 = yes)	0
ICFRQ	Concentration print interval (timesteps)	1
IDFRQ	Dry deposition flux print interval (timesteps)	1
IWFRQ	Wet deposition flux print interval (timesteps)	1
IPRTU	Units for line printer output (e.g., 3 = ug/m**3 - ug/m**2/s, 5 = odor units)	3
IMESG	Message tracking run progress on screen (0 = no, 1 and 2 = yes)	2
LDEBUG	Enable debug output? (0 = no, 1 = yes)	F
IPFDEB	First puff to track in debug output	1
NPFDEB	Number of puffs to track in debug output	1000
NN1	Starting meteorological period in debug output	1
NN2	Ending meteorological period in debug output	10

INPUT GROUP: 6 -- Subgrid Scale Complex Terrain Inputs		
Parameter	**Description**	**Value**
NHILL	Number of terrain features	0
NCTREC	Number of special complex terrain receptors	0
MHILL	Terrain and CTSG receptor data format (1= CTDM, 2 = OPTHILL)	2
XHILL2M	Horizontal dimension conversion factor to meters	1.0
ZHILL2M	Vertical dimension conversion factor to meters	1.0
XCTDMKM	X origin of CTDM system relative to CALPUFF system (km)	0.0
YCTDMKM	Y origin of CTDM system relative to CALPUFF system (km)	0.0

INPUT GROUP: 9 -- Miscellaneous Dry Deposition Parameters		
Parameter	**Description**	**Value**
RCUTR	Reference cuticle resistance (s/cm)	30
RGR	Reference ground resistance (s/cm)	10
REACTR	Reference pollutant reactivity	8

INPUT GROUP: 9 -- Miscellaneous Dry Deposition Parameters		
Parameter	**Description**	**Value**
NINT	Number of particle size intervals for effective particle deposition velocity	9
IVEG	Vegetation state in unirrigated areas (1 = active and unstressed, 2 = active and stressed, 3 = inactive)	1

INPUT GROUP: 11 -- Chemistry Parameters		
Parameter	**Description**	**Value**
MOZ	Ozone background input option (0 = monthly, 1 = hourly from OZONE.DAT)	1
BCKO3	Monthly ozone concentrations (ppb)	80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00
MNH3	Ammonia background input option (0 = monthly, 1 = from NH3Z.DAT)	0
MAVGNH3	Ammonia vertical averaging option (0 = no average, 1 = average over vertical extent of puff)	1
BCKNH3	Monthly ammonia concentrations (ppb)	10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00
RNITE1	Nighttime SO2 loss rate (%/hr)	0.2
RNITE2	Nighttime NOx loss rate (%/hr)	2
RNITE3	Nighttime HNO3 loss rate (%/hr)	2
MH2O2	H2O2 background input option (0 = monthly, 1 = hourly from H2O2.DAT)	1
BCKH2O2	Monthly H2O2 concentrations (ppb)	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00
RH_ISRP	Minimum relative humidity for ISORROPIA	50.0
SO4_ISRP	Minimum SO4 for ISORROPIA	0.4
BCKPMF	SOA background fine particulate (ug/m**3)	1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00
OFRAC	SOA organic fine particulate fraction	0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15
VCNX	SOA VOC/NOX ratio	50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00
NDECAY	Half-life decay blocks	0

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters		
Parameter	**Description**	**Value**
SYTDEP	Horizontal puff size for time-dependent sigma equations (m)	550
MHFTSZ	Use Heffter equation for sigma-z? (0 = no, 1 = yes)	0
JSUP	PG stability class above mixed layer	5
CONK1	Vertical dispersion constant - stable conditions	0.01

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters		
Parameter	**Description**	**Value**
CONK2	Vertical dispersion constant - neutral/unstable conditions	0.1
TBD	Downwash scheme transition point option (<0 = Huber-Snyder, 1.5 = Schulman-Scire, 0.5 = ISC)	0.5
IURB1	Beginning land use category for which urban dispersion is assumed	10
IURB2	Ending land use category for which urban dispersion is assumed	19
ILANDUIN	Land use category for modeling domain	20
Z0IN	Roughness length for modeling domain (m)	.25
XLAIIN	Leaf area index for modeling domain	3.0
ELEVIN	Elevation above sea level (m)	.0
XLATIN	Meteorological station latitude (deg)	-999.0
XLONIN	Meteorological station longitude (deg)	-999.0
ANEMHT	Anemometer height (m)	10.0
ISIGMAV	Lateral turbulence format (0 = read sigma-theta, 1 = read sigma-v)	1
IMIXCTDM	Mixing heights read option (0 = predicted, 1 = observed)	0
XMXLEN	Slug length (met grid units)	1
XSAMLEN	Maximum travel distance of a puff/slug (met grid units)	1
MXNEW	Maximum number of slugs/puffs release from one source during one time step	99
MXSAM	Maximum number of sampling steps for one puff/slug during one time step	99
NCOUNT	Number of iterations used when computing the transport wind for a sampling step that includes gradual rise	2
SYMIN	Minimum sigma-y for a new puff/slug (m)	1
SZMIN	Minimum sigma-z for a new puff/slug (m)	1
SZCAP_M	Maximum sigma-z allowed to avoid numerical problem in calculating virtual time or distance (m)	5000000
SVMIN	Minimum turbulence velocities sigma-v (m/s)	0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.37, 0.37, 0.37, 0.37, 0.37, 0.37
SWMIN	Minimum turbulence velocities sigma-w (m/s)	0.2, 0.12, 0.08, 0.06, 0.03, 0.016, 0.2, 0.12, 0.08, 0.06, 0.03, 0.016
CDIV	Divergence criterion for dw/dz across puff (1/s)	0, 0
NLUTIBL	TIBL module search radius (met grid cells)	4
WSCALM	Minimum wind speed allowed for non-calm conditions (m/s)	0.5
XMAXZI	Maximum mixing height (m)	3000
XMINZI	Minimum mixing height (m)	50
TKCAT	Emissions scale-factors temperature categories (K)	265., 270., 275., 280., 285., 290., 295., 300., 305., 310., 315.
PLX0	Wind speed profile exponent for stability classes 1 to 6	0.07, 0.07, 0.1, 0.15, 0.35, 0.55
PTG0	Potential temperature gradient for stable classes E and F (deg K/m)	0.02, 0.035

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters		
Parameter	**Description**	**Value**
PPC	Plume path coefficient for stability classes 1 to 6	0.5, 0.5, 0.5, 0.5, 0.35, 0.35
SL2PF	Slug-to-puff transition criterion factor (sigma-y/slug length)	10
FCLIP	Hard-clipping factor for slugs (0.0 = no extrapolation)	0
NSPLIT	Number of puffs created from vertical splitting	3
IRESPLIT	Hour for puff re-split	0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
ZISPLIT	Minimum mixing height for splitting (m)	100
ROLDMAX	Mixing height ratio for splitting	0.25
NSPLITH	Number of puffs created from horizontal splitting	5
SYSPLITH	Minimum sigma-y (met grid cells)	1
SHSPLITH	Minimum puff elongation rate (SYSPLITH/hr)	2
CNSPLITH	Minimum concentration (g/m**3)	0
EPSSLUG	Fractional convergence criterion for numerical SLUG sampling integration	0.0001
EPSAREA	Fractional convergence criterion for numerical AREA source integration	1E-006
DSRISE	Trajectory step-length for numerical rise integration (m)	1.0
HTMINBC	Minimum boundary condition puff height (m)	500
RSAMPBC	Receptor search radius for boundary condition puffs (km)	10
MDEPBC	Near-surface depletion adjustment to concentration (0 = no, 1 = yes)	1

INPUT GROUP: 13 -- Point Source Parameters		
Parameter	**Description**	**Value**
NPT1	Number of point sources	3
IPTU	Units used for point source emissions (e.g., 1 = g/s)	1
NSPT1	Number of source-species combinations with variable emission scaling factors	0
NPT2	Number of point sources in PTEMARB.DAT file(s)	0

INPUT GROUP: 14 -- Area Source Parameters		
Parameter	**Description**	**Value**
NAR1	Number of polygon area sources	0
IARU	Units used for area source emissions (e.g., 1 = g/m**2/s)	1
NSAR1	Number of source-species combinations with variable emission scaling factors	0
NAR2	Number of buoyant polygon area sources in BAEMARB.DAT file(s)	0

INPUT GROUP: 15 -- Line Source Parameters		
Parameter	**Description**	**Value**
NLN2	Number of buoyant line sources in LNEMARB.DAT file	0
NLINES	Number of buoyant line sources	0

INPUT GROUP: 15 -- Line Source Parameters		
Parameter	**Description**	**Value**
ILNU	Units used for line source emissions (e.g., 1 = g/s)	1
NSLN1	Number of source-species combinations with variable emission scaling factors	0
NLRISE	Number of distances at which transitional rise is computed	6

INPUT GROUP: 16 -- Volume Source Parameters		
Parameter	**Description**	**Value**
NVL1	Number of volume sources	0
IVLU	Units used for volume source emissions (e.g., 1 = g/s)	1
NSVL1	Number of source-species combinations with variable emission scaling factors	0
NVL2	Number of volume sources in VOLEMARB.DAT file(s)	0

INPUT GROUP: 17 -- FLARE Source Control Parameters (variable emissions file)		
Parameter	**Description**	**Value**
NFL2	Number of flare sources defined in FLEMARB.DAT file(s)	0

INPUT GROUP: 18 -- Road Emissions Parameters		
Parameter	**Description**	**Value**
NRD1	Number of road-links sources	0
NRD2	Number of road-links in RDEMARB.DAT file	0
NSFRDS	Number of road-links and species combinations with variable emission-rate scale-factors	0

INPUT GROUP: 19 -- Emission Rate Scale-Factor Tables		
Parameter	**Description**	**Value**
NSFTAB	Number of emission scale-factor tables	0

INPUT GROUP: 20 -- Non-gridded (Discrete) Receptor Information		
Parameter	**Description**	**Value**
NREC	Number of discrete receptors (non-gridded receptors)	1355
NRGRP	Number of receptor group names	0

CALMET Parameters

INPUT GROUP: 0 -- Input and Output File Names		
Parameter	**Description**	**Value**
GEODAT	Input file of geophysical data (GEO.DAT)	GEO.DAT
METLST	Output file name of CALMET list file (CALMET.LST)	CALMET.LST
METDAT	Output file name of generated gridded met files (CALMET.DAT)	CALMET.DAT
LCFILES	Lower case file names (T = lower case, F = upper case)	F
NUSTA	Number of upper air stations	0
NOWSTA	Number of overwater stations	0
NM3D	Number of prognostic meteorological data files (3D.DAT)	6
NIGF	Number of IGF-CALMET.DAT files used as initial guess	0

INPUT GROUP: 1 -- General Run Control Parameters		
Parameter	**Description**	**Value**
IBYR	Starting year	2019
IBMO	Starting month	1
IBDY	Starting day	1
IBHR	Starting hour	0
IBSEC	Starting second	0
IEYR	Ending year	2020
IEMO	Ending month	1
IEDY	Ending day	1
IEHR	Ending hour	0
IESEC	Ending second	0
ABTZ	Base time zone	UTC+1200
NSECDT	Length of modeling time-step (seconds)	3600
IRTYPE	Output run type (0 = wind fields only, 1 = CALPUFF/CALGRID)	1
LCALGRD	Compute CALGRID data fields (T = true, F = false)	T
ITEST	Flag to stop run after setup phase (1 = stop, 2 = run)	2
MREG	Regulatory checks (0 = no checks, 1 = US EPA LRT checks)	0

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	**Description**	**Value**
PMAP	Map projection system	UTM
FEAST	False easting at projection origin (km)	0.0
FNORTH	False northing at projection origin (km)	0.0
IUTMZN	UTM zone (1 to 60)	59
UTMHEM	Hemisphere of UTM projection (N = northern, S = southern)	S
XLAT1	1st standard parallel latitude (decimal degrees)	30S

INPUT GROUP: 2 -- Map Projection and Grid Control Parameters		
Parameter	**Description**	**Value**
XLAT2	2nd standard parallel latitude (decimal degrees)	60S
DATUM	Datum-Region for the coordinates	WGS-84
NX	Meteorological grid - number of X grid cells	30
NY	Meteorological grid - number of Y grid cells	30
DGRIDKM	Meteorological grid spacing (km)	0.2
XORIGKM	Meteorological grid - X coordinate for SW corner (km)	294.6796
YORIGKM	Meteorological grid - Y coordinate for SW corner (km)	4885.1506
NZ	Meteorological grid - number of vertical layers	10
ZFACE	Meteorological grid - vertical cell face heights (m)	0.00,20.00,40.00,80.00,160.00,320.00,640.00,1200.00,2000.00,3000.00,4000.00

INPUT GROUP: 3 -- Output Options		
Parameter	**Description**	**Value**
LSAVE	Save met fields in unformatted output file (T = true, F = false)	T
IFORMO	Type of output file (1 = CALPUFF/CALGRID, 2 = MESOPUFF II)	1
LPRINT	Print met fields (F = false, T = true)	F
IPRINF	Print interval for output wind fields (hours)	1
STABILITY	Print gridded PGT stability classes? (0 = no, 1 = yes)	0
USTAR	Print gridded friction velocities? (0 = no, 1 = yes)	0
MONIN	Print gridded Monin-Obukhov lengths? (0 = no, 1 = yes)	0
MIXHT	Print gridded mixing heights? (0 = no, 1 = yes)	0
WSTAR	Print gridded convective velocity scales? (0 = no, 1 = yes)	0
PRECIP	Print gridded hourly precipitation rates? (0 = no, 1 = yes)	0
SENSHEAT	Print gridded sensible heat fluxes? (0 = no, 1 = yes)	0
CONVZI	Print gridded convective mixing heights? (0 = no, 1 = yes)	0
LDB	Test/debug option: print input met data and internal variables (F = false, T = true)	F
NN1	Test/debug option: first time step to print	1
NN2	Test/debug option: last time step to print	1
LDBCST	Test/debug option: print distance to land internal variables (F = false, T = true)	F
IOUTD	Test/debug option: print control variables for writing winds? (0 = no, 1 = yes)	0
NZPRN2	Test/debug option: number of levels to print starting at the surface	1
IPR0	Test/debug option: print interpolated winds? (0 = no, 1 = yes)	0
IPR1	Test/debug option: print terrain adjusted surface wind? (0 = no, 1 = yes)	0
IPR2	Test/debug option: print smoothed wind and initial divergence fields? (0 = no, 1 = yes)	0
IPR3	Test/debug option: print final wind speed and direction? (0 = no, 1 = yes)	0

INPUT GROUP: 3 -- Output Options		
Parameter	**Description**	**Value**
IPR4	Test/debug option: print final divergence fields? (0 = no, 1 = yes)	0
IPR5	Test/debug option: print winds after kinematic effects? (0 = no, 1 = yes)	0
IPR6	Test/debug option: print winds after Froude number adjustment? (0 = no, 1 = yes)	0
IPR7	Test/debug option: print winds after slope flow? (0 = no, 1 = yes)	0
IPR8	Test/debug option: print final winds? (0 = no, 1 = yes)	0

INPUT GROUP: 4 -- Meteorological Data Options		
Parameter	**Description**	**Value**
NOOBS	Observation mode (0 = stations only, 1 = surface/overwater stations with prognostic upper air, 2 = prognostic data only)	2
NSSTA	Number of surface stations	0
NPSTA	Number of precipitation stations	-1
ICLDOUT	Output the CLOUD.DAT file? (0 = no, 1 = yes)	0
MCLOUD	Method to compute cloud fields (1 = from surface obs, 2 = from CLOUD.DAT, 3 = from prognostic (Teixera), 4 = from prognostic (MM5toGrads)	3
IFORMS	Surface met data file format (1 = unformatted, 2 = formatted)	2
IFORMP	Precipitation data file format (1 = unformatted, 2 = formatted)	2
IFORMC	Cloud data file format (1 = unformatted, 2 = formatted)	1

INPUT GROUP: 5 -- Wind Field Options and Parameters		
Parameter	**Description**	**Value**
IWFCOD	Wind field model option (1 = objective analysis, 2 = diagnostic)	1
IFRADJ	Adjust winds using Froude number effects? (0 = no, 1 = yes)	1
IKINE	Adjust winds using kinematic effects? (0 = no, 1 = yes)	0
IOBR	Adjust winds using O'Brien velocity procedure? (0 = no, 1 = yes)	0
ISLOPE	Compute slope flow effects? (0 = no, 1 = yes)	1
IEXTRP	Extrapolation of surface winds to upper layers method (1 = none, 2 = power law, 3 = user input, 4 = similarity theory, - = same except layer 1 data at upper air stations are ignored)	1
ICALM	Extrapolate surface winds even if calm? (0 = no, 1 = yes)	0
BIAS	Weighting factors for surface and upper air stations (NZ values)	0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
RMIN2	Minimum upper air station radius of influence for surface extrapolation exclusion (km)	4
IPROG	Use prognostic winds as input to diagnostic wind model (0 = no, 13 = use winds from 3D.DAT as Step 1 field, 14 = use winds from 3D.DAT as initial guess field, 15 = use winds from 3D.DAT file as observations)	14
ISTEPPGS	Prognostic data time step (seconds)	3600
IGFMET	Use coarse CALMET fields as initial guess? (0 = no, 1 = yes)	0
LVARY	Use varying radius of influence (F = false, T = true)	F
RMAX1	Maximum radius of influence in the surface layer (km)	0

INPUT GROUP: 5 -- Wind Field Options and Parameters		
Parameter	**Description**	**Value**
RMAX2	Maximum radius of influence over land aloft (km)	0
RMAX3	Maximum radius of influence over water (km)	0
RMIN	Minimum radius of influence used in wind field interpolation (km)	0.1
TERRAD	Radius of influence of terrain features (km)	0.5
R1	Relative weight at surface of step 1 fields and observations (km)	0
R2	Relative weight aloft of step 1 field and observations (km)	0
RPROG	Weighting factors of prognostic wind field data (km)	0
DIVLIM	Maximum acceptable divergence	5E-006
NITER	Maximum number of iterations in the divergence minimization procedure	50
NSMTH	Number of passes in the smoothing procedure (NZ values)	2,9*4
NINTR2	Maximum number of stations used in each layer for interpolation (NZ values)	10*99
CRITFN	Critical Froude number	1
ALPHA	Empirical factor triggering kinematic effects	0.1
NBAR	Number of barriers to interpolation of the wind fields	0
KBAR	Barrier - level up to which barriers apply (1 to NZ)	10
IDIOPT1	Surface temperature (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
ISURFT	Surface station to use for surface temperature (between 1 and NSSTA)	-1
IDIOPT2	Temperature lapse rate used in the computation of terrain-induced circulations (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPT	Upper air station to use for the domain-scale lapse rate (between 1 and NUSTA)	-1
ZUPT	Depth through which the domain-scale lapse rate is computed (m)	200
IDIOPT3	Initial guess field winds (0 = compute from obs/prognostic, 1 = read from DIAG.DAT)	0
IUPWND	Upper air station to use for domain-scale winds	-1
ZUPWND	Bottom and top of layer through which the domain-scale winds are computed (m)	1.0, 1.00
IDIOPT4	Read observed surface wind components (0 = from SURF.DAT, 1 = from DIAG.DAT)	0
IDIOPT5	Read observed upper wind components (0 = from UPn.DAT, 1 = from DIAG.DAT)	0
LLBREZE	Use Lake Breeze module (T = true, F = false)	F
NBOX	Lake Breeze - number of regions	0

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters		
Parameter	**Description**	**Value**
CONSTB	Mixing height constant: neutral, mechanical equation	1.41
CONSTE	Mixing height constant: convective equation	0.15
CONSTN	Mixing height constant: stable equation	2400
CONSTW	Mixing height constant: overwater equation	0.16

INPUT GROUP: 6 -- Mixing Height, Temperature and Precipitation Parameters		
Parameter	**Description**	**Value**
FCORIOL	Absolute value of Coriolis parameter (1/s)	0.0001
IAVEZI	Spatial mixing height averaging? (0 = no, 1 = yes)	1
MNMDAV	Maximum search radius in averaging process (grid cells)	1
HAFANG	Half-angle of upwind looking cone for averaging (degrees)	30
ILEVZI	Layer of winds used in upwind averaging (between 1 and NZ)	1
IMIXH	Convective mixing height method (1 = Maul-Carson, 2 = Batchvarova-Gryning, - for land cells only, + for land and water cells)	1
THRESHL	Overland threshold boundary flux (W/m**3)	0
THRESHW	Overwater threshold boundary flux (W/m**3)	0.05
ITWPROG	Overwater lapse rate and deltaT options (0 = from SEA.DAT, 1 = use prognostic lapse rates and SEA.DAT deltaT, 2 = from prognostic)	0
ILUOC3D	Land use category in 3D.DAT	16
DPTMIN	Minimum potential temperature lapse rate (K/m)	0.001
DZZI	Depth of computing capping lapse rate (m)	200
ZIMIN	Minimum overland mixing height (m)	50
ZIMAX	Maximum overland mixing height (m)	3000
ZIMINW	Minimum overwater mixing height (m)	50
ZIMAXW	Maximum overwater mixing height (m)	3000
ICOARE	Overwater surface fluxes method	10
DSHELF	Coastal/shallow water length scale (km)	0
IWARM	COARE warm layer computation (0 = off, 1 = on)	0
ICOOL	COARE cool skin layer computation (0 = off, 1 = on)	0
IRHPROG	Relative humidity read option (0 = from SURF.DAT, 1 = from 3D.DAT)	1
ITPROG	3D temperature read option (0 = stations, 1 = surface from station and upper air from prognostic, 2 = prognostic)	2
IRAD	Temperature interpolation type (1 = 1/R, 2 = 1/R**2)	1
TRADKM	Temperature interpolation radius of influence (km)	500
NUMTS	Maximum number of stations to include in temperature interpolation	5
IAVET	Conduct spatial averaging of temperatures? (0 = no, 1 = yes)	1
TGDEFB	Default overwater mixed layer lapse rate (K/m)	-0.0098
TGDEFA	Default overwater capping lapse rate (K/m)	-0.0045
JWAT1	Beginning land use category for temperature interpolation over water	999
JWAT2	Ending land use category for temperature interpolation over water	999
NFLAGP	Precipitation interpolation method (1 = 1/R, 2 = 1/R**2, 3 = EXP/R**2)	2
SIGMAP	Precipitation interpolation radius of influence (km)	100.
CUTP	Minimum precipitation rate cutoff (mm/hr)	0.01

AB Lime Limited Resource Consent Application

Groundwater Quality Technical Memo

IZ000400-LFC-NW-RPT-0003 | 1

29 May 2020

AB Lime Limited

Document history and status

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AB Lime Limited Resource Consent Application

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Contents

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for water quality to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime Limited (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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Executive Summary

AB Lime Limited propose to increase the operations of their existing landfill, which will change the status of the activities for a number of resource consents. At the core of this proposal is the removal of the 100,000 tonnes per year limit to allow the AB Lime landfill to take a varying degree of waste depending on the needs of the wider region, as well as providing the ability to accept waste for crisis and emergency response scenarios. The assessment of effects for the resource consent application is based on managing the effects of operations at the landfill at all levels of activity.

This technical memo summarises groundwater quality and investigates the impact on groundwater quality of removing the limit of waste acceptance on the resource consent application for discharge of solid waste onto or into land.

The application for resource consent is prepared by Jacobs New Zealand Limited (Jacobs) on behalf of AB Lime Limited in support of an application for the expanded operation of the AB Lime Landfill, located at 10-20 Kings Bend, Winton. The purpose of this technical memo for groundwater quality is to assist in this application for resource consent and provide technical input into the Assessment of Effects on the Environment (AEE).

This technical memo concludes that the landfill is having very little, if any effect on groundwater quality moving beyond the boundary of the site. Only concentrations of zinc and copper exceed the environmental trigger level (TL2) in SKM 108, the downgradient bore. TL2 is based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) for the protection of 95% of species in freshwater (formerly known as the Australian and New Zealand Environment and Conservation Council Guidelines, ANZECC), so is a very conservative tool for assessing groundwater quality against. All results from this bore are compliant with the human health based New Zealand Drinking Water Standard.

The memo found that groundwater upgradient of the site (SKM 104, SKM 106) has elevated zinc, phosphorus and nitrate, likely to reflect the agricultural land use surrounding the AB Lime site as they are all elements typically found in NZ fertilisers.

This technical memo recommends the following actions:

- It is recommended that two further down-gradient monitoring wells are installed at the site, either close to or on the southern boundary to give greater confidence in measuring potential offsite discharges. It would be feasible to reduce monitoring of up to two of the SKM 201 – 204 wells, as these wells provide limited information on environmental effect.

- It is also recommended that the trigger levels set under condition 34 of AUTH-201346-V3 of the consent should be reviewed. Currently the TL1, based on mean data from 2010/11 provides limited value when applied to every well on the site. A better indicator may be to apply trend analysis in the annual monitoring report and track the data changes in this way. Additionally, TL2 may be appropriate for the down gradient/boundary wells, but provides little value when applied to the upgradient, or mid-site wells. It is recommended that the TLs are removed from these wells (SKM 104, 106, 201, 202, 203, 204).

- Lastly, AB Lime should consider a simplification of the annual reports so that they focus on compliance of key leachate parameters only and provide the remaining parameters in just a tabular form. Additionally, the reporting would benefit from the inclusion of long-term data trends as a way of assessing change.

1. Purpose of this Report

The purpose of this report is to assess if there will be any change to groundwater quality and therefore a need for a change in groundwater management due to the potential removal of a limit for incoming waste quantities. It is proposed that the current upper limit of 100,000 tonnes/annum is revised to accept waste at all levels of operation.

If it is established that there will a change to groundwater quality management, this report will assess if this is likely to lead to non-compliance with the existing consent limits (Consent No: AUTH-201346-V3) and with current regulatory requirements to inform an assessment of appropriate conditions to impose on the new consents.

2. Existing Groundwater Quality Monitoring

2.1 Consent Requirements

AB Lime are currently required to monitor groundwater quality in seven monitoring wells in accordance with Conditions 29 and 32 of Environment Southland (ES) Discharge Permit 201346. The wells are monitored:

- 6-monthly for the primary analytical suite of major anions and cations, field parameters, nutrients and bacteria, Carbonaceous Oxygen Demand, Biological Oxygen Demand and trace metals (Refer to Attachment 1 for the full analytical suite); and
- Annually for Volatile Organic Compounds (VOC) and Semi-VOC's coinciding with summer groundwater minimum.

Samples are collected by AB Lime's Environmental Officer and are shipped under chain of custody to Hill Laboratories in Christchurch for analysis. Reporting of the results is undertaken annually and provided to ES.

2.2 Monitoring Well Details

The construction and water level details of the monitoring wells is presented in Table 1 below. The locations of the monitoring wells can be seen in Drawing IZ000400-1000-NG-DRG-1008 in Attachment 2.

Table 1: Current Monitoring Well Details

Bore	ES ID		Piezometer Diameter (mm)	Top of Casing (m AMSL*)	Ground Elevation (m AMSL)	Drilled Depth (m BGL***)	Screened Interval (m BGL)	SWL (m BGL) Dec 19
SKM104	E45/0297	Upgradient	50	187.68	187.42	77.0	55.7 - 67.7	56.9
SKM106	E45/0300	Upgradient	50	186.98	186.79	77.5	65.5 - 77.5	Dry
SKM108	E45/0303	Down-gradient	50	66.32	66.19	20.5	14.5 - 20.5	4.38
SKM201	E45/0304	Down-gradient	50	75.5	73.7	10.2	1.6 - 10.1	1.5
SKM202	E45/0305	Down-gradient	50	75.0	74.3	10.1	1.4 - 10.0	5.36
SKM203	E45/0306	Down-gradient	50	74.7	74.0	10.0	1.4 – 10.0	5.24
SKM204	E45/0307	Down-gradient	50	77.0	76.3	10.0	1.5 - 10.0	4.19

*AMSL – Above Mean Sea Level
**SWL – Standing Water Level
***BGL – Below Ground Level

In addition to the monitoring wells listed above, two other groundwater samples are monitored. Site 13 collects a sample from the landfill underdrainage system, this is water drained from beneath the liner and serves as an early warning of liner failure. Site 17 collects water from the leachate pond underdrainage system for the same purpose.

2.3 Landfill Trigger Levels

Two trigger levels are currently set for each monitoring location. Trigger levels (TL) are a set of standards used to gauge the effects on the environment from the operation of the landfill. The response required following a breach of Trigger Level is outlined in the Groundwater Monitoring and Management Plan (GMMP).

Trigger levels are set at two levels, namely Trigger Level 1 (a lower response limit / warning level) and Trigger Level 2 (upper response limit / alarm level).

TL1 levels are based on median plus two times the standard deviation value of the water quality results collected in 2010 and 2011. The median has been implemented rather than the mean as it places less emphasis on extreme values. Please note that prior to May 2020, TL1 also included the median minus two standard deviations. This has now been removed from the summary table as it was a superfluous TL, with the exception of pH, where a decrease is relevant.

TL2 levels were based primarily on Australia New Zealand Environment and Conservation Council (ANZECC) (2000) or United States Environmental Protection Authority (USEPA, 1999) guidelines where available, with a focus on the protection of aquatic life. Drinking water guidelines are not considered relevant as there are no downgradient users of the water for potable supply purposes. Where no regulatory standards are defined for a parameter or where background levels exceed regulatory standards, the TL2 is defined as the median background concentration plus three standard deviations. Please note, TL2 has now been updated to reflect the Australia New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018).

The relevance of TL2 (i.e. the use of a freshwater ecological standard) is debatable as groundwater beyond the site boundary is understood to migrate downwards and flow down the valley. It is not understood to flow into any nearby surface water bodies. A revision of the TLs is discussed later in this report (see Section 3.6).

The trigger levels set for each monitoring well are presented in the GMMP and in the data tables in Attachment 3.

3. Description of Groundwater Quality

3.1 Pre-Landfill Groundwater Quality

As part of the original AEE a comprehensive groundwater investigation was completed at the site by SKM[1]. This investigation included baseline water quality sampling of four monitoring wells, before any waste was placed in the quarry pit. This data provides a useful baseline against which to assess the effects of the landfill operation to date.

Data from 2002 is provided in Attachment 4. Values exceeding either the ANZG (2018) guidelines for the protection of 95% of aquatic organisms or NZ Drinking Water Standards (NZDWS) 2000 guidelines are highlighted. The following summarises the results:

- pH was typically around 7.4, with limited variation between the bores.
- The high bicarbonate and total hardness levels recorded in all bores is typical of limestone aquifers and is of aesthetic significance only.
- Chemical concentrations of all parameters were below the ANZECC guidelines and the NZDWS, with the exception of:
  - dissolved lead in SKM104 (0.0282 mg/l) is less than the ANZECC guideline (0.0633 mg/l), but greater than NZDWS (0.01 mg/l); and
  - dissolved copper concentration in SKM104 (0.0101 mg/l) is marginally greater than the ANZECC guideline (0.0099 mg/l), but less that the NZDWS (2.0 mg/l).
  - Nitrate nitrogen is higher than the ANZECC guidelines (0.16 mg/l) in all groundwater samples obtained, but lower than NZDWS. Nitrate N is likely derived from stock effluent and fertilisers use.

3.2 2010 – 2019 Groundwater Quality Data

Groundwater has been monitored at the site since the landfill became operational in 2004. For this assessment, only data from 2010 to 2019 are assessed as the older data were not available electronically at the time of writing this report.

All historical data collected between 2010 and 2019 is presented in Attachment 3. Data in these tables is summarised by Well ID and presented chronologically. The trigger levels (TL1 & TL2) for each well is highlighted and exceedances highlighted in the tables. The results are discussed in the following sub-sections.

3.3 Water Type

Figure 3-1 shows a tri-linear chemical characterisation diagram (Piper diagram) for groundwater, which displays the chemical signature of the major groundwater constituents converted into per milli-equivalents (concentration/molecular weight). This plot is useful for comparing water characteristics from different areas and assessing the influence of geological materials on water chemistry.

The plot shows the samples to be tightly clustered showing the similarity in base geochemistry and indicates the bores are proportionally high in bicarbonate and calcium as expected from a karst aquifer. The only well showing differences is SKM 202. This well has elevated sulphate, concentrations of which exceeded the alert TL1 between 2012 and 2016 but have since reduced.

[1] SKM, 2003. AB Lime Hydrogeology Review.

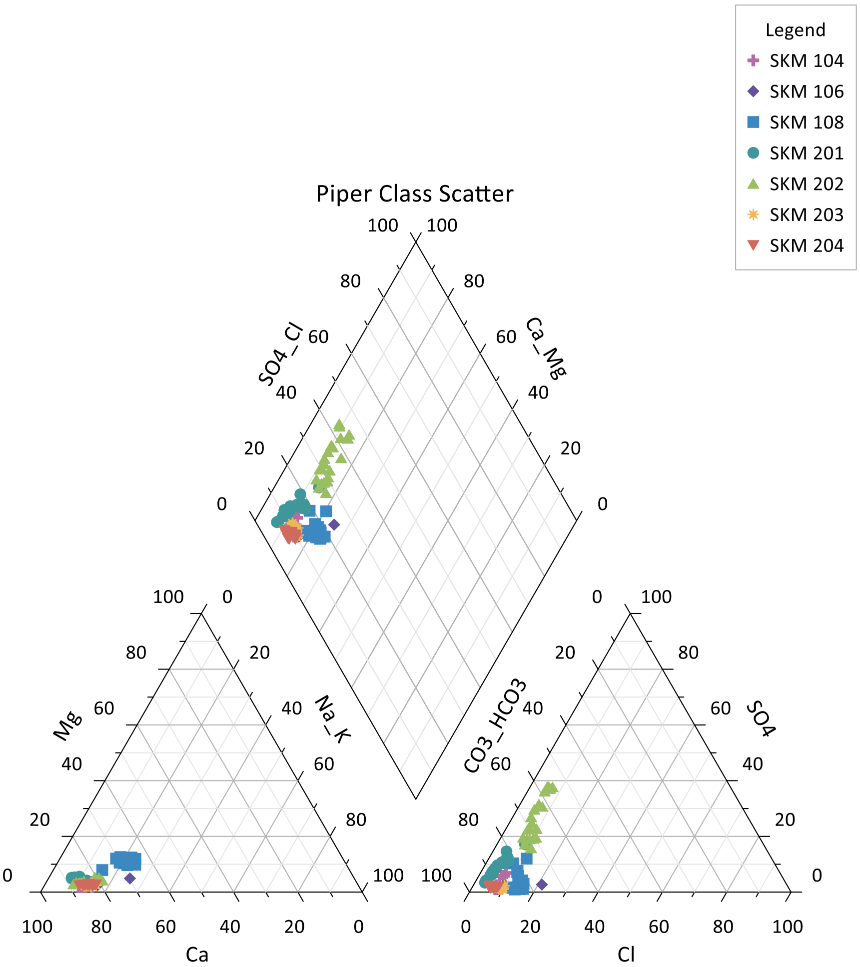

Figure 3-1: Tri-Linear (Piper) Plot of Water Chemistry

3.4 Comparison of Pre and Post Landfill Data

A comparison of pre-landfill groundwater quality[2] to the average of 2010-2019 data has been undertaken to assess changes in groundwater quality over time (and as a result of the landfill). For this comparison we have used the most upgradient and down gradient monitoring wells. The data comparison is shown in Table 2 below.

SKM 104 (upgradient), as expected shows very little change in groundwater quality between 2004 and 2010-2019. The only notable increases are in sulphate, nitrate and total kjeldahl nitrogen. All of these are likely a reflection of the intensification of the pastoral land use surrounding the AB Lime property.

SKM 108 (down gradient) has seen decreased in sulphate, nitrate and total kjeldahl nitrogen, but very slight increases in manganese and electrical conductivity. Overall, it is fair to conclude that the quality has not change significantly.

[2] SKM, 2003. AB Lime Hydrogeology Review.

Table 2: Historical data comparison

Parameter	Unit	SKM104				SKM108			
		TL1	TL2	Pre-Landfill	Post-Landfill Mean (Apr 2010-Jun 2018)	TL1	TL2	Pre-Landfill	Post-Landfill Mean (Dec 2009-Nov 2019)
pH	ph Units	7.6	7.2-7.8	7.2	*7.1*	7.8	7.2-7.8	7.4	7.4
Electrical Conductivity	mS/m	73.4	-	59.4	69.0	77.6	-	61.2	75
Total Dissolved Solids	g/m^3	-	-	271	22	-	-	288	9
Alkalinity (as CaCO3)	g/m^3 as $CaCO_3$	337	20	**319**	**321**	320	20	**320**	***324***
Dissolved Aluminium	g/m^3	0.003	0.055	< 0.003	0.003	0.003	0.055	< 0.003	0.003
Dissolved Arsenic	g/m^3	0.001	0.024	< 0.001	0.0010	0.005	0.024	*0.006*	0.0024
Bicarbonate	g/m^3 at 25°C	419	-	388	392	399	-	389	392
Dissolved Boron	g/m^3	-	-	0.01	0.011	-	-	0.03	0.018
Dissolved Cadmium	g/m^3	0.00005	0.00155	< 0.00005	0.00005	0.00005	0.00155	< 0.00005	0.00005
Dissolved Calcium	g/m^3	141.5	-	129	128	115	-	99.5	104
Chloride	g/m^3	31.1	230	*34.8*	29	71.2	230	45.1	53
Dissolved Chromium	g/m^3	0.006	0.0218	< 0.0005	0.0007	0.0005	0.0218	< 0.0005	0.0005
Dissolved Copper	g/m^3	0.0034	0.0099	0.0101	0.0018	0.002	0.0099	*0.0039*	*0.0024*
Dissolved Iron	g/m^3	0.25	0.3	< 0.02	0.050	0.51	0.3	< 0.02	0.16
Dissolved Lead	g/m^3	0.002	0.0633	*0.0282*	0.00015	0.0001	0.0633	0.0012	0.00010
Dissolved Magnesium	g/m^3	3.3	-	3.13	2.9	21.7	-	15.9	17.0
Dissolved Manganese	g/m^3	0.0142	1.7	0.0041	0.0025	0.093	1.7	0.0317	*0.1016*
Dissolved Nickel	g/m^3	0.001	0.0779	*0.0025*	0.0012	0.0005	0.0779	*0.0029*	*0.0006*
Nitrate N	g/m^3	2.2	0.16	**1.2**	**1.86**	0.064	0.16	***0.41***	*0.11*
Nitrite N	g/m^3	-	-	< 0.05	3.132	-	-	0.05	0.105
Dissolved Potassium	g/m^3	1.6	-	0.85	0.88	2.4	-	1.53	0.95
Dissolved Sodium	g/m^3	19.2	-	18.3	18.1	41.3	-	34.9	32.0
Sulphate	g/m^3	14.4	-	4.9	10.8	7.7	-	*18.9*	*13.8*
Total Ammoniacal-N	g/m^3	3.7	-	< 0.01	0.7579	0.023	-	*0.09*	*0.049*
Total Hardness	g/m^3 as $CaCO_3$	372	-	336	330	382	-	314	328
Total Kjeldahl Nitrogen	g/m^3	3.3	-	0.4	1.90	0.2	-	*0.4*	0.18
Dissolved Zinc	g/m^3	0.0391	0.057	0.026	0.029	0.0244	0.057	0.017	0.019

3.5 Well by Well Summary

Plots of the major leachate indicators (pH, electrical conductivity, carbonaceous oxygen demand (COD), sulphate, nitrate-nitrogen, ammoniacal-nitrogen, chloride, zinc and iron) are presented in Attachment 5. The plots should be referred to when reading the following sub-sections.

3.5.1 SKM 104

This well is located upgradient of the quarry and landfill and is therefore treated as a background reference well. The well has a geochemistry typical of a recharge dominant karstic aquifer, except for elevated zinc, nitrate, COD, NH4-N and on occasion, phosphorus which all exceed the current trigger levels regularly. Given the upgradient location of this well, it is evident the elevated concentrations are not a result of the landfilling. Given zinc, nitrate and phosphorus are present in fertiliser, it is likely to reflect the surrounding agricultural practices. In addition, the presence of COD up until 2018 is unique amongst all wells, and may indicate an issue with bore security or connection to the land surface.

3.5.2 SKM106

This well is located upgradient of the quarry and landfill and is therefore treated as a background reference well. The well has a base geochemistry very similar to SKM 104 - typical of a recharge dominant karstic aquifer, except for elevated zinc, nitrate and on occasion, phosphorus which all exceed the current trigger levels regularly. This chemistry appears to be the best representation of background quality. Given the upgradient location of this well, it is evident the elevated concentrations are not a result of the landfilling. Given all three compounds are present in fertiliser, it is likely to reflect the surrounding agricultural practices.

3.5.3 SKM108

SKM 108 is the southernmost monitoring well and is located on the down gradient boundary. Of all the wells, SKM 108 provides the best indication of the quality of groundwater discharging off-site.

At SKM 108 the pH is relatively neutral (7.4) and consistent with all other monitoring wells, as is alkalinity. Like the background monitoring wells, it has elevated zinc and phosphorus but lower nitrate. In addition, the well has elevated sulphate, copper, nickel, manganese and ammoniacal N concentrations that typically exceed TL1 (median concentration), and in the case of copper and zinc exceed TL2 (environmental, ANZG) and chloride (elevated but not above TLs). These compounds are all common landfill leachate indicators, although, based on historical data, were already present in groundwater prior to the landfill being operational (see to Section 3.4).

Whilst some compounds exceed TL1 and TL2 at SKM108, it should be noted that the concentrations present may be reflective of very diluted leachate concentrations, they are low when compared to drinking water Standards. Copper and zinc are compliant with the New Zealand Drinking Water Standards (NZDWS, 2008) which indicates how low the concentration is.

Currently SKM 108 is the only monitoring well on the downgradient property boundary. Given the length of the boundary, an additional two monitoring wells would increase the confidence in the ability of the monitoring network to measure the quality of groundwater moving offsite. These two additional monitoring wells are shown on Drawing IZ000400-1000-NG-DRG-1008 (Attachment 2).

3.5.4 SKM 201

SKM 201 is located adjacent to the leachate tank, immediately downgradient of the toe of the first landfilled cell. SKM 201 is in a location that should provide an early indication of any groundwater contamination but is not indicative of off-site discharges as it is in the middle of the property.

The results from SKM 201 show consistently elevated zinc (above TL2 but less than 50% of background), as well as occasionally elevated (above TL2) concentrations of boron, chromium and copper (no exceedances of phosphorus since 2011). These later three compounds are all common landfill leachate indicators however as with SKM 108 are still compliant with the New Zealand Drinking Water Standards (NZDWS, 2008).

3.5.5 SKM 202

SKM 202 (along with 203 and 204) is located on a transect that cuts across the main groundwater flow path down gradient of the landfill. Based on the placement of these three wells, they should all provide data that is representative of groundwater flowing downgradient of the landfill, toward the site boundary.

Groundwater at SKM 202 has consistently elevated zinc (TL2) and the occasional elevated copper (TL2). However, the zinc concentration is 50% lower than that observed in SKM 104 and 106, the background monitoring wells. Most notably at SKM 202 the sulphate that has increased form 50 mg/L, peaked at 200 mg/L and then receded back to 50 mg/L between 2009 and 2019 (refer plot in Attachment 5). This peak is likely indicative of landfill leachate and reflects the landfill moving through the aerobic and fermentative phases of anaerobic degradation where sulphate production is high.

3.5.6 SKM 203

SKM 203 is located on a transect that cuts across the main groundwater flow path down gradient of the landfill. Based on the placement of these three wells, it should provide data that is representative of groundwater flowing downgradient of the landfill, toward the site boundary.

Groundwater results at SKM 203 show similar indicators of landfill leachate, albeit at low concentrations. Manganese exceeds TL1, zinc and phosphorus regularly exceed TL2 (but are still less than background) and copper and chromium and nitrate occasionally exceed TL2.

The presence of nitrate (range between 3 and 6 mg/L) at this site makes it different from the other downgradient wells. Given the location, it is likely the nitrate measured is sourced from the landfill, rather than background sources. Nitrogen is typically generated in a landfill as ammoniacal nitrogen but can oxidise to nitrate in the presence of oxygen. Concentration appear to be increasing (Attachment 5).

3.5.7 SKM 204

SKM 204 is located on a transect that cuts across the main groundwater flow path down gradient of the landfill. It is the eastern most down-gradient well and should provide data that is representative of groundwater flowing downgradient of the landfill, toward the site boundary.

Apart from the very occasional exceedance of TL2 for phosphorus (still below background concentrations) SKM 204 has good groundwater quality that is currently compliant with all trigger levels.

3.5.8 SKM 13

Site 13 collects a sample from the landfill underdrainage system. This is water drained from beneath the liner and serves as an early warning of liner failure. The raw data are presented in Attachment 3, data is plotted in Attachment 5.

Site 13 data has been reviewed for pH, electrical conductivity (EC), chloride and total ammoniacal nitrogen, all indicators of landfill leachate. pH results have increased between 2006 and 2018 from 7.2 to 7.8, perhaps a reflection of the increased upwelling of groundwater coming from the base of the quarry. EC varies between 40 and 90 ms/m indicating some level of influence of contaminants on the underlying groundwater. Chloride and ammoniacal nitrogen have remained relatively stable. The outliers of the data only occur as large spikes, typically in winter, indicating that they may be related to large rainfall event, and perhaps affected by surficial flows of contaminated stormwater.

3.5.9 SKM 17

Site 17 collects water from the leachate pond underdrainage system for the same purpose as 13. The raw data are presented in Attachment 3**.**

pH has remained relatively stable between 7.2 and 8. EC, like site 13, is variable, ranging from 20 to 100 ms/m indicating some level of influence of contaminants on the underlying groundwater. Chloride in Site 17 varies considerably, ranging between 20 and 100 mg/L and ammoniacal nitrogen between 0 and 5 mg/L. These sharp increases suggest some influence of landfill leachate on the underlying groundwater. Because the increases are not consistent it is unlikely to be a result of liner failure, but more likely related to overtopping of the liner or overland flow affecting the sample. Further investigation is warranted.

3.6 The Effectiveness of Current Processes in Managing Groundwater Quality

Overall the results indicate that the current management practices onsite are effective in managing groundwater quality. Whilst some trace concentrations of landfill leachate indicators are present at the boundary well SKM 108, in general the concentrations observed are compliant with the current trigger levels, and in the case of copper and zinc, whilst above the current TL2 (ANZG level) are still compliant with the New Zealand Drinking Water Standards. Beyond the site boundary, groundwater flows into deeper aquifers and does not pose a risk to surface water features.

Worthy of note are the concentrations of nitrate, phosphorus, sulphate and zinc in the upgradient wells. These analytes all exceed TL2 as a result of the surrounding agricultural land use and are in fact higher concentrations than observed downgradient of the landfill, indicating the discharge of groundwater from the base of the quarry is likely to be diluting groundwater down-gradient of the landfill.

4. The Expected Changes to Groundwater Quality Resulting from a Removal of the Limit of Waste Accepted

The Applicant seeks to remove the daily limit of waste into the landfill. In addition, proposed changes to the day-to-day operational management include:

- Reducing the working face of the landfill to 1000 m^2
- Improved temporary capping
- Reduction steep slopes to reduce stormwater infiltration
- Reduced daily cover area to reduce stormwater infiltration

Whilst this increase in the daily waste limit will result in quicker filling of the landfill space it will not result in an increase in the final landfill footprint, overall volume of waste accepted at the site or means of controlling leachate (liner, collection or treatment). Therefore, it is expected that the amount of groundwater contamination from the site will remain similar. This is because the overall landfill volume limit remains the same, it is just that the landfill will be filled quicker. In some respects, decreasing the time that the landfill cells remain open and uncapped is a positive effect, and will results in less leachate production, and therefore less chance of groundwater contamination.

5. Conclusion

AB Lime has collected groundwater quality data since 2004 as part of their consent conditions. This long-term monitoring provides a substantial dataset that has been used to complete an assessment of the effects of the landfill (and quarry) operation on groundwater.

The results show that overall the landfill is having very little, if any effect on groundwater quality moving beyond the boundary of the site. SKM 108 is the well closest to the southern (and down-gradient) boundary and best reflect the groundwater quality moving offsite. At this location copper and zinc exceed TL2, and there are other typical leachate indicator present, but at levels at or below TL1. Interestingly, when compared to the pre-landfill data, concentrations are very similar, suggesting these contaminants were already present in groundwater prior to the landfill being operational (see to Section 3.4). Nevertheless, and regardless of the source, concentrations are compliant with the New Zealand Drinking Water Standards (NZDWS, 2008) so the risk to downgradient groundwater users is negligible.

Downgradient of the landfill monitoring wells SKM 201-204 all display some very low concentrations of compounds that may indicate landfill leachate but this will not affect any other users or receptors.

Upgradient of the landfill monitoring wells SKM 104 and 106 are impacted by agricultural land use and show the highest concentrations of zinc, phosphorus and nitrate. This groundwater flows through the quarry and appears to be diluted by the upwelling of deeper groundwater into the quarry.

It is recommended that two further down-gradient monitoring wells are installed at the site, either close to or on the southern boundary to give greater confidence in offsite discharges. It would be feasible to reduce monitoring of up to two of the SKM 201 – 204 wells, as these wells provide limited information on environmental effect.

It is also recommended that the trigger levels should be reviewed. Currently the TL1, based on mean data from 2010/11 provides very little value. A better indicator would be to do trend analysis in the annual monitoring report and track the data changes in this way. Additionally, TL2 may be appropriate for the down gradient/boundary wells, but provides little value when applied to the upgradient, or mid-site wells. It is recommended that the TLs are removed from these wells (SKM 104, 106, 201, 202, 203, 204).

Attachment 1. Analytical Suite

Parameter	Detection Limit
Alkalinity	1 mg/L
Bicarbonate	1 mg/L
Calcium	0.05 mg/L
Chloride	0.5 mg/L
COD	6 mg/L
Conductivity (field & laboratory)	0.1 m/Sm
Dissolved Aluminium	0.003 mg/L
Dissolved Arsenic	0.001 mg/L
Dissolved Boron	0.005 mg/L
Dissolved Cadmium	0.00005 mg/L
Dissolved Chromium	0.0005 mg/L
Dissolved Copper	0.0005 mg/L
Dissolved Iron	0.02 mg/L
Dissolved Lead	0.0001 mg/L
Dissolved Manganese	0.0005 mg/L
Dissolved Nickel	0.0005 mg/L
Dissolved Reactive Phosphorus	0.004 mg/L
Dissolved Zinc	0.001 mg/L
Magnesium	0.02 mg/L
Nitrate-Nitrogen	0.002 mg/L
pH (field & laboratory)	0.1 pH units
Potassium	0.05 mg/L
Sodium	0.02 mg/L
Sulphate	0.5 mg/L
Total Ammoniacal Nitrogen	0.01 mg/L
Total Hardness	1 mg/L
Total Kjeldahl Nitrogen	0.1 mg/L
NPOC (Organic Carbon)	0.5 mg/L
Total Phenols	0.002 mg/L
Turbidity	0.05 NTU
Volatile Acids	5 mg/L
Semi-volatile Organic Compounds	0.003 mg/L
Volatile Organic Compounds	0.04 mg/L

Attachment 2. Drawing

LEGEND

- SKM104 — SKM PIEZOMETERS
- SKM107 — SKM BOREHOLES
- LFG6 — LANDFILL GAS MONITORING PROBE
- 08 — LANDFILL, STORMWATER AND LEACHATE SAMPLING LOCATIONS
- CELL DEVELOPMENT OF LANDFILL
- CELL DEVELOPMENT OF FUTURE LANDFILL
- CONSENTED LANDFILL FOOTPRINT
- SINKHOLE LOCATIONS INTERPRETED FROM AERIAL IMAGERY

NOTES

1. THE HORIZOTNAL COORDINATE SYSTEM FOR THE SITE IS NEW ZEALAND MAP GRID 1949.
2. THE LATEST SURVEY FOR THE SITE WAS PERFORMED BY DRONE SURVEY, FLOWN ON 12/03/2020.

CONSENT ISSUE

REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

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PROJECT: LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
NBL	KJ	CW	VP
DESIGNED: LJ	DESIGN REVIEW: CW	DATE 29.05.20	DATE 29.05.20

TITLE: GROUNDWATER, STORMWATER & GAS BOREHOLE LOCATIONS PLAN

SCALE: AS SHOWN | DRAWING No: IZ000400-1000-NG-DRG-1008 | REV: A

A1

Attachment 3. 2010 – 2019 Data Tables

Bore ID	Date	Sum of Anions	Sum of Cations	Turbidity	pH	Total Alkalinity	Bicarbonate	Total Hardness	Electrical Conductivity (EC)	Total Suspended Solids	Dissolved Aluminium	Dissolved Boron
		meq/L	meq/L	NTU	pH Units	g/m^3 as $CaCO_3$	g/m^3 at 25°C	g/m^3 as $CaCO_3$	mS/m	g/m^3	g/m^3	g/m^3
SKM 104 Trigger Level 1		7.8	8.3	26.7	6.7-7.6	337	419	372	73.4		0.003	
SKM 104 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 104	Apr-2010	7.5	6.8	5.3	7.2	320	390	300	68.7		0.003	
SKM 104	Sep-2010	7.5	7.5	18.2	7.4	320	390	340	68.7		0.003	
SKM 104	Dec-2010	7.8	7.3	54	7.1	330	410	330	69.1		0.003	
SKM 104	Jun-2011	7.8	7.7	13.6	6.9	310.0	380.0	340.0	72.1		0.003	
SKM 104	Sep-2011	7.5	7.2	2.2	7.2	320	390	320	69.1		0.003	
SKM 104	Dec-2011	7.6	7.7	7.8	7	320	390	340	70.6		0.003	
SKM 104	Mar-2012	7.5	7.1	3.5	7	320	390	320	65.8		< 0.003	
SKM 104	Jun-2014	7.6	7.9	5.2	7	310	380	340	71.2		< 0.003	
SKM 104	Sep-2014	7.5	7.7		7.2	330	400	340	69.2	31	< 0.003	0.011
SKM 104	Jun-2015	7.7	7.5		7.4	320	380	340	69.9	21	< 0.003	0.012
SKM 104	Oct-2015	7.4	7.7		7.3	320	390	330	69	13	< 0.003	0.011
SKM 104	Jun-2016	7.4	7.7	6.1	7.1	320	390	340	68.4		< 0.003	
SKM 104	Dec-2016	7.63	7.8	10.5	7	320	390	350	69.6		< 0.003	
SKM 104	Jun-2017	7.3	7.8	3.2	7.1	320	390	320	65.8		< 0.003	
SKM 104	Feb-2018	7.7	7.1	16	7.2	320	400	310	67.8		< 0.003	
SKM 104	Jun-2018	8	7.4		7.2	340	410	320	68.6		< 0.0030	
SKM 104	Mean (Apr 2010-Jun 2018)	7.6	7.5	12.1	7.1	321	392	330	69.0	22	0.003	0.011
SKM 106 Trigger Level 1		11.3	9.9	29.4	6.5-8.2	515	620	447	70.2		0.003	
SKM 106 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 106	Apr/2010	7.4	6.3	3.8	7.5	310	380	270	67.4		0.003	
SKM 106	Sep/2010	7.5	6.8	3.2	7.8	320	380	290	68.7		0.003	
SKM 106	Dec/2010	7.4	6.8	19.5	7.2	320	380	300	66.5		0.003	
SKM 106	Jun/2011										0.003	
SKM 106	Sep/2011	3.5	3.9	30	7	115	140	150	334		0.003	
SKM 106	Dec/2011	7.2	7.4	11.4	7.3	310	380	320	66.1		0.003	
SKM 106	Sep/2014	7.5	7.4	7.3		320	390	320	69.4	73	< 0.003	0.014
SKM 106	Oct/2015	6.9	7.2		7.4	290	360	310	64.2	7	< 0.003	0.013
SKM 106	Mean (Apr 2010-Oct 2015)	6.8	6.5	12.5	7.4	284	344	280	105.2	40	0.003	0.014
SKM 108 Trigger Level 1		8.5	9	28.8	7.1-7.8	320	399	382	77.6		0.003	
SKM 108 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 108	Dec/2009	8.2	8	3.3	7.7	320	390	320	74.8		0.003	
SKM 108	Apr/2010	8.2	6.8	3.3	7.4	320	390	270	75.3		0.003	
SKM 108	Sep/2010	8.1	8	5	7.6	320	390	330	72		0.003	
SKM 108	Dec/2010	7.8	7.9	-	7.4	320	390	340	71.6		0.003	
SKM 108	Mar/2011	7.9	7.3	4.5	7.4	320	380	300	72.8		0.003	
SKM 108	Jun/2011	8.1	8.1	15	7.5	320	390	320	74.1		0.003	
SKM 108	Sep/2011	8.2	7.7	16	7.4	320	390	310	75		0.003	
SKM 108	Dec/2011	7.9	8	19.3	7.4	320	390	340	72.6		0.003	
SKM 108	Mar/2012	8.2	7.3	11.4	7.1	330	400	300	71.9		< 0.003	
SKM 108	Oct/2012	7.9	7.6	18.5	7.5	320	390	310	73		< 0.003	
SKM 108	Jun/2014	9	9.1	27	7.2	350	420	360	81.3		< 0.003	
SKM 108	Sep/2014	8.7	9		7.1	340	410	370	79.6	9	< 0.003	0.018
SKM 108	Jun/2016	8.6	8.9	17.7	7.2	330	400	360	79.5		< 0.003	
SKM 108	Dec/2016	8.7	9	10.4	7.3	330	410	370	80.1		< 0.003	
SKM 108	Jun/2017	8.2	7.3	11.4	7.1	330	399	300	71.9		< 0.003	
SKM 108	Feb/2018	8.2	7.5	11	7.5	330	400	310	72.6		< 0.0030	
SKM 108	Jun/2018	8.1	7.7	14	7.4	320	390	310	74		< 0.0030	
SKM 108	Dec/2018	8.5	9	19.2	7.5	330	400	360	80.6		< 0.003	
SKM 108	Apr/2019	6.7	6.9	0.44	7.3	260	310	300	63.3		< 0.003	
SKM 108	Nov/2019	8.8	8.9	12.1	7.5	340	410	370	80.2		0.005	
SKM 108	Mean (Dec 2009-Nov 2019)	8.2	8.0	12.2	7.4	324	392	328	75	9	0.003	0.018
SKM 201 Trigger Level 1		15.05	14.81	12.17	6.7-7.3	643	791	668	124.3		0.003	
SKM 201 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 201	Dec/2009	12	12	0.45	7.2	470	570	520	102		0.003	
SKM 201	Apr/2010	12.2	11.1	0.48	7	480	590	490	104.7		0.003	
SKM 201	Sep/2010	12	11.7	3.6	7.1	480	590	520	101.3		0.003	
SKM 201	Dec/2010	11.8	11.5	5.6	6.9	480	590	530	101.1		0.003	
SKM 201	Mar/2011	8.2	7.9	9.8	7	290	350	350	75.8		0.003	
SKM 201	Jun/2011	11.7	11.3	2.3	7	482	590	510	101		0.003	
SKM 201	Sep/2011	10.3	10.1	0.72	7	440	530	470	89.5		0.003	
SKM 201	Dec/2011	11.7	12	2.2	6.9	500	610	550	101.3		0.003	
SKM 201	Mar/2012	10.1	9.5	0.67	7	430	530	440	83.6		< 0.003	
SKM 201	Oct/2012	9.4	8.7	0.22	7.1	400	490	410	82.4		< 0.003	
SKM 201	Jun/2014	10.1	10.1	0.44	6.9	440	530	470	89.5		0.003	
SKM 201	Sep/2014	10.9	11.1		6.9	480	580	510	94.4	< 5	< 0.003	0.164
SKM 201	Jun/2015	10.5	10.3		7.5	460	560	480	91.3	< 3	< 0.003	0.156
SKM 201	Oct/2015	9.7	10		7.1	430	520	460	86.5	< 5	< 0.003	0.134
SKM 201	Jun/2016	8.8	8.9	0.92	7.1	390	470	410	78.5		< 0.003	
SKM 201	Dec/2016	9.5	9.2	0.57	7	420	520	430	83.9		< 0.003	
SKM 201	Jun/2017	10	9.5	0.61	7	430	510	440	83.2		< 0.003	
SKM 201	Feb/2018	12	11	0.39	7	500	610	510	103		< 0.0030	
SKM 201	Jun/2018	13	12	0.34	7	500	600	560	105		< 0.0030	
SKM 201	Dec/2018	8.5	8.5	2.6	7.2	390	470	400	77.4		< 0.003	
SKM 201	Apr/2019	11.4	9.8	4.8	7	500	610	450	100.3		0.006	
SKM 201	Nov/2019	8.9	8.8	3.8	7.2	410	500	410	77.9		< 0.003	
SKM 201	Mean (Dec 2009-Nov 2019)	10.6	10.2	2.1	7.1	446	542	469	92	< 5	0.003	0.151

Bore ID	Date	Dissolved Calcium	Dissolved Cobalt	Dissolved Iron	Dissolved Magnesium	Dissolved Manganese	Dissolved Potassium	Dissolved Sodium	Chloride	Total Ammoniacal-N	Nitrite-N	Nitrate-N
		g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3
SKM 104 Trigger Level 1		141.5		0.25	3.3	0.0142	1.6	19.2	31.1	3.7		2.2
SKM 104 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 104	Apr-2010	117		0.02	2.7	0.0005	0.71	16	30	0.0118		1.8
SKM 104	Sep-2010	130		0.04	2.9	0.0113	1.4	17.7	29	0.113		1.89
SKM 104	Dec-2010	126		0.02	2.9	0.0024	0.75	17.2	30	0.45		1.98
SKM 104	Jun-2011	130.0		0.2	3.0	0.001	0.8	17.6	29	2.8		1.8
SKM 104	Sep-2011	125		0.02	2.7	0.0022	0.68	17.3	30	0.048		2
SKM 104	Dec-2011	132		0.02	3.1	0.0018	0.7	18	30	1		2
SKM 104	Mar-2012	122		< 0.02	2.7	0.0045	1	16.9	29	0.81	0.025	1.84
SKM 104	Jun-2014	131		0.03	2.8	0.0056	0.81	19.4	28	2.7	0.086	1.68
SKM 104	Sep-2014	132	< 0.0002	< 0.02	3	0.0021	0.76	18.7	27	0.025	0.003	2
SKM 104	Jun-2015	131	< 0.0002	< 0.02	2.8	0.0006	0.74	17	27	0.166	0.019	1.99
SKM 104	Oct-2015	128	< 0.0002	< 0.02	3	0.002	1.83	23	27	0.3	0.013	1.72
SKM 104	Jun-2016	133		< 0.02	2.9	0.0015	0.76	19.4	26	0.053	0.004	1.91
SKM 104	Dec-2016	134		< 0.02	3.2	0.0007	0.74	18.6	28	0.96	0.129	1.82
SKM 104	Jun-2017	131		< 0.02	2.7	0.0015	0.88	16.4	29	0.81	0.025	1.84
SKM 104	Feb-2018	120		< 0.020	2.8	0.001	0.76	18	31	0.68	31	1.8
SKM 104	Jun-2018	120		< 0.020	3.1	0.0007	0.77	19	30	1.2	0.013	1.7
SKM 104	Mean (Apr 2010-Jun 2018)	128	< 0.0002	0.050	2.9	0.0025	0.88	18.1	29	0.7579	3.132	1.86
SKM 106 Trigger Level 1		173		0.02	4.5	0.0016	2.38	23.4	37	0.018		3
SKM 106 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 106	Apr/2010	103		0.02	3.3	0.0005	0.57	18.4	32	0.010		0.82
SKM 106	Sep/2010	110		0.02	3.8	0.0013	1.88	22	35	0.010		0.83
SKM 106	Dec/2010	113		0.02	3.3	0.0005	0.9	19.8	30	0.010		0.98
SKM 106	Jun/2011			0.02		0.0008				0.016		
SKM 106	Sep/2011	54		0.02	3.8	0.0005	0.8	19.6	32	0.010		2.4
SKM 106	Dec/2011	123		0.02	4	0.0005	0.64	20	30	0.010		0.92
SKM 106	Sep/2014	121	< 0.0002	< 0.02	4.3	< 0.0005	0.71	22	33	< 0.010	< 0.002	0.85
SKM 106	Oct/2015	118	< 0.0002	< 0.02	3.6	< 0.0005	0.71	24	29	< 0.010	< 0.002	0.9
SKM 106	Mean (Apr 2010-Oct 2015)	106	< 0.0002	0.02	3.7	0.0007	0.89	20.8	32	0.011	< 0.002	1.10
SKM 108 Trigger Level 1		115		0.51	21.7	0.093	2.4	41.3	71.2	0.023		0.064
SKM 108 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 108	Dec/2009	99		0.22	18	0.04	0.57	36	62	0.014		0.0076
SKM 108	Apr/2010	86		0.197	14.5	0.054	0.5	29	59	0.0196		0.0093
SKM 108	Sep/2010	101		0.02	18.4	0.0063	0.54	32	56	< 0.010		0.03
SKM 108	Dec/2010	105		0.02	17.9	0.0076	1.16	26	45	0.016		0.027
SKM 108	Mar/2011	96		0.4	15.7	0.041	0.62	29	53	< 0.010		0.015
SKM 108	Jun/2011	99		0.1	18.3	0.041	1.66	36	60	< 0.010		0.046
SKM 108	Sep/2011	97		0.02	17.1	0.0124	1.69	32	58	< 0.010		0.04
SKM 108	Dec/2011	104		0.06	19	0.061	0.58	28	51	< 0.010		0.021
SKM 108	Mar/2012	95		< 0.02	16	0.022	0.56	28	52	< 0.010	< 0.002	0.008
SKM 108	Oct/2012	98		< 0.02	17	0.023	1.84	28	47	0.015	< 0.002	0.13
SKM 108	Jun/2014	115		0.69	17.2	0.46	0.58	43	48	0.101	0.003	0.036
SKM 108	Sep/2014	117	< 0.0002	< 0.02	18.5	0.138	0.62	38	47	< 0.010	< 0.002	0.126
SKM 108	Jun/2016	117		0.13	16.6	0.21	0.5	38	57	0.031	< 0.002	0.024
SKM 108	Dec/2016	119		0.02	17.9	0.0038	0.52	36	58	0.01	< 0.002	0.061
SKM 108	Jun/2017	95		< 0.02	16	0.022	0.56	28	52	< 0.010	< 0.002	0.008
SKM 108	Feb/2018	96		< 0.020	17	0.016	0.54	29	51	< 0.010	< 0.0020	0.028
SKM 108	Jun/2018	95		0.04	18	0.43	0.73	32.0	57.0	0.052	0.003	0.014
SKM 108	Dec/2018	116		< 0.02	18.1	0.0163	0.51	39	62	< 0.010	< 0.002	0.33
SKM 108	Apr/2019	101		< 0.02	10.4	0.077	4.2	20	27	0.179	0.31	1.13
SKM 108	Nov/2019	120		0.13	18.1	0.35	0.54	33	51	< 0.010	< 0.002	0.077
SKM 108	Mean (Dec 2009-Nov 2019)	104	< 0.0002	0.16	17.0	0.1016	0.95	32.0	53	0.049	0.105	0.11
SKM 201 Trigger Level 1		245		0.67	14.9	1.225	1.52	37.2	47	0.431		2.04
SKM 201 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 201	Dec/2009	190		0.02	9.4	0.36	1.2	28	32	0.19		0.41
SKM 201	Apr/2010	183		0.02	7	0.166	1.12	30	38	0.14		0.51
SKM 201	Sep/2010	196		0.02	8.2	0.176	1.19	29	34	0.111		0.51
SKM 201	Dec/2010	194		0.02	10.2	0.25	1.28	23	31	0.119		0.54
SKM 201	Mar/2011	130		0.02	5.8	0.0005	1.37	22	34	0.01		1.79
SKM 201	Jun/2011	189		0.02	10.2	0.66	1.33	23	27	0.2		0.173
SKM 201	Sep/2011	171		0.02	10	0.6	1.07	16.5	19.9	0.155		0.28
SKM 201	Dec/2011	200		0.6	12.3	0.88	1.28	20	23	0.35		0.06
SKM 201	Mar/2012	161		< 0.02	8.9	0.29	1.13	17	19.6	0.038	0.004	0.41
SKM 201	Oct/2012	148		< 0.02	9	0.109	1.02	14.1	17.4	< 0.010	< 0.002	0.44
SKM 201	Jun/2014	171		< 0.02	9.2	0.24	1.4	17.6	18.7	0.167	< 0.002	0.054
SKM 201	Sep/2014	187	0.0008	0.39	11.4	0.4	1.31	17.2	19.8	0.198	0.002	0.012
SKM 201	Jun/2015	176	0.0005	0.17	9.8	0.182	1.21	14.5	18.3	0.127	< 0.002	0.02
SKM 201	Oct/2015	169	0.0006	< 0.02	9.6	0.26	1.3	17.4	18.8	0.152	0.004	0.195
SKM 201	Jun/2016	153		< 0.02	7.9	0.059	1.21	14.2	15.7	0.029	0.004	0.36
SKM 201	Dec/2016	156		0.04	8.5	0.118	1.17	14.1	16.1	0.084	0.002	0.096
SKM 201	Jun/2017	158		< 0.02	8.9	0.104	1.22	14.2	17.3	0.094	< 0.002	0.41
SKM 201	Feb/2018	190		< 0.020	9.2	0.089	1.3	28	33	0.14	< 0.0020	0.29
SKM 201	Jun/2018	200		< 0.020	13	0.77	1.5	22	26	0.18	0.0025	0.021
SKM 201	Dec/2018	146		0.2	8.3	0.106	1.14	12.4	12.9	0.078	0.002	0.145
SKM 201	Apr/2019	164		1.26	10	0.72	2.6	15.4	19.5	0.57	0.002	0.004
SKM 201	Nov/2019	150		0.08	8.8	0.21	1.11	12.1	13.8	0.081	< 0.0020	0.131
SKM 201	Mean (Dec 2009-Nov 2019)	172	0.0006	0.21	9.3	0.3068	1.29	19.2	23	0.153	0.003	0.31

Bore ID	Date	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Sulphate	Chemical Oxygen Demand (COD)	Non-Purgeable Organic Carbon (NPOC)	Total Phenols	Volatile Fatty Acids (VFA), Total	Dissolved Arsenic	Dissolved Cadmium	Dissolved Chromium
		g/m^3	g/m^3	g/m^3	g/m^3	$g\ O_2/m^3$	g/m^3	g/m^3	g/m^3 as acetic acid	g/m^3	g/m^3	g/m^3
SKM 104 Trigger Level 1			3.3	0.004	14.4	170.1	20.8	0.0143	5	0.001	0.00005	0.006
SKM 104 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 104	Apr-2010		0.61	0.004	4.2	90	12.6	0.0097		0.001	0.00005	0.0005
SKM 104	Sep-2010		1.3	0.004	4.6	125	7.4	0.009		0.001	0.00005	0.0005
SKM 104	Dec-2010		0.45	0.004	7.3	52	108	0.003		0.001	0.00005	0.0005
SKM 104	Jun-2011		7.1	0.004	25.0	630.0	15.5	0.002		0.001	0.00005	0.0005
SKM 104	Sep-2011		0.42	0.004	3.8	54	8.3	0.004		0.001	0.00005	0.0005
SKM 104	Dec-2011		2.4	0.004	11.1	520	105	0.003		0.001	0.00005	0.0006
SKM 104	Mar-2012	1.87	3.6	< 0.004	11	171	19.9	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Jun-2014	1.77	4.1	< 0.004	21	50	10.8	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Sep-2014	2	0.17	0.008	3.9	39	11.3	< 0.002	< 5	< 0.0010	< 0.00005	0.0006
SKM 104	Jun-2015	2	0.27	< 0.004	21	67	42	< 0.002	< 5	< 0.0010	< 0.00005	0.0009
SKM 104	Oct-2015	1.73	1.3	0.07	5.5	17	9.5	< 0.02	< 5	< 0.0010	< 0.00005	0.002
SKM 104	Jun-2016	1.92	0.78	0.008	5	57	31	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Dec-2016	1.95	2	< 0.004	12.9	126	10.1	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Jun-2017	1.87	2.1	< 0.004	11	125	19.9	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Feb-2018	1.8	0.26	0.004	10	86	20	0.018	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Jun-2018	1.7	3.6	< 0.004	15	35	5.6	0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 104	Mean (Apr 2010-Jun 2018)	1.86	1.90	0.0114	10.8	140.3	27.3	0.006	< 5	0.0010	0.00005	0.0007
SKM 106 Trigger Level 1			0.84	0.051	10.4	9	1.8	0.024	5	0.001	0.0004	0.002
SKM 106 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 106	Apr/2010		0.1	0.004	7.5	6	1.32	0.0111		0.0010	0.000084	0.0005
SKM 106	Sep/2010		0.1	0.004	7.4	6	1	0.017		0.0010	0.00005	0.0014
SKM 106	Dec/2010		0.5	0.036	6.6	6	1.1	0.002		0.0010	0.00024	0.0009
SKM 106	Jun/2011		0.43			6		0.002		0.0010	0.00005	0.0005
SKM 106	Sep/2011		0.46	0.018	4.1	8	1.4	0.003		0.0010	0.00028	0.0005
SKM 106	Dec/2011		0.41	0.018	4.5	6	0.8	0.002		0.0010	0.00011	0.0005
SKM 106	Sep/2014	0.85	0.21	< 0.004	6.5	< 6	1.6	< 0.002	< 5	< 0.0010	0.00011	0.0006
SKM 106	Oct/2015	0.91	0.19	0.011	5.9	< 6	1.4	< 0.02	< 5	< 0.0010	0.00008	< 0.0005
SKM 106	Mean (Apr 2010-Oct 2015)	0.88	0.30	0.015	6.1	6	1.2	0.006	< 5	0.0010	0.00013	0.0007
SKM 108 Trigger Level 1			0.2	0.022	7.7	6	1.6	0.003	5	0.0053	0.00005	0.0005
SKM 108 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 108	Dec/2009		0.1	0.0055	4.5	6	0.83	0.002		0.0031	0.00005	0.0005
SKM 108	Apr/2010		0.1	0.007	4.7	6	1.12	0.0021		0.0043	0.00005	0.0005
SKM 108	Sep/2010		0.1	0.01	6.2	6	1.1	0.002		0.0024	0.00005	0.0005
SKM 108	Dec/2010		0.16	0.004	6.3	6	1.3	0.002		0.0017	0.00005	0.0005
SKM 108	Mar/2011		0.1	0.004	5.1	6	0.8	0.002		0.0029	0.00005	0.0005
SKM 108	Jun/2011		0.1	0.015	5.3	6	1.1	0.002		0.0035	0.00005	0.0005
SKM 108	Sep/2011		0.1	0.016	4.1	6	1.3	0.003		0.0022	0.00005	0.0005
SKM 108	Dec/2011		0.1	0.011	3.5	6	0.9	0.002		0.0017	0.00005	0.0005
SKM 108	Mar/2012	0.009	< 0.10	0.016	5.4	< 6	0.9	0.002	< 5	0.002	< 0.00005	< 0.0005
SKM 108	Oct/2012	0.13	< 0.10	0.011	5.6	< 6	1.2	< 0.002	< 5	0.0019	< 0.00005	< 0.0005
SKM 108	Jun/2014	0.039	0.23	< 0.004	33	< 6	3.1	0.002	< 5	0.0045	< 0.00005	< 0.0005
SKM 108	Sep/2014	0.127	0.19	< 0.004	30	< 6	3.4	0.002	< 5	0.0017	< 0.00005	< 0.0005
SKM 108	Jun/2016	0.025	0.1	< 0.004	14.7	< 6	3.8	< 0.02	< 5	0.0022	< 0.00005	< 0.0005
SKM 108	Dec/2016	0.061	0.18	0.007	17	< 6	3.5	< 0.02	< 5	0.0014	< 0.00005	< 0.0005
SKM 108	Jun/2017	0.009	< 0.10	0.016	5.4	< 6	0.9	0.002	< 5	0.002	< 0.00005	< 0.0005
SKM 108	Feb/2018	0.028	< 0.10	0.0066	52	< 6.0	1.4	< 0.0020	< 5	0.0014	< 0.00005	< 0.00050
SKM 108	Jun/2018	0.017	< 0.010	0.012	4.2	< 6	0.79	0.0076	< 5	0.005	< 0.000050	< 0.00050
SKM 108	Dec/2018	0.33	0.16	0.005	12.1	< 6	3.4	< 0.002	< 5	0.0017	< 0.00005	0.0006
SKM 108	Apr/2019	1.44	0.65	< 0.004	33	34	9.6	< 0.02	< 5	0.0016	< 0.00005	0.0006
SKM 108	Nov/2019	0.077	0.39	0.004	24	13	4.7	< 0.02	< 5	0.0011	< 0.00005	< 0.0005
SKM 108	Mean (Dec 2009-Nov 2019)	0.19	0.18	0.009	13.8	10	2.3	0.003	< 5	0.0024	0.00005	0.0005
SKM 201 Trigger Level 1			0.85	0.01	84	9.2	5.47	0.0036	5	0.001	0.00005	0.00554
SKM 201 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 201	Dec/2009		0.39	0.0064	72	6	3	0.002		0.001	0.00005	0.0005
SKM 201	Apr/2010		0.24	0.0124	66	6.9	3	0.0024		0.001	0.00005	0.001
SKM 201	Sep/2010		0.53	0.008	64	6	3.1	0.002		0.001	0.00005	0.005
SKM 201	Dec/2010		0.41	0.048	59	8	3	0.002		0.001	0.00005	0.0007
SKM 201	Mar/2011		0.17	0.018	67	8	1.8	0.002		0.001	0.00005	0.0005
SKM 201	Jun/2011		0.53	0.004	61	6	3.7	0.003		0.001	0.00005	0.0005
SKM 201	Sep/2011		0.37	0.004	49	6	4.4	0.003		0.001	0.00005	0.0005
SKM 201	Dec/2011		0.64	0.004	50	6	4	0.002		0.001	0.00005	0.0005
SKM 201	Mar/2012	0.41	0.25	< 0.004	41	< 6	3.5	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Oct/2012	0.44	0.19	< 0.004	39	< 6	3.4	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Jun/2014	0.054	0.28	0.004	43	< 6	5.1	0.003	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Sep/2014	0.014	0.37	< 0.004	39	< 6	5.7	0.003	< 5	0.0012	< 0.00005	< 0.0005
SKM 201	Jun/2015	0.021	0.37	< 0.004	39	9	5.4	0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Oct/2015	0.199	0.41	< 0.004	31	8	3.4	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Jun/2016	0.37	0.21	0.006	28	6	4.2	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Dec/2016	0.098	0.32	0.006	28	< 6	4.6	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Jun/2017	0.41	0.28	< 0.004	29	< 6	4.4	4.2	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 201	Feb/2018	0.3	0.41	< 0.0040	71	8.6	4.3	< 0.0020	< 5	< 0.0010	< 0.00005	< 0.00050
SKM 201	Jun/2018	0.023	0.28	< 0.0040	90	7.1	4.2	0.0035	< 5	< 0.0010	< 0.000050	< 0.00050
SKM 201	Dec/2018	0.147	0.4	0.01	17.5	< 6	4	< 0.0020	< 5	< 0.0010	< 0.00005	0.0006
SKM 201	Apr/2019	0.006	1.06	< 0.0040	39	11	6.9	< 0.0020	< 5	0.0034	< 0.00005	< 0.00050
SKM 201	Nov/2019	0.131	0.28	< 0.0040	14.8	7	5	< 0.0020	< 5	0.0013	< 0.00005	< 0.00050
SKM 201	Mean (Dec 2009-Nov 2019)	0.19	0.38	0.011	47.2	7	4.1	0.325	< 5	0.0013	0.00005	0.0011

Bore ID	Date	Dissolved Copper g/m³	Dissolved Lead g/m³	Dissolved Nickel g/m³	Dissolved Zinc g/m³
SKM 104 Trigger Level 1		0.0034	0.002	0.0012	0.0391
SKM 104 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 104	Apr-2010	0.00084	0.0001	0.0005	0.0062
SKM 104	Sep-2010	0.0012	0.0001	0.001	0.0145
SKM 104	Dec-2010	0.0014	0.0001	0.0007	0.0155
SKM 104	Jun-2011	0.0027	0.0002	0.0008	0.0260
SKM 104	Sep-2011	0.0005	0.0001	0.0005	0.027
SKM 104	Dec-2011	0.0005	0.0001	0.0008	0.0126
SKM 104	Mar-2012	0.0015	< 0.00010	0.0011	*0.083*
SKM 104	Jun-2014	0.001	0.00014	< 0.0005	*0.043*
SKM 104	Sep-2014	0.001	< 0.00010	< 0.0010	0.034
SKM 104	Jun-2015	< 0.0005	< 0.00010	< 0.0010	0.0148
SKM 104	Oct-2015	*0.0038*	< 0.00010	*0.0044*	*0.067*
SKM 104	Jun-2016	*0.0065*	0.00039	< 0.0010	*0.049*
SKM 104	Dec-2016	< 0.0005	< 0.00010	< 0.0010	0.024
SKM 104	Jun-2017	0.0015	< 0.00010	0.0011	0.026
SKM 104	Feb-2018	0.0016	< 0.00010	< 0.00050	0.016
SKM 104	Jun-2018	0.0011	0.00012	< 0.00050	0.012
SKM 104	Mean (Apr 2010-Jun 2018)	0.0018	0.00015	0.0012	0.029
SKM 106 Trigger Level 1		0.002	0.001	0.002	0.051
SKM 106 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 106	Apr/2010	0.0005	0.00067	0.0005	0.0065
SKM 106	Sep/2010	0.0005	0.0001	0.0005	0.022
SKM 106	Dec/2010	0.0013	0.00012	0.0017	0.0147
SKM 106	Jun/2011	0.0011	0.0001	0.0012	0.024
SKM 106	Sep/2011	0.0005	0.0001	0.0012	0.039
SKM 106	Dec/2011	0.0005	0.0001	0.0005	0.0114
SKM 106	Sep/2014	< 0.0005	< 0.00010	< 0.0010	0.033
SKM 106	Oct/2015	< 0.0005	< 0.00010	0.0013	0.036
SKM 106	Mean (Apr 2010-Oct 2015)	0.0007	0.00020	0.0010	0.023
SKM 108 Trigger Level 1		0.002	0.0001	0.0005	0.0244
SKM 108 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 108	Dec/2009	0.0005	0.0001	0.0005	0.013
SKM 108	Apr/2010	0.0005	0.0001	0.0005	0.003
SKM 108	Sep/2010	0.0005	0.0001	0.0005	0.006
SKM 108	Dec/2010	0.0018	0.0001	0.0005	0.0187
SKM 108	Mar/2011	0.0005	0.0001	0.0005	0.0124
SKM 108	Jun/2011	0.0005	0.0001	0.0005	0.0081
SKM 108	Sep/2011	0.0005	0.0001	0.0005	0.0137
SKM 108	Dec/2011	0.0005	0.0001	0.0005	0.0081
SKM 108	Mar/2012	< 0.0005	< 0.00010	< 0.0005	0.0054
SKM 108	Oct/2012	0.0007	< 0.00010	< 0.0005	0.0074
SKM 108	Jun/2014	< 0.0005	< 0.00010	< 0.0005	0.0093
SKM 108	Sep/2014	< 0.0005	< 0.00010	< 0.0005	0.0174
SKM 108	Jun/2016	0.002	< 0.00010	< 0.0005	0.021
SKM 108	Dec/2016	0.0008	< 0.00010	< 0.0005	*0.028*
SKM 108	Jun/2017	< 0.0005	< 0.00010	< 0.0005	0.0054
SKM 108	Feb/2018	0.00065	< 0.00010	< 0.00050	0.01
SKM 108	Jun/2018	0.00056	< 0.00010	< 0.00050	0.0038
SKM 108	Dec/2018	< 0.0005	< 0.00010	< 0.0005	*0.178*
SKM 108	Apr/2019	*0.022*	< 0.00010	*0.0017*	0.0154
SKM 108	Nov/2019	*0.0037*	< 0.00010	*0.0006*	0.0057
SKM 108	Mean (Dec 2009-Nov 2019)	*0.0024*	0.00010	*0.0006*	0.019
SKM 201 Trigger Level 1		0.0056	0.0001	0.006	0.0185
SKM 201 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 201	Dec/2009	0.0005	0.0001	0.002	0.0079
SKM 201	Apr/2010	0.001	0.0001	0.00185	0.0026
SKM 201	Sep/2010	0.005	0.0001	0.002	0.0032
SKM 201	Dec/2010	0.0011	0.0001	0.0019	0.0121
SKM 201	Mar/2011	0.0005	0.0001	0.0005	0.005
SKM 201	Jun/2011	0.0006	0.0001	0.0041	0.0064
SKM 201	Sep/2011	0.0008	0.0001	0.0035	0.0122
SKM 201	Dec/2011	0.0015	0.0001	0.004	0.0111
SKM 201	Mar/2012	0.0006	< 0.00010	0.0046	0.0126
SKM 201	Oct/2012	0.0006	< 0.00010	0.0013	0.0032
SKM 201	Jun/2014	0.0006	< 0.00010	0.0022	0.0052
SKM 201	Sep/2014	< 0.0005	< 0.00010	0.0033	0.0126
SKM 201	Jun/2015	0.0009	< 0.00010	0.0012	0.0073
SKM 201	Oct/2015	0.0005	< 0.00010	0.0022	0.0064
SKM 201	Jun/2016	< 0.0005	< 0.00010	< 0.0010	0.0085
SKM 201	Dec/2016	0.0024	< 0.00010	< 0.0010	0.0034
SKM 201	Jun/2017	< 0.0005	< 0.00010	0.0046	0.0026
SKM 201	Feb/2018	0.00059	< 0.00010	0.0015	0.011
SKM 201	Jun/2018	0.0013	< 0.00010	0.0051	0.0091
SKM 201	Dec/2018	0.001	< 0.00010	0.001	0.0132
SKM 201	Apr/2019	0.0033	< 0.00010	0.0038	0.072
SKM 201	Nov/2019	0.0012	< 0.00010	0.001	0.0121
SKM 201	Mean (Dec 2009-Nov 2019)	0.0013	0.00010	0.0026	0.011

Bore ID	Date	Sum of Anions	Sum of Cations	Turbidity	pH	Total Alkalinity	Bicarbonate	Total Hardness	Electrical Conductivity (EC)	Total Suspended Solids	Dissolved Aluminium	Dissolved Boron
		meq/L	meq/L	NTU	pH Units	g/m^3 as $CaCO_3$	g/m^3 at 25°C	g/m^3 as $CaCO_3$	mS/m	g/m^3	g/m^3	g/m^3
SKM 202 Trigger Level 1		12.1	12.2	20.3	6.9-7.3	403	482	561	105		0.008	
SKM 202 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 202	Dec/2009	8.7	8.3	1.3	7.2	280	340	360	78.8		0.003	
SKM 202	Apr/2010	9.1	8.3	1.21	7.1	310	380	360	80.8		0.003	
SKM 202	Sep/2010	9.4	9.1	2.4	7.1	330	400	410	81.5		0.003	
SKM 202	Dec/2010	7.1	6.8	12.6	7.2	240	300	290	65.5		0.004	
SKM 202	Mar/2011	8.2	7.9	9.8	7	290	350	350	75.8		0.003	
SKM 202	Jun/2011	9.9	9.7	*41*	7.1	320	390	440	87.3		0.007	
SKM 202	Sep/2011	10.2	9.5	11.9	7.2	340	410	430	90.2		0.003	
SKM 202	Dec/2011	10.1	10.7	4.2	7	340	410	480	91		0.005	
SKM 202	Mar/2012	10	10.3	1.83	7	300	360	470	85.1		< 0.003	
SKM 202	Oct/2012	11.1	10.8	4	7	300	360	490	98.4		0.005	
SKM 202	Jun/2014	8.7	8.7	8	6.9	230	280	380	79.6		< 0.003	
SKM 202	Sep/2014	9.7	8.5		7	260	310	370	89.1	18	< 0.003	0.46
SKM 202	Jun/2015	10.9	*13*		*7.4*	290	350	*600*	95.6	6	< 0.003	0.63
SKM 202	Oct/2015	*12.5*	*12.4*		7.1	340	420	550	*110.5*	14	< 0.003	0.61
SKM 202	Jun/2016	10.2	10.9	17.4	7	300	370	490	91		0.003	
SKM 202	Dec/2016	11	10.7	19.1	7	340	410	490	*950*		0.003	
SKM 202	Jun/2017	10	10.3	1.83	7	300	360	470	85.1		< 0.003	
SKM 202	Feb/2018	9.1	8.4	1.3	7.2	300	360	360	82.1		0.0045	
SKM 202	Jun/2018	9.4	8.8	0.68	7.1	320	390	380	82.1		< 0.0030	
SKM 202	Dec/2018	7.6	6.9	6.2	7.2	220	270	300	72.1		0.034	
SKM 202	Apr/2019	10.7	10.6	1.3	7.1	340	420	480	96.6		< 0.0030	
SKM 202	Nov/2019	5.2	6.8	6.1	7.2	164	199	300	50.3		< 0.0030	
SKM 202	Mean (Dec 2009-Nov 2019)	9.5	9.4	8.0	7.1	293	356	420	*124*	13	0.006	0.567
SKM 203 Trigger Level 1		7.9	7.3	62	7.1-7.5	337	416	332	66.5		0.003	
SKM 203 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 203	Dec/2009	7.2	6.6	*320*	7.3	300	370	300	63.3		0.003	
SKM 203	Apr/2010	7.1	6.3	44	7.3	290	360	280	62.6		0.003	
SKM 203	Sep/2010	6.9	6.7	22	7.4	290	350	300	61.4		0.003	
SKM 203	Dec/2010	7.1	6.9		7.3	290	360	310	63.4		0.003	
SKM 203	Mar/2011	6.7	6.3	*108*	7.2	280	330	280	64.6		0.003	
SKM 203	Jun/2011	7	6.5	42	7.3	290	350	280	62.2		0.003	
SKM 203	Sep/2011	7.7	6.8	*149*	7.4	330	400	300	65		0.003	
SKM 203	Dec/2011	7	6.9	28	7.3	290	350	310	62.6		0.003	
SKM 203	Mar/2012	6.8	6.8	5.4	7.2	280	350	300	60.5		0.003	
SKM 203	Oct/2012	6.9	6.6	10.4	7.4	290	350	290	62.7		*0.005*	
SKM 203	Jun/2014	7.2	7.2	57	7.3	300	360	320	64		*0.004*	
SKM 203	Sep/2014	7.2	7		7.3	290	360	310	66.2	31	0.003	0.016
SKM 203	Jun/2015	6.8	6.9		*7.7*	280	340	310	62.9	14	0.003	0.015
SKM 203	Oct/2015	7	7.1		7.4	290	350	310	64.5	39	*0.008*	0.013
SKM 203	Jun/2016	6.8	*7.5*	6.1	7.4	280	340	330	63.5		0.003	
SKM 203	Dec/2016	7.7	*7.4*	19.4	7.3	320	390	320	*69.3*		0.003	
SKM 203	Jun/2017	6.8	6.8	5.1	7.2	280	350	300	60.5		0.003	
SKM 203	Feb/2018	7.1	6.3	25	7.4	300	360	270	61.9		*0.0067*	
SKM 203	Jun/2018	7.1	6.5	*90*	7.4	300	370	280	62		< 0.0030	
SKM 203	Dec/2018	7.3	*7.6*	3.4	7.5	290	350	330	*69.5*		< 0.003	
SKM 203	Apr/2019	6.8	6.7	1.1	7.5	280	340	290	64.1		< 0.003	
SKM 203	Nov/2019	7.7	*7.7*	1.01	7.5	310	380	*340*	*70.2*		< 0.003	
SKM 203	Mean (Dec 2009-Nov 2019)	7.1	6.9	52.1	7.4	293	357	303	64	28	*0.004*	0.015
SKM 204 Trigger Level 1		6.8	7.2	5	7.1-7.6	310	377	330	60.6		0.004	
SKM 204 Trigger Level 2					6.5-9.0	20					0.055	0.037
SKM 204	Dec/2009	6.3	6.2	3.8	7.4	270	330	270	58.2		0.003	
SKM 204	Apr/2010	6.3	5.8	2.2	7.4	270	330	250	58.1		0.003	
SKM 204	Sep/2010	6.5	6.5	0.94	7.4	290	350	290	58.2		0.003	
SKM 204	Dec/2010	6.6	6.3	-	7.3	290	360	290	59.7		0.003	
SKM 204	Mar/2011	6.2	5.8	2.9	7.3	260	320	250	58.4		0.003	
SKM 204	Jun/2011	6.3	6.1	2.4	7.4	270	330	270	57.2		0.003	
SKM 204	Sep/2011	6.4	6.5	1.91	7.5	280	340	290	58.6		0.003	
SKM 204	Dec/2011	6.5	6.7	*23*	7.2	290	350	300	59.2		0.004	
SKM 204	Mar/2012	6.3	6	*6.6*	7.2	270	330	260	55.6		0.022	
SKM 204	Oct/2012	6.4	6.2	2.8	7.4	280	340	280	57.7		< 0.003	
SKM 204	Jun/2014	6.3	6.3	*5.3*	7.3	270	320	270	58.6		< 0.003	
SKM 204	Sep/2014	6.5	6.5		7.3	290	350	290	60.4	10	< 0.003	0.014
SKM 204	Jun/2015	6.4	6.6		*7.7*	290	350	300	58.7	< 3	< 0.003	0.012
SKM 204	Oct/2015	6.8	6.8		7.3	300	370	300	*62.6*	< 5	0.003	0.011
SKM 204	Jun/2016	6.3	6.7	0.53	7.4	270	330	290	59.1		< 0.003	
SKM 204	Dec/2016	6.4	6.4	0.4	7.3	270	330	280	59.4		< 0.003	
SKM 204	Jun/2017	6.4	6.2	2.1	7.2	267.3	326.7	257.4	55.044		< 0.003	
SKM 204	Feb/2018	6.5	6.1	0.82	7.4	290	350	270	57.5		< 0.0030	
SKM 204	Jun/2018	6	6	*8.3*	7.4	270	330	260	56.7		< 0.0030	
SKM 204	Dec/2018	6.6	7.1	1.87	7.4	290	350	310	*62.6*		< 0.003	
SKM 204	Apr/2019	6.5	6.4	0.08	7.5	280	340	280	*61.1*		< 0.003	
SKM 204	Nov/2019	*7.4*	*7.4*	0.87	7.5	*330*	*400*	330	*67.3*		< 0.003	
SKM 204	Mean (Dec 2009-Nov 2019)	6.5	6.4	3.7	7.4	281	342	281	59	10	0.005	0.012

Bore ID	Date	Dissolved Calcium	Dissolved Cobalt	Dissolved Iron	Dissolved Magnesium	Dissolved Manganese	Dissolved Potassium	Dissolved Sodium	Chloride	Total Ammoniacal-N	Nitrite-N	Nitrate-N
		g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3
SKM 202 Trigger Level 1		211		0.02	8.2	0.0005	1.58	25	46	1.18		3.54
SKM 202 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 202	Dec/2009	130		0.02	7	0.0005	1.4	24	44	0.01		3.1
SKM 202	Apr/2010	135		0.02	6.5	0.0005	1.46	23	36	0.01		2.3
SKM 202	Sep/2010	152		0.02	6.7	0.0005	1.26	21	31	0.01		2.4
SKM 202	Dec/2010	106		0.02	5.7	0.0005	1.29	23	37	0.01		1.56
SKM 202	Mar/2011	130		0.02	5.8	0.0005	1.37	22	34	0.01		1.79
SKM 202	Jun/2011	162		0.02	7.4	0.0005	1.29	22	33	0.01		2
SKM 202	Sep/2011	161		0.02	6.2	0.0005	1.16	21	34	0.01		2.3
SKM 202	Dec/2011	181		0.02	7	0.0005	1.25	23	33	0.01		2.4
SKM 202	Mar/2012	177		< 0.02	6.6	*0.0008*	1.17	21	28	< 0.010	< 0.002	1.89
SKM 202	Oct/2012	186		< 0.02	7.4	< 0.0005	1.18	20	28	< 0.010	< 0.002	2.4
SKM 202	Jun/2014	144		< 0.02	5.7	*0.0014*	1.29	24	29	< 0.010	< 0.002	1.57
SKM 202	Sep/2014	140	< 0.0002	< 0.02	5.8	*0.0008*	1.18	24	30	< 0.010	< 0.002	2.4
SKM 202	Jun/2015	*230*	< 0.0002	< 0.02	7.5	*0.0006*	1.39	23	30	< 0.010	< 0.002	2.8
SKM 202	Oct/2015	210	< 0.0002	< 0.02	7.3	< 0.0005	1.56	*29*	31	< 0.010	< 0.002	3.5
SKM 202	Jun/2016	187		< 0.02	6.6	< 0.0005	1.25	24	28	< 0.010	< 0.002	2.4
SKM 202	Dec/2016	184		0.02	6.5	< 0.0005	1.25	22	28	< 0.010	< 0.002	2.7
SKM 202	Jun/2017	177		< 0.02	6.6	< 0.0005	1.17	21	28	< 0.010	< 0.002	1.89
SKM 202	Feb/2018	130		< 0.020	6.8	< 0.00050	*1.6*	25	44	< 0.010	< 0.0020	2.6
SKM 202	Jun/2018	140		< 0.020	6.6	< 0.00050	*1.6*	25	41	< 0.010	0.0032	2.5
SKM 202	Dec/2018	107		*0.03*	7	*0.0169*	1.05	21	26	< 0.010	< 0.002	2.2
SKM 202	Apr/2019	181		< 0.020	6.9	*0.0006*	1.4	22	29	< 0.010	< 0.002	2.8
SKM 202	Nov/2019	107		< 0.020	7.1	*0.0017*	0.89	18.9	23	< 0.010	< 0.002	1.51
SKM 202	Mean (Dec 2009-Nov 2019)	157	< 0.0002	0.02	6.7	*0.0018*	1.29	22.7	32	0.010	0.003	2.32
SKM 203 Trigger Level 1		126		0.02	3.9	0.0005	1.04	19.4	34	0.025		3.8
SKM 203 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 203	Dec/2009	110		0.02	3.6	0.0005	0.79	16	32	0.01		3
SKM 203	Apr/2010	105		0.02	3.2	0.0005	0.91	17	32	0.01		2.8
SKM 203	Sep/2010	114		0.02	3.4	0.0005	0.91	17.5	30	0.01		3.1
SKM 203	Dec/2010	118		0.02	3.3	0.0005	0.96	16.6	31	0.023		3.1
SKM 203	Mar/2011	106		0.02	3	0.0005	0.9	16.7	30	0.01		3.2
SKM 203	Jun/2011	109		0.02	3.3	0.0005	0.89	18	32	0.01		3
SKM 203	Sep/2011	116		0.02	3.1	0.0005	0.84	17.2	31	0.01		3.6
SKM 203	Dec/2011	117		0.02	3.5	0.0005	0.93	18.4	32	0.01		3.3
SKM 203	Mar/2012	114		0.02	3.2	0.0005	0.87	17.4	30	0.01	0.002	3.2
SKM 203	Oct/2012	112		0.02	3.4	0.0005	0.85	16	29	0.01	0.002	3.2
SKM 203	Jun/2014	121		0.02	3.3	0.0005	1.02	*21*	32	0.01	0.002	3.3
SKM 203	Sep/2014	118	0.0002	0.02	3.6	*0.0006*	1.02	*19.5*	30	0.01	0.002	*4.7*
SKM 203	Jun/2015	117	0.0002	0.02	3.4	0.0005	0.92	17.38	30	0.01	0.002	3.7
SKM 203	Oct/2015	117	0.0002	0.02	3.4	0.0005	*1.06*	*23*	31	0.01	0.002	*4.1*
SKM 203	Jun/2016	125		< 0.02	3.4	< 0.0005	0.96	*22*	31	< 0.010	< 0.002	3.9
SKM 203	Dec/2016	122		< 0.02	3.7	< 0.0005	0.97	*24*	29	< 0.010	< 0.002	*5.6*
SKM 203	Jun/2017	114		< 0.02	3.2	< 0.0005	0.87	17.4	30	< 0.010	< 0.002	3.2
SKM 203	Feb/2018	100		< 0.020	3.2	0.0005	0.98	18	31	< 0.010	< 0.0020	3
SKM 203	Jun/2018	110		< 0.020	3.3	< 0.00050	0.94	18	30	< 0.010	0.0034	2.7
SKM 203	Dec/2018	124		< 0.02	*4.6*	< 0.0005	*1.19*	*22*	32	< 0.010	< 0.002	*6.1*
SKM 203	Apr/2019	112		< 0.02	3.3	< 0.0005	0.97	18.5	30	< 0.010	< 0.002	3.6
SKM 203	Nov/2019	*128*		< 0.02	*4.6*	< 0.0005	*1.29*	*22*	31	< 0.010	< 0.002	*6.1*
SKM 203	Mean (Dec 2009-Nov 2019)	115	0.0002	0.02	3.5	0.0005	0.96	18.8	31	0.011	0.002	3.70
SKM 204 Trigger Level 1		125		0.02	3.9	0.0008	0.92	19.4	27.7	0.01		3.7
SKM 204 Trigger Level 2				1		1.9			230	0.9		2.4
SKM 204	Dec/2009	100		0.02	3.5	0.0008	0.63	16	23	0.01		2.7
SKM 204	Apr/2010	97		0.02	3.2	0.0005	0.76	17.1	23	0.01		2.5
SKM 204	Sep/2010	111		0.02	3.2	0.0005	0.54	15.5	16.3	0.01		1.43
SKM 204	Dec/2010	109		0.02	3	0.0005	0.49	13.6	17	0.01		1.25
SKM 204	Mar/2011	96		0.02	2.8	0.0005	0.76	17.3	23	0.01		2.7
SKM 204	Jun/2011	102		0.02	3.3	0.0005	0.65	16.9	19.7	0.01		1.97
SKM 204	Sep/2011	110		0.02	3.2	0.0005	0.48	16.4	20	0.01		1.55
SKM 204	Dec/2011	115		0.02	3.5	0.0005	0.53	15.9	19.4	0.01		1.26
SKM 204	Mar/2012	99		< 0.02	3.1	< 0.0005	0.67	16.7	21	< 0.010	< 0.002	2.3
SKM 204	Oct/2012	106		< 0.02	3.1	< 0.0005	0.52	15.1	17.9	< 0.010	< 0.002	1.7
SKM 204	Jun/2014	104		< 0.02	3.2	< 0.0005	0.84	19.3	24	< 0.010	< 0.002	2.4
SKM 204	Sep/2014	109	< 0.0002	< 0.02	3.4	< 0.0005	0.69	17.9	19.4	< 0.010	< 0.002	1.81
SKM 204	Jun/2015	113	< 0.0002	< 0.02	3.3	< 0.0005	0.57	15.7	17.3	*0.016*	< 0.002	1.48
SKM 204	Oct/2015	115	< 0.0002	< 0.02	3.3	< 0.0005	0.62	19.2	18.2	< 0.010	< 0.002	1.45
SKM 204	Jun/2016	111		< 0.02	3.2	< 0.0005	0.78	*19.8*	23	< 0.010	< 0.002	2.4
SKM 204	Dec/2016	105		< 0.02	3.3	< 0.0005	0.81	*19.9*	23	< 0.010	< 0.002	2.4
SKM 204	Jun/2017	98.01		< 0.02	3.2	< 0.0005	0.6633	19.1	22	< 0.010	< 0.002	2.277
SKM 204	Feb/2018	100		< 0.020	3	< 0.00050	0.52	16	16	< 0.010	< 0.0020	1.4
SKM 204	Jun/2018	100		< 0.020	2.9	< 0.00050	0.5	16	16	< 0.010	< 0.0020	1.4
SKM 204	Dec/2018	119		< 0.02	3.7	< 0.0005	0.91	19.1	22	< 0.010	< 0.002	2.3
SKM 204	Apr/2019	106		< 0.02	3.5	< 0.0005	0.91	17.3	23	< 0.010	< 0.002	2.5
SKM 204	Nov/2019	*127*		< 0.02	3.8	< 0.0005	0.62	18	21	< 0.010	< 0.002	2.3
SKM 204	Mean (Dec 2009-Nov 2019)	107	< 0.0002	0.02	3.3	0.0005	0.66	17.2	20	*0.011*	< 0.002	1.98

Bore ID	Date	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Sulphate	Chemical Oxygen Demand (COD)	Non-Purgeable Organic Carbon (NPOC)	Total Phenols	Volatile Fatty Acids (VFA), Total	Dissolved Arsenic	Dissolved Cadmium	Dissolved Chromium
		g/m^3	g/m^3	g/m^3	g/m^3	g O_2/m^3	g/m^3	g/m^3	g/m^3 as acetic acid	g/m^3	g/m^3	g/m^3
SKM 202 Trigger Level 1			0.3	0.035	152	8	2.9	0.005	5	0.0011	0.00005	0.0006
SKM 202 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 202	Dec/2009		0.2	0.017	79	6	2.3	0.0029		0.0011	0.00005	0.0005
SKM 202	Apr/2010		0.142	0.022	81	6	1.93	0.0038		0.001	0.00005	0.0005
SKM 202	Sep/2010		0.15	0.015	88	6	1.5	0.004		0.001	0.00005	0.0006
SKM 202	Dec/2010		0.21	0.02	52	6	1.9	0.002		0.001	0.00005	0.0005
SKM 202	Mar/2011		0.17	0.018	67	8	1.8	0.002		0.001	0.00005	0.0005
SKM 202	Jun/2011		0.14	0.012	116	6	2.4	0.002		0.001	0.00005	0.0005
SKM 202	Sep/2011		0.18	0.03	112	6	1.5	0.002		0.001	0.00005	0.0005
SKM 202	Dec/2011		0.26	0.012	108	6	1.3	0.002		0.001	0.00005	0.0005
SKM 202	Mar/2012	1.89	0.16	0.01	150	< 6	1.5	< 0.002	< 5	< 0.0010	0.00006	0.0008
SKM 202	Oct/2012	2.4	0.25	0.005	200	< 6	2	< 0.002	< 5	< 0.0010	0.00006	0.0008
SKM 202	Jun/2014	1.57	0.14	0.01	157	< 6	2.5	0.002	< 5	< 0.0010	0.00006	0.0006
SKM 202	Sep/2014	2.4	0.17	0.01	171	< 6	2.2	< 0.002	< 5	< 0.0010	< 0.00005	0.0011
SKM 202	Jun/2015	2.8	0.29	0.013	194	< 6	41	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 202	Oct/2015	3.5	0.27	0.01	210	< 6	2.1	< 0.02	< 5	< 0.0010	0.00006	< 0.0005
SKM 202	Jun/2016	2.4	0.16	0.013	151	< 6	2.5	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 202	Dec/2016	2.7	0.21	0.009	155	< 6	3	< 0.02	< 5	< 0.0010	0.00006	0.0006
SKM 202	Jun/2017	1.89	0.16	0.01	150	< 6	1.5	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 202	Feb/2018	2.6	0.24	0.018	82	< 6	2.8	< 0.0020	< 5	< 0.0010	< 0.00005	< 0.00050
SKM 202	Jun/2018	2.5	0.13	0.019	85	< 6	1.4	< 0.0020	< 5	< 0.0010	< 0.000050	< 0.00050
SKM 202	Dec/2018	2.2	0.26	0.01	109	< 6	2.9	< 0.02	< 5	< 0.0010	< 0.00005	0.004
SKM 202	Apr/2019	2.8	0.39	0.008	136	8	2.7	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 202	Nov/2019	1.51	0.13	0.008	55	< 6	3.1	< 0.02	< 5	< 0.0010	< 0.00005	0.0029
SKM 202	Mean (Dec 2009-Nov 2019)	2.37	0.20	0.014	123.1	6	3.9	0.003	< 5	0.0010	0.00005	0.0010
SKM 203 Trigger Level 1			0.19	0.035	6.3	6	1.3	0	5	0.001	0.00005	0.0005
SKM 203 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 203	Dec/2009		0.1	0.004	3.7	6	0.31	0.002		0.001	0.00005	0.0005
SKM 203	Apr/2010		0.1	0.008	4	6	0.58	0.0032		0.001	0.00005	0.0005
SKM 203	Sep/2010		0.1	0.007	5.2	6	1.1	0.002		0.001	0.00005	0.0005
SKM 203	Dec/2010		0.1	0.004	5.3	6	0.7	0.002		0.001	0.00005	0.0005
SKM 203	Mar/2011		0.1	0.007	4.4	6	0.3	0.002		0.001	0.00005	0.0005
SKM 203	Jun/2011		0.1	0.007	4.6	6	0.7	0.002		0.001	0.00005	0.0005
SKM 203	Sep/2011		0.1	0.008	4.7	6	0.7	0.002		0.001	0.00005	0.0005
SKM 203	Dec/2011		0.18	0.009	3.4	6	0.4	0.002		0.001	0.00005	0.0005
SKM 203	Mar/2012	3.2	0.01	0.009	4.2	6	0.4	0.002	5	0.001	0.00005	0.0005
SKM 203	Oct/2012	3.2	0.01	< 0.004	4.3	6	0.8	0.002	5	0.001	0.00005	0.0005
SKM 203	Jun/2014	3.3	0.01	0.008	4.3	6	1.8	0.002	5	0.001	0.00005	0.0005
SKM 203	Sep/2014	4.7	0.01	0.008	4.9	6	1.5	0.003	5	0.001	0.00005	0.0005
SKM 203	Jun/2015	3.7	0.01	0.016	5	6	1.4	0.002	5	0.001	0.00005	0.0005
SKM 203	Oct/2015	4.1	0.01	0.008	4.3	6	0.7	0.02	5	0.001	0.00005	0.0005
SKM 203	Jun/2016	3.9	< 0.10	0.006	4.5	< 6	1.4	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 203	Dec/2016	5.6	< 0.10	0.008	6.9	< 6	1.8	< 0.02	< 5	< 0.0010	< 0.00005	0.0005
SKM 203	Jun/2017	3.2	< 0.10	0.009	4.2	6	1.2	< 0.02	5	< 0.0010	< 0.00005	0.0005
SKM 203	Feb/2018	3	< 0.10	< 0.0040	4	< 6.0	1.3	< 0.0020	< 5	< 0.0010	< 0.00005	< 0.00050
SKM 203	Jun/2018	2.7	< 0.10	0.0058	3.6	< 6	< 0.30	0.0023	< 5	< 0.0010	< 0.000050	< 0.00050
SKM 203	Dec/2018	6.1	0.1	0.013	7.5	< 6	1.9	< 0.02	< 5	< 0.0010	< 0.000050	0.0008
SKM 203	Apr/2019	3.6	0.1	0.007	4.2	< 6	1.6	< 0.02	< 5	< 0.0010	< 0.000050	< 0.00050
SKM 203	Nov/2019	6.1	< 0.10	0.021	7.7	< 6	1.7	< 0.02	< 5	< 0.0010	< 0.000050	0.0007
SKM 203	Mean (Dec 2009-Nov 2019)	4.03	0.07	0.009	4.8	6	1.1	0.003	5	0.0010	0.00005	0.0005
SKM 204 Trigger Level 1			0.37	0.01	7.6	6	1.7	0.004	5	0.001	0.00005	0.0005
SKM 204 Trigger Level 2								0.32		0.024	0.0002	0.001
SKM 204	Dec/2009		0.1	0.004	4.7	6	0.37	0.002		0.001	0.00005	0.0005
SKM 204	Apr/2010		0.1	0.008	5.6	6	0.79	0.0034		0.001	0.00005	0.0005
SKM 204	Sep/2010		0.1	0.004	7.1	6	0.9	0.002		0.001	0.00005	0.0005
SKM 204	Dec/2010		0.16	0.004	6	6	1	0.002		0.001	0.00005	0.0005
SKM 204	Mar/2011		0.1	0.007	5.4	6	0.6	0.002		0.001	0.00005	0.0005
SKM 204	Jun/2011		0.1	0.007	5.8	6	0.7	0.002		0.001	0.00005	0.0005
SKM 204	Sep/2011		0.1	0.006	5.2	6	1.2	0.002		0.001	0.00005	0.0005
SKM 204	Dec/2011		0.34	0.005	5.2	6	1.2	0.002		0.001	0.00005	0.0005
SKM 204	Mar/2012	2.3	0.12	0.008	5.3	< 6	0.6	0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Oct/2012	1.7	< 0.10	< 0.004	5.8	< 6	1.2	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Jun/2014	2.4	< 0.10	0.008	5.7	< 6	1.6	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Sep/2014	1.81	0.12	0.006	5.5	< 6	1.2	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Jun/2015	1.48	< 0.10	0.012	6	< 6	1.3	< 0.002	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Oct/2015	1.45	0.16	0.004	5.2	< 6	0.8	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Jun/2016	2.4	< 0.10	0.009	5	< 6	1.8	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Dec/2016	2.4	< 0.10	0.007	5	< 6	1.6	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Jun/2017	2.277	< 0.10	0.008	5	< 6	1.3	< 0.02	< 5	< 0.0010	< 0.00005	< 0.0005
SKM 204	Feb/2018	1.4	< 0.10	< 0.0040	6	< 6.0	1.1	< 0.0020	< 5	< 0.0010	< 0.00005	< 0.00050
SKM 204	Jun/2018	1.4	< 0.010	< 0.0040	5.5	< 6	0.3	0.0026	< 5	< 0.0010	< 0.000050	< 0.00050
SKM 204	Dec/2018	2.3	0.17	0.005	4.6	< 6	1.7	< 0.02	< 5	< 0.0010	< 0.00005	0.0008
SKM 204	Apr/2019	2.5	< 0.010	0.005	4.9	< 6	1.9	< 0.02	< 5	< 0.0010	< 0.00005	0.0005
SKM 204	Nov/2019	2.3	< 0.10	0.007	4.8	< 6	3.2	< 0.02	< 5	< 0.0010	< 0.00005	0.0005
SKM 204	Mean (Dec 2009-Nov 2019)	2.01	0.14	0.007	5.4	6	1.2	0.002	< 5	0.0010	0.00005	0.0005

Bore ID	Date	Dissolved Copper	Dissolved Lead	Dissolved Nickel	Dissolved Zinc
		g/m^3	g/m^3	g/m^3	g/m^3
SKM 202 Trigger Level 1		0.0012	0.00011	0.0089	0.0116
SKM 202 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 202	Dec/2009	0.00063	0.0001	0.001	0.006
SKM 202	Apr/2010	0.001	0.0001	0.0005	0.0026
SKM 202	Sep/2010	0.0005	0.0001	0.0005	0.0036
SKM 202	Dec/2010	0.0009	0.0001	0.008	0.0058
SKM 202	Mar/2011	0.0005	0.0001	0.0005	0.005
SKM 202	Jun/2011	0.0005	0.0001	0.0005	0.0067
SKM 202	Sep/2011	0.0005	0.0001	0.0005	0.0081
SKM 202	Dec/2011	0.0005	0.00011	0.0005	0.0087
SKM 202	Mar/2012	< 0.0005	< 0.00010	< 0.0010	*0.0163*
SKM 202	Oct/2012	< 0.0005	< 0.00010	< 0.0010	0.0065
SKM 202	Jun/2014	< 0.0005	< 0.00010	0.001	0.0049
SKM 202	Sep/2014	< 0.0005	< 0.00010	0.0015	0.0022
SKM 202	Jun/2015	< 0.0005	< 0.00010	< 0.0010	*0.014*
SKM 202	Oct/2015	< 0.0005	< 0.00010	0.0007	0.0056
SKM 202	Jun/2016	< 0.0005	< 0.00010	< 0.0010	0.0032
SKM 202	Dec/2016	< 0.0010	< 0.00010	< 0.0010	0.0083
SKM 202	Jun/2017	< 0.0005	< 0.00010	< 0.0010	0.0043
SKM 202	Feb/2018	*0.0018*	*0.00017*	< 0.00050	*0.018*
SKM 202	Jun/2018	0.00075	< 0.00010	< 0.00050	*0.017*
SKM 202	Dec/2018	*0.0016*	< 0.00010	0.0032	*0.0182*
SKM 202	Apr/2019	< 0.0005	< 0.00010	0.0015	0.0072
SKM 202	Nov/2019	< 0.0005	< 0.00010	0.0019	0.0096
SKM 202	Mean (Dec 2009-Nov 2019)	0.0008	0.00011	0.0016	0.008
SKM 203 Trigger Level 1		0.0012	0.0001	0.0005	0.015
SKM 203 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 203	Dec/2009	0.0005	*0.00014*	0.0005	0.0037
SKM 203	Apr/2010	0.0005	*0.000162*	0.0005	0.00175
SKM 203	Sep/2010	0.0005	*0.00014*	0.0005	0.002
SKM 203	Dec/2010	0.0011	*0.00021*	0.0005	0.0128
SKM 203	Mar/2011	0.0005	*0.00019*	0.0005	0.0059
SKM 203	Jun/2011	0.0005	*0.00014*	0.0005	0.0052
SKM 203	Sep/2011	0.0005	*0.00015*	0.0005	0.0054
SKM 203	Dec/2011	0.0005	*0.00016*	0.0005	0.005
SKM 203	Mar/2012	0.0005	*0.00012*	0.0005	0.0044
SKM 203	Oct/2012	*0.0013*	*0.00017*	0.0005	0.0061
SKM 203	Jun/2014	0.0012	*0.00015*	0.0005	0.0055
SKM 203	Sep/2014	0.0008	*0.00013*	0.0005	0.011
SKM 203	Jun/2015	0.0005	*0.00013*	0.001	0.0047
SKM 203	Oct/2015	0.0005	0.0001	0.0005	0.003
SKM 203	Jun/2016	< 0.0005	*0.00016*	< 0.0005	0.0026
SKM 203	Dec/2016	< 0.0005	*0.00013*	< 0.0010	0.0064
SKM 203	Jun/2017	< 0.0005	*0.00012*	< 0.0010	0.0034
SKM 203	Feb/2018	*0.0021*	*0.00067*	< 0.00050	0.015
SKM 203	Jun/2018	< 0.00050	< 0.00019	< 0.00050	0.003
SKM 203	Dec/2018	0.0009	*0.00012*	0.0007	0.0113
SKM 203	Apr/2019	< 0.00050	*0.00016*	0.0006	0.0037
SKM 203	Nov/2019	0.0005	< 0.00010	< 0.00050	0.0052
SKM 203	Mean (Dec 2009-Nov 2019)	0.0008	*0.00017*	0.0006	0.006
SKM 204 Trigger Level 1		0.0012	0.0002	0.0005	0.0181
SKM 204 Trigger Level 2		0.0014	0.0034	0.011	0.008
SKM 204	Dec/2009	0.0005	0.0001	0.0005	0.0073
SKM 204	Apr/2010	0.0005	0.0001	0.0005	0.0017
SKM 204	Sep/2010	0.0005	0.00016	0.0005	0.0033
SKM 204	Dec/2010	0.0009	0.0001	0.0005	0.0119
SKM 204	Mar/2011	0.0005	0.0001	0.0005	0.0056
SKM 204	Jun/2011	0.0005	0.0001	0.0005	0.0128
SKM 204	Sep/2011	0.0005	0.0001	0.0005	0.0032
SKM 204	Dec/2011	*0.0026*	0.0001	0.0005	0.0079
SKM 204	Mar/2012	0.0011	< 0.00010	< 0.0005	0.0073
SKM 204	Oct/2012	0.0011	< 0.00010	< 0.0005	0.0105
SKM 204	Jun/2014	< 0.0005	< 0.00010	< 0.0005	0.0049
SKM 204	Sep/2014	0.0007	< 0.00010	< 0.0005	0.0107
SKM 204	Jun/2015	< 0.0005	< 0.00010	< 0.0010	0.0035
SKM 204	Oct/2015	< 0.0005	< 0.00010	*0.0006*	0.0034
SKM 204	Jun/2016	< 0.0005	< 0.00010	< 0.0005	0.0023
SKM 204	Dec/2016	< 0.0005	< 0.00010	< 0.0005	0.0031
SKM 204	Jun/2017	< 0.0005	< 0.00010	< 0.0005	0.0028
SKM 204	Feb/2018	< 0.00050	< 0.00010	< 0.00050	0.0058
SKM 204	Jun/2018	< 0.00050	< 0.00010	< 0.00050	0.002
SKM 204	Dec/2018	0.001	< 0.00010	*0.0006*	0.0107
SKM 204	Apr/2019	0.0005	< 0.00010	0.0005	0.0034
SKM 204	Nov/2019	0.0007	< 0.00010	< 0.00050	0.0158
SKM 204	Mean (Dec 2009-Nov 2019)	0.0008	0.00011	0.0005	0.006

Site ID	Date	pH (pH units)	Electrical Conductivity (mS/m)	Total Ammoniacal-N (g/m^3)	Chloride (g/m^3)	Site ID	Date	pH (pH units)	Electrical Conductivity (mS/m)	Total Ammoniacal-N (g/m^3)	Chloride (g/m^3)
Site 13 Trigger Level 1		6.9	55.6	0	24.8	Site 17 Trigger Level 1		6.9	55.6	0	24.8
Site 13 Trigger Level 1		7.6	76.3	0.032	35.2	Site 17 Trigger Level 1		7.6	76.3	0.032	35.2
Site 13	Jan/2007					Site 17	Jan/2007				
Site 13	Feb/2007					Site 17	Feb/2007				
Site 13	Mar/2007					Site 17	Mar/2007				
Site 13	Apr/2007	7.2	72.4	0.010	32.2	Site 17	Apr/2007				
Site 13	May/2007	7.2	72.4	0.010	32.2	Site 17	May/2007				
Site 13	Jun/2007	7.2	66.6	0.010	25.0	Site 17	Jun/2007				
Site 13	Jul/2007	7.3	73.1	0.010	31.8	Site 17	Jul/2007				
Site 13	Aug/2007	7.3	70.4	0.010	30.4	Site 17	Aug/2007				
Site 13	Sep/2007	7.3	70.7	0.010	28.7	Site 17	Sep/2007				
Site 13	Oct/2007	7.4	65.8	0.010	31.5	Site 17	Oct/2007				
Site 13	Nov/2007	7.4	65.5	0.010	28.9	Site 17	Nov/2007				
Site 13	Dec/2007	7.3	67.2	0.010	31.4	Site 17	Dec/2007				
Site 13	Jan/2008	7.6	69.5	0.010	30.2	Site 17	Jan/2008				
Site 13	Feb/2008	7.5	70.3	0.010	32.3	Site 17	Feb/2008				
Site 13	Mar/2008	7.6	69.3	0.010	30.7	Site 17	Mar/2008				
Site 13	Apr/2008	7.5	56.4	0.020	29.8	Site 17	Apr/2008				
Site 13	May/2008	7.4	65	0.010	32.7	Site 17	May/2008				
Site 13	Jun/2008	7.3	72.3	0.010	33.5	Site 17	Jun/2008				
Site 13	Jul/2008	7.4	61	0.010	34.4	Site 17	Jul/2008				
Site 13	Aug/2008	7.4	66.3	0.010	29.8	Site 17	Aug/2008				
Site 13	Sep/2008	6.9	60.3	0.010	32.7	Site 17	Sep/2008				
Site 13	Oct/2008	7.4	60.3	0.010	31.4	Site 17	Oct/2008				
Site 13	Nov/2008	7.6	70	0.010	33.0	Site 17	Nov/2008				
Site 13	Dec/2008	7.3	68.3	0.010	31.4	Site 17	Dec/2008				
Site 13	Jan/2009	6.9	72.7	0.010	31.0	Site 17	Jan/2009	7.2	32.9	0.240	17
Site 13	Feb/2009	7.1	65.8	0.010	30.0	Site 17	Feb/2009	7.5	38.2	0.120	32
Site 13	Mar/2009	7.1	67.3	0.010	31.0	Site 17	Mar/2009	7.9	36.8	0.024	28
Site 13	Apr/2009	7.1	75.5	0.010	31.0	Site 17	Apr/2009	7.9	63.9	0.034	58
Site 13	May/2009	7.0	68.9	0.039	29.0	Site 17	May/2009	7.9	47.4	0.010	26
Site 13	Jun/2009	6.9	75.4	0.065	34.0	Site 17	Jun/2009	7.7	64.8	0.010	51
Site 13	Jul/2009	6.9	65	0.013	28.0	Site 17	Jul/2009	7.7	51.5	0.035	39
Site 13	Aug/2009	7.2	73.7	0.010	33.0	Site 17	Aug/2009	7.9	39.3	0.026	34
Site 13	Sep/2009	7.0	73.3	0.032	32.0	Site 17	Sep/2009	7.8	73.0	0.042	42
Site 13	Oct/2009					Site 17	Oct/2009				
Site 13	Nov/2009	7.2	70.3	0.010	37.0	Site 17	Nov/2009	7.9	40.0	0.010	29
Site 13	Dec/2009	7.2	63.5	0.010	33.0	Site 17	Dec/2009	7.7	29.9	0.063	17
Site 13	Jan/2010	7.4	62.8	0.010	28.0	Site 17	Jan/2010	8.2	41.7	0.020	26
Site 13	Feb/2010	7.1	72.1	0.010	32.0	Site 17	Feb/2010				
Site 13	Mar/2010					Site 17	Mar/2010				
Site 13	Apr/2010	7.0	64.2	0.010	33.0	Site 17	Apr/2010				
Site 13	May/2010	7.0	49.6	0.010	25.0	Site 17	May/2010	7.7	39.8	0.014	25
Site 13	Jun/2010	7.0	66.7	0.012	30.0	Site 17	Jun/2010	7.7	57.3	0.010	27
Site 13	Jul/2010	7.2	60.9	0.010	30.0	Site 17	Jul/2010	7.9	33.7	0.025	21
Site 13	Aug/2010	7.2	50	0.010	24.0	Site 17	Aug/2010	7.2	50.0	0.010	24
Site 13	Sep/2010	7.1	56.5	0.012	27.0	Site 17	Sep/2010	7.9	29.9	0.016	50
Site 13	Oct/2010	7.0	62.3	0.010	29.0	Site 17	Oct/2010	7.6	28.3	0.131	41
Site 13	Nov/2010	7.1	63.1	0.010	32.0	Site 17	Nov/2010	7.5	29.1	0.020	29
Site 13	Dec/2010	7.4	60.4	0.010	25.0	Site 17	Dec/2010	7.4	17.2	0.240	8
Site 13	Jan/2011	7.2	63.3	0.010	30.0	Site 17	Jan/2011	7.6	29.3	0.062	12
Site 13	Feb/2011	7.5	60.4	0.010	31.0	Site 17	Feb/2011	7.6	72.6	0.010	37
Site 13	Mar/2011	6.9	80.3	0.010	13.5	Site 17	Mar/2011	7.8	56.7	0.013	38
Site 13	Apr/2011	7.3	55.4	0.010	30.0	Site 17	Apr/2011	7.6	73.1	0.010	42
Site 13	May/2011	7.5	62.8	0.010	32.0	Site 17	May/2011	7.7	69.3	0.010	39
Site 13	Jun/2011	7.0	60.4	0.010	29.0	Site 17	Jun/2011	7.2	71.7	0.010	41
Site 13	Jul/2011	7.2	64.3	0.010	27.0	Site 17	Jul/2011	7.6	54.3	0.010	30
Site 13	Aug/2011					Site 17	Aug/2011	7.6	54.3	0.010	30
Site 13	Sep/2011	7.1	64.5	0.130	27.0	Site 17	Sep/2011	7.6	56.1	0.014	26
Site 13	Oct/2011	7.2	64.2	0.010	27.0	Site 17	Oct/2011	7.6	63.4	0.240	44
Site 13	Nov/2011					Site 17	Nov/2011	7.7	65.1	0.210	38
Site 13	Dec/2011					Site 17	Dec/2011	7.6	74.8	0.320	49
Site 13	Jan/2012	7.2	66.9	0.010	31.0	Site 17	Jan/2012	7.5	67.7	0.162	29
Site 13	Feb/2012	7.1	65.8	0.010	25.0	Site 17	Feb/2012	7.4	56.1	0.150	29
Site 13	Mar/2012	6.9	63.8	0.010	24.0	Site 17	Mar/2012	7.4	102.5	0.790	92
Site 13	Apr/2012	7.1	66.1	0.010	30.0	Site 17	Apr/2012	7.8	85.1	0.390	62
Site 13	May/2012	7.3	63.5	0.010	28.0	Site 17	May/2012	7.7	59.0	0.091	35
Site 13	Jun/2012	7.2	63.1	0.010	25.0	Site 17	Jun/2012	7.5	105.0	1.600	98
Site 13	Jul/2012	7.2	60.4	0.010	29.0	Site 17	Jul/2012	7.7			
Site 13	Aug/2012	7.2	58.8	0.010	28.0	Site 17	Aug/2012	7.5			
Site 13	Sep/2012	7.1	60.2	0.010	29.0	Site 17	Sep/2012	7.5	65.9	4.600	48
Site 13	Oct/2012	7.2	59.1	0.010	23.0	Site 17	Oct/2012	7.5			
Site 13	Nov/2012	7.3	66	0.010	29.0	Site 17	Nov/2012	7.6	69.9	4.600	40
Site 13	Dec/2012	7.1	65.7	0.053	25.0	Site 17	Dec/2012	7.6	69.9	4.600	40
Site 13	Jan/2013	7.0	68.2	0.010	29.0	Site 17	Jan/2013	7.4	84.7	4.200	50
Site 13	Feb/2013	7.1	68.3	0.027	31.0	Site 17	Feb/2013	8.0	71.7	0.210	32
Site 13	Mar/2013	7.2	69.2	0.021	31.0	Site 17	Mar/2013	7.8	98.7	0.025	87
Site 13	Apr/2013	7.4	61.3	0.050	26.0	Site 17	Apr/2013	7.8	57.9	0.440	37
Site 13	May/2013	7.4	64.5	0.022	28.0	Site 17	May/2013	7.8	61.5	0.186	36
Site 13	Jun/2013	7.5	59.1	0.012	21.0	Site 17	Jun/2013	7.8	47.6	0.053	24
Site 13	Jul/2013	7.3	70	0.019	29.0	Site 17	Jul/2013	7.9	54.6	0.028	27
Site 13	Aug/2013	7.4	66.6	0.010	28.0	Site 17	Aug/2013	7.9	61.5	0.109	32
Site 13	Sep/2013	7.5	63.6	0.010	25.0	Site 17	Sep/2013	7.8	54.5	0.029	26
Site 13	Oct/2013	7.6	64	0.010	28.0	Site 17	Oct/2013	8.0	60.2	0.045	31

Site ID	Date	pH (pH units)	Electrical Conductivity (mS/m)	Total Ammoniacal-N (g/m^3)	Chloride (g/m^3)	Site ID	Date	pH (pH units)	Electrical Conductivity (mS/m)	Total Ammoniacal-N (g/m^3)	Chloride (g/m^3)
Site 13 Trigger Level 1		6.9	55.6	0	24.8	Site 17 Trigger Level 1		6.9	55.6	0	24.8
Site 13 Trigger Level 1		7.6	76.3	0.032	35.2	Site 17 Trigger Level 1		7.6	76.3	0.032	35.2
Site 13	Nov/2013	8.1	61.6	0.010	27.0	Site 17	Nov/2013	8.1	68.1	0.138	35
Site 13	Dec/2013	7.4	67.3	0.010	29.0	Site 17	Dec/2013	8.0	63.5	0.121	31
Site 13	Jan/2014	7.5	65	0.010	29.0	Site 17	Jan/2014	7.9	62.9	0.134	31
Site 13	Feb/2014	7.6	68	0.010	30.0	Site 17	Feb/2014	8.0	73.7	0.240	45
Site 13	Mar/2014	7.6	60.4	0.010	24.0	Site 17	Mar/2014	7.9	49	0.010	26
Site 13	Apr/2014	7.3	72.1	0.010	24.0	Site 17	Apr/2014	7.9	48.9	0.010	26
Site 13	May/2014	7.5	72.1	0.023	31.0	Site 17	May/2014	7.9	58.6	0.098	34
Site 13	Jun/2014	7.8	56.9	0.012	29.0	Site 17	Jun/2014	7.9	73.9	0.080	32
Site 13	Jul/2014	7.2	79.6	0.010	27.0	Site 17	Jul/2014	7.9	73.9	0.087	32
Site 13	Aug/2014	7.7	56.9	0.014	28.0	Site 17	Aug/2014	7.9	74	0.082	32
Site 13	Sep/2014	7.7	57.4	0.010	29.0	Site 17	Sep/2014	7.9	67.5	0.115	33
Site 13	Oct/2014	7.4	69.4	0.010	26.0	Site 17	Oct/2014	7.9	52	0.010	25
Site 13	Nov/2014	7.6	57.4	0.010	27.0	Site 17	Nov/2014	7.9	61.3	0.083	24
Site 13	Dec/2014	7.6	63	0.010	30.0	Site 17	Dec/2014	7.9	70.9	0.082	33
Site 13	Jan/2015	7.8	51.8	0.010	32.0	Site 17	Jan/2015	7.9	69.7	0.079	37
Site 13	Feb/2015	7.5	58.5	0.010	28.0	Site 17	Feb/2015	7.8	81.9	0.440	59
Site 13	Mar/2015	7.5	66.7	0.010	28.0	Site 17	Mar/2015	8.0	60.2	0.053	35
Site 13	Apr/2015	7.7	59	0.010	28.0	Site 17	Apr/2015	7.9	61.1	0.074	35
Site 13	May/2015	7.6	63.4	0.010	29.0	Site 17	May/2015	8.0	61.2	0.052	36
Site 13	Jun/2015	7.8	57.4	0.015	25.0	Site 17	Jun/2015	8	49.8	0.010	26.0
Site 13	Jul/2015	7.8	57.6	0.016	25.0	Site 17	Jul/2015	8	49.9	0.010	26.0
Site 13	Aug/2015	7.8	57.5	0.011	23.0	Site 17	Aug/2015	8	49.7	0.055	24.0
Site 13	Sep/2015	7.6	68	0.039	28.0	Site 17	Sep/2015	7.8	72.5	0.010	31.0
Site 13	Oct/2015	7.7	56.8	0.010	23.0	Site 17	Oct/2015	7.9	53.3	0.010	23.0
Site 13	Nov/2015	7.8	61.4	0.010	26.0	Site 17	Nov/2015	7.9	61	0.010	27.0
Site 13	Dec/2015	7.7	61	0.010	26.0	Site 17	Dec/2015	7.9	68	0.010	29.0
Site 13	Jan/2016	7.8	62.9	0.010	23.0	Site 17	Jan/2016	7.9	64.7	0.010	30.0
Site 13	Feb/2016	7.5	49.9	0.010	23.0	Site 17	Feb/2016	7.8	43.1	0.010	22.0
Site 13	Mar/2016	7.4	72.6	0.010	28.0	Site 17	Mar/2016	7.9	76.0	0.010	38.0
Site 13	Apr/2016	7.5	62.3	0.010	23.0	Site 17	Apr/2016	7.9	58.5	0.010	27.0
Site 13	May/2016	7.5	63.1	0.010	24.0	Site 17	May/2016	7.8	54.4	0.010	23.0
Site 13	Jun/2016	7.5	66.7	0.012	28.0	Site 17	Jun/2016	7.9	72.0	0.010	32.0
Site 13	Jul/2016	7.5	66.7	0.018	27.0	Site 17	Jul/2016	7.9	55.2	0.010	23.0
Site 13	Aug/2016	7.5	71	0.039	31.0	Site 17	Aug/2016	7.7	83.3	2.900	46.0
Site 13	Sep/2016	7.7	65.6	0.010	28.0	Site 17	Sep/2016	7.8	77.7	0.240	36.0
Site 13	Oct/2016	7.7	64.4	0.010	26.0	Site 17	Oct/2016	7.9	58.3	0.035	26.0
Site 13	Nov/2016	7.5	65.1	0.010	26.0	Site 17	Nov/2016	7.9	67.3	0.012	26.0
Site 13	Dec/2016	7.4	60.8	0.010	28.0	Site 17	Dec/2016	7.7	71.8	0.024	33.0
Site 13	Jan/2017	7.4	56	0.010	24.0	Site 17	Jan/2017	7.8	59.4	0.010	28
Site 13	Feb/2017	7.7	58.2	0.010	28.0	Site 17	Feb/2017	7.8	70.6	0.010	29.0
Site 13	Mar/2017	7.7	53.4	0.010	27.0	Site 17	Mar/2017	8.2	71.7	0.01	33.0
Site 13	Apr/2017	8.2	52.7	0.010	27.0	Site 17	Apr/2017	8	71.7	0.01	33.0
Site 13	May/2017	8.1	71.4	0.010	33.0	Site 17	May/2017	8.1	71.4	0.01	33.0
Site 13	Jun/2017	8.1	47.1	0.010	22.0	Site 17	Jun/2017	8.2	52.3	0.01	38.0
Site 13	Jul/2017	7.5	53.1	0.017	25.0	Site 17	Jul/2017	7.7	69.6	0.02	52.0
Site 13	Aug/2017	8.0	50.4	0.010	25.0	Site 17	Aug/2017	8	74.8	<0.010	45
Site 13	Sep/2017	7.7	49.1	0.010	25.0	Site 17	Sep/2017	7.7	73.4	0.580	43.0
Site 13	Oct/2017	7.8	49.8	0.010	27.0	Site 17	Oct/2017	7.8	79.6	0.195	44.0
Site 13	Nov/2017		94.6	0.010	26	Site 17	Nov/2017	7.8	72.9	0.037	44
Site 13	Dec/2017	7.5	52.8	0.010	31	Site 17	Dec/2017	7.6	79.4	0.042	44
Site 13	Jan/2018	7.6	54.7	0.010	36.0	Site 17	Jan/2018	7.8	80.0	0.159	45.0
Site 13	Feb/2018	7.6	51.8	0.010	28.0	Site 17	Feb/2018	7.7	75.8	0.760	45.0
Site 13	Mar/2018	7.7	48.5	<0.010	26.0	Site 17	Mar/2018	7.9	72.6	0.033	38.0
Site 13	Apr/2018	7.7	42.3	<0.010	20	Site 17	Apr/2018	8.0	44.6	0.022	29
Site 13	May/2018	7.6	63.4	0.510	30.0	Site 17	May/2018	7.7	97.0	5.300	88.0
Site 13	Jun/2018	8.1	75	1.890	39.0	Site 17	Jun/2018	8.1	75.0	1.890	39
Site 13	Jul/2018	7.4	78.2	1.420	38.0	Site 17	Jul/2018	7.4	78.2	1.420	38
Site 13	Aug/2018	7.4	77.8	1.020	35.0	Site 17	Aug/2018				
Site 13	Sep/2018					Site 17	Sep/2018				
Site 13	Oct/2018					Site 17	Oct/2018				
Site 13	Nov/2018	7.1	73.1	0.131	26	Site 17	Nov/2018				
Site 13	Dec/2018					Site 17	Dec/2018				

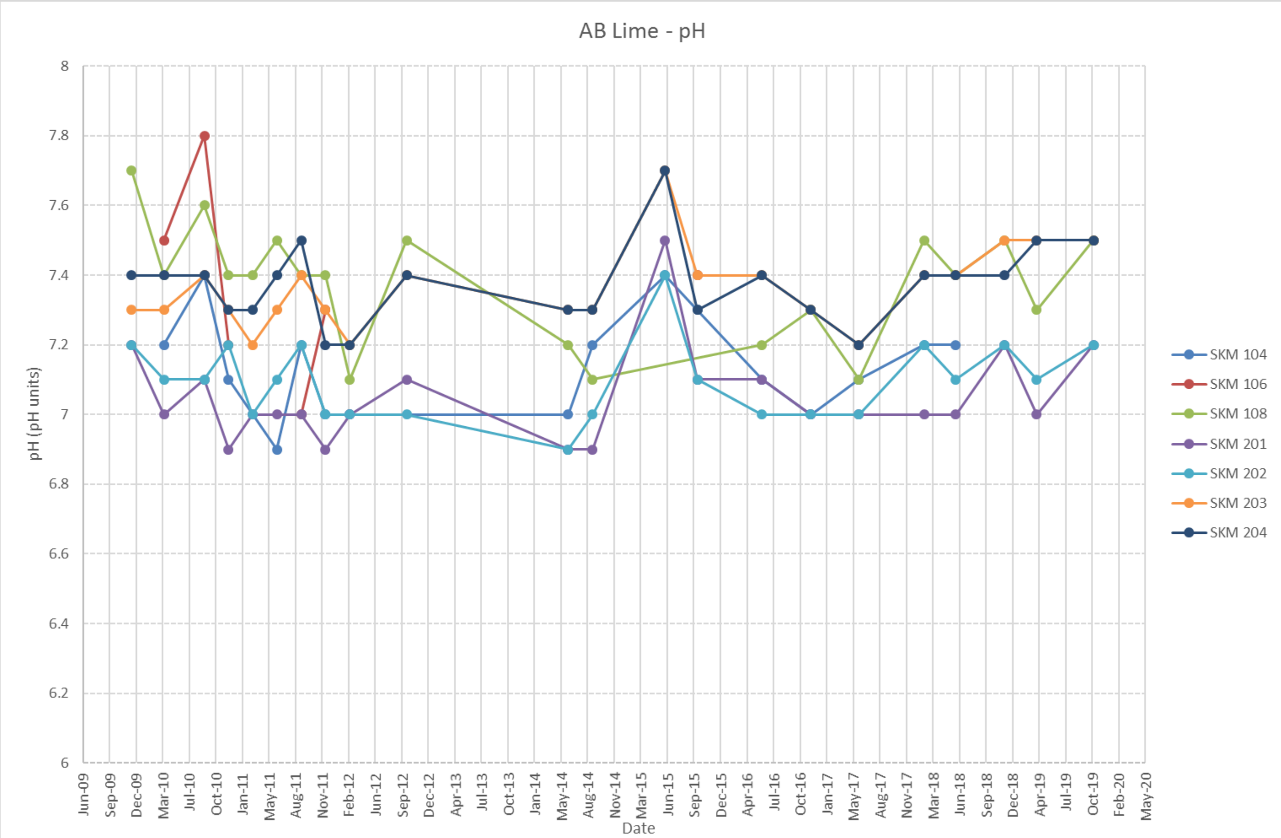
Attachment 4. 2002 Pre-Landfill Data

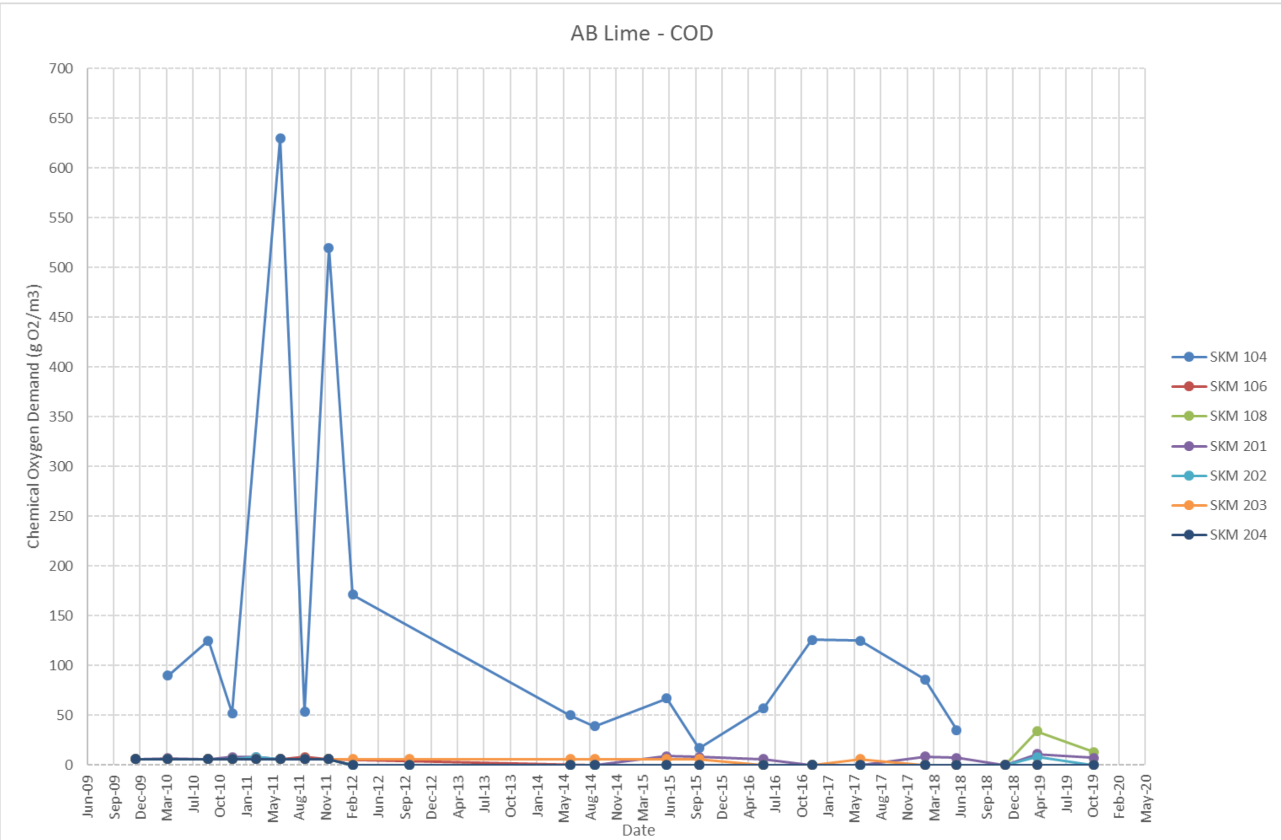
Data from samples collected 14 March 2002.

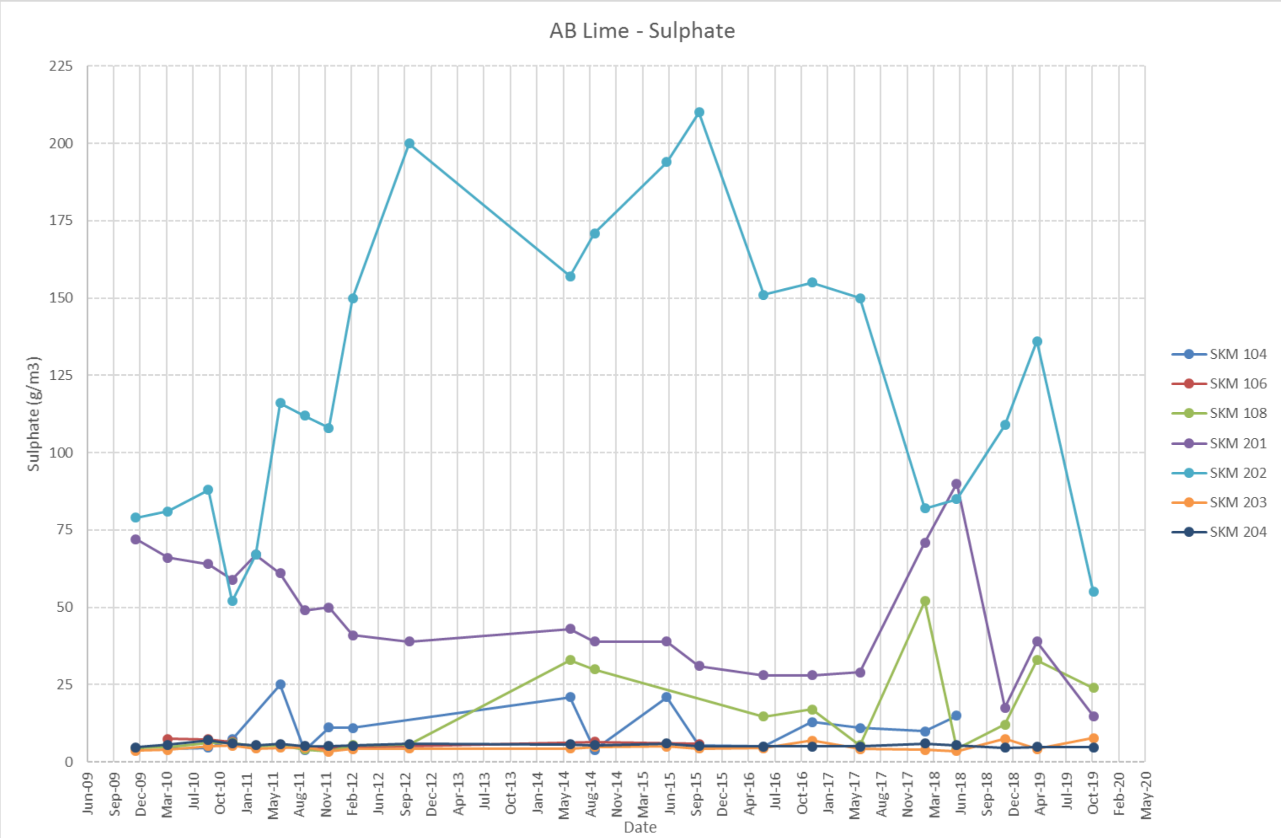
Parameter	SKM101A	SKM102A	SKM104	SKM108	ANZECC (2000) Guideline	NZ Drinking Water Standards (2000)
Water Level (mAMSL)	79.27	90.38	137.03	65.33	-	-
Temp (field)	12.1	10.8	11	12	-	-
pH (lab, pH units)	7.4	7.6	7.2	7.4	7.2-7.8	7.0-8.5
Electrical Conductivity (mS/m, lab)	52.8	64.9	59.4	61.2	-	-
Total Dissolved Solids (ppm, field)	251	300	271	288	-	1000
Alkalinity (as CaCO3)	689	374	319	320	-	-
Aluminium (dissolved)	0.003	<0.003	<0.003	<0.003	0.055	0.15
Arsenic (dissolved)	<0.001	<0.001	<0.001	0.006	0.024	0.01
Bicarbonate (at 25°C)	838	454	388	389	-	
Boron (dissolved)	0.025	0.043	0.01	0.03	0.37	1.4
Cadmium (dissolved)	<0.00005	<0.00005	<0.00005	<0.00005	0.00162	0.003
Calcium (dissolved)	97.3	70.4	129	99.5	-	
Carbonate (at 25°C)	<1	<1	<1	<1	-	
Chloride (dissolved)	35.4	35.4	34.8	45.1	-	250
Chromium (dissolved)	<0.0005	0.0007	<0.0005	<0.0005	0.00162	0.05
Cobalt (dissolved)	<0.0002	<0.0002	<0.0002	0.0006	0.00144	
Copper (dissolved)	0.002	0.0011	0.0101	0.0039	0.00992	2.0
Iron (dissolved)	<0.02	<0.02	<0.02	<0.02	0.34	0.2
Lead (dissolved)	0.0002	<0.0001	0.0282	0.0012	0.06332	0.01
Magnesium (dissolved)	5.5	12.4	3.13	15.9	-	
Manganese (dissolved)	0.0035	<0.0005	0.0041	0.0317	1.9	0.5
Nickel (dissolved)	0.0007	0.0006	0.0025	0.0029	0.0782	0.02
Nitrate N	1.71	0.27	1.2	0.41	0.16	11.3
Nitrite N	<0.05	<0.05	<0.05	0.05	-	0.91
Potassium (dissolved)	1.18	1.89	0.85	1.53	-	
Sodium (dissolved)	23.5	76.6	18.3	34.9	-	200
Sulphate (dissolved)	16.9	34.3	4.9	18.9	-	250
Total Ammoniacal-N	0.03	0.01	<0.01	0.09	2.333	1.47
Total Hardness (as CaCO3)	266	227	336	314	-	200
Total Kjeldahl Nitrogen	0.6	1.1	0.4	0.4	-	
Total Organic Nitrogen	0.6	1	0.4	0.3	-	

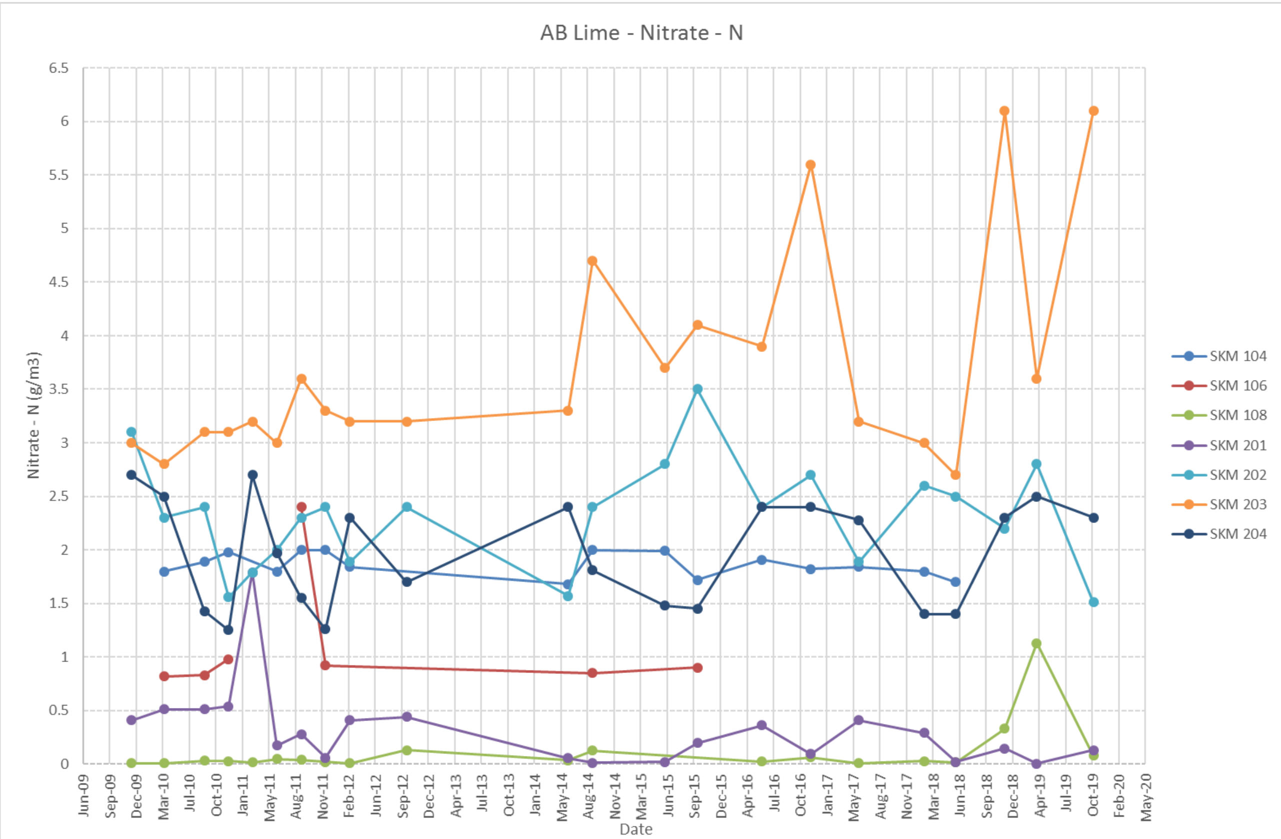
Parameter	SKM101A	SKM102A	SKM104	SKM108	ANZECC (2000) Guideline	NZ Drinking Water Standards (2000)
Zinc (dissolved)	0.008	<0.001	0.026	0.017	0.0572	3.0

Attachment 5. Data Plots






AB Lime - Sulphate
Sulphate (g/m3)
225
200
175
150
125
100
75
50
25
0
Jun-09
Sep-09
Dec-09
Mar-10
Jul-10
Oct-10
Jan-11
May-11
Aug-11
Nov-11
Feb-12
Jun-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Jan-14
May-14
Aug-14
Nov-14
Mar-15
Jun-15
Sep-15
Dec-15
Apr-16
Jul-16
Oct-16
Jan-17
May-17
Aug-17
Nov-17
Mar-18
Jun-18
Sep-18
Dec-18
Apr-19
Jul-19
Oct-19
Feb-20
May-20
Date
SKM 104
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204


AB Lime - Nitrate - N
Nitrate - N (g/m3)
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jun-09
Sep-09
Dec-09
Mar-10
Jul-10
Oct-10
Jan-11
May-11
Aug-11
Nov-11
Feb-12
Jun-12
Sep-12
Dec-12
Apr-13
Jul-13
Oct-13
Jan-14
May-14
Aug-14
Nov-14
Mar-15
Jun-15
Sep-15
Dec-15
Apr-16
Jul-16
Oct-16
Jan-17
May-17
Aug-17
Nov-17
Mar-18
Jun-18
Sep-18
Dec-18
Apr-19
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Feb-20
May-20
Date
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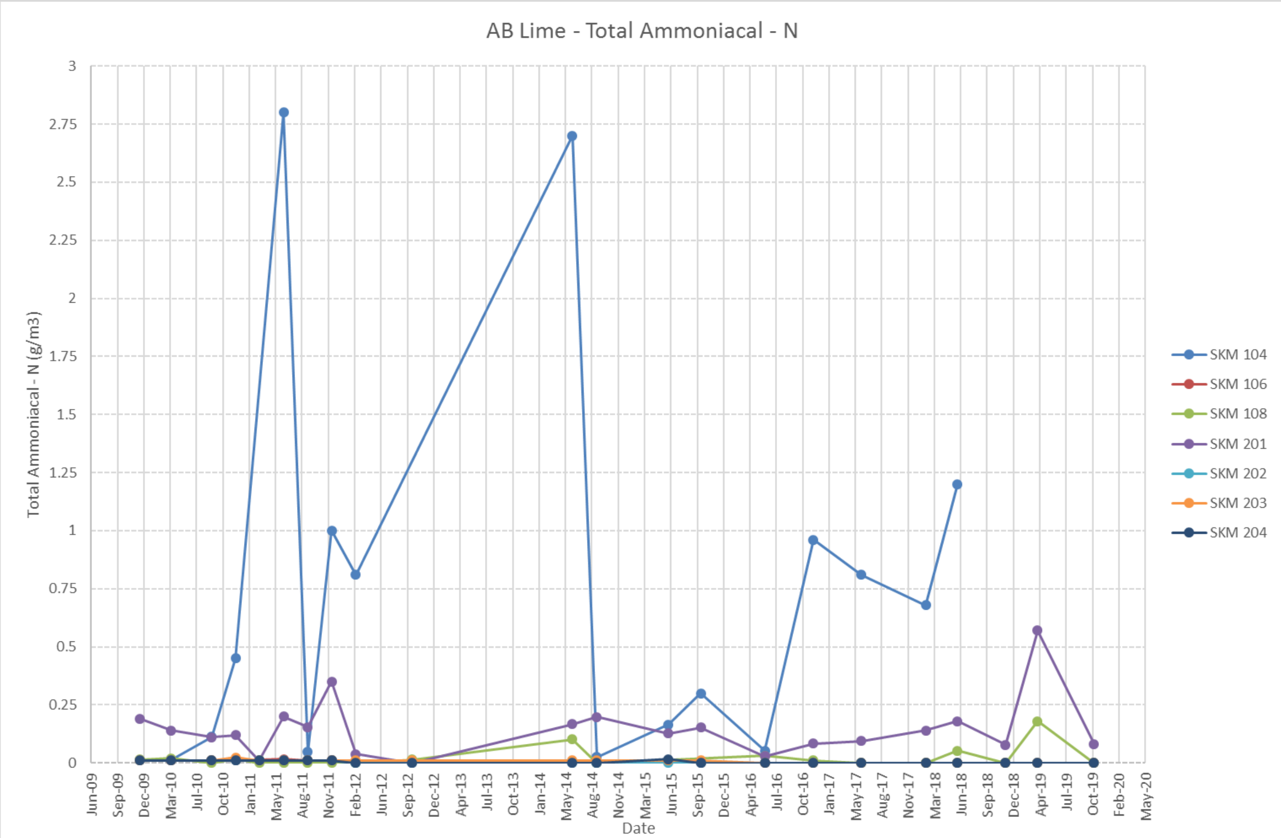
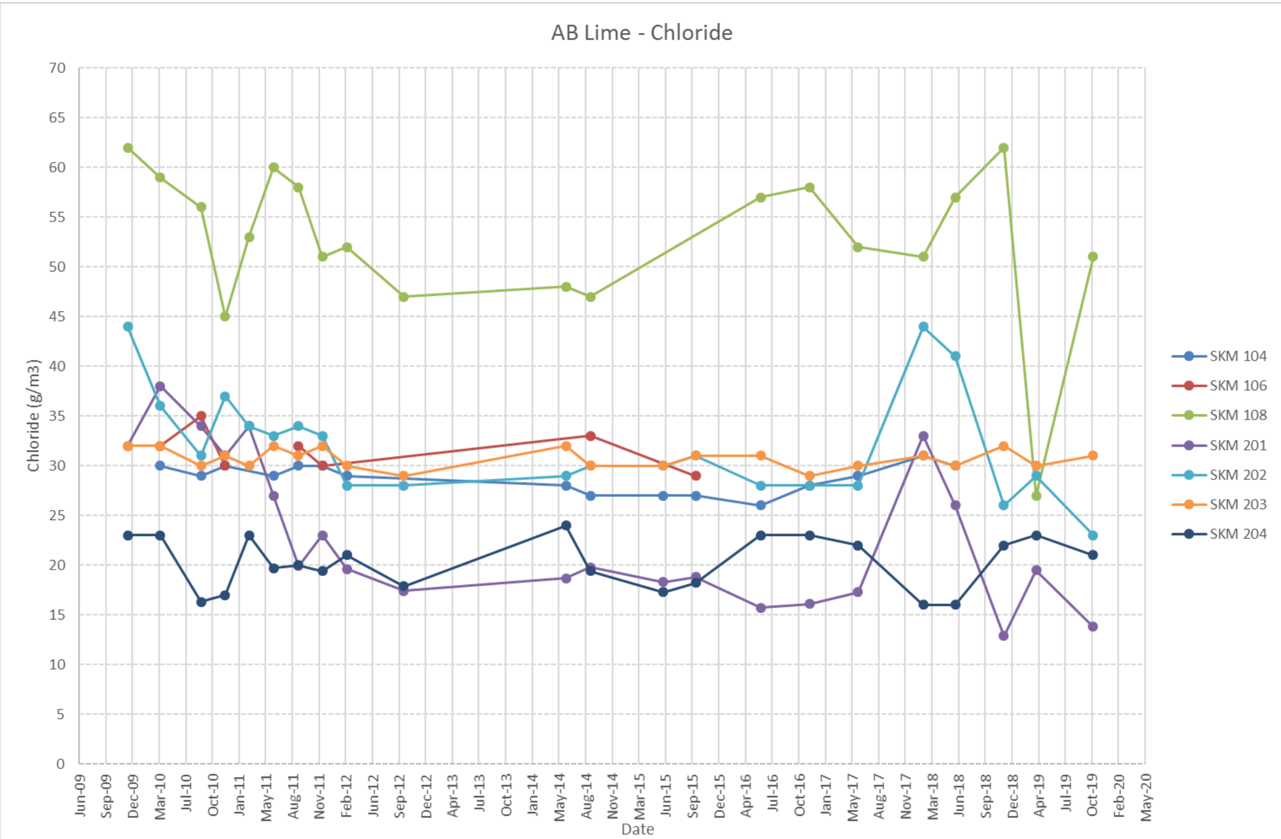
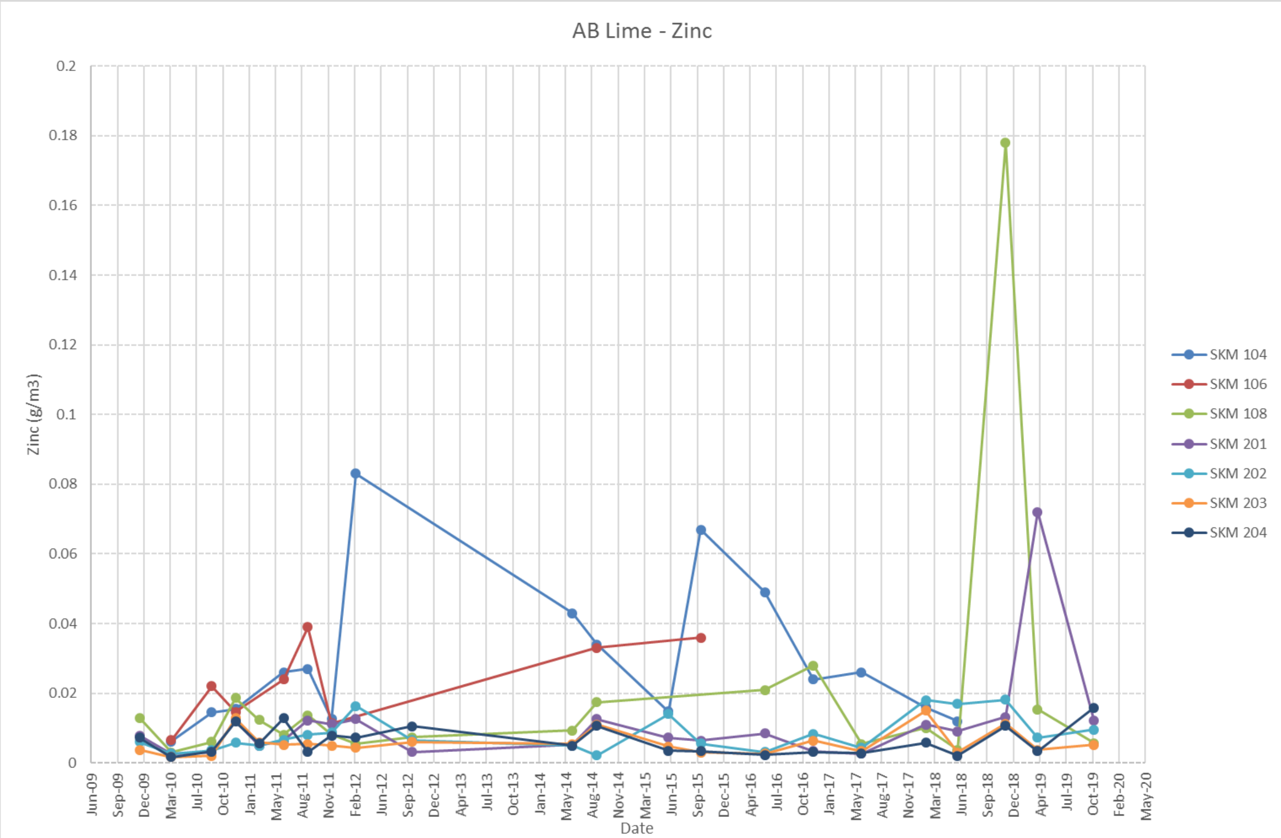
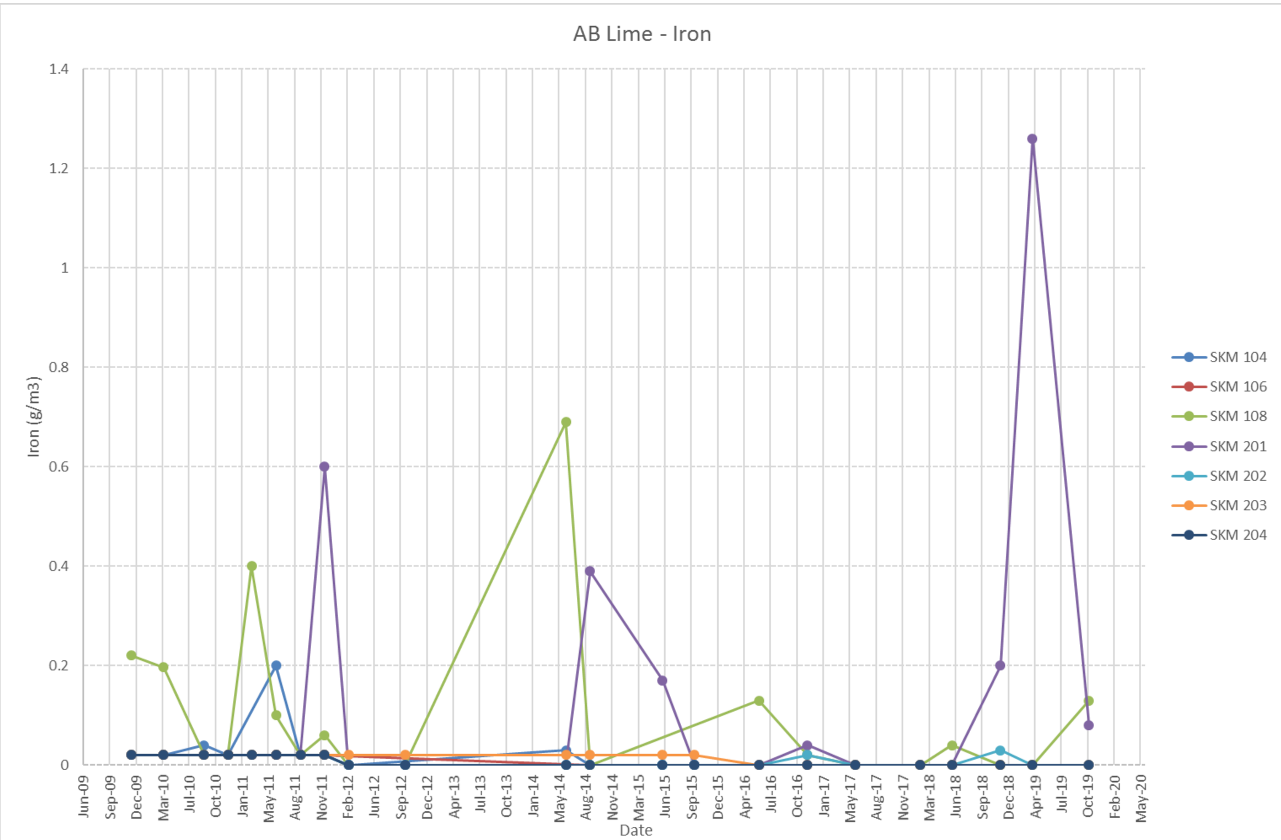
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204


AB Lime - Total Ammoniacal - N
Total Ammoniacal - N (g/m3)
Date
SKM 104
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204


AB Lime - Chloride
Chloride (g/m3)
Date
SKM 104
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204


AB Lime - Zinc
Zinc (g/m3)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Date
SKM 104
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204


AB Lime - Iron
Iron (g/m3)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Date
SKM 104
SKM 106
SKM 108
SKM 201
SKM 202
SKM 203
SKM 204

AB Lime Limited Resource Consent Application

Site Traffic Technical Memorandum

IZ000400-LFC-CT-RPT-0001 | 1

29 May 2020

AB Lime Limited

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	22 May 2020	Draft Issue	Kerstin Rupp	Andrew Prosser	Andrew Prosser	Vince Pace
1	29 May 2020	Final	Kerstin Rupp	Andrew Prosser	Andrew Prosser	Vince Pace

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AB Lime Limited Resource Consent Application

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Author:	Kerstin Rupp
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Contents

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for traffic management to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime Limited (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or that was available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Executive Summary

AB Lime Limited propose to increase the operations of their existing landfill, which will change the status of the activities for a number of resource consents. This technical memo summarises the design, operation and management of the traffic management system and investigates the impact of increasing waste acceptance on traffic management and on the resource consent application for land use.

The application for resource consent is prepared by Jacobs New Zealand Limited (Jacobs) on behalf of AB Lime Limited in support of an application for the expanded operation of the AB Lime Landfill, located at 10-20 Kings Bend, Winton. The purpose of this technical memo for traffic management is to assist in this application for resource consent and provide technical input into the Assessment of Effects on the Environment (AEE).

From the key findings that emerged, it was found that the roading network has plenty of spare capacity. The only limiting factor for transporting waste material to the site relates to the volume of Heavy Commercial Vehicles (HCV's) the site can effectively and safely process. This therefore will limit the volume of HCV's that can enter and/or exit the site without impacting on the roading network. This assessment has confirmed that an addition of up to 9 HCVs/hr can be accommodated without any overspill onto the adjacent local roads.

With the future addition of a secondary weighbridge as well as improvements made to the site's existing processing procedures of all arriving and departing vehicles, it is further assessed that an additional 40 HCVs would be able to be safely and effectively accommodated within the site.

With the application of these additional site improvements, it is concluded that the proposed development can be appropriately accommodated on the local network with no noticeable or detrimental effects to other road users or to the local roading network.

1. Purpose of this Report

The purpose of this report is to assess whether the existing traffic management system associated with the operation of the AB Lime landfill will be changed due to the proposed change to incoming waste quantities. It is proposed that the current upper limit of 100,000 tonnes/annum is revised such that there is no limitation on the tonnage of waste that may be received. Removal of the limit means that although the overall area of the landfill will not be altered, the rate at which the landfill is exhausted over time may be accelerated.

This document sets out the current traffic environment and operation as well as analysing the extent to which movements through the SH96/Cahill Road intersection could be increased due to additional waste traffic generated by the proposal. The analysis is based on the current form of the intersection to determine the point at which it would no longer be effectively operating and/or when existing road users would be compromised in terms of changes in efficiency or road safety.

The report is set out in the following sections:

1) Purpose of this report (this section)

2) Description of the existing traffic environment and the effectiveness of current traffic arrangements in managing effects

3) The expected changes to traffic resulting from a removal of a tonnage limit for waste acceptance and the effects of the changes resulting from removing a limit for waste acceptance on traffic management

4) Conclusion

2. Description of the Existing Traffic Environment

2.1 Site Location

AB Lime (the site) is located in the south of the South Island close to State Highway 96, halfway between the townships of Winton and Browns. The site is about 35km north of Invercargill with the main State Highway connection being SH6. The site is about 160km south of Queenstown along SH6, about 200km west of Dunedin using SH96/SH93/SH1 and about 130km south east of Te Anau using SH6/SH94.

This is illustrated in Figure 1.

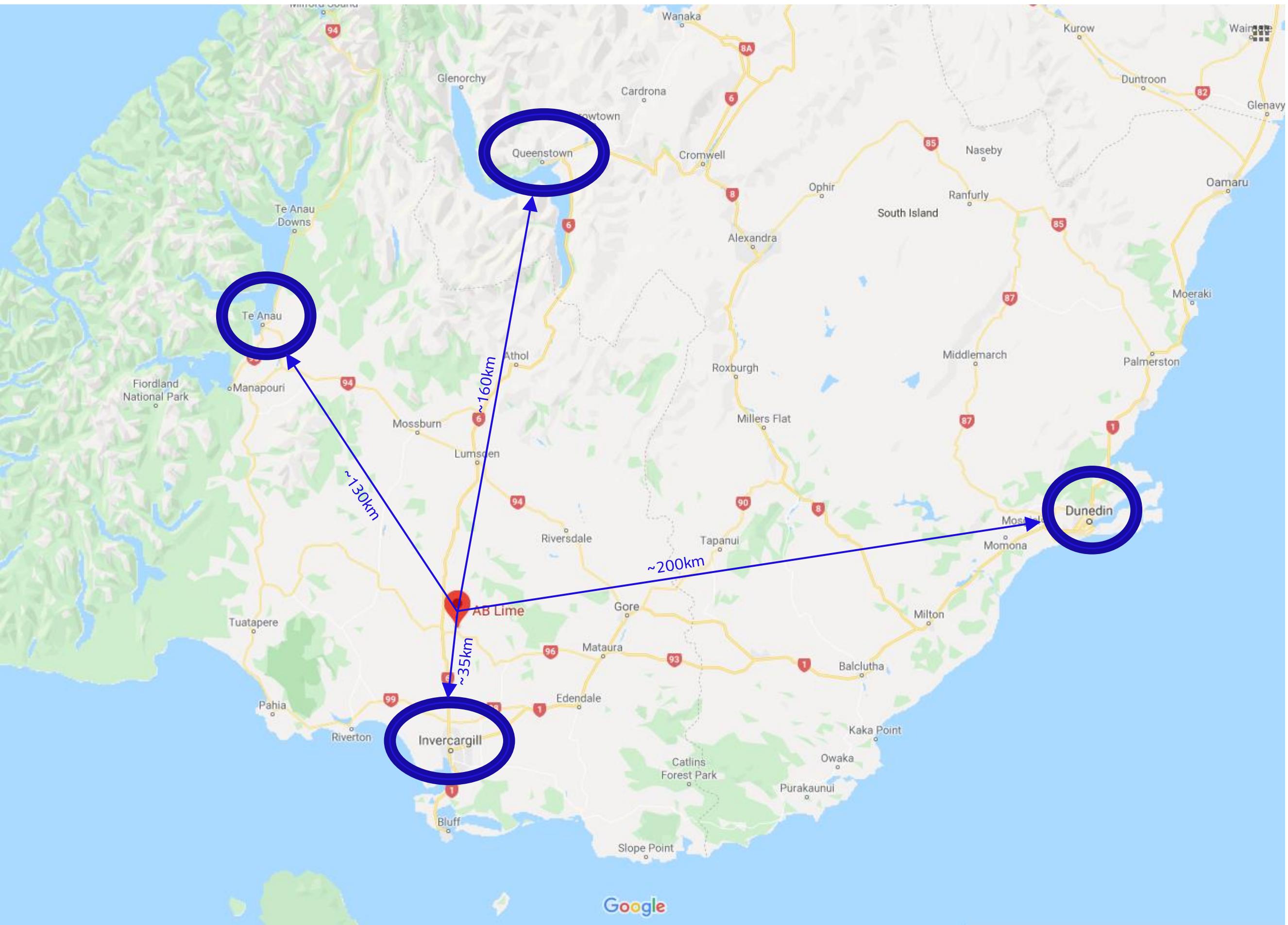


Figure 1: Location Overview (Google Maps, 2020)[1]

[1] Indicated distances are not as the crow flies

2.2 Site Specifics

2.2.1 Site Access

The quarry and proposed landfill site activities can be accessed off the intersection Cahill Road with SH96 and Bend Road, as can be seen in Figure 2.

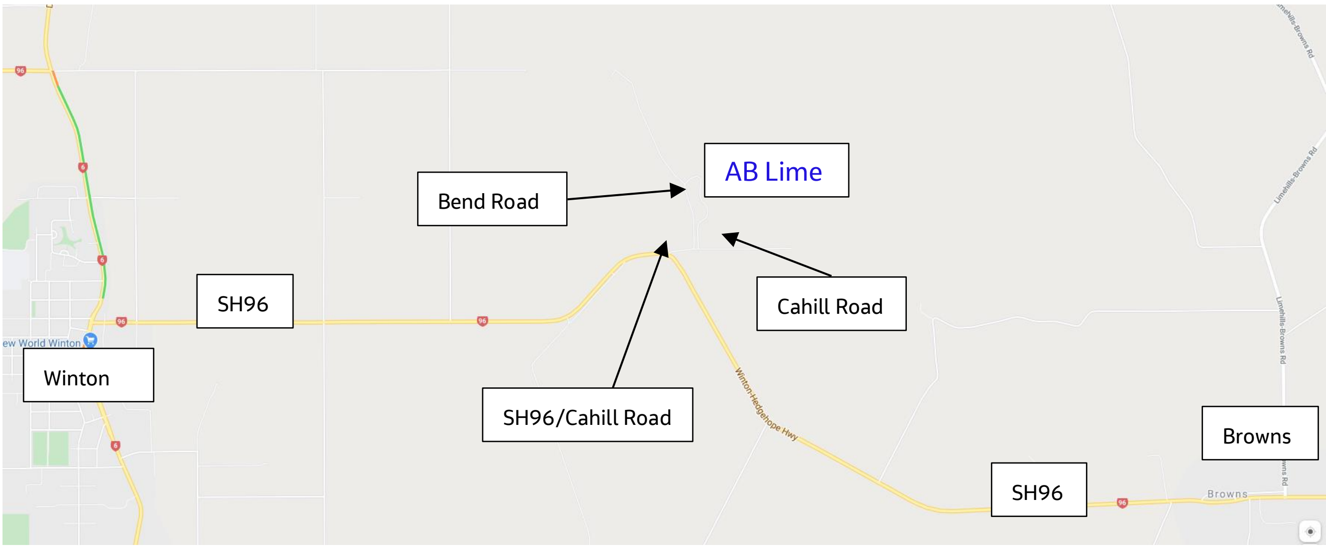


Figure 2: AB Lime Location Overview (Google Maps, 2020)

2.2.2 SH96, Cahill Road and Bend Road

SH96 is classified as a Regional Arterial Road in the Southland District Plan (Chapter 5.11). Cahill Road and Bend Road are considered to be local roads as they are not otherwise classified.

The SH96/Cahill Road intersection is a Give-Way priority intersection where the Cahill Road approach traffic has to give way to the SH96 traffic. All approaches are two way with one lane in each direction. Although the Cahill Road approach is widened at the intersection, it would not allow for two trucks being side by side. There is a slip lane of approximately 70m provided, turning left into Cahill Road from the West and a right turning bay of approximately 40m plus additional median strip length approaching from the East. The intersection is shown in Picture 1.

Picture 1: SH96/Cahill Road Intersection (looking towards Winton and Cahill Road going off to the right)

The intersection is located on a curve and speed advisory signs of 65km/h are provided on either side (on the approaches from Winton and Browns townships). The sign posted speed limit is 100km/hr on SH96. Site observations have confirmed that the existing intersection is well laid out with adequate forward sight distance and intervisibility.

The closest State Highway count site is near Browns. Attachment 1 contains the hourly flows per direction and shows an average hourly flow of around 65-70 vehicles/hour in either direction. Figure 3 shows the AADTs for the five-year period 2014 - 2018[2]. The traffic has increased from approx. 1,270 vehicles/day in 2014 to 1,340 vehicles/day in 2016 but has subsequently marginally decreased in both 2017 and 2018. Averaging the traffic growth over the same 5-year period shows an increase of approximately 1% per year.

[2] Information for the year 2019 is not available.

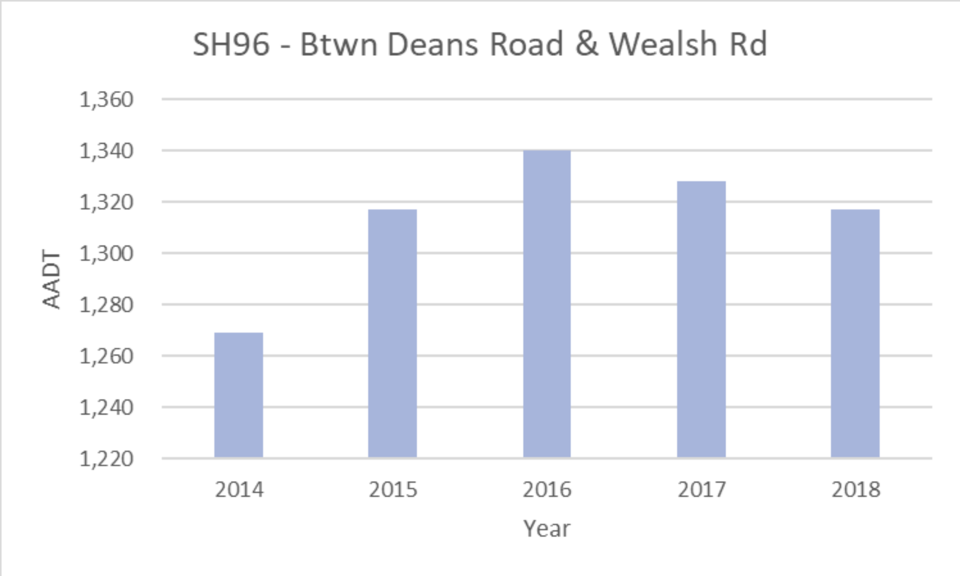


Figure 3: SH96 AADTs near Browns (East of AB Lime) for 2014-2018

Cahill Road is approximately 800m long. It is sealed until the AB Lime site office entry just past Bend Road, then it turns into a gravel road, as shown in Picture 2.

Picture 2: Cahill Road at AB Lime office access

Cahill Road does not have any speed advisory signs. The section of road from SH96 to Bend Road (being only some 160m of length) and the bend at the intersection restricts vehicular speeds to around 50-60 km/h. Traffic speeds thereafter are even slower due to the existing gravel surface of Cahill Road from the AB Lime office entrance. Cahill Road also provides access to a dairy farm (owned by AB Lime) and one other rural lifestyle property. As it is a public road the speed limit is 100km/hr however, for the above reasons, the open speed limit is not likely achieved.

The Cahill Road/Bend Road intersection is a Give-Way priority-controlled intersection with Cahill Road having right of way.

Bend Road is approximately 730m long and is sealed for approximately 420m. Bend Road connects to one property at the northern end via gravel road but otherwise is only used by the traffic created by the AB Lime operations, effectively functioning as a direct access to the AB Lime operations. This is a public road with a 100km/h speed limit, however the operational speed is much lower and is approximately 30km/hr. Whenever the AB Lime site is accessed off Bend Road, Reduce Speed or 20km/h speed signs are mounted to make sure the quarry and waste traffic slows down. The AB Lime site accessways require all exiting site traffic to yield and Give Way to Bend Road traffic.

2.2.3 SH6/SH96 intersection

As with the SH96 site, State Highway counts for SH6 north and south of the intersection with SH96 are available and presented in Figure 4 and Figure 5. Further, Attachment 1 provides the corresponding Average Annual Daily Traffic (AADT) and Traffic Growth data for the three State Highway locations.

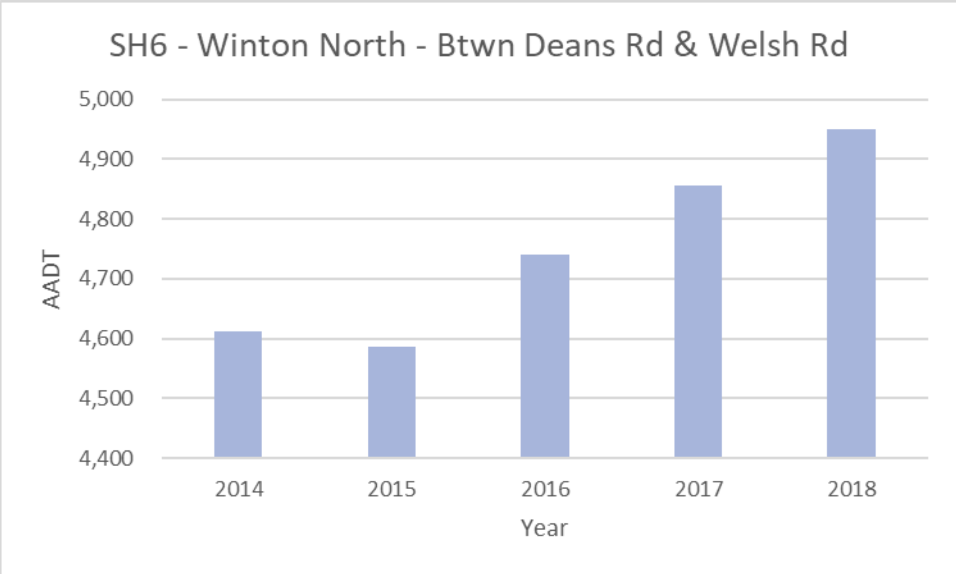


Figure 4: SH6 AADTs in Winton North for 2014-2018

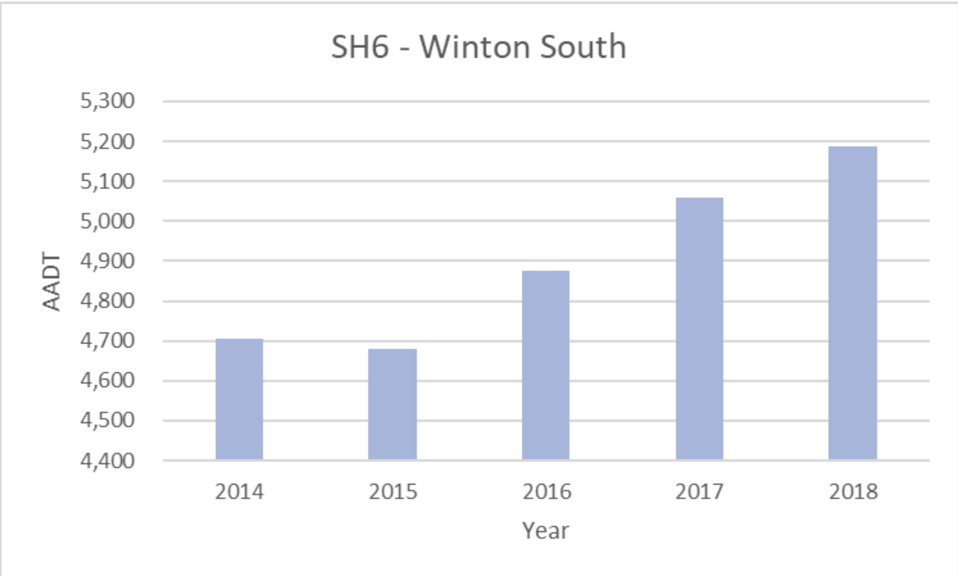


Figure 5: SH6 AADTs in Winton South for 2014-2018

As can be seen above, traffic north and south through Winton has increased steadily over the 2016 -2018 period with a slight dip having occurred immediately prior during 2015. The average traffic growth per year on SH6 is assessed to be 2.5% by averaging the yearly growth rates between 2014-2018.

The SH6/SH96 intersection is approximately 4km West of the SH96/Cahill Road intersection. The typical traffic as provided by Google Maps for a typical Wednesday shows that at approximately midday slight queuing back from the intersection along SH96 can occur. Similarly, at around 2.40pm some slowing of traffic occurs through Winton in both directions on SH6.

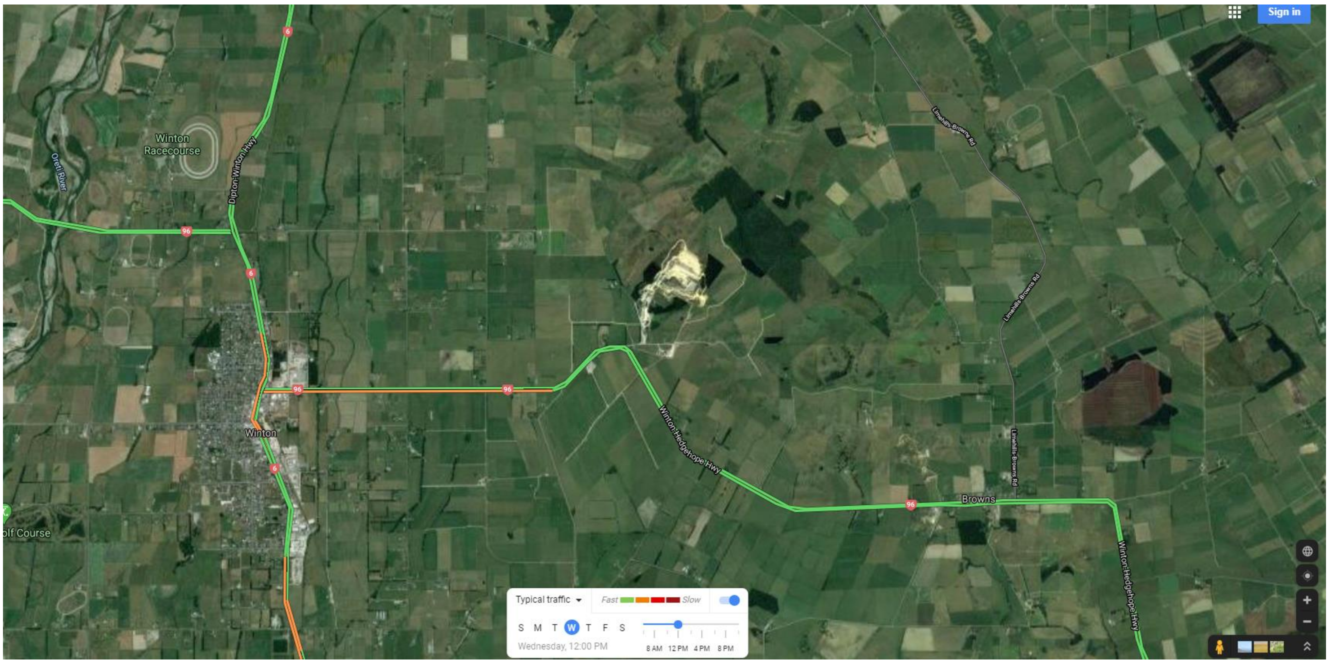


Figure 6: Typical Traffic - SH96 slowing of traffic (Google Maps, 2020)

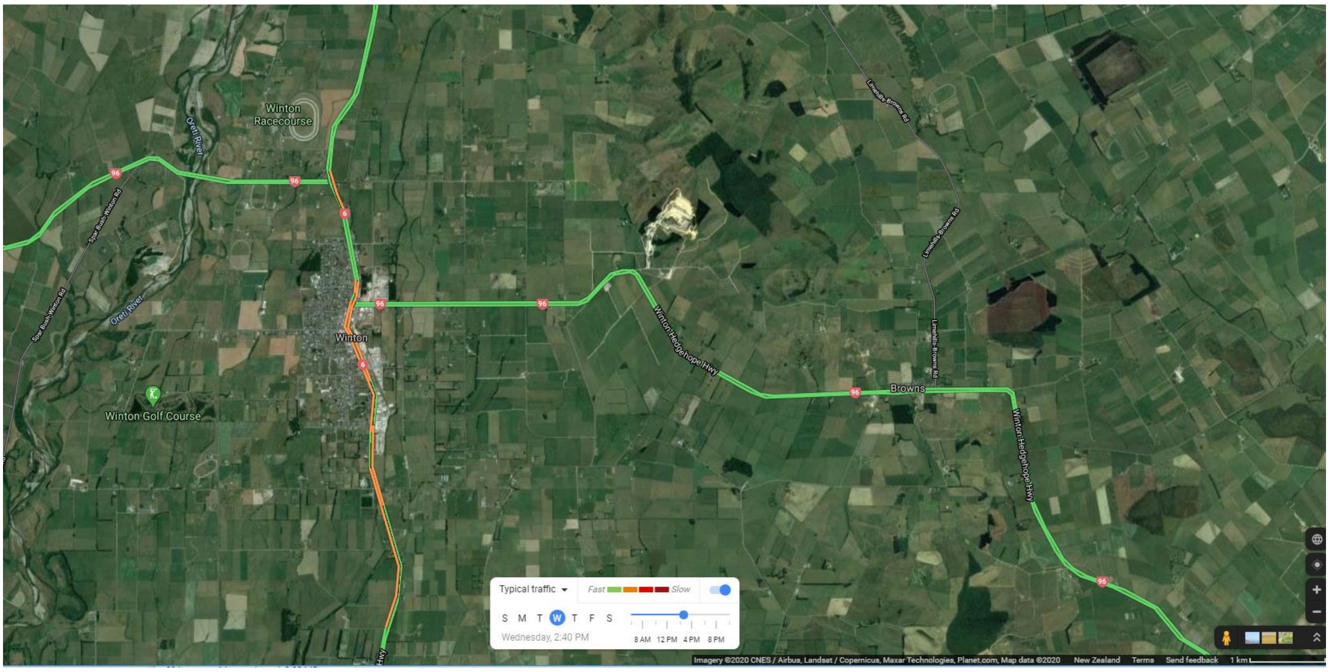


Figure 7: Typical Traffic – SH6 slowing of traffic (Google Maps, 2020)

It is understood that most AB Lime traffic does not presently use the SH6/SH96 intersection. It is also understood that AB Lime recommends that AB Lime related traffic detours around Winton. Many of the drivers are local and are familiar with the local routes and traffic patterns, and if delays are expected will utilise alternative routes. Given this, it has not been considered necessary to include the SH6/SH96 intersection in the traffic impact assessment for the AB Lime waste increase analysis.

2.2.4 Existing AB Lime Site Description

AB Lime operates a landfill and quarry operation. As part of the landfill operation construction is also required to prepare parcels (known as 'cells') for new landfill development. The site and the operations within it are shown in Attachment 2.

The different traffic flows are shown on Drawing IZ000400-1000-NG-DRG-1007 in Attachment 2. All traffic enters off Cahill Road and travels around Bend Road and enters the site via the one-way weighbridge. Site observations show that the one-way weighbridge is causing some queuing, as traffic from either side needs to wait for clearance before being able to proceed to being weighed or to exit the site. The weighbridge is located on site, approximately 100m north of the Cahill Rd intersection and is sign posted with 5km/h speed controls.

After the weighbridge, traffic follows dedicated routes depending on their operational needs and/or requirements. All truck drivers entering the site are aware of these routes and the speed and advisory signs have been well established within the site for some considerable time.

The operating hours for AB Lime truck movements are between 6.30am to 5pm, and typically the morning is the busiest time for the quarry. However, after the early morning peak, traffic is fairly steady for the rest of the day, as illustrated in more detail in the following Section 2.2.5.

2.2.5 Weighbridge Traffic

Figure 8 provides the average hourly trips over the weekdays between 01 July 2018 and 27 June 2019. This shows that, on average Monday to Friday, approximately 7 veh/hour enter/leave the site after an initial morning peak of 8 veh/hr. Saturdays have shorter operating hours and generally lower truck movements, and therefore have not been included in the daily averages.

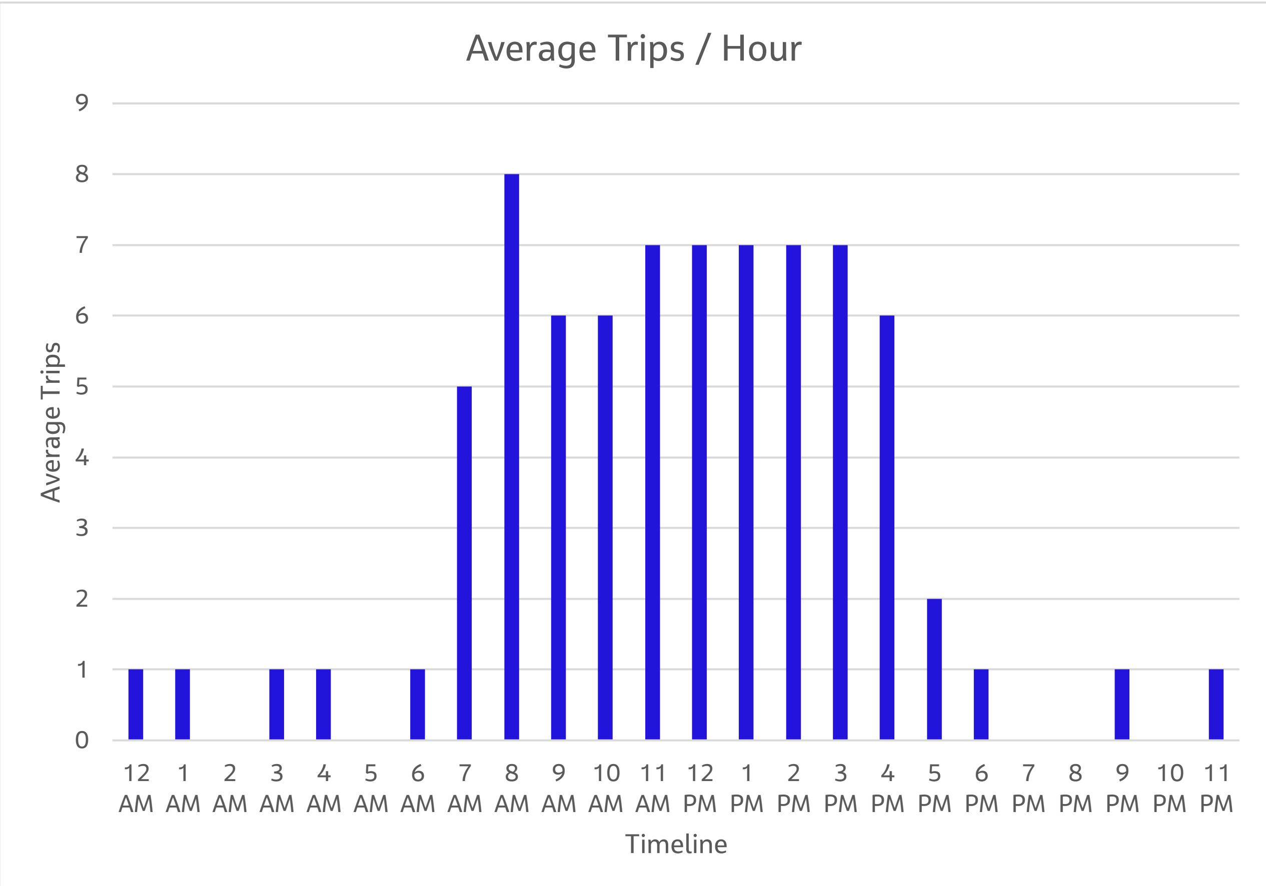


Figure 8: Weighbridge average trips per hour (Monday to Friday average)

This is limited to the weighbridge traffic and additional trips to the office (which utilise a separate access) or trips not needing the weighbridge are not included in these average figures. Furthermore, investigations have been made into whether there is a daily variation between Monday and Saturdays, and this is illustrated in Figure 9. This shows that towards the end of the working week the total weighbridge traffic shows slight increases, but also shows greater variation in traffic numbers throughout the day.

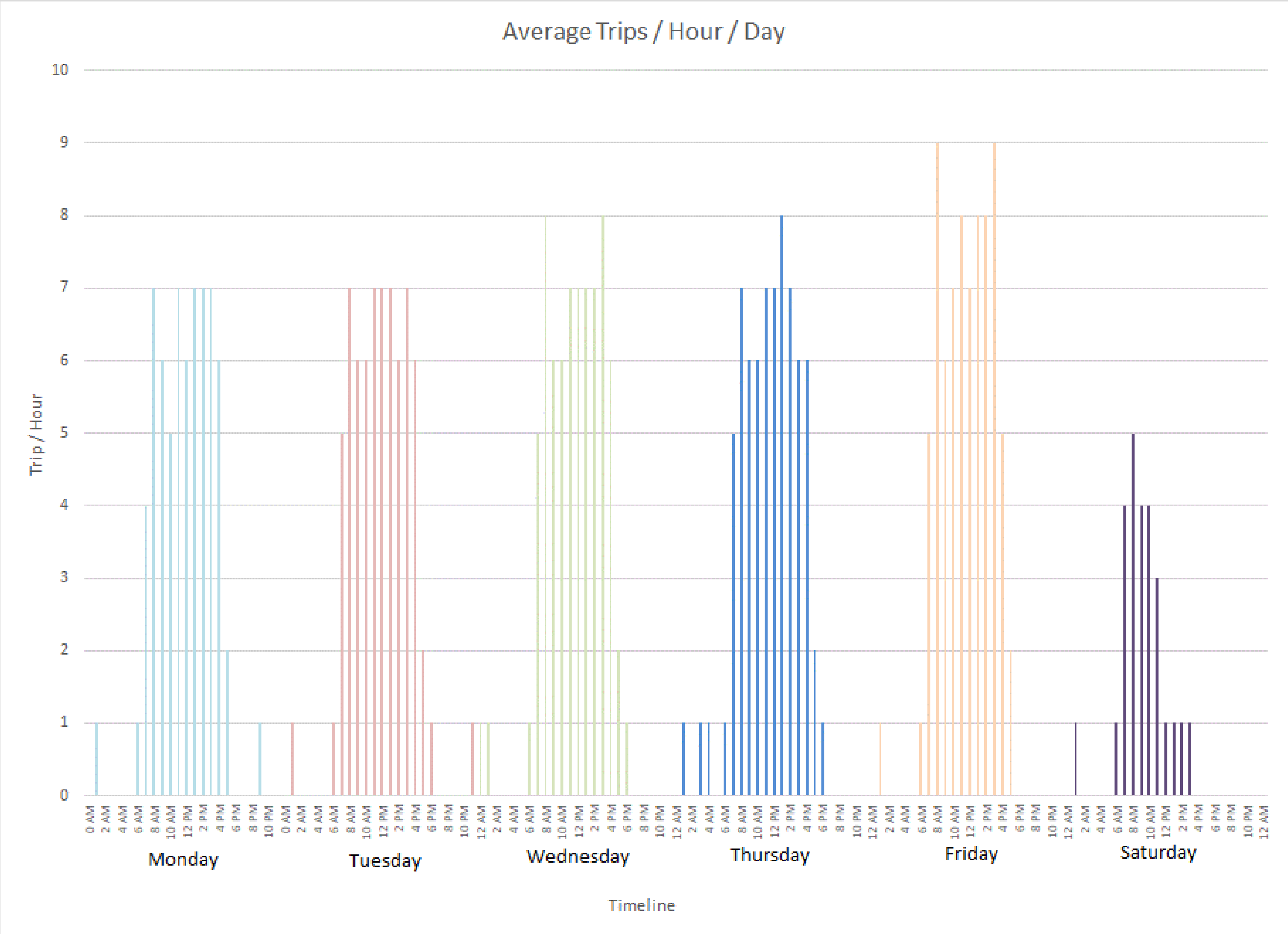


Figure 9: Weighbridge average trips per hour by day

2.2.6 Site Traffic

There are public road users as well as heavy machinery on site. The internal site speed is sign posted at 20km/h with a separate limit of 5km/h over the weighbridge. The public roads users visit the site for the following operations:

- Blended product traffic
- Lime & Fertiliser traffic
- Waste traffic

Machinery such as fork lifts and excavators are used within the site only and are not accessing public roads. Site internal traffic is not contributing to the potential of traffic queuing back from the weighbridge causing impacts on the roading network. Hence, only the traffic entering/exiting the site via the weighbridge are of interest for this analysis due to the potential impact to either queue up the site and bringing the operation to a standstill or queuing back from the weighbridge via Cahill Road all the way to the SH6/Cahill Road intersection impacting on the general road users.

2.3 Crash Analysis

Crash data for the 10-year period 2010-2019 has been examined for a 1km radius centred on the intersection of SH96/Cahill Road. The accidents have been extracted from the Waka Kotahi New Zealand Transport Agency Crash Analysis System (CAS). Over the considered 10-year period there were a total of 13 crashes which equates to 1.3 crashes per annum. Figure 10 gives an overview of where the accidents occurred, the type of accidents, severity and environmental factors involved. Of the 13 accidents, one accident was severe and 4 were minor injury accidents.

The majority of the accidents were "lost control" accidents for either turning left or right on midblocks.

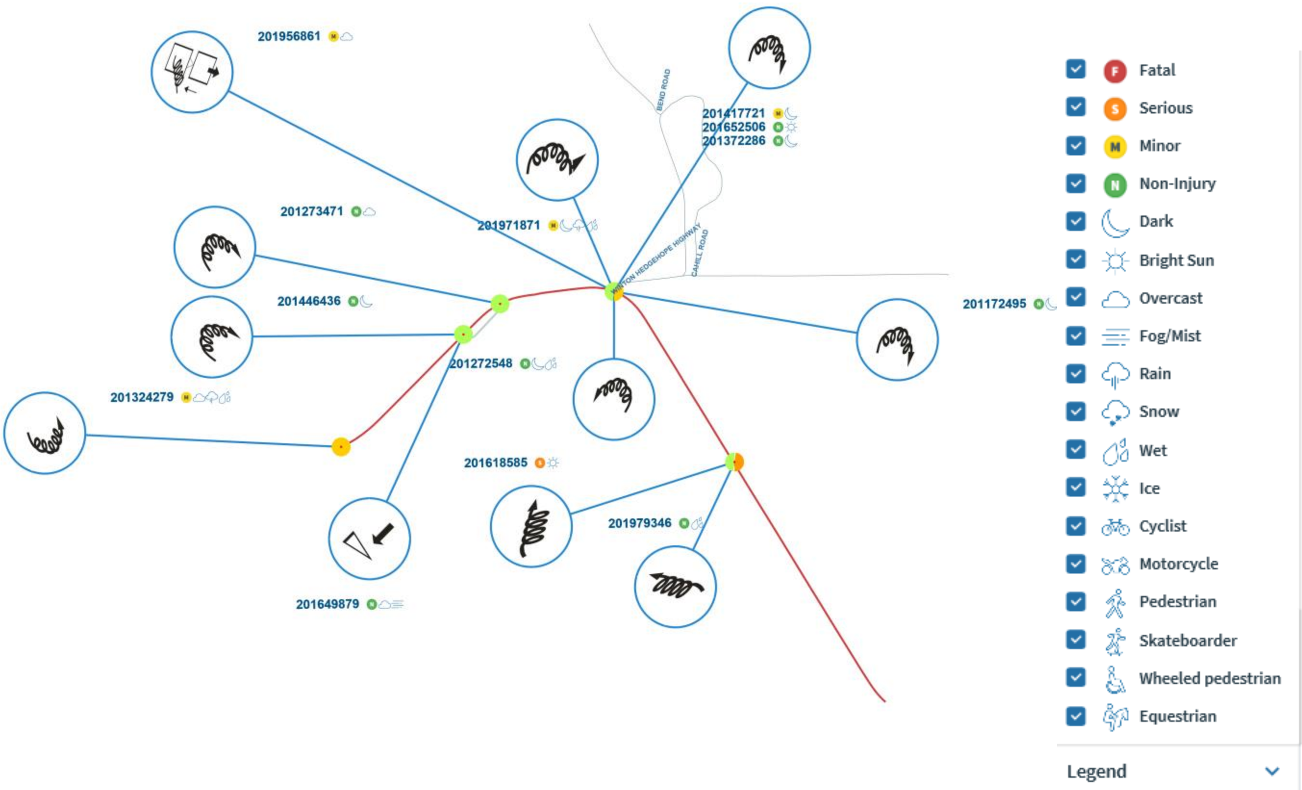


Figure 10: Collision Diagram (2010-2019)

Attachment 3 provides the crash information in more detail. This shows that none of the reported accidents occurred at the intersection of SH96 / Cahill Road. They are known to have occurred on the midblock sections east and west of the intersection, approximately 40-200m on either side.

Only one accident involved more than one party and none of the accidents were caused by traffic turning in or out of Cahill Road. Given the data available from the CAS system, it can therefore be concluded that the current intersection form and layout is working effectively for the current traffic conditions.

2.4 The Effectiveness of Current Traffic Arrangements in Managing Effects

An assessment of the current traffic arrangements has been completed to understand the effects of AB Lime's proposal relative to the SH96/Cahill Road intersection. All traffic accessing the site as well as the other two properties located off Cahill and Bend Roads (one each) use this intersection.

2.4.1 Methodology

The following methodology has been carried out to analyse the SH96/Cahill Road intersection:

1) Utilise the 2019/2020 TMS State Highway count data for Browns SH96 to determine the average SH96 flows per hour. The maximum number of traffic on any weekday hour was applied.
2) Data for in and out flows from the entrance of the AB Lime site off Cahill Road for the 23rd and 24th March 2020 are used to determine movements along Cahill Road, with the maximum numbers used in the analysis.
3) Cahill Road entrance counts were received as a daily number with steady flows between 8am – 5pm. As a conservative scenario, the daily numbers were divided by 4 hours instead of 9 hours. This ensures that the current situation has higher traffic flows to account for any peaks that may have occurred. This number was compared to the weighbridge traffic recorded over the time (01 July 2018 to 27 June 2019). This comparison provides a benchmark of the daily traffic received against historic traffic to provide additional information regarding the robustness of the recorded numbers and to stay conservative with the traffic numbers exceeding what is typically expected during times of "normal" operations.
4) Sensitivity tests (what-if scenarios) are applied to different turning patterns as follows:

Table 1: Sensitivity Tests (What-if Scenarios)

Traffic from/to Winton to AB Lime site	Traffic from/to Browns to AB Lime site
100%	0%
75%	25%
50%	50%
25%	75%
0%	100%

5) The assumption is made that traffic exits out of Cahill Road from the same direction it arrived.
6) The intersection performance has been analysed using SIDRA. This is an industry recognised software tool able to aid in the design and evaluation of individual intersections and networks of intersections. The controls of the intersections can be either unsignalised or signalised. It uses the following table to identify the Level of Service (LOS) for the intersection turns and aids in establishing the performance of the intersection confirming also its operating capacity. For the SH96/Cahill Road intersection the "Sign Control" column applies as it is a Give-Way intersection. As an example, a turn is classified as LOS D if the delays are 35 seconds or less. At 25 seconds it is classified as LOS C and so forth.

Table 2: LOS categorisation (extract from SIDRA Guidelines Table 5.14.1)

Level of Service	Control delay per vehicle in seconds (d) Sign Control
A	$d \leq 10$
B	$10 < d \leq 15$

C	15 < d ≤ 25
D	25 < d ≤ 35
E	35 < d ≤ 50
F	50 < d

Also, for modelling purposes the volume of traffic for each turn is a minimum of 1 vehicle/hour.

2.4.2 Weighbridge Traffic

As discussed in Section 2.2.5, the average hourly trips over the weekdays between 01 July 2018 and 27 June 2019 is approximately 7 vehicle/hour entering/leaving the site. The SIDRA analysis conservatively assumes Heavy Commercial Vehicle (HCV) flows approximately twice as high as this figure to ascertain the SH96/Cahill Road intersection will not be experiencing undue queuing. Using a more conservative number will also account for busier than normal (average) days. Attachment 4 illustrates the traffic counts received and the data processing undertaken to produce the SIDRA input figures as described in Section 2.4.1.

Following this initial check (actual weighbridge movements vs data processed hourly flows), the condition has been satisfied that the traffic flows in the modelling have not been underrepresented and is providing a conservative approach.

2.4.3 Analysis and Outputs

Figure 11 shows the site layout for SH96/Cahill Road as used in the SIDRA modelling.

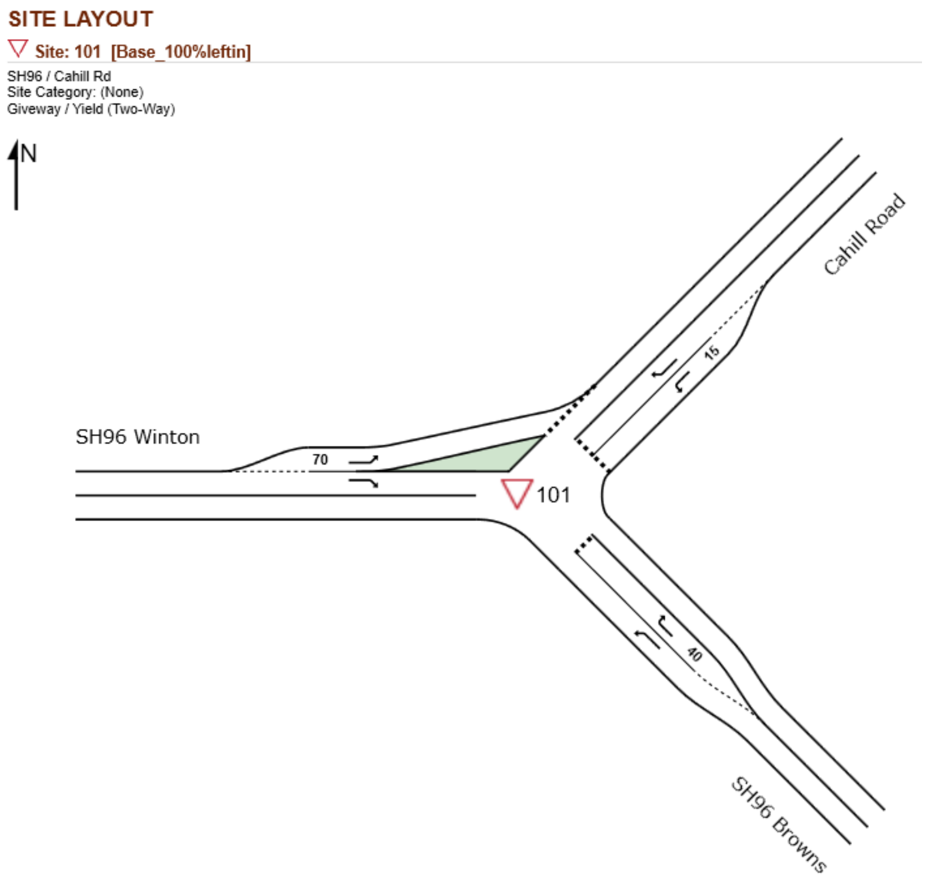


Figure 11: Current Site Layout

The following Table 3 to Table 5 provide the SIDRA results for the intersection. The SIDRA Movement Summary and LOS Summary charts are provided in Attachment 4.

Table 3: SIDRA Results – Base Year - Delays

Traffic from/to Winton to AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	***Traffic from/to Browns to AB Lime site***
Proportion	Average Delay (sec) - rounded						*Proportion*
100%	8	8	9	10	3	4	*0%*
75%	8	8	9	10	3	4	*25%*
50%	8	8	9	10	3	4	*50%*
25%	8	8	9	10	3	4	*75%*
0%	8	8	9	10	3	3	*100%*

Table 4: SIDRA Results – Base Year - Queuing

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	*Traffic from/to Browns to/from AB Lime site*
Proportion	Distance (m) - rounded						*Proportion*
100%	0	0	1	0	0	3	*0%*
75%	0	0	1	1	0	2	*25%*
50%	0	0	1	1	1	1	*50%*
25%	0	0	0	1	1	1	*75%*
0%	0	0	0	2	2	0	*100%*

Table 5: SIDRA Results – Base Year - Level of Service (LOS)

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	*Traffic from/to Browns to/from AB Lime site*
Proportion	LOS						*Proportion*
100%	A	A	A	A	A	A	*0%*
75%	A	A	A	B	A	A	*25%*
50%	A	A	A	B	A	A	*50%*
25%	A	A	A	B	A	A	*75%*
0%	A	A	A	B	A	A	*100%*

In general, this intersection has a lot of spare capacity and current traffic arrangements are not causing any substantial delays. The performance is well above an acceptable LOS D. Some of the current delays experienced are due to the alignment being curved and turning traffic having to give way. However, the general public travelling through the site will not have to stop. General public accessing the properties on Cahill Road and Bend Road, AB Lime site or dairy farm traffic experience delays of roughly 10 seconds for the right turn into Cahill Road under all 5 scenario tests.

Taking the information above into consideration, it can be concluded that the intersection performance is currently not negatively impacted by AB Lime traffic. It is also concluded that the proportion of traffic from either Winton or Browns does not change the outcome of the analysis.

3. The Expected Changes to Traffic Resulting from a Removal of Tonnage Limit for Waste Acceptance

This section analyses the intersection capacity for the SH96/Cahill Road intersection. This is important as the removal of the waste limit will need to be managed so that the public roading network experiences no more than a minor impact or any adverse effects are mitigated to a level acceptable to the council and Waka Kotahi. Given the minimal traffic using Cahill Road and Bend Road, the key assessment issues are considered to relate to the effects of additional turning movements on the SH96/Cahill Road intersection and the weighbridge capacity to avoid queuing.

This assessment is approached in two ways. Firstly, a general discussion is presented around motorway capacity, and secondly, a more detailed SIDRA analysis is applied based on the same models used for the current traffic arrangements but with increased turning volumes of traffic applied. Finally, an assessment of the weighbridge capacity is undertaken.

3.1 Motorway Capacity

The typical motorway capacity is approx. 1,400 – 2,400 vehicles/hour/lane depending on vehicle travel speeds, as shown in

Figure 12. The speed limit along SH96 passing the Cahill Road intersection is 100km/h albeit the speed advisory signs on approach to the intersection shows 65km/h due to the existing curve. The pavement widths, the amount of side friction and intersection configurations are all contributors to the actual capacity for a motorway (as well as roading) lane, but in general one of the greatest influencers is the speed which is determined by the road environment such as curvature, steepness and widths.

Using the chart below 100km/hr is approximately 62 mi/h, meaning that the motorway capacity should be conservatively approximately 1,700 vehicles/hour before any reductions in speed would occur. This also assumes that the motorway is built to its current standards with appropriate lane widths and keeping friction sufficiently low to not impede on the capacity.

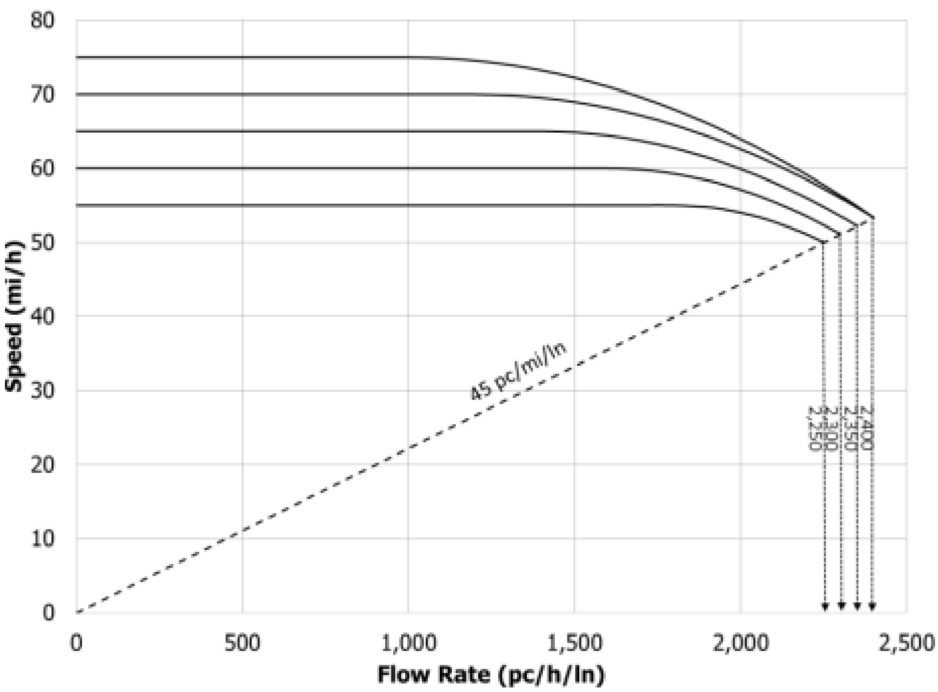


Figure 12: HCM Speed - flow chart

The figure above is only for midblock/through movement capacity and does not take into account any interruptions by turning movements.

As described in Section 2.4.1, the analysis uses the EB and WB traffic for the SH96 site at Browns. Table 6 shows an overview of the expected midblock/through movement flows for both the current situation and future flows for the maximum hourly flows. The applied growth rate for SH96 at Browns is 1% per annum, as stated Section 2.2.2.

Table 6: Traffic Flows

	SH96 EB (Winton to Browns)			SH96 WB (Browns to Winton)		
Maximum Flows	**Light Vehicles/h**	**Heavy Vehicles/h**	**Total Vehicles/h**	**Light Vehicles/h**	**Heavy Vehicles/h**	**Total Vehicles/h**
2019-2020 Maximum	**74**	**20**	**94**	**89**	**24**	**113**
2055 Maximum	**105**	**28**	**133**	**125**	**33**	**158**

Table 6 shows the maximum through movement flows. Taking into account the general motorway capacity per lane from above, the hourly flows are nowhere close to causing any form of delay. The level of traffic is too light to cause congestion. It is therefore crucial to analyse how much turning traffic can be added to the intersection without causing blocking back into the through movements and therefore causing impacts to the general public.

3.2 Methodology

As with the Base year analysis, the following methodology has been carried out to analyse the SH96/Cahill Road intersection:

1) Utilise the 2019/2020 TMS State Highway count data for Brown SH96 to determine the average SH96 flows
2) The average maximum hourly SH96 flow will be factored up by 1% growth rates as determined over the 2014-2018 time period, for 35 years until 2055.
3) Data for in and out flows from the entrance of the AB Lime site off Cahill Road for the 23rd and 24th March 2020 are used to determine movements along Cahill Road, with the maximum numbers used in the analysis.
4) Information was received on a daily number with steady flows between 8am – 5pm. As a conservative scenario, the daily numbers were divided by 4 hours instead of 9 hours. This ensures that the current situation has higher traffic flows to account for any peaks that may have occurred.
5) Sensitivity tests (what-if scenarios) will be applied to different turning patterns as follows:

Table 7: Sensitivity Tests (What-if Scenarios)

Traffic from Winton to A B Lime site	Traffic from Browns to A B Lime site
100%	0%
75%	25%
50%	50%
25%	75%
0%	100%

6) The assumption is made that traffic exits out of Cahill Road from the same direction it arrived.

7) The intersection will be analysed using SIDRA. This is a software tool able to aid in the design and evaluation of individual intersections and networks of intersections. Intersections can be unsignalised or signalised.

8) The light vehicle and truck movements in and out of Cahill Road will be increased in increments to assess the performance of the SH96/Cahill Road intersection. (For example, adding 50 vehicles to determine when the performance starts to deteriorate and narrow it down.)

   The SIDRA analysis will determine when the intersection starts to perform at a **Level of Service of D** or worse, which is commonly referred to as the tipping point for being an unacceptable performance of an intersection as shown in Table 2 above (LOS categorisation).

3.3 Analysis and Outputs

The intersection layout in Figure 13 shows the same intersection layout for SH96/Cahill Road as used in the current traffic arrangement SIDRA modelling. No changes to the current form of intersection are proposed as part of this assessment.

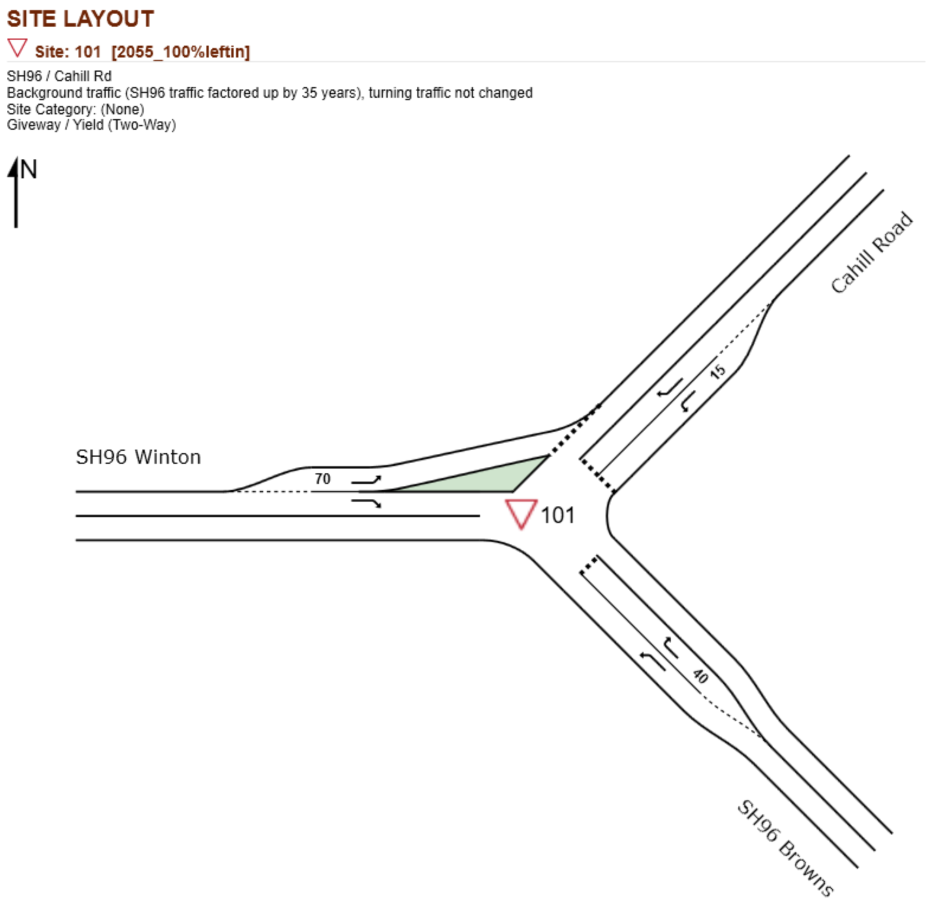


Figure 13: Future Site Layout

A trial and error assessment has been undertaken to assess when the turning movements reach a LOS D and the resulting HCV numbers are shown in Table 8.

Table 8: HCV Volumes achieving LOS D

Traffic from/to Winton to/from AB Lime site	**Achieve LOS D or better/turning movement**	***Traffic from/to Browns to/from AB Lime site***
Proportion	Number of HCVs (veh/hr)	*Proportion*
100%	225	*0%*
75%	300	*25%*
50%	460	*50%*
25%	350	*75%*
0%	275	*100%*

Table 9 to Table 11 provide the SIDRA results for the intersection to achieve a LOS D or less on all movements. The SIDRA Movement Summary and LOS Summary charts are provided in Attachment 6.

Table 9: SIDRA Results - Year 2055- Delays – LOS D

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	***Traffic from/to Browns to/from AB Lime site***
Proportion	Average Delay (sec) - rounded						*Proportion*
100%	8	8	10	10	3	32	*0%*
75%	8	8	11	13	3	33	*25%*
50%	8	9	15	20	4	29	*50%*
25%	8	10	14	26	4	8	*75%*
0%	8	13	11	31	4	4	*100%*

Table 10: SIDRA Results – Year 2055 – Queuing – LOS D

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	***Traffic from/to Browns to/from AB Lime site***
Proportion	Distance (m) - rounded						*Proportion*
100%	0.0	0.0	16	0	0	118	*0%*
75%	0.0	0.0	18	8	5	116	*25%*
50%	0.0	9	28	49	18	97	*50%*
25%	0.0	10	9	89	23	13	*75%*
0%	0.0	11	0	117	25	0	*100%*

Table 11: SIDRA Results – Year 2055 - Level of Service (LOS) – LOS D

Traffic from/to Winton to/from AB Lime site	SH96 EB (Winton to Browns)	SH96 WB (Browns to Winton)	SH96 left turn into Cahill Road	SH96 right turn into Cahill Road	Cahill Road left turn out on SH96 towards Browns	Cahill Road right turn out on SH96 towards Winton	*Traffic from/to Browns to/from AB Lime site*
Proportion	LOS						*Proportion*
100%	A	A	A	B	A	D	*0%*
75%	A	A	B	B	A	D	*25%*
50%	A	A	B	C	A	D	*50%*
25%	A	A	B	D	A	A	*75%*
0%	A	B	B	D	A	A	*100%*

To settle on a ceiling number of additional HCV traffic per hour that could comfortably be facilitated within the current intersection layout and achieving acceptable levels of delay and providing some resilience for out of the ordinary days it has been deemed acceptable to add an additional 200 HCVs per hour. Table 12 to Table 14 present the results for this analysis.

Table 12: SIDRA Results - Year 2055- Delays - +200 HCVs

Traffic from/to Winton to/from AB Lime site	SH96 EB (Winton to Browns)	SH96 WB (Browns to Winton)	SH96 left turn into Cahill Road	SH96 right turn into Cahill Road	Cahill Road left turn out on SH96 towards Browns	Cahill Road right turn out on SH96 towards Winton	*Traffic from/to Browns to/from AB Lime site*
Proportion	Average Delay (sec) - rounded						*Proportion*
100%	8	8	10	10	3	22	*0%*
75%	8	8	10	13	3	13	*25%*
50%	8	8	11	14	3	9	*50%*
25%	8	8	12	16	3	7	*75%*
0%	8	9	10	19	4	4	*100%*

Table 13: SIDRA Results – Year 2055 - Queuing - +200 HCVs

Traffic from/to Winton to/from AB Lime site	SH96 EB (Winton to Browns)	SH96 WB (Browns to Winton)	SH96 left turn into Cahill Road	SH96 right turn into Cahill Road	Cahill Road left turn out on SH96 towards Browns	Cahill Road right turn out on SH96 towards Winton	*Traffic from/to Browns to/from AB Lime site*
Proportion	Distance (m) - rounded						*Proportion*
100%	0	0	14	0	0	76	*0%*
75%	0	0	11	5	4	37	*25%*

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	*Traffic from/to Browns to/from AB Lime site*
50%	0	0	8	11	8	17	*50%*
25%	0	0	4	24	12	7	*75%*
0%	0	9	0	46	17	0	*100%*

Table 14: SIDRA Results – Year 2055 - Level of Service (LOS) - +200 HCVs

Traffic from/to Winton to/from AB Lime site	**SH96 EB (Winton to Browns)**	**SH96 WB (Browns to Winton)**	**SH96 left turn into Cahill Road**	**SH96 right turn into Cahill Road**	**Cahill Road left turn out on SH96 towards Browns**	**Cahill Road right turn out on SH96 towards Winton**	*Traffic from/to Browns to/from AB Lime site*
Proportion	LOS						*Proportion*
100%	A	A	A	B	A	C	*0%*
75%	A	A	B	B	A	B	*25%*
50%	A	A	B	B	A	A	*50%*
25%	A	A	B	C	A	A	*75%*
0%	A	A	B	C	A	A	*100%*

By only using an additional 200 HCVs per hour, regardless of the proportions used, the intersection will perform at a LOS C or better for the same corresponding turns that flagged LOS D before.

3.4 Weighbridge Analysis

To understand how many HCVs can enter and leave the site, it is important to understand the capacity of the weighbridge as this feature is the main restrictive activity/operation within the site. Accordingly, the weighbridge operation dictates the practical volume of HCV traffic that can be effectively processed at the site without causing any spill over onto the general roading network.

Table 15 below summarises data received from AB Lime Ltd regarding processing times for the different trucks associated with the various onsite activities[3]:

Table 15: Weighbridge Clearance Times and Minimum

Truck Type	In (time needed)	Out (time needed)	Minimum/ Return Trip	Maximum/ Return Trip
Waste	30-40 seconds	3-4 minutes	3.5 minutes	4.67 minutes
Lime	30-40 seconds	2 minutes	2.5 minutes	2.67 minutes
Fertiliser	2-4 minutes	2 minutes	4 minutes	6 minutes
Blend truck	2-4 minutes	2 minutes	4 minutes	6 minutes

The table above presents the assessed return trip times. Using the information above, it can be concluded that the single weighbridge can process between 10-24 HCVs per hour. As the increase proposed is specifically for waste trucks, the number of HCVs/hr would be between 12-17 HCVs. Peak times see approximately 8 HCVs/hr already, so the spare capacity is no more than an additional 4-9 HCVs/hr. Site observations support an increase of 9 HCVs/hr as a reasonable figure that will not artificially constrain the site's operational capacity. The blend of trucks will also play an important role with lime and waste being faster to process than fertiliser and blend trucks.

A greater number of HCVs would be able to enter/leave the site if any of the following criteria applied:

- the percentage of lime trucks is greater;
- the trucks utilising the site were scheduled instead of arriving randomly; or
- a second weighbridge were installed.

Removing the requirement to Give Way to opposing traffic at the weighbridge would double the current number of vehicles that could access and/or leave the site. This therefore confirms that the removal of the need to Give Way to other weighbridge users with the installation of a secondary structure will increase the operational capability of the site by up to an additional 40HCVs/hr.

There is about 250m between the existing stop line and the SH96/Cahill Road intersection. Assuming an individual standard HCV is roughly 15m and a truck and trailer unit roughly 20m in length (including headway

[3] Email dated 01st May 2020 from AB Lime:

How long does it take for a truck to enter and to leave?

- Waste or lime truck weighing in = 30 to 40 seconds
- Fertiliser or blend truck weighing in = depends on the order and communication needed, but generally between 2 to 4 minutes
- Waste truck weighing out = depends on the waste truck, but generally about 3 to 4 minutes
- Lime or blend truck weighing out = about 2 minutes

space), there is available space for around 15[4] queued HCVs on the local road network before any impact would be realised on the State Highway network. The volumes of traffic on Bend Road and Cahill Road are sufficiently low that queues along there are not considered a problem due to only connecting to another two properties and the dairy farm all currently owned by AB Lime.

The possible stacking capacity is approximately twice the traffic that can be accommodated over the weighbridge. It is therefore highly unlikely that excessive queuing would occur that could impact on SH96, especially if communication with the truck drivers is possible holding off any further deliveries if queuing occurs.

[4] Assuming that the number of truck and trailer units is a small percentage in comparison to the standard HCVs.

4. The Effects Resulting from Removing A Limit for Waste Acceptance on Traffic Management

As demonstrated in Section 3.3 the SH96/Cahill Road intersection will not deteriorate in performance if an additional 200 HCV/hour are added to the current traffic volumes.

The limiting factor for AB Lime in attempting to determine how much additional waste can be accommodated is the number of HCVs that can be processed through the weighbridge per hour. As a lower limit the increase in waste that could be accommodated is an additional 4 HCVs/hr which is approximately a 50% increase assuming the current max of 8 HCVs/hr. An upper limit would be an additional 9 HCVs/hr which is more than doubling of the current operation. As discussed above, site observations confirm that it is reasonable to assume a further 9 HCVs can be accommodated.

The introduction of a more scheduled operation, smoothing out the trucks over the day, or the duplication of the weighbridge which would instantly double the capacity are two ways of further increasing the AB Lime waste increase capacity. A third increase would be expanding the operations further into the weekend or having longer operating hours.

To facilitate an increase in operations, it is suggested that the current level of queuing along Bend and Cahill Roads be monitored and the following mitigation measures be applied depending upon the level of queuing identified:

Queue length	Mitigation Measures
Along Bend Road	Improve/Introduce scheduling to increase capacity by smoothing out hourly variations or increase hours of operation or include longer working hours on the weekends.
Extending into Cahill Road	Install second weighbridge to double capacity.

Monitoring the queues will have to be undertaken continuously, to flag when queues are occurring regularly and are not an abnormality.

The weighbridge logs should also be monitored frequently to make sure that if average daily traffic increases by more than the 9HCVs/hr, measures are put in place to increase capacity to avoid HCVs queuing onto Cahill Road.

5. Conclusion

The SH96/Cahill Road intersection is the point where the AB Lime traffic will have the greatest potential impact on the general public. The effects of increased traffic movements resulting from the proposal therefore required investigation to determine whether the increases in AB Lime traffic would negatively impact on the general public and the current levels of service experienced at the intersections.

Options are available (and are presently used) to enable landfill traffic to be detoured so that additional pinch points in the network do not arise.

The analysis in this report has shown that the current intersection layout and design is fitting for the current traffic flow. It has also been shown that no change to the intersection layout is required even if an additional 200 HCVs/hr are introduced. The performance of the intersection has been modelled using SIDRA, and overall has been determined to be acceptable. The level of service does not fall below LOS C for all movements.

It has also been concluded that the weighbridge will ultimately determine the actual increase in waste that can be accepted into the site. Currently, an additional 9HCVs/hr can be accommodated before further mitigation measures are required. In order to determine when additional measures are necessary monitoring needs to be carried out continuously when the weighbridge operates to identify any level of queuing and when it occurs. To increase the capacity of the site, the following measures can be introduced as required:

1) Introducing scheduling to spread truck movements across the whole day;

2) Extend the operating hours over the weekend to utilise the entire consented period from 8:00 am to 6:00 pm 7 days per week; and

3) Installing a second weighbridge to increase the maximum capacity

It is also noted that if, after introducing all of these measures, the queuing persists and queues extend to the Cahill Road/Bend Road intersection, the limit for waste intake has likely been reached and no further increases will be able to be accommodated without further interventions.

Attachment 1. Additional Information

1.1 Hourly Flows

SH96 near Browns - EB

			00:00 - 01:00	01:00 - 02:00	02:00 - 03:00	03:00 - 04:00	04:00 - 05:00	05:00 - 06:00	06:00 - 07:00	07:00 - 08:00	08:00 - 09:00	09:00 - 10:00	10:00 - 11:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:00	14:00 - 15:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	18:00 - 19:00	19:00 - 20:00	20:00 - 21:00	21:00 - 22:00	22:00 - 23:00	23:00 - 00:00
All Entries	**Weekday**	avg	3	2	2	2	6	14	19	43	62	45	42	48	51	49	53	54	63	59	43	24	16	10	8	8
		max	**6**	**5**	**5**	**5**	**14**	**23**	**31**	**50**	**80**	**56**	**55**	**62**	**60**	**64**	**69**	**71**	**78**	**83**	**58**	**35**	**30**	**18**	**12**	**51**

SH96 near Browns - WB

			00:00 - 01:00	01:00 - 02:00	02:00 - 03:00	03:00 - 04:00	04:00 - 05:00	05:00 - 06:00	06:00 - 07:00	07:00 - 08:00	08:00 - 09:00	09:00 - 10:00	10:00 - 11:00	11:00 - 12:00	12:00 - 13:00	13:00 - 14:00	14:00 - 15:00	15:00 - 16:00	16:00 - 17:00	17:00 - 18:00	18:00 - 19:00	19:00 - 20:00	20:00 - 21:00	21:00 - 22:00	22:00 - 23:00	23:00 - 00:00
All Entries	**Weekday**	avg	4	4	3	2	5	12	20	45	48	53	44	48	48	50	53	54	59	69	39	25	19	13	8	7
		max	**10**	**7**	**6**	**5**	**8**	**20**	**33**	**57**	**66**	**69**	**54**	**64**	**102**	**66**	**75**	**74**	**83**	**92**	**58**	**46**	**28**	**21**	**18**	**46**

1.2 AADTs and Average Traffic Growth

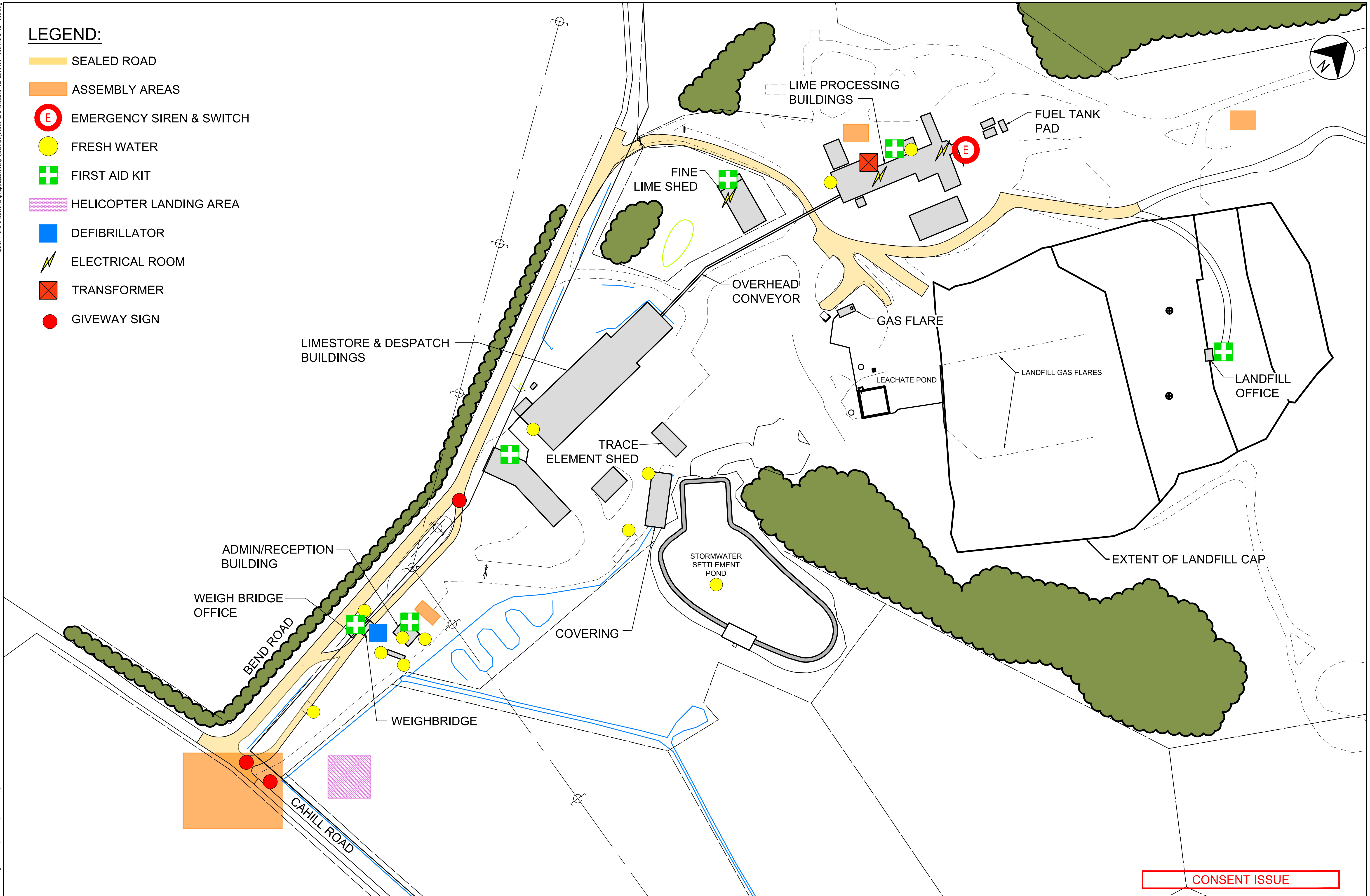
Region	SH	Site Ref	Description	Lane	Type	pment (Curr	AADT (2014)	AADT (2015)	AADT (2016)	AADT (2017)	AADT (2018)	% Heavy	Accepted Days
14 - Southland	6	ID:00601143	Btwn Deans Rd & Welsh Rd	Both	Non-Continuous	Dual Loop	4612	4587	4741	4855	4950	11.8	37
14 - Southland	6	ID:00601147	WINTON - Telemetry Site 46	Both	National	Telemetry	4912	4949	5113	5259	5411	10.3	365
14 - Southland	6	ID:00601148	Winton	Both	Non-Continuous	Dual Loop	4705	4679	4875	5057	5188	8.9	37
14 - Southland	96	ID:09600042	Browns	Both	Non-Continuous	Dual Loop	1269	1317	1340	1328	1317	14.5	33

SH6 Winton North - Btwn Deans Rd & Welsh Rd					
Region	SH	Site Ref	Year	AADT	Traffic Growth (prev year)
14 - Southland	6	ID:00601143	AADT (2014)	4612	-
			AADT (2015)	4587	-0.5%
			AADT (2016)	4741	3.4%
			AADT (2017)	4855	2.4%
			AADT (2018)	4950	2.0%
			Avg per year		**1.8%**

SH6 Winton South - WINTON - Telemetry Site 46					
Region	SH	Site Ref	Year	AADT	Traffic Growth (prev year)
14 - Southland	6	ID:00601147	AADT (2014)	4912	-
			AADT (2015)	4949	0.8%
			AADT (2016)	5113	3.3%
			AADT (2017)	5259	2.9%
			AADT (2018)	5411	2.9%
			Avg per year		**2.5%**

SH96 - Btwn Deans Rd & Welsh Rd - East of AB Lime					
Region	SH	Site Ref	Year	AADT	Traffic Growth (prev year)
14 - Southland	96	ID:09600042	AADT (2014)	1269	-
			AADT (2015)	1317	3.8%
			AADT (2016)	1340	1.7%
			AADT (2017)	1328	-0.9%
			AADT (2018)	1317	-0.8%
			Avg per year		**1.0%**

Attachment 2. Site Overview and Operations Drawings



REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

AB LIME

Jacobs
Level 2, Wynn Williams Building
47 Hereford Street
CHRISTCHURCH CENTRAL 8013
NEW ZEALAND
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Fax: +64 3 940 4901
Web: www.jacobs.com

CLIENT AB LIME LTD.
PROJECT LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
JK	KJ	CW	VP
DESIGNED KR	DESIGN REVIEW AP	DATE 29.05.20	DATE 29.05.20

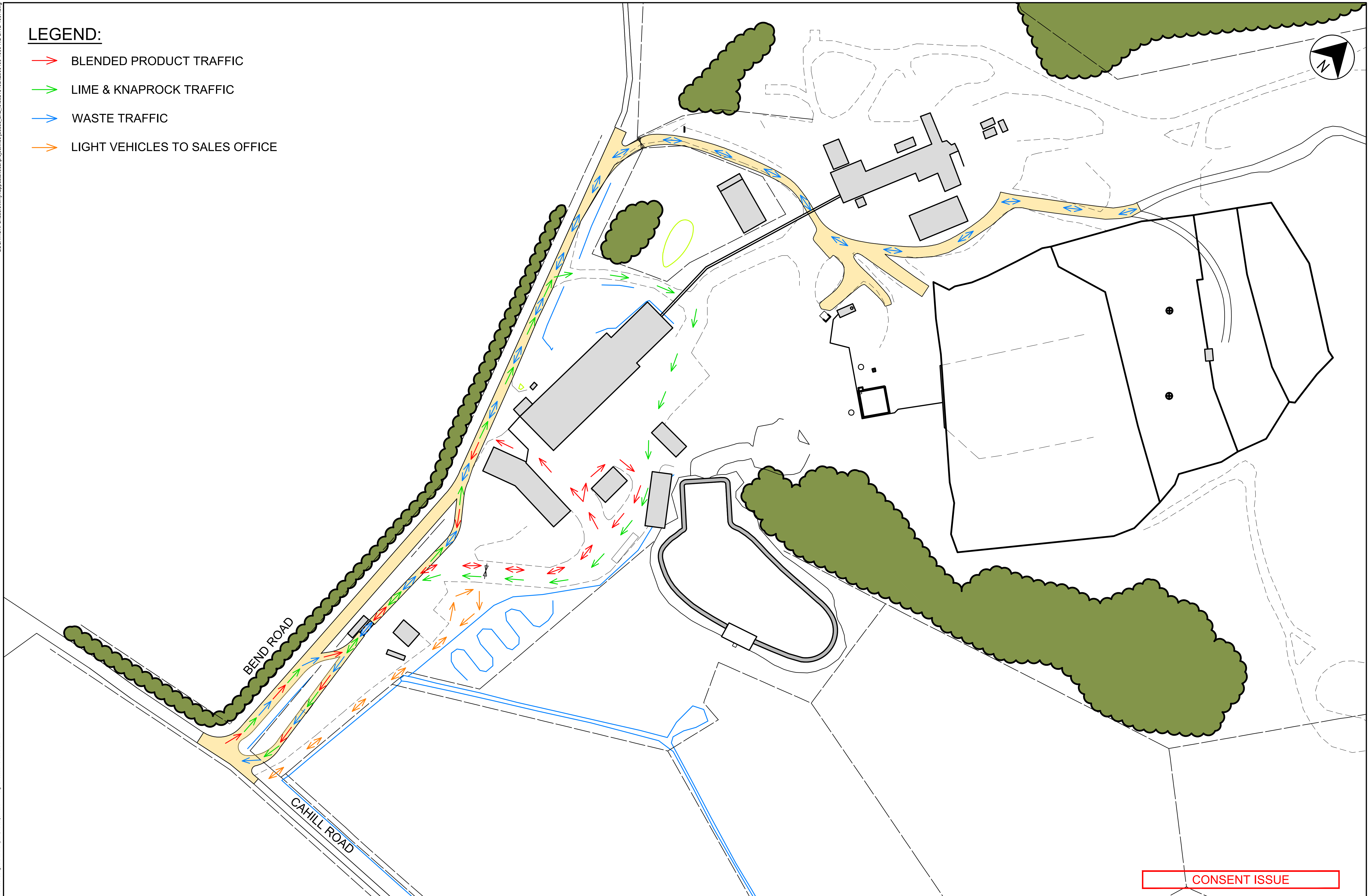
TITLE
TRAFFIC FLOW PLAN
OVERVIEW

SCALE AS SHOWN | DRAWING No IZ000400-1000-NG-DRG-1006 | REV A

A1

LEGEND:

- BLENDED PRODUCT TRAFFIC
- LIME & KNAPROCK TRAFFIC
- WASTE TRAFFIC
- LIGHT VEHICLES TO SALES OFFICE



CONSENT ISSUE

REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

AB LIME

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CLIENT	AB LIME LTD.
PROJECT	LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
JK	KJ	CW	VP
DESIGNED: KR	DESIGN REVIEW: AP	DATE 29.05.20	DATE 29.05.20

TITLE
TRAFFIC FLOW PLAN
TRUCK AND LIGHT VEHICLE MOVEMENT

SCALE	DRAWING No	REV
AS SHOWN	IZ000400-1000-NG-DRG-1007	A

A1

DATE: 29/05/2020 11:55:25 AM NAME: KIM, JOHN
LOCATION: C:\users\kimjh\appdata\local\projectwise\jacobs_anz_ie\d0213192\IZ000400-1000-NG-DRG-1007.dwg

Attachment 3. Crash Report

ID	Crash road	Distance	Direction	Side road	Date	Day of week	Description of events	Surface condition	Natural light	Weather	Junction	Crash count fatal	Crash count severe	Crash count minor
201971871	SH 96	40	S	CAHILL ROAD	24-10-19	Thu	Ute1 SDB on WINTON HEDGEHOPE HIGHWAY, BROWNS, SOUTHLAND lost control turning right; went off road to left, Ute1 hit fence, ditch	Wet	Dark	Light rain	Nil (Default)	0	0	1
201979346	SH 96	542	S	CAHILL ROAD	26-08-19	Mon	Truck1 NDB on WINTON HEDGEHOPE HIGHWAY lost control; went off road to left, Truck1 hit culvert	Wet	Twilight	Fine	Nil (Default)	0	0	0
201956861	SH 96	120	W	CAHILL ROAD	29-05-19	Wed	load or trailer from SUV1 EDB on WINTON HEDGEHOPE HIGHWAY, BROWNS, SOUTHLAND hit Truck2, SUV1 hit substantial vegetation (causing vehicle damage or stopping the vehicle), non specified object	Dry	Overcast	Fine	Nil (Default)	0	0	1
201618585	SH 96	440	E	CAHILL ROAD	16-12-16	Fri	Car/Wagon1 NDB on Winton Hedgehope HWY lost control; went off road to right, Car/Wagon1 hit non specific cliff	Dry	Bright sun	Fine	Nil (Default)	0	1	0
201652506	SH 96	100	S	CAHILL ROAD	12-11-16	Sat	Car/Wagon1 SDB on Winton Hedgehope Highway lost control turning right, Car/Wagon1 hit non specific ditch	Dry	Bright sun	Fine	Nil (Default)	0	0	0
201649879	SH 96	420	W	CAHILL ROAD	30-09-16	Fri	Van1 SDB on Winton browns road. Sh96 hit obstruction, Van1 hit non specific animal	Dry	Overcast	Mist or Fog	Nil (Default)	0	0	0
201417721	SH 96	100	S	CAHILL ROAD	21-12-14	Sun	SUV1 SDB on SH 96 lost control turning right, SUV1 hit non specific ditch	Dry	Dark	Fine	Nil (Default)	0	0	1
201446436	SH 96	300	E	BENNETT ROAD	17-08-14	Sun	Car/Wagon1 EDB on SH 96 lost control turning right, Car/Wagon1 hit non specific cliff	Dry	Dark	Fine	Nil (Default)	0	0	0
201324279	SH 96	160	N	BENNETT ROAD	08-11-13	Fri	SUV1 EDB on SH 96 lost control turning left, SUV1 hit non specific pole	Wet	Overcast	Light rain	Nil (Default)	0	0	1
201372286	SH 96	110	S	CAHILL ROAD	01-08-13	Thu	Car/Wagon1 SDB on SH 96 lost control turning right	Dry	Dark	Fine	Nil (Default)	0	0	0
201273471	SH 96	600	E	BENNETT ROAD	29-11-12	Thu	Car/Wagon1 EDB on SH 96 lost control turning right, Car/Wagon1 hit non specific pole	Dry	Overcast	Fine	Nil (Default)	0	0	0
201272548	SH 96	40	W	CAHILL ROAD	03-09-12	Mon	Car/Wagon1 WDB on SH 96 lost control turning left	Wet	Dark	Fine	Nil (Default)	0	0	0
201172495	SH 96	190	S	CAHILL ROAD	05-08-11	Fri	Car/Wagon1 EDB on SH 96 lost control turning right, Car/Wagon1 hit non specific fence	Dry	Dark	Fine	Nil (Default)	0	0	0

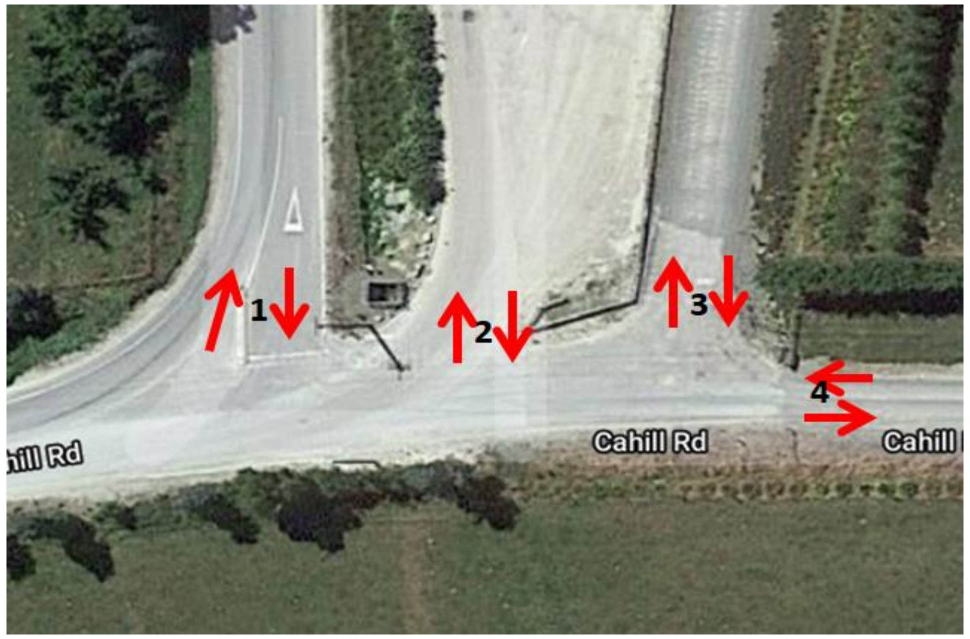
Attachment 4. Traffic Counts and Data Processing

AVG	Entrance1	Entrance 2	Entrance 3	Entrance 4	Total Daily	Peak
Light vehicle in	20	1	27	7	**55**	14
Light vehice out	31	9	28	5	**73**	19
Heavy vehicle in	72	3	4	2	**81**	21
Heavy vehicle out	10	72	3	2	**87**	22

MAX	Entrance1	Entrance 2	Entrance 3	Entrance 4	Total Daily	Peak
Light vehicle in	20	1	30	10	**61**	16
Light vehice out	36	10	31	8	**85**	22
Heavy vehicle in	76	3	4	2	**85**	22
Heavy vehicle out	10	74	3	3	**90**	23

IN

OUT



no traffic movement after 7pm both days and the traffic was steady from 8-5pm each day

Steady traffic for 9hrs

Use hours to get to peak hour: 4 hr

MAX - Peak

traffic growth 1% per annum

no of years 35

LEFT IN	0%
RIGHT IN	100%
RIGHT OUT	0%
LEFT OUT	100%

105 0

28 0

0
0
23
22

LV 16

HCV 22

23 HCV

22 LV

33 22

125 16

Attachment 5. SIDRA Outputs – Current Traffic Arrangements

5.1 Sensitivity Test 1: Base – 100% left in from/right out to Winton; 0% right in from/left out to Browns

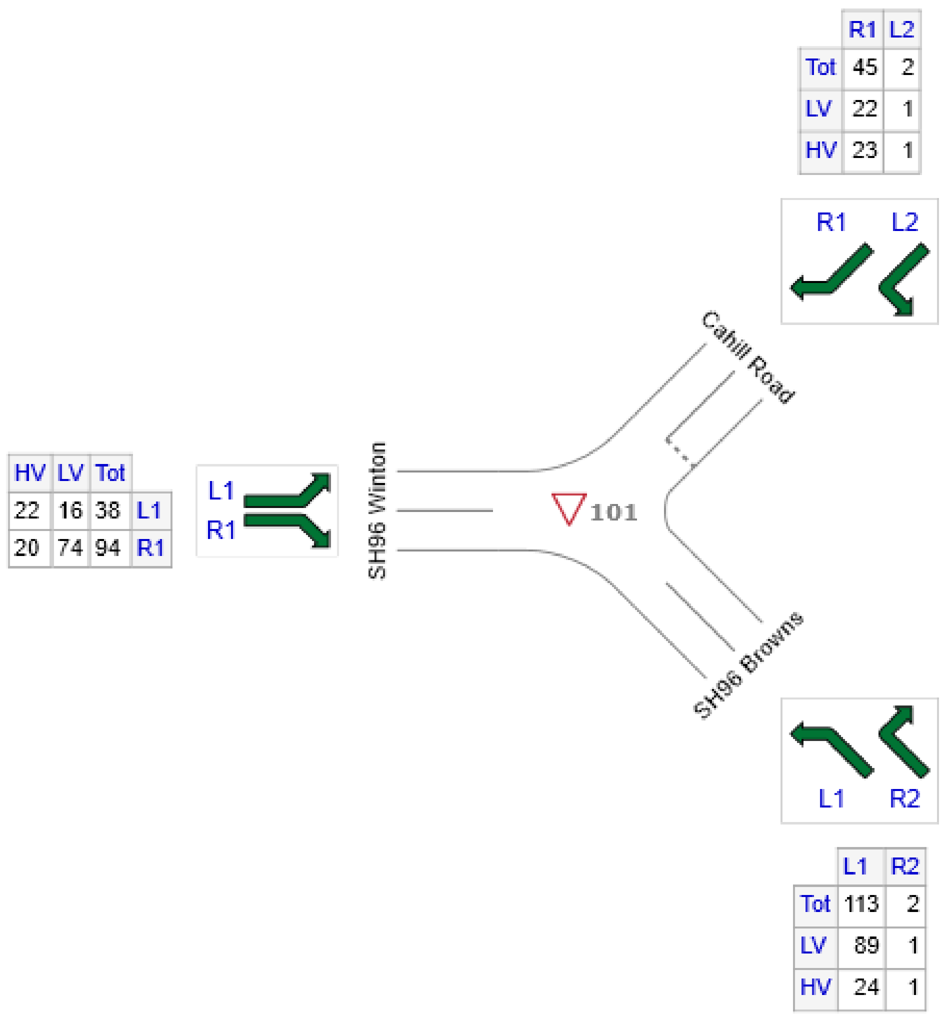
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [Base_100%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	115	90	25
NE: Cahill Road	47	23	24
W: SH96 Winton	132	90	42
Total	294	203	91

MOVEMENT SUMMARY

▽ **Site: 101 [Base_100%leftin]**

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

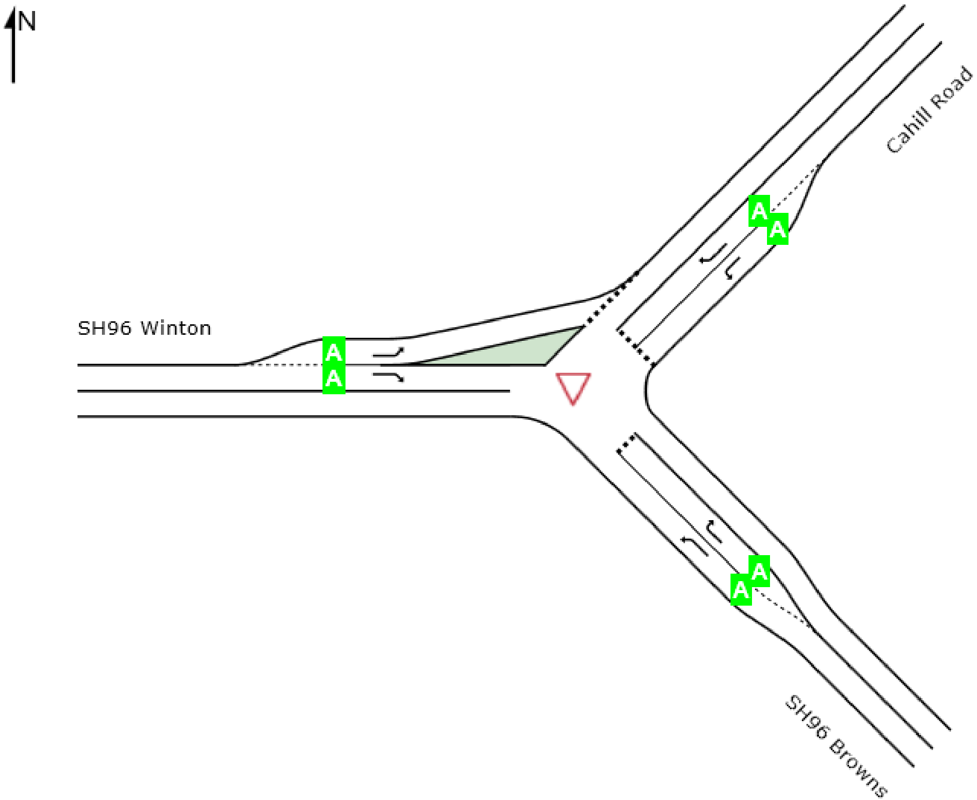
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	119	21.2	0.071	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.7
23	R2	2	50.0	0.003	9.7	LOS A	0.0	0.1	0.23	0.61	0.23	53.6
Approach		121	21.7	0.071	7.7	LOS A	0.0	0.1	0.00	0.66	0.00	67.5
NorthEast: Cahill Road												
24	L2	2	50.0	0.002	2.5	LOS A	0.0	0.1	0.22	0.31	0.22	41.1
26a	R1	47	51.1	0.074	3.8	LOS A	0.3	2.5	0.38	0.46	0.38	40.5
Approach		49	51.1	0.074	3.8	LOS A	0.3	2.5	0.38	0.46	0.38	40.5
West: SH96 Winton												
10a	L1	40	57.9	0.032	8.6	LOS A	0.1	1.3	0.02	0.67	0.02	54.7
12a	R1	99	21.3	0.059	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		139	31.8	0.059	7.8	LOS A	0.1	1.3	0.01	0.66	0.01	64.7
All Vehicles		309	31.0	0.074	7.1	NA	0.3	2.5	0.07	0.63	0.07	61.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Site: 101 [Base_100%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

5.2 Sensitivity Test 1: Base – 75% left in from/right out to Winton; 25% right in from/left out to Browns

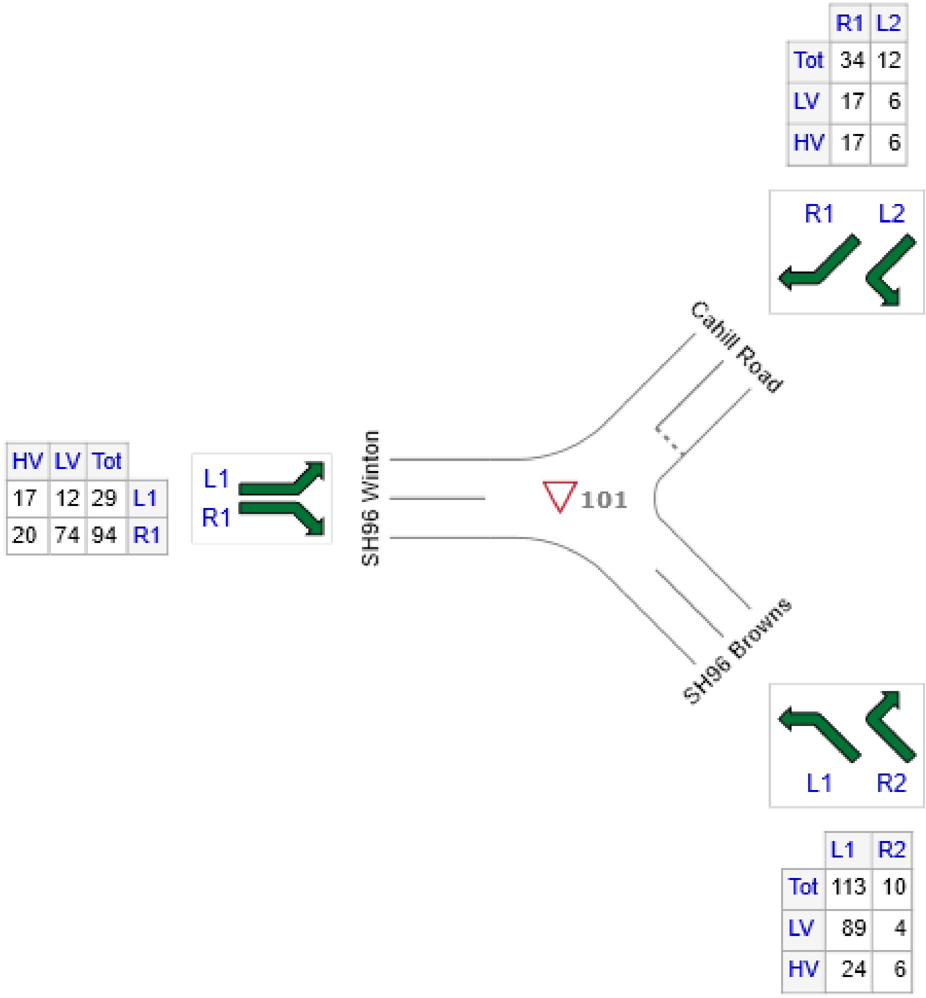
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [Base_75%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	123	93	30
NE: Cahill Road	46	23	23
W: SH96 Winton	123	86	37
Total	292	202	90

MOVEMENT SUMMARY

▽ Site: 101 [Base_75%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	119	21.2	0.071	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.7
23	R2	11	60.0	0.014	10.1	LOS B	0.0	0.5	0.24	0.63	0.24	53.5
Approach		129	24.4	0.071	7.9	LOS A	0.0	0.5	0.02	0.66	0.02	66.7
NorthEast: Cahill Road												
24	L2	13	50.0	0.011	2.6	LOS A	0.0	0.4	0.22	0.33	0.22	41.1
26a	R1	36	50.0	0.055	3.7	LOS A	0.2	1.8	0.37	0.45	0.37	40.8
Approach		48	50.0	0.055	3.4	LOS A	0.2	1.8	0.33	0.42	0.33	40.9
West: SH96 Winton												
10a	L1	31	58.6	0.024	8.7	LOS A	0.1	1.0	0.07	0.65	0.07	54.5
12a	R1	99	21.3	0.059	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		129	30.1	0.059	7.8	LOS A	0.1	1.0	0.02	0.66	0.02	65.3
All Vehicles		307	30.8	0.071	7.1	NA	0.2	1.8	0.07	0.62	0.07	61.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

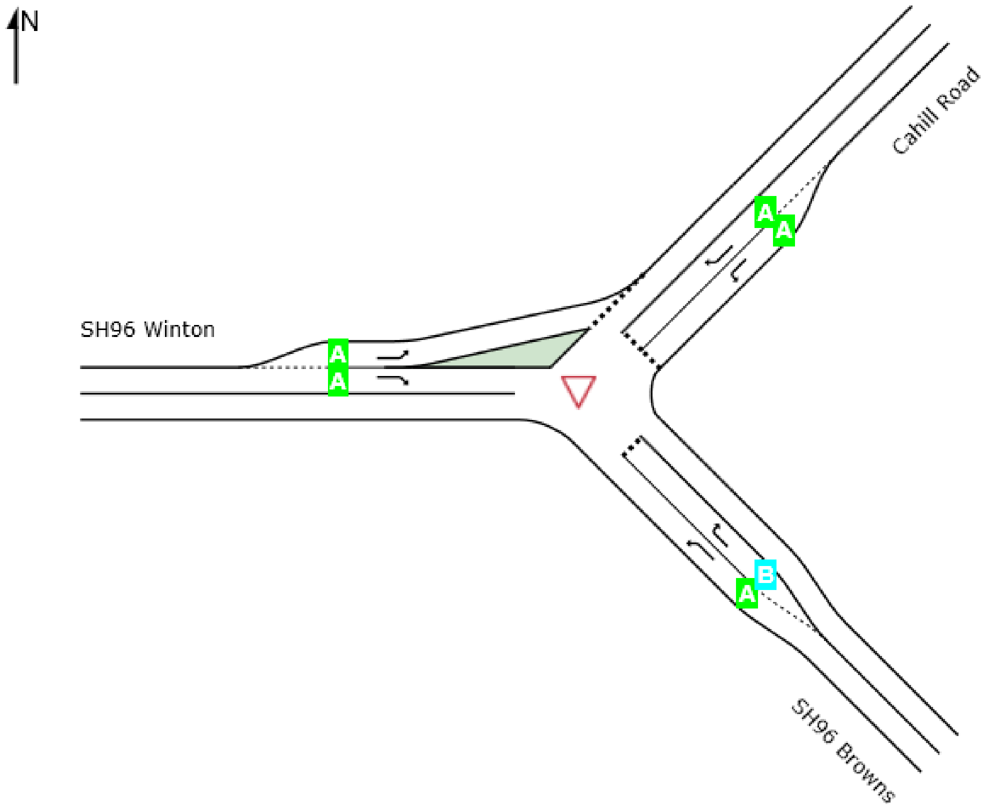
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [Base_75%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

5.3 Sensitivity Test 1: Base – 50% left in from/right out to Winton; 50% right in from/left out to Browns

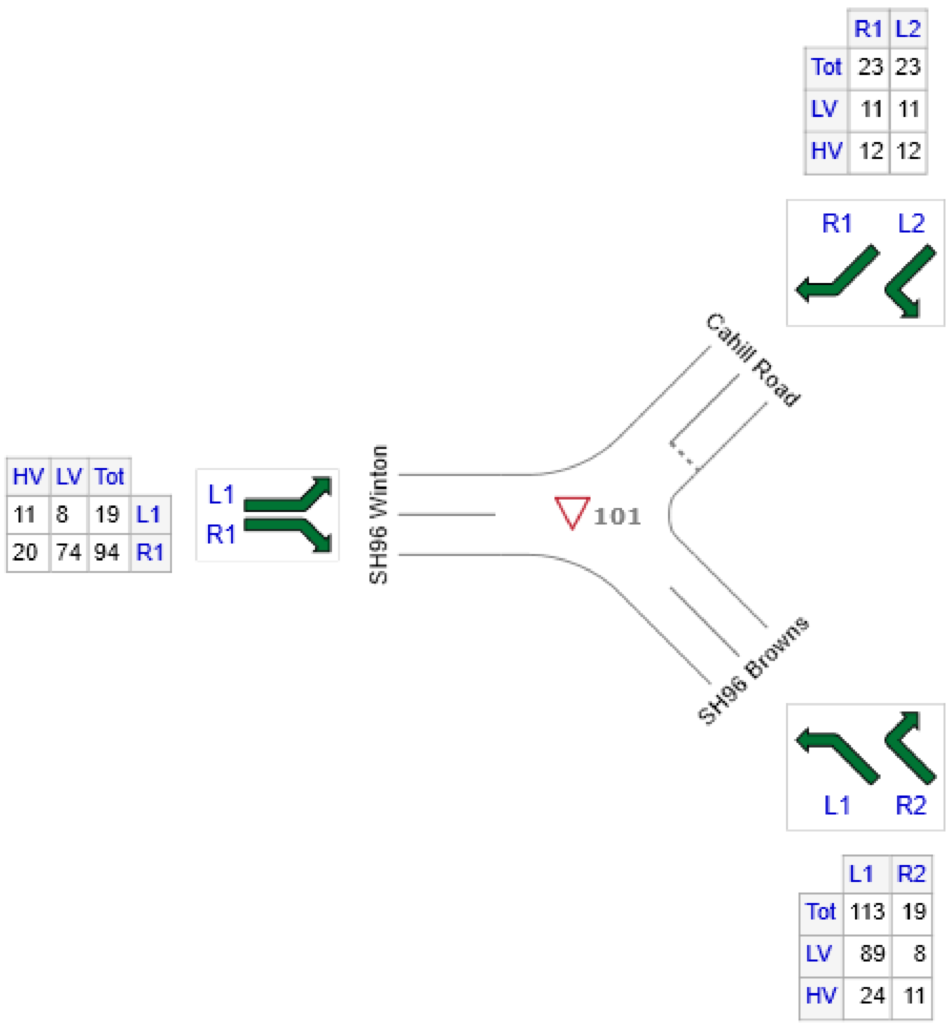
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [Base_50%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	132	97	35
NE: Cahill Road	46	22	24
W: SH96 Winton	113	82	31
Total	291	201	90

MOVEMENT SUMMARY

▽ **Site: 101 [Base_50%leftin]**

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	119	21.2	0.071	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.7
23	R2	20	57.9	0.027	10.1	LOS B	0.1	0.9	0.25	0.64	0.25	53.4
Approach		139	26.5	0.071	8.0	LOS A	0.1	0.9	0.04	0.66	0.04	65.9
NorthEast: Cahill Road												
24	L2	24	52.2	0.021	2.6	LOS A	0.1	0.8	0.22	0.33	0.22	40.7
26a	R1	24	52.2	0.038	3.6	LOS A	0.1	1.2	0.37	0.43	0.37	40.5
Approach		48	52.2	0.038	3.1	LOS A	0.1	1.2	0.30	0.38	0.30	40.6
West: SH96 Winton												
10a	L1	20	57.9	0.016	8.7	LOS A	0.1	0.7	0.10	0.64	0.10	54.3
12a	R1	99	21.3	0.059	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		119	27.4	0.059	7.7	LOS A	0.1	0.7	0.02	0.66	0.02	66.1
All Vehicles		306	30.9	0.071	7.1	NA	0.1	1.2	0.07	0.62	0.07	61.5

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

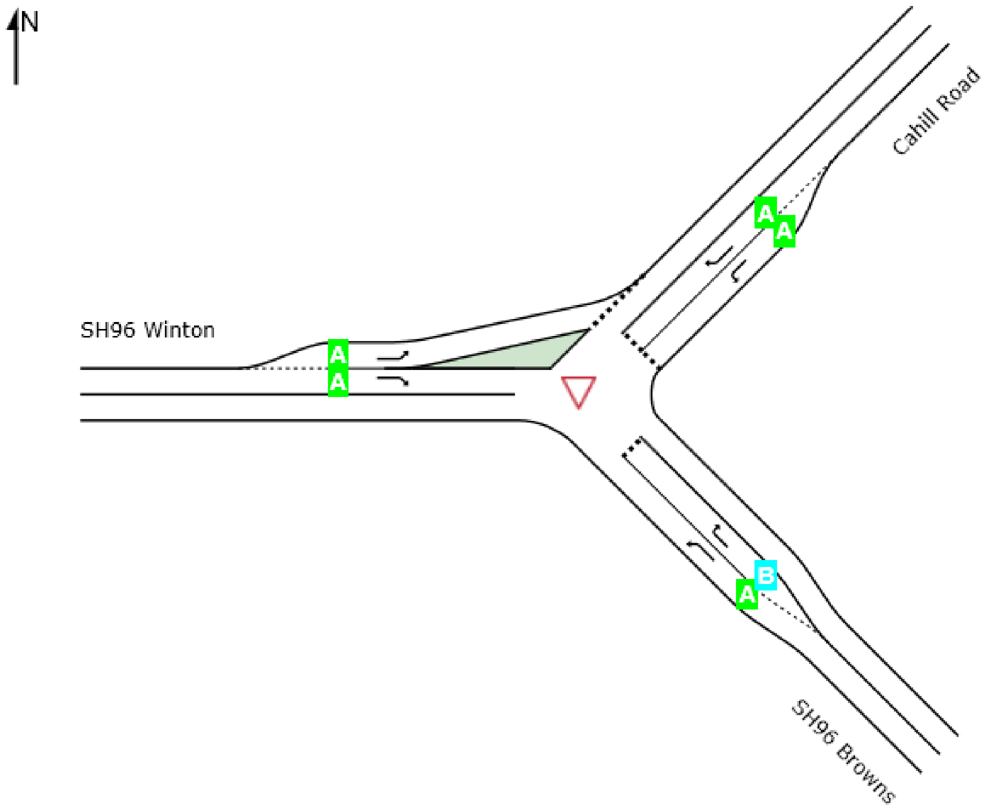
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [Base_50%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

5.4 Sensitivity Test 1: Base – 25% left in from/right out to Winton; 75% right in from/left out to Browns

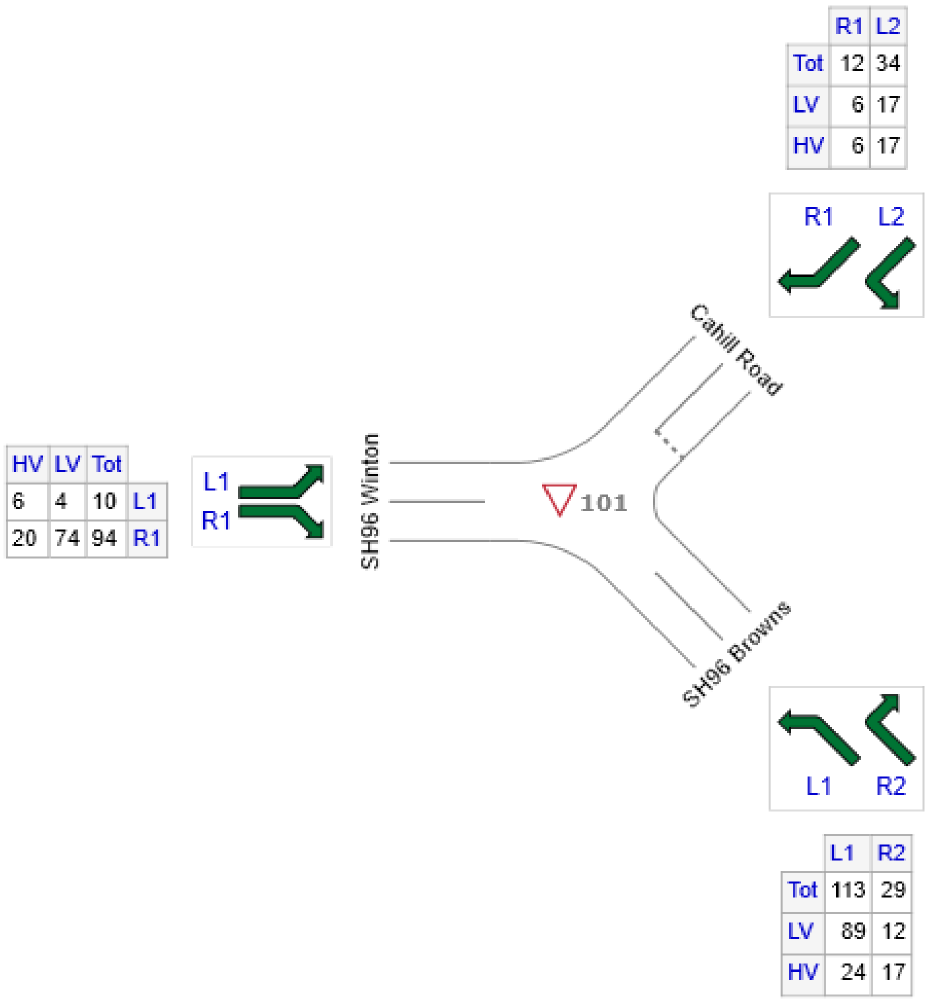
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [Base_25%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	142	101	41
NE: Cahill Road	46	23	23
W: SH96 Winton	104	78	26
Total	292	202	90

MOVEMENT SUMMARY

▽ **Site: 101 [Base_25%leftin]**

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	119	21.2	0.071	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.7
23	R2	31	58.6	0.042	10.2	LOS B	0.1	1.4	0.26	0.64	0.26	53.4
Approach		149	28.9	0.071	8.2	LOS A	0.1	1.4	0.05	0.66	0.05	65.1
NorthEast: Cahill Road												
24	L2	36	50.0	0.031	2.6	LOS A	0.1	1.2	0.23	0.34	0.23	41.1
26a	R1	13	50.0	0.019	3.5	LOS A	0.1	0.6	0.36	0.41	0.36	41.0
Approach		48	50.0	0.031	2.8	LOS A	0.1	1.2	0.26	0.36	0.26	41.1
West: SH96 Winton												
10a	L1	11	60.0	0.009	8.8	LOS A	0.0	0.4	0.12	0.63	0.12	54.2
12a	R1	99	21.3	0.059	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		109	25.0	0.059	7.6	LOS A	0.0	0.4	0.01	0.66	0.01	66.9
All Vehicles		307	30.8	0.071	7.1	NA	0.1	1.4	0.07	0.61	0.07	61.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

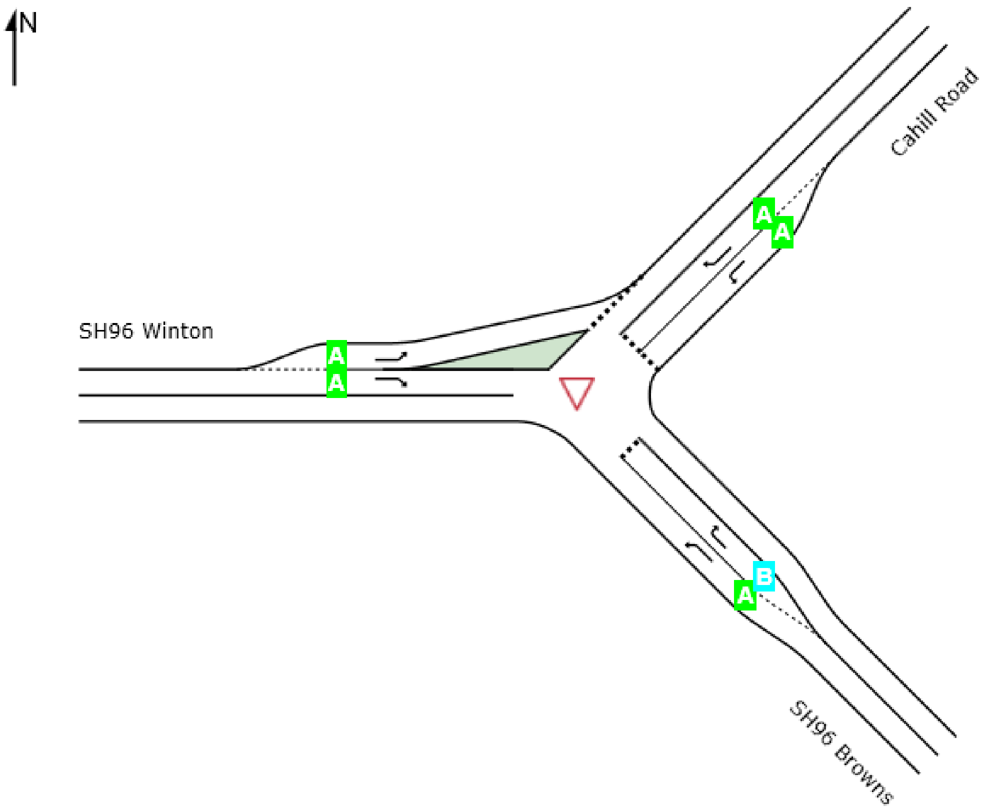
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [Base_25%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

5.5 Sensitivity Test 1: Base – 0% left in from/right out to Winton; 100% right in from/left out to Browns

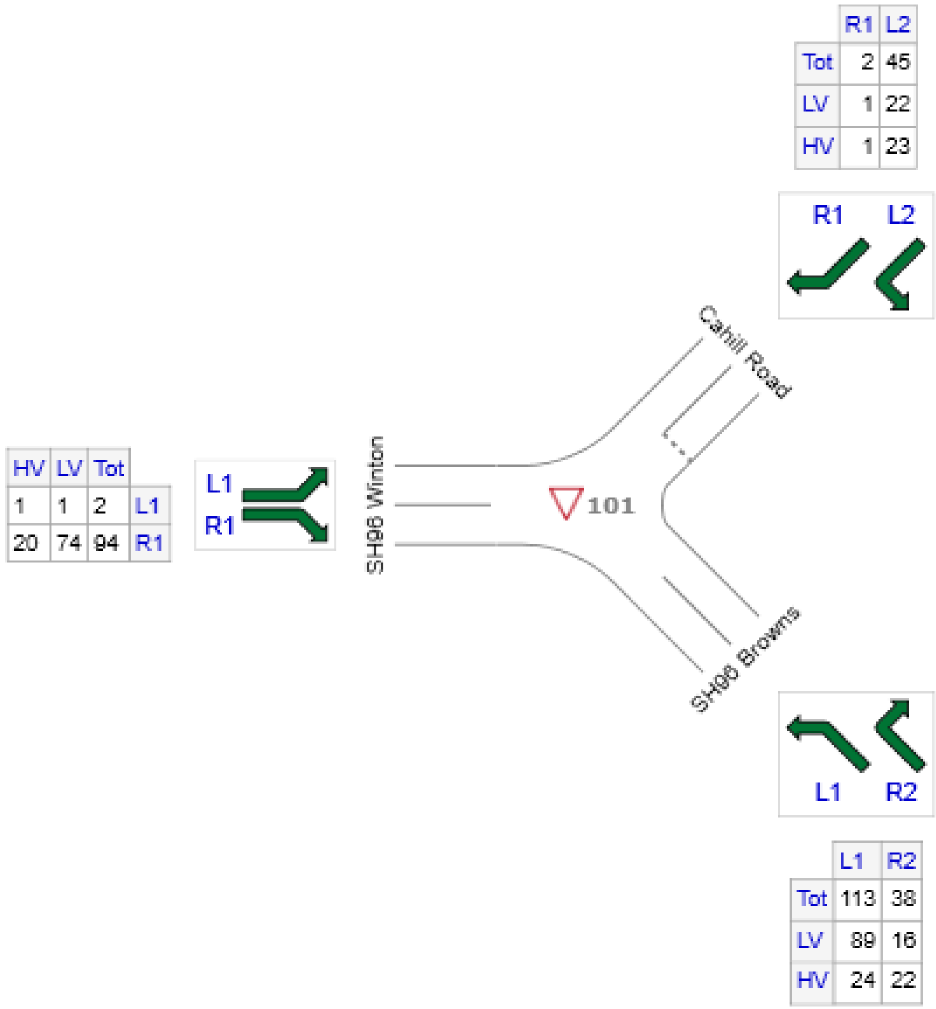
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [Base_0%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	151	105	46
NE: Cahill Road	47	23	24
W: SH96 Winton	96	75	21
Total	294	203	91

MOVEMENT SUMMARY

▽ Site: 101 [Base_0%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	119	21.2	0.071	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.7
23	R2	40	57.9	0.055	10.3	LOS B	0.2	1.9	0.27	0.65	0.27	53.3
Approach		159	30.5	0.071	8.3	LOS A	0.2	1.9	0.07	0.66	0.07	64.5
NorthEast: Cahill Road												
24	L2	47	51.1	0.041	2.6	LOS A	0.2	1.6	0.23	0.34	0.23	40.9
26a	R1	2	50.0	0.003	3.3	LOS A	0.0	0.1	0.35	0.37	0.35	41.0
Approach		49	51.1	0.041	2.6	LOS A	0.2	1.6	0.23	0.34	0.23	40.9
West: SH96 Winton												
10a	L1	2	50.0	0.002	8.6	LOS A	0.0	0.1	0.14	0.62	0.14	54.2
12a	R1	99	21.3	0.059	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		101	21.9	0.059	7.5	LOS A	0.0	0.1	0.00	0.66	0.00	67.8
All Vehicles		309	31.0	0.071	7.1	NA	0.2	1.9	0.07	0.61	0.07	61.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

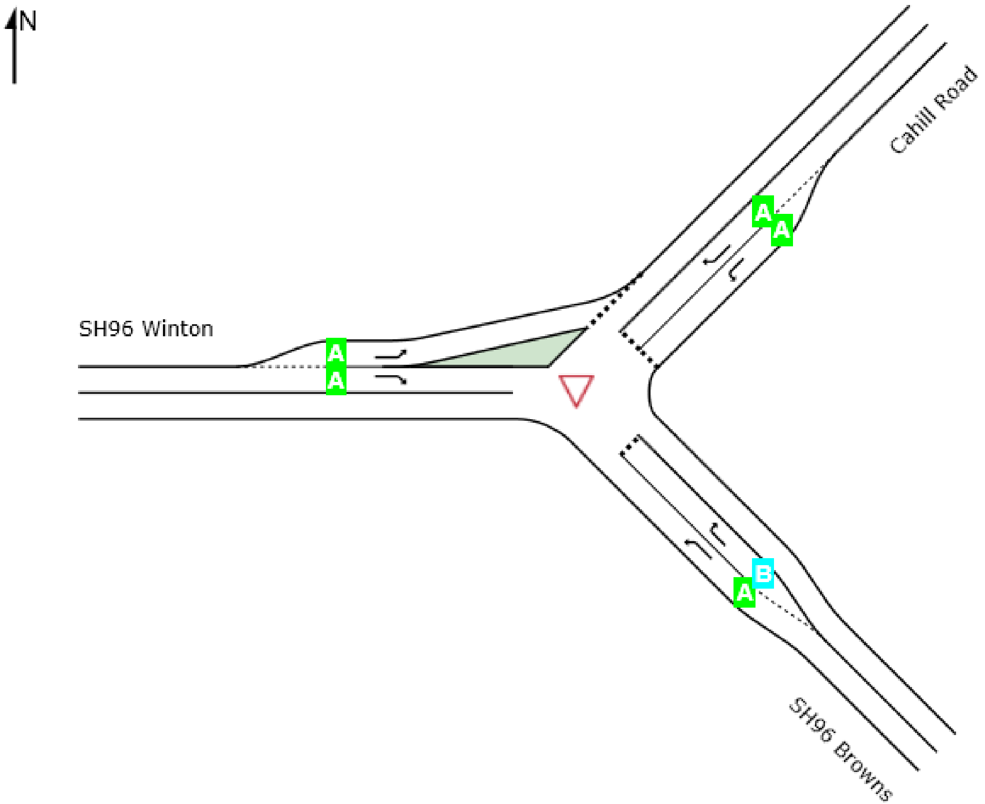
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [Base_0%leftin]

SH96 / Cahill Rd
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Attachment 6. SIDRA Outputs – Future Traffic Arrangement LOS D

6.1 Sensitivity Test 1: 2055 – 100% left in from/right out to Winton; 0% right in from/left out to Browns +225HCV

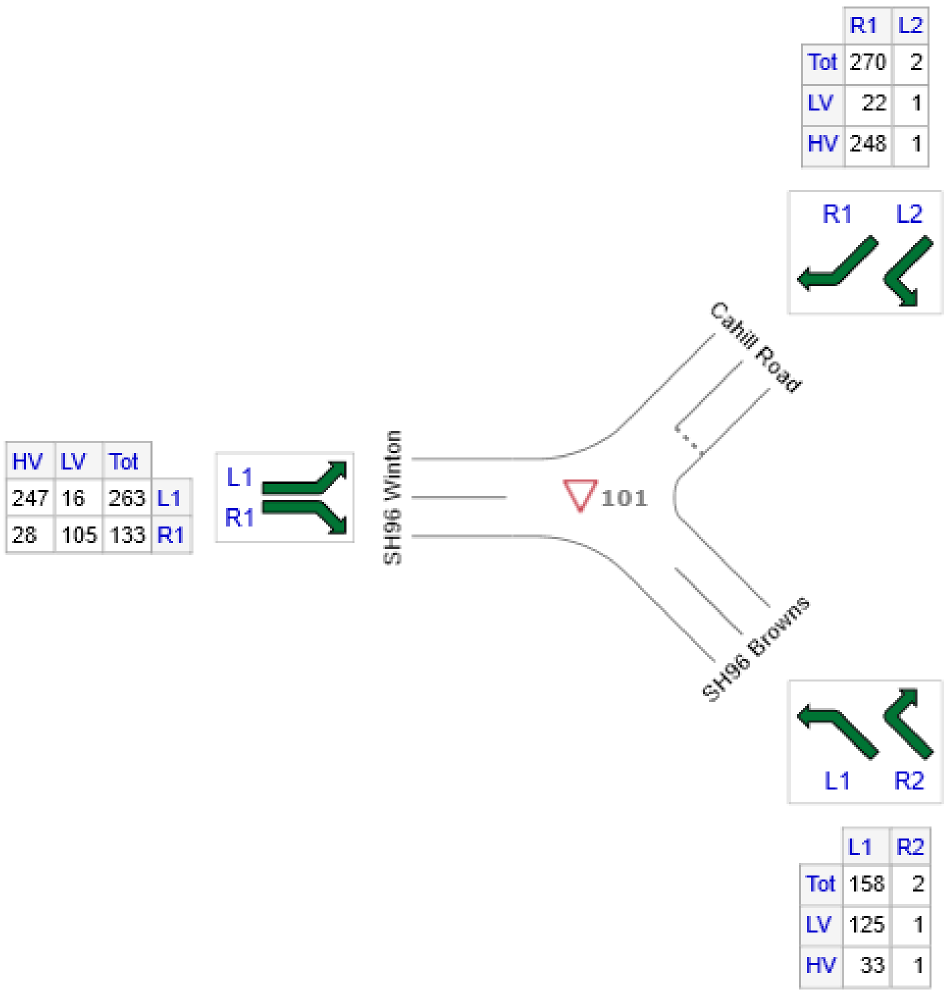
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_100%leftin +225HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	160	126	34
NE: Cahill Road	272	23	249
W: SH96 Winton	396	121	275
Total	828	270	558

MOVEMENT SUMMARY

▽ **Site: 101 [2055_100%leftin +225HCV - tick]**

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	2	50.0	0.003	10.0	LOS B	0.0	0.1	0.28	0.61	0.28	53.4
Approach		168	21.3	0.100	7.7	LOS A	0.0	0.1	0.00	0.66	0.00	67.6
NorthEast: Cahill Road												
24	L2	2	50.0	0.002	2.8	LOS A	0.0	0.1	0.27	0.33	0.27	41.0
26a	R1	284	91.9	0.870	31.8	LOS D	9.5	118.3	0.91	2.21	2.83	24.8
Approach		286	91.5	0.870	31.6	LOS D	9.5	118.3	0.91	2.20	2.81	24.8
West: SH96 Winton												
10a	L1	277	93.9	0.249	9.6	LOS A	1.3	16.1	0.03	0.68	0.03	54.5
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		417	69.4	0.249	8.9	LOS A	1.3	16.1	0.02	0.67	0.02	59.7
All Vehicles		872	67.4	0.870	16.1	NA	9.5	118.3	0.31	1.17	0.93	43.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

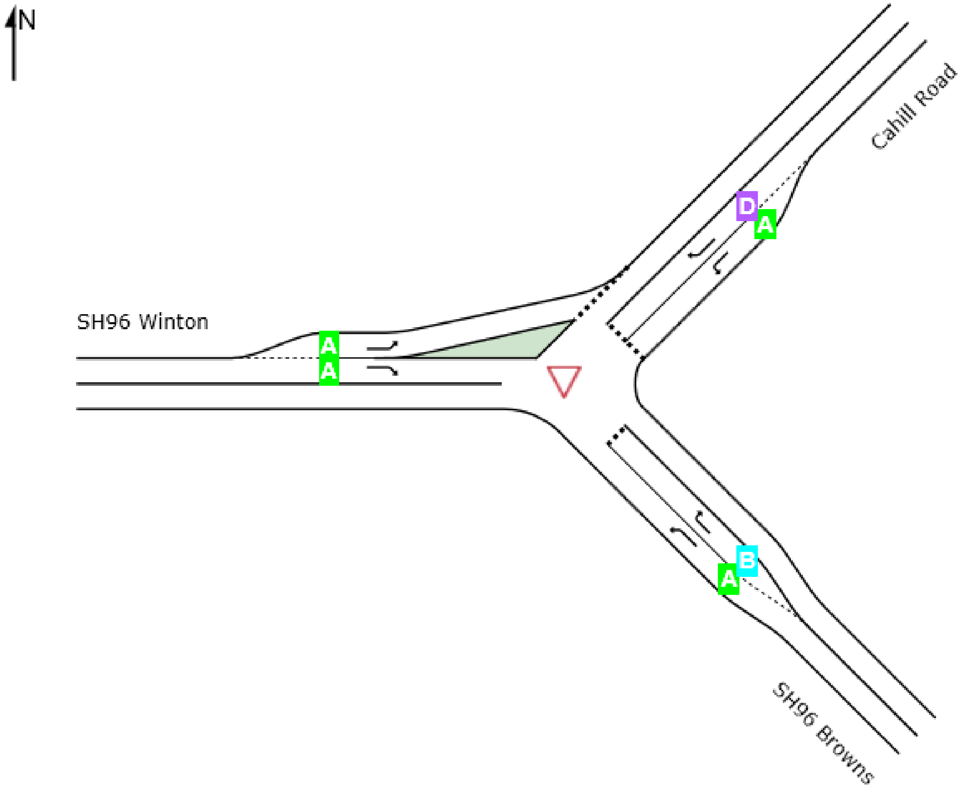
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_100%leftin +225HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	D	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

6.2 Sensitivity Test 1: 2055 – 75% left in from/right out to Winton; 25% right in from/left out to Browns +300HCV

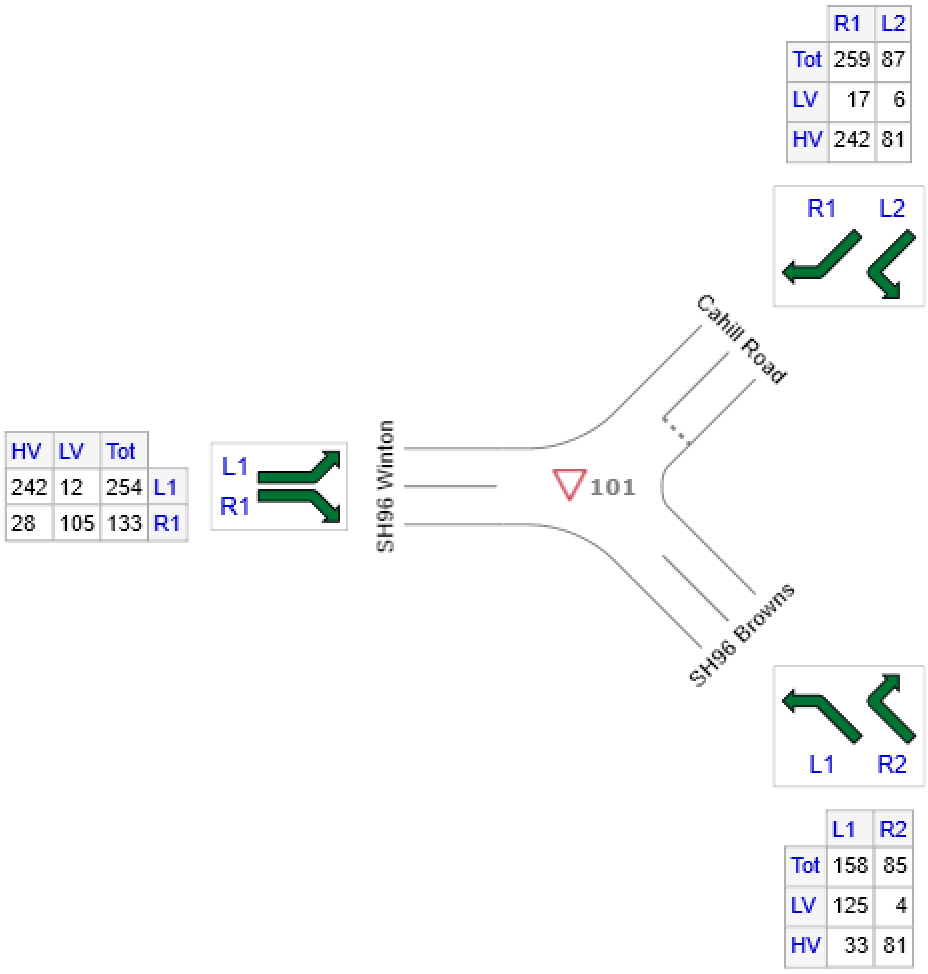
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

▽ Site: 101 [2055_75%leftin +300HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	243	129	114
NE: Cahill Road	346	23	323
W: SH96 Winton	387	117	270
Total	976	269	707

MOVEMENT SUMMARY

▽ Site: 101 [2055_75%leftin +300HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	89	95.3	0.165	13.0	LOS B	0.6	7.5	0.41	0.74	0.41	51.2
Approach		256	46.9	0.165	9.5	LOS A	0.6	7.5	0.14	0.69	0.14	62.4
NorthEast: Cahill Road												
24	L2	92	93.1	0.100	3.3	LOS A	0.4	5.2	0.32	0.39	0.32	34.6
26a	R1	273	93.4	0.879	32.9	LOS D	9.2	115.9	0.89	2.24	2.85	24.4
Approach		364	93.4	0.879	25.4	LOS D	9.2	115.9	0.75	1.77	2.22	26.4
West: SH96 Winton												
10a	L1	267	95.3	0.285	10.8	LOS B	1.4	18.0	0.35	0.67	0.35	53.1
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		407	69.8	0.285	9.6	LOS A	1.4	18.0	0.23	0.67	0.23	58.8
All Vehicles		1027	72.4	0.879	15.2	NA	9.2	115.9	0.39	1.06	0.91	43.2

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

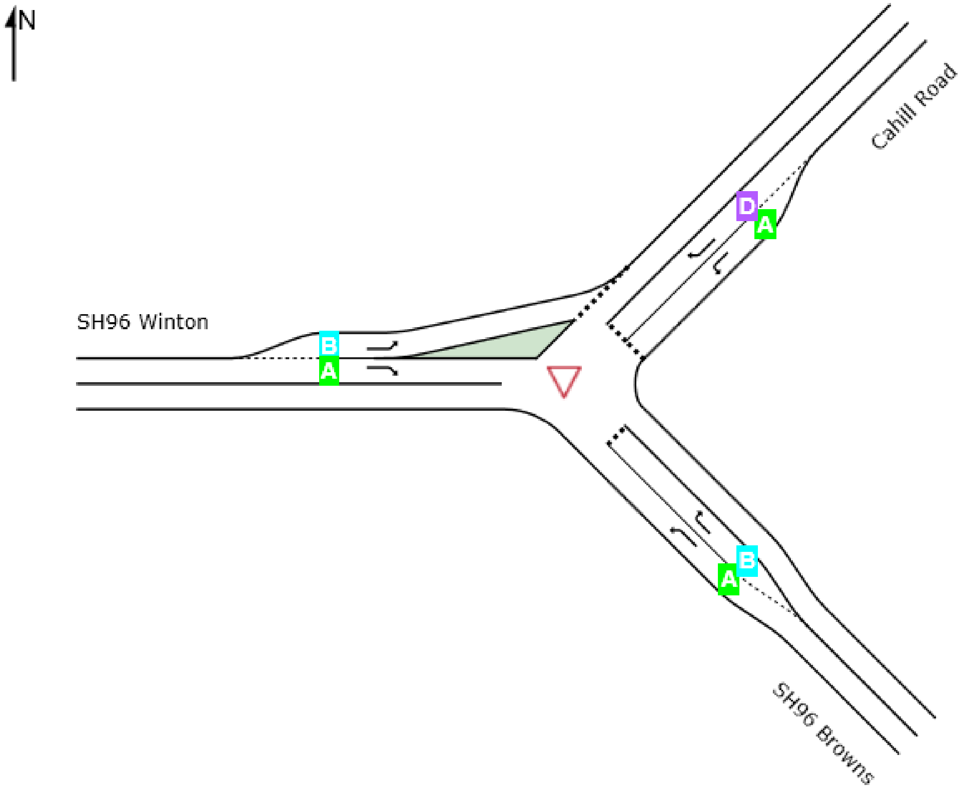
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_75%leftin +300HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	D	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

6.3 Sensitivity Test 1: 2055 – 50% left in from/right out to Winton; 50% right in from/left out to Browns +460HCV

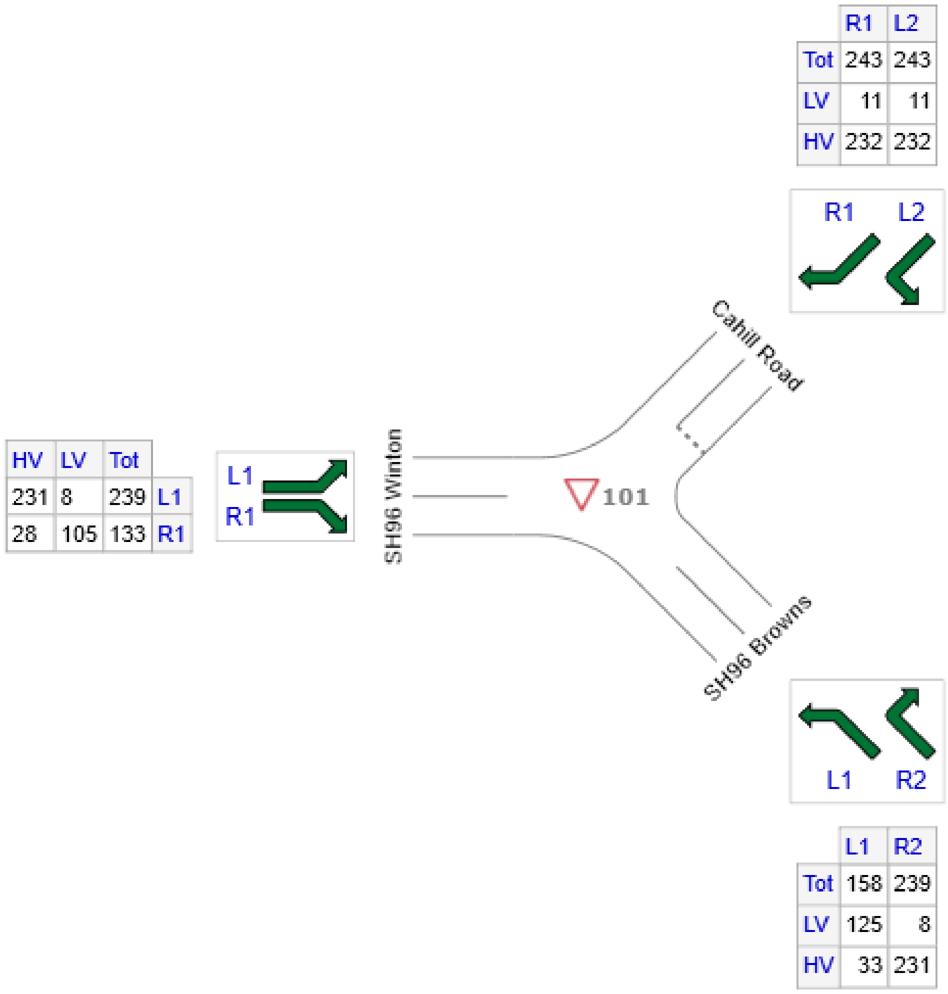
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

▽ Site: 101 [2055_50%leftin +460HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	397	133	264
NE: Cahill Road	486	22	464
W: SH96 Winton	372	113	259
Total	1255	268	987

MOVEMENT SUMMARY

▽ Site: 101 [2055_50%leftin +460HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.154	9.1	LOS A	1.1	9.1	0.43	0.38	0.43	65.8
23	R2	252	96.7	0.571	19.8	LOS C	3.9	49.3	0.66	1.00	1.08	44.8
Approach		418	66.5	0.571	15.5	LOS C	3.9	49.3	0.57	0.75	0.82	53.3
NorthEast: Cahill Road												
24	L2	256	95.5	0.281	3.6	LOS A	1.4	17.5	0.37	0.43	0.37	34.2
26a	R1	256	95.5	0.847	28.8	LOS D	7.6	97.3	0.85	2.00	2.48	25.3
Approach		512	95.5	0.847	16.2	LOS C	7.6	97.3	0.61	1.22	1.43	29.1
West: SH96 Winton												
10a	L1	252	96.7	0.387	14.6	LOS B	2.2	28.3	0.60	0.90	0.75	49.1
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		392	69.6	0.387	12.1	LOS B	2.2	28.3	0.39	0.81	0.48	56.3
All Vehicles		1321	78.6	0.847	14.8	NA	7.6	97.3	0.53	0.95	0.96	41.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

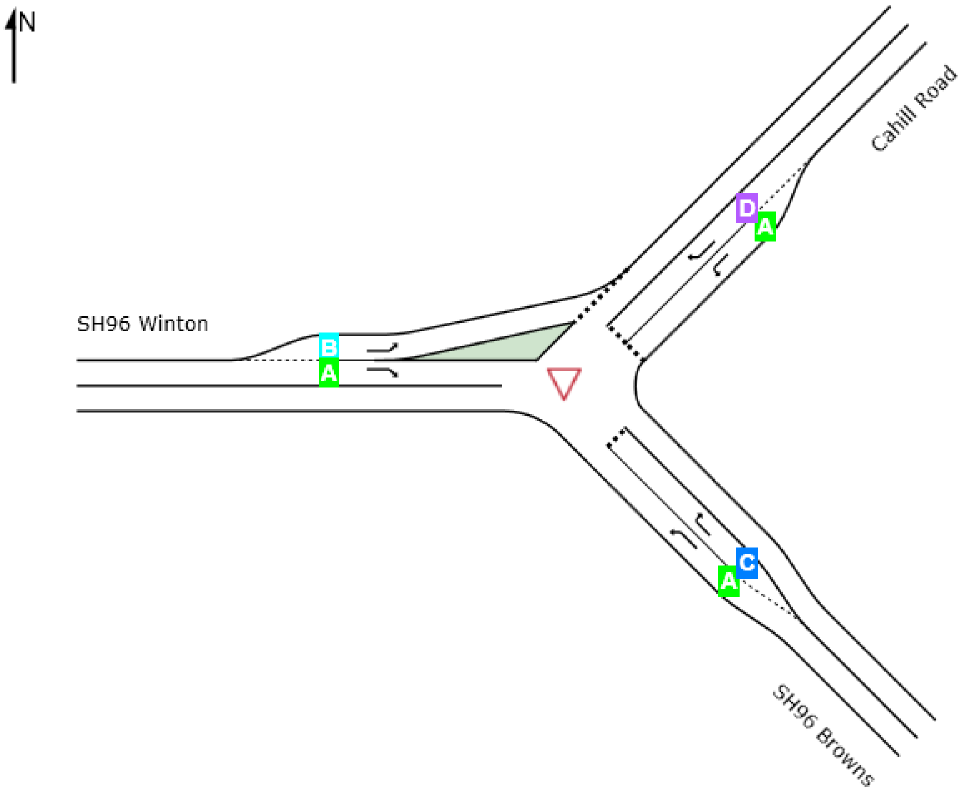
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_50%leftin +460HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	C	C	B	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

6.4 Sensitivity Test 1: 2055 – 25% left in from/right out to Winton; 75% right in from/left out to Browns +350HCV

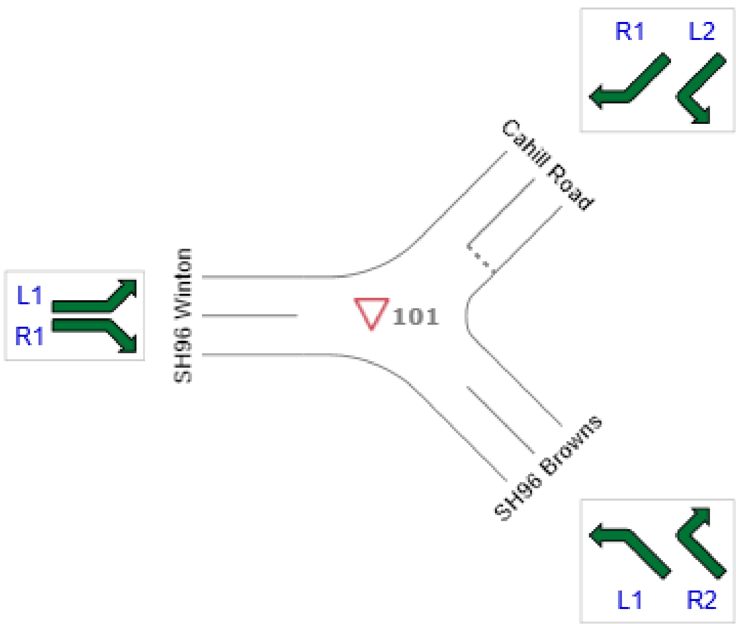
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_25%leftin +350HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



Cahill Road (NE):

	R1	L2
Tot	100	297
LV	6	17
HV	94	280

SH96 Winton (W):

HV	LV	Tot	
94	4	98	L1
28	105	133	R1

SH96 Browns (SE):

	L1	R2
Tot	158	292
LV	125	12
HV	33	280

	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	450	137	313
NE: Cahill Road	397	23	374
W: SH96 Winton	231	109	122
Total	1078	269	809

MOVEMENT SUMMARY

▽ Site: 101 [2055_25%leftin +350HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.167	9.6	LOS A	1.2	10.2	0.45	0.36	0.45	65.4
23	R2	307	95.9	0.750	26.0	LOS D	7.0	88.6	0.78	1.18	1.74	40.2
Approach		474	69.6	0.750	20.2	LOS C	7.0	88.6	0.67	0.89	1.29	48.6
NorthEast: Cahill Road												
24	L2	313	94.3	0.342	3.7	LOS A	1.8	22.5	0.40	0.45	0.40	34.3
26a	R1	105	94.0	0.263	8.4	LOS A	1.0	12.9	0.56	0.73	0.62	32.4
Approach		418	94.2	0.342	4.9	LOS A	1.8	22.5	0.44	0.52	0.45	33.8
West: SH96 Winton												
10a	L1	103	95.9	0.182	14.3	LOS B	0.7	9.2	0.58	0.85	0.58	49.4
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		243	52.8	0.182	10.4	LOS B	0.7	9.2	0.24	0.74	0.24	60.6
All Vehicles		1135	75.0	0.750	12.5	NA	7.0	88.6	0.49	0.72	0.76	44.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

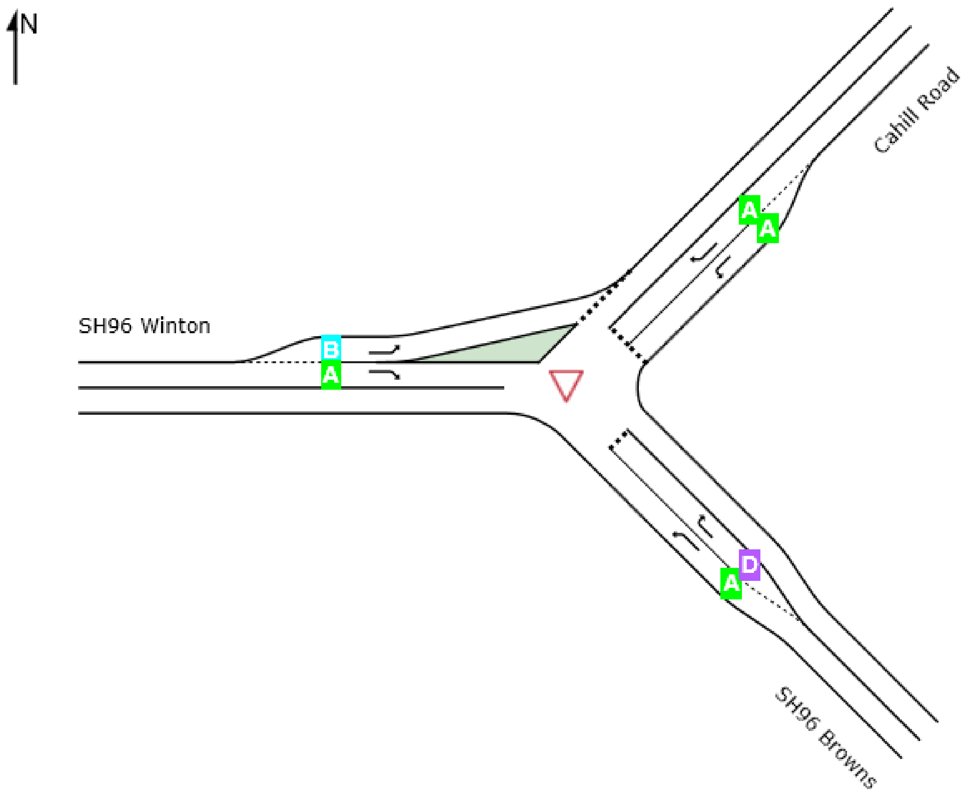
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_25%leftin +350HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	C	A	B	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

6.5 Sensitivity Test 1: 2055 – 0% left in from/right out to Winton; 100% right in from/left out to Browns +275HCV

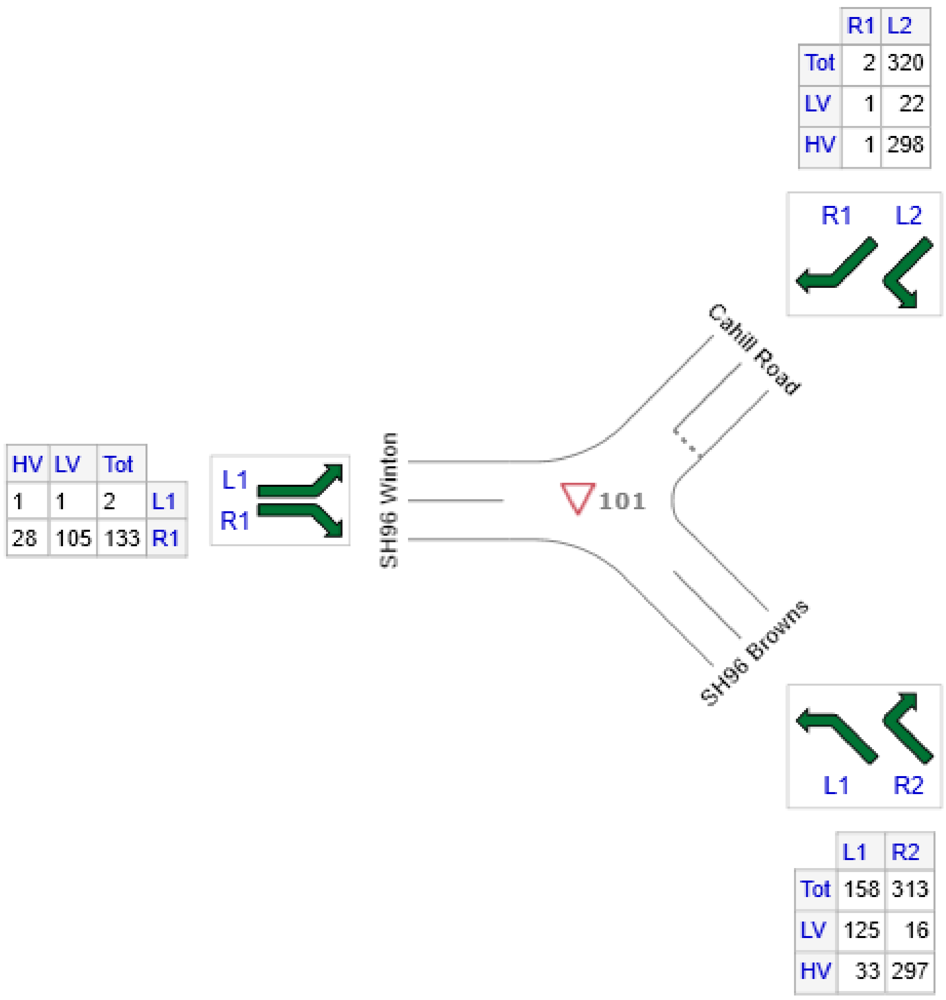
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_0%leftin +275HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	471	141	330
NE: Cahill Road	322	23	299
W: SH96 Winton	135	106	29
Total	928	270	658

MOVEMENT SUMMARY

▽ Site: 101 [2055_0%leftin +275HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.173	12.7	LOS B	1.3	10.6	0.47	0.35	0.47	61.9
23	R2	329	94.9	0.826	30.8	LOS D	9.2	116.9	0.84	1.31	2.25	37.2
Approach		496	70.1	0.826	24.7	LOS C	9.2	116.9	0.72	0.99	1.65	45.0
NorthEast: Cahill Road												
24	L2	337	93.1	0.367	3.7	LOS A	2.0	24.6	0.41	0.45	0.41	34.4
26a	R1	2	50.0	0.004	4.2	LOS A	0.0	0.1	0.42	0.42	0.42	40.4
Approach		339	92.9	0.367	3.7	LOS A	2.0	24.6	0.41	0.45	0.41	34.4
West: SH96 Winton												
10a	L1	2	50.0	0.003	11.3	LOS B	0.0	0.1	0.51	0.65	0.51	51.5
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		142	21.5	0.084	7.5	LOS A	0.0	0.1	0.01	0.66	0.01	67.9
All Vehicles		977	70.9	0.826	14.9	NA	9.2	116.9	0.50	0.76	0.98	43.7

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

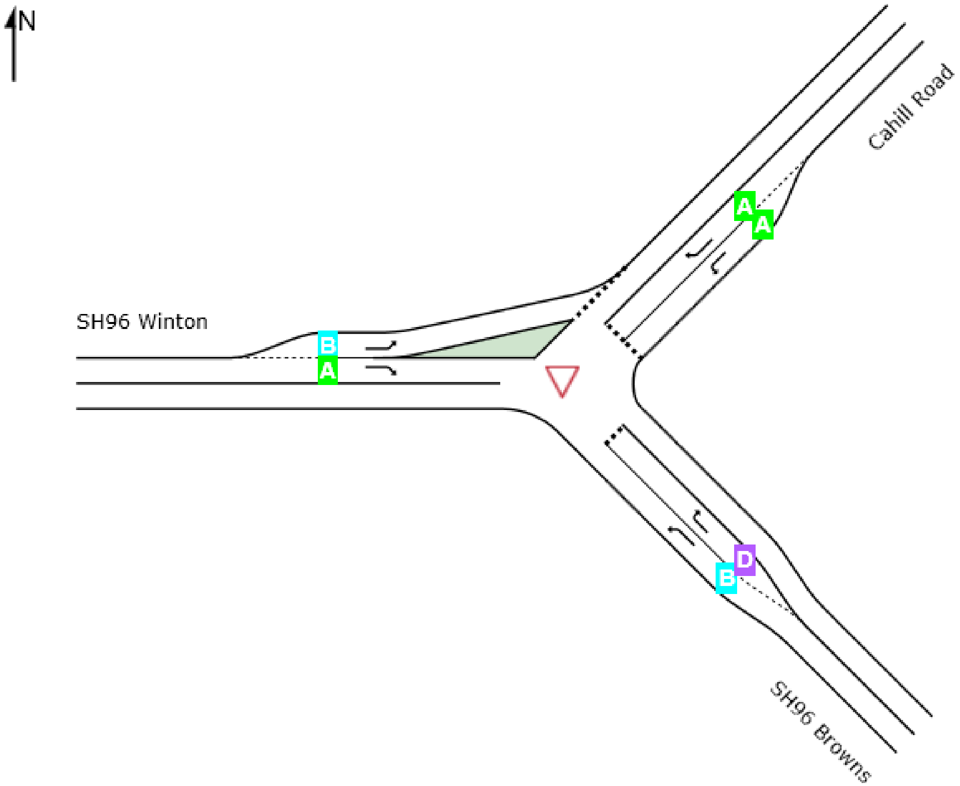
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_0%leftin +275HCV - tick]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	C	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Attachment 7. SIDRA Outputs – Future Traffic Arrangement +200HCV

7.1 Sensitivity Test 1: 2055 – 100% left in from/right out to Winton; 0% right in from/left out to Browns +200HCV

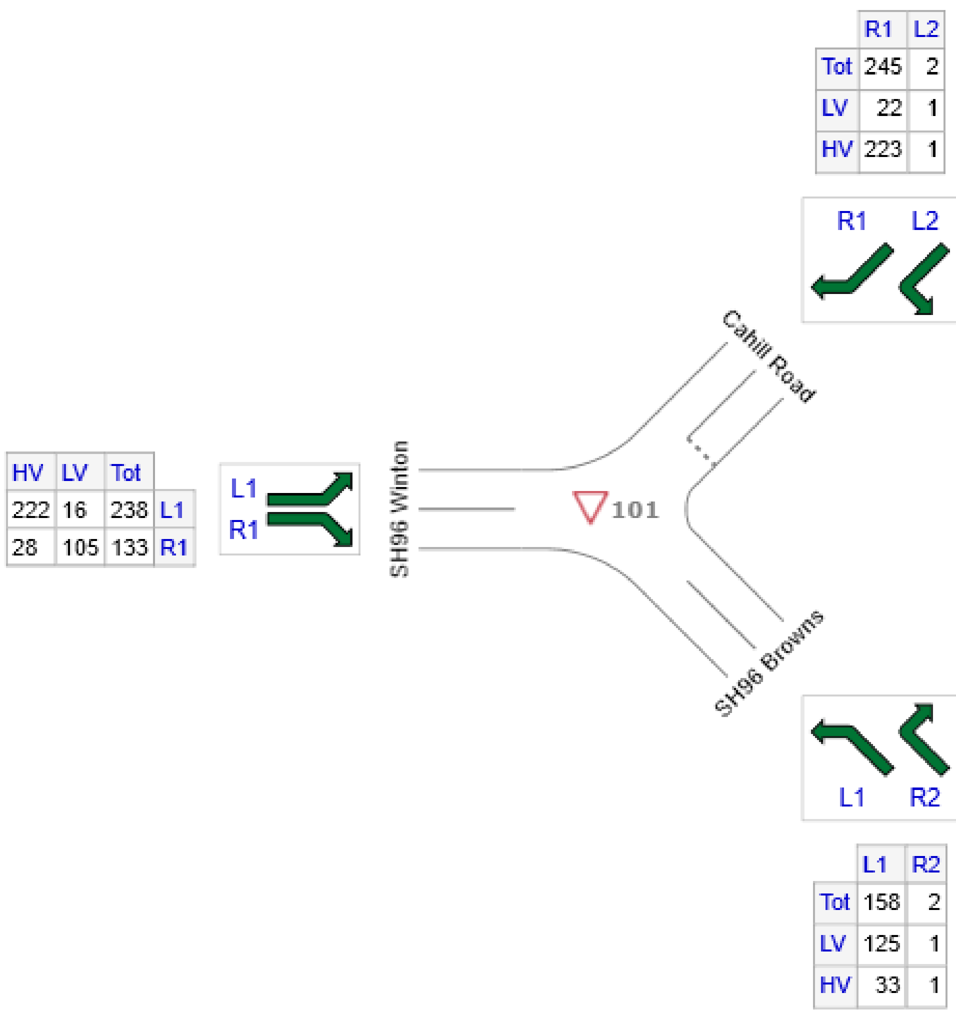
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_100%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	160	126	34
NE: Cahill Road	247	23	224
W: SH96 Winton	371	121	250
Total	778	270	508

MOVEMENT SUMMARY

▽ **Site: 101 [2055_100%leftin +200HCV]**

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	2	50.0	0.003	10.0	LOS B	0.0	0.1	0.28	0.61	0.28	53.4
Approach		168	21.3	0.100	7.7	LOS A	0.0	0.1	0.00	0.66	0.00	67.6
NorthEast: Cahill Road												
24	L2	2	50.0	0.002	2.8	LOS A	0.0	0.1	0.27	0.33	0.27	41.0
26a	R1	258	91.0	0.756	21.6	LOS C	6.1	76.0	0.84	1.61	1.92	27.7
Approach		260	90.7	0.756	21.5	LOS C	6.1	76.0	0.83	1.60	1.91	27.8
West: SH96 Winton												
10a	L1	251	93.3	0.225	9.6	LOS A	1.1	14.1	0.03	0.68	0.03	54.5
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		391	67.4	0.225	8.8	LOS A	1.1	14.1	0.02	0.67	0.02	60.0
All Vehicles		819	65.3	0.756	12.6	NA	6.1	76.0	0.28	0.97	0.62	46.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

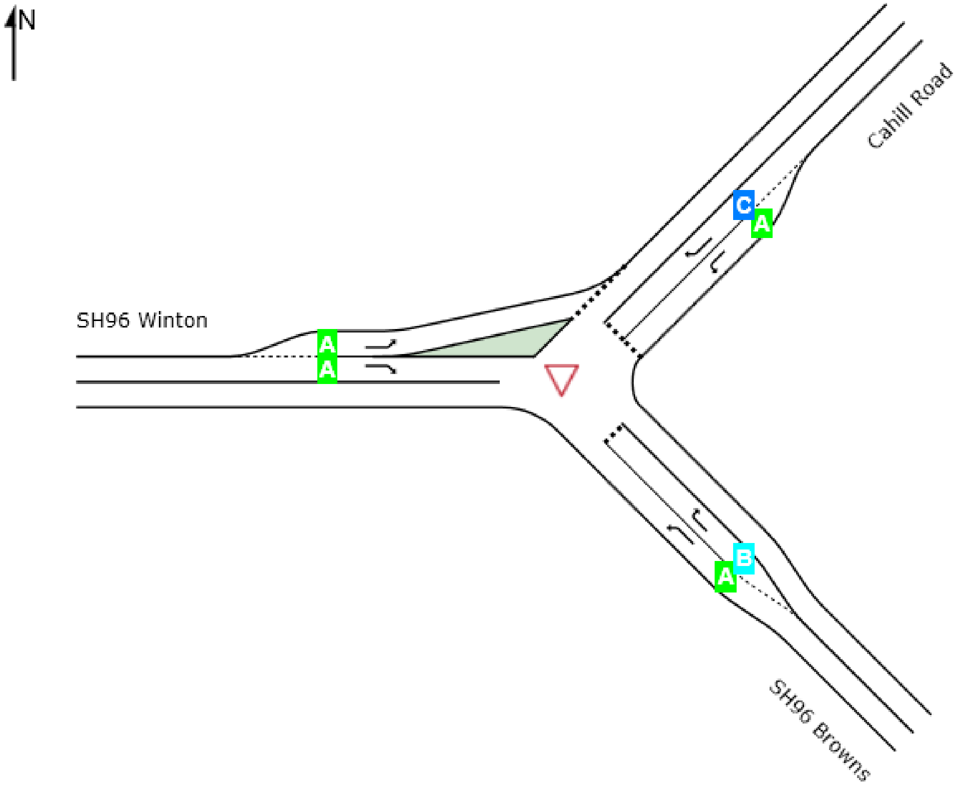
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_100%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	C	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

7.2 Sensitivity Test 1: 2055 – 75% left in from/right out to Winton; 25% right in from/left out to Browns +200HCV

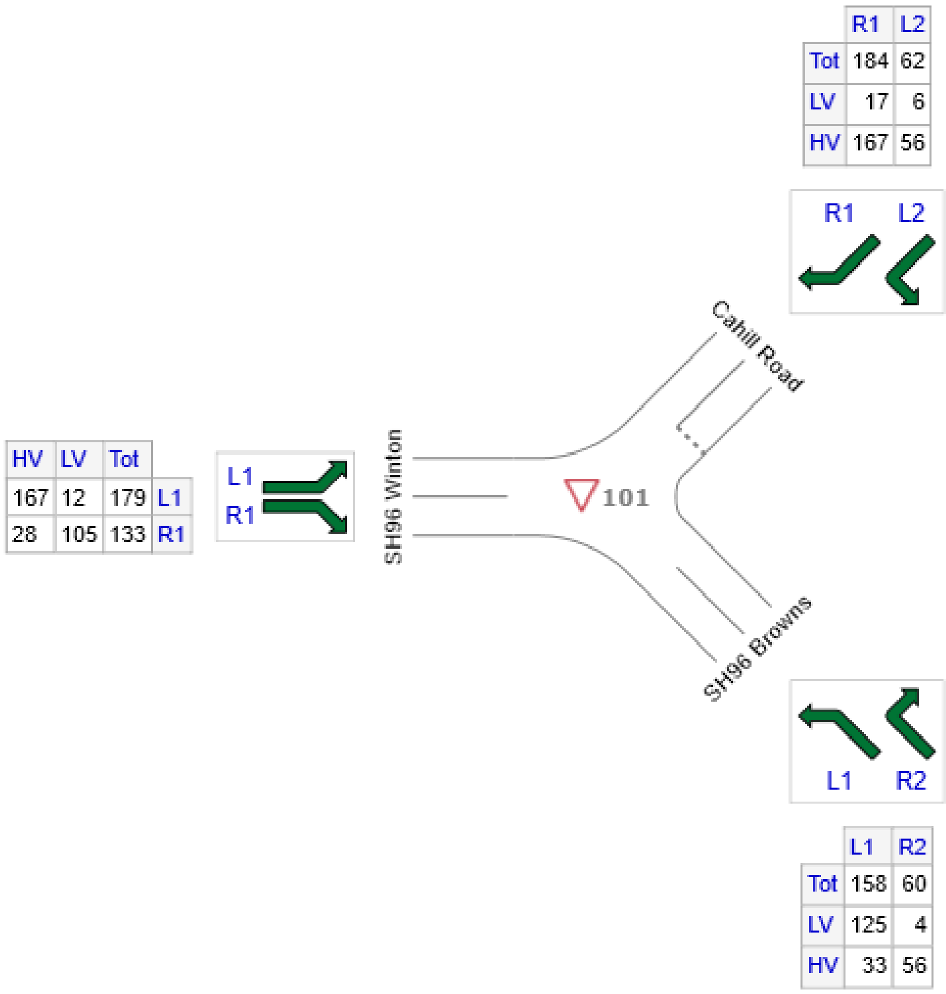
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_75%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	218	129	89
NE: Cahill Road	246	23	223
W: SH96 Winton	312	117	195
Total	776	269	507

MOVEMENT SUMMARY

▽ Site: 101 [2055_75%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	63	93.3	0.112	12.5	LOS B	0.4	4.9	0.37	0.71	0.37	51.7
Approach		229	40.8	0.112	9.0	LOS A	0.4	4.9	0.10	0.68	0.10	63.8
NorthEast: Cahill Road												
24	L2	65	90.3	0.070	3.2	LOS A	0.3	3.5	0.31	0.38	0.31	34.9
26a	R1	194	90.8	0.525	13.3	LOS B	2.9	36.6	0.70	1.06	1.10	30.7
Approach		259	90.7	0.525	10.8	LOS B	2.9	36.6	0.60	0.89	0.90	31.6
West: SH96 Winton												
10a	L1	188	93.3	0.189	10.2	LOS B	0.9	11.0	0.26	0.65	0.26	53.5
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		328	62.5	0.189	9.1	LOS A	0.9	11.0	0.15	0.65	0.15	60.3
All Vehicles		817	65.3	0.525	9.6	NA	2.9	36.6	0.28	0.74	0.37	49.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

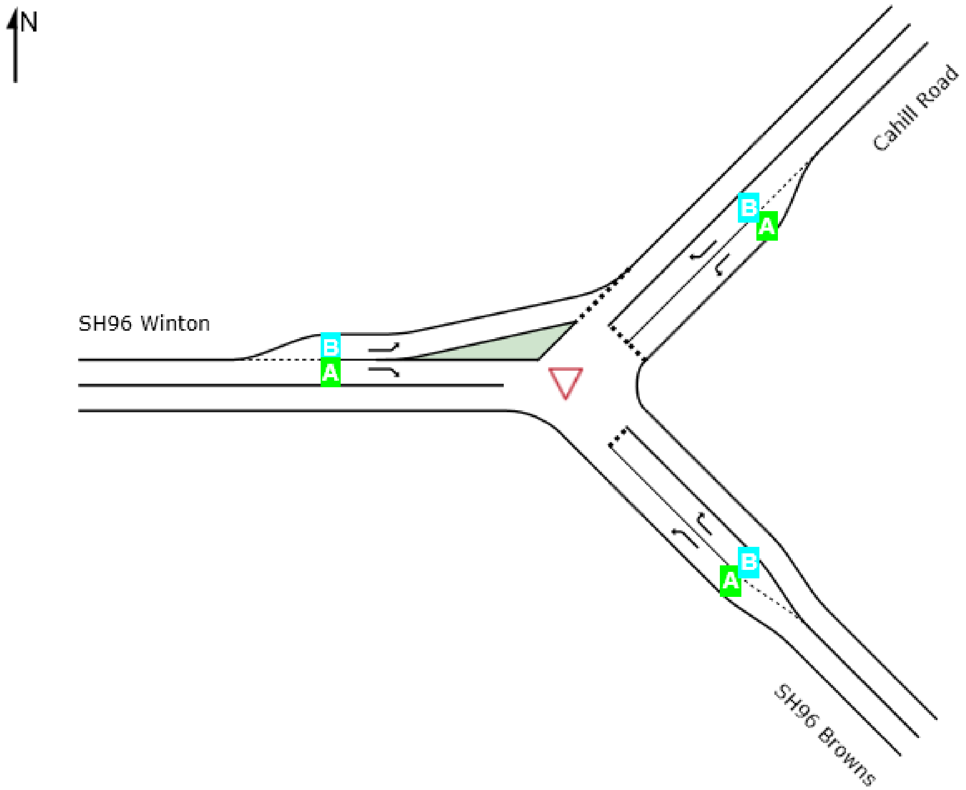
LANE LEVEL OF SERVICE

Lane Level of Service

▽ Site: 101 [2055_75%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	A	B	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

7.3 Sensitivity Test 1: 2055 – 50% left in from/right out to Winton; 50% right in from/left out to Browns +200HCV

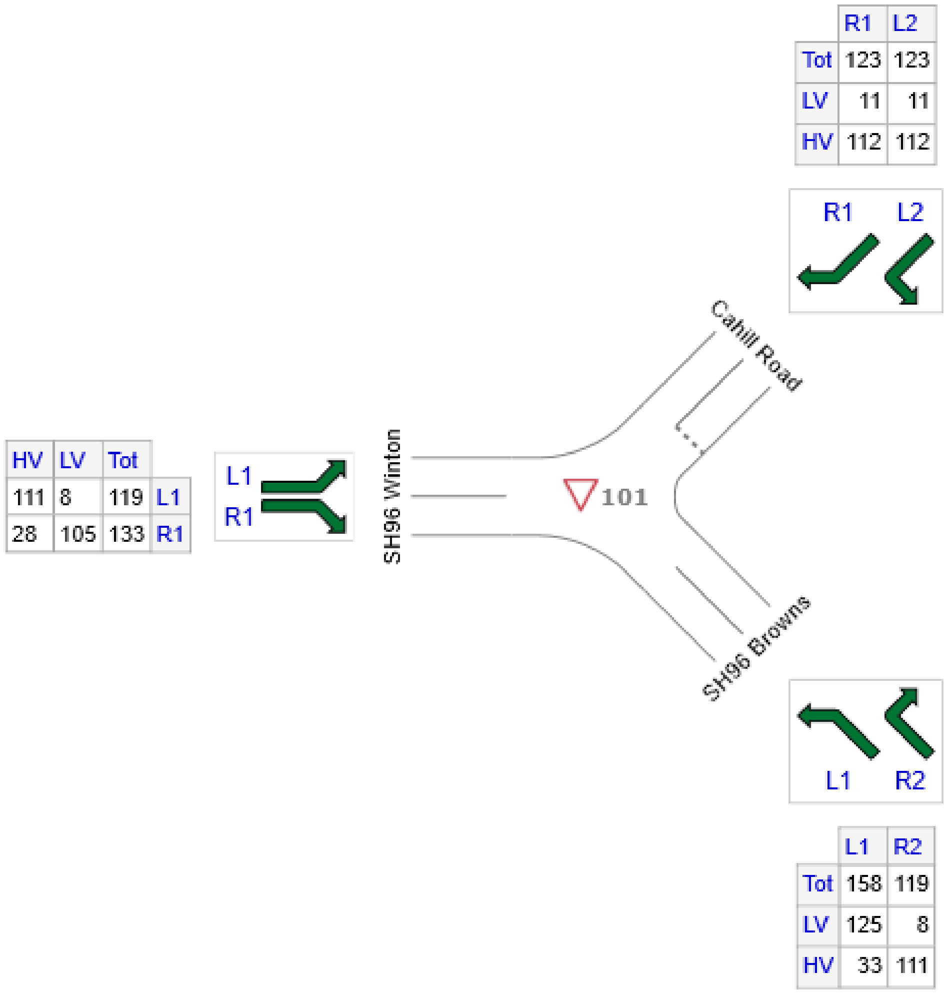
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

▽ Site: 101 [2055_50%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	277	133	144
NE: Cahill Road	246	22	224
W: SH96 Winton	252	113	139
Total	775	268	507

MOVEMENT SUMMARY

▽ **Site: 101 [2055_50%leftin +200HCV]**

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	125	93.3	0.238	13.6	LOS B	0.9	11.3	0.45	0.77	0.45	50.6
Approach		292	52.0	0.238	10.2	LOS B	0.9	11.3	0.20	0.71	0.20	60.9
NorthEast: Cahill Road												
24	L2	129	91.1	0.140	3.3	LOS A	0.6	7.5	0.33	0.40	0.33	34.8
26a	R1	129	91.1	0.326	9.3	LOS A	1.4	17.4	0.59	0.80	0.72	32.3
Approach		259	91.1	0.326	6.3	LOS A	1.4	17.4	0.46	0.60	0.52	33.5
West: SH96 Winton												
10a	L1	125	93.3	0.142	10.9	LOS B	0.6	7.6	0.36	0.68	0.36	53.0
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		265	55.2	0.142	9.1	LOS A	0.6	7.6	0.17	0.67	0.17	61.6
All Vehicles		816	65.4	0.326	8.6	NA	1.4	17.4	0.27	0.66	0.29	50.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

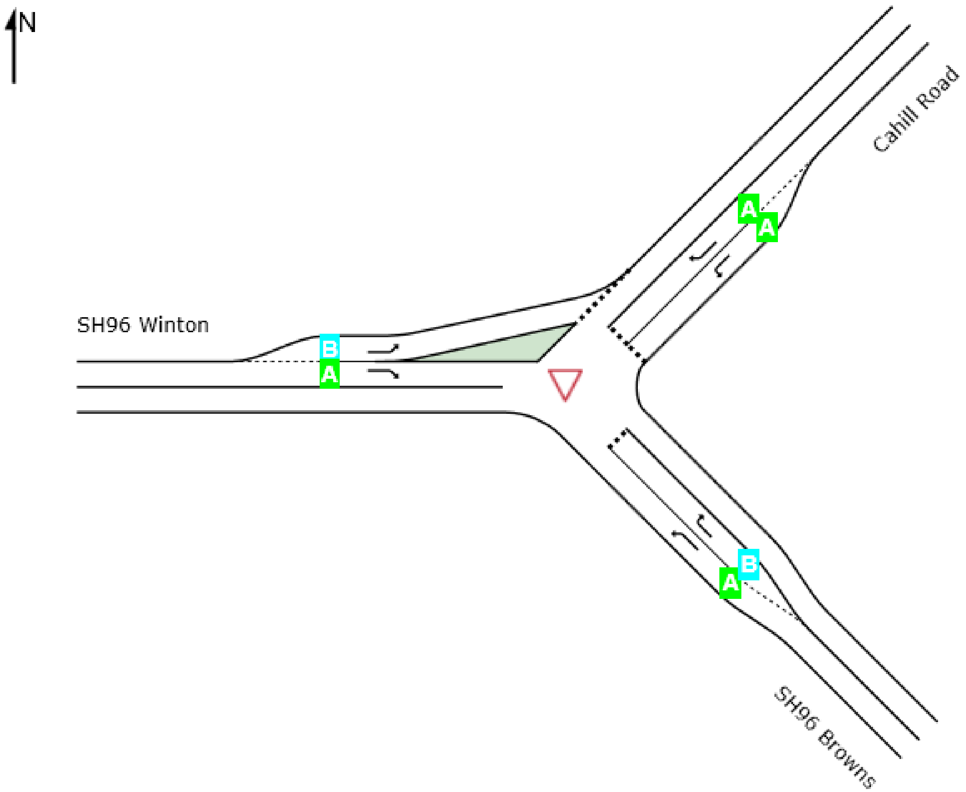
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_50%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	B	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
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Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

7.4 Sensitivity Test 1: 2055 – 25% left in from/right out to Winton; 75% right in from/left out to Browns +200HCV

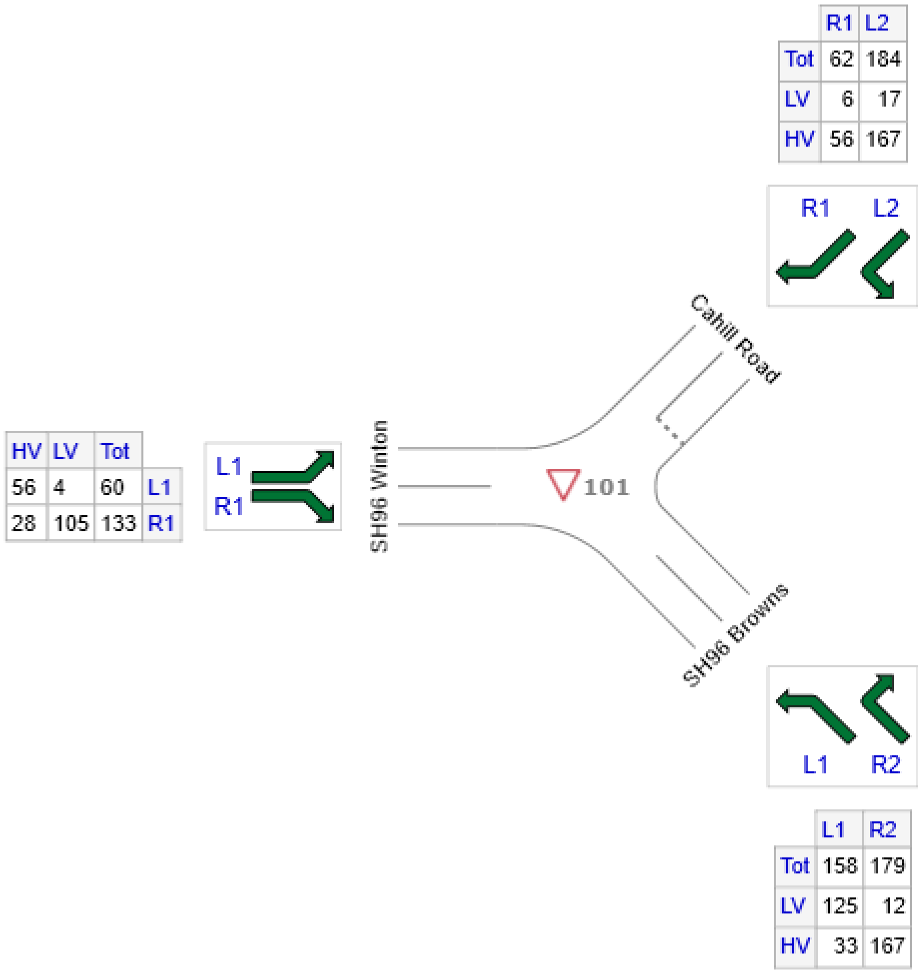
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

▽ Site: 101 [2055_25%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	337	137	200
NE: Cahill Road	246	23	223
W: SH96 Winton	193	109	84
Total	776	269	507

MOVEMENT SUMMARY

▽ Site: 101 [2055_25%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.100	7.6	LOS A	0.0	0.0	0.00	0.66	0.00	67.8
23	R2	188	93.3	0.386	15.7	LOS C	1.9	24.4	0.55	0.88	0.68	48.4
Approach		355	59.3	0.386	11.9	LOS B	1.9	24.4	0.29	0.78	0.36	57.8
NorthEast: Cahill Road												
24	L2	194	90.8	0.209	3.4	LOS A	1.0	11.9	0.35	0.42	0.35	34.8
26a	R1	65	90.3	0.152	6.9	LOS A	0.5	6.5	0.51	0.63	0.51	33.4
Approach		259	90.7	0.209	4.3	LOS A	1.0	11.9	0.39	0.47	0.39	34.5
West: SH96 Winton												
10a	L1	63	93.3	0.082	11.7	LOS B	0.3	4.1	0.43	0.71	0.43	52.2
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		203	43.5	0.084	8.8	LOS A	0.3	4.1	0.13	0.68	0.13	63.6
All Vehicles		817	65.3	0.386	8.7	NA	1.9	24.4	0.28	0.66	0.31	50.0

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

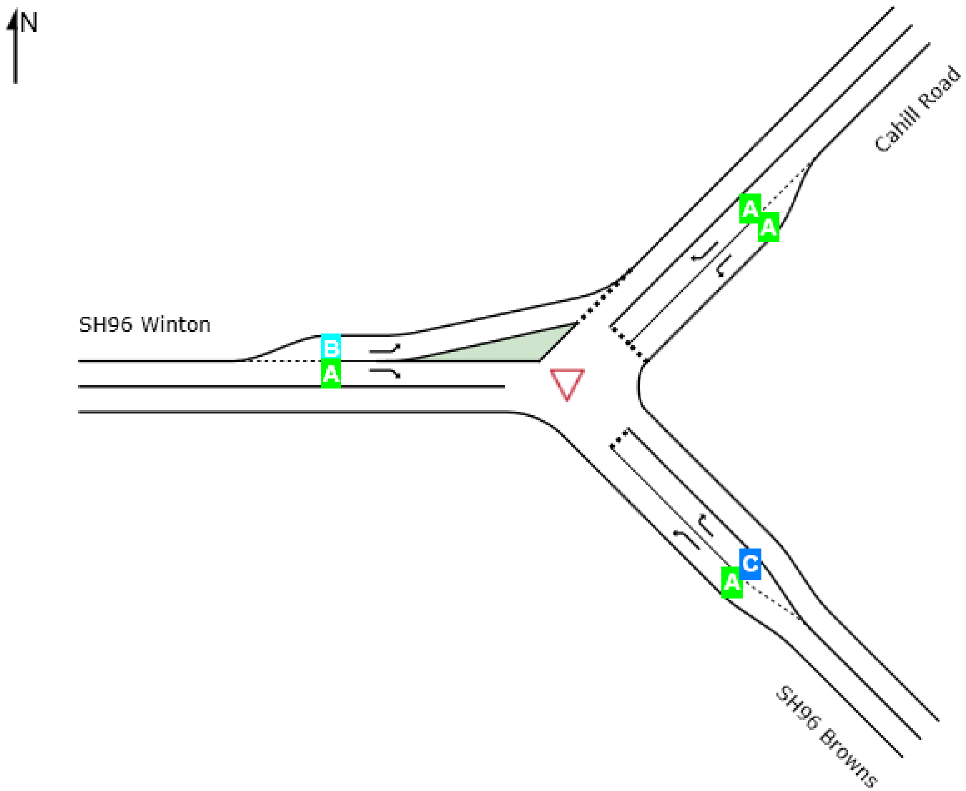
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_25%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	B	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

7.5 Sensitivity Test 1: 2055 – 0% left in from/right out to Winton; 100% right in from/left out to Browns +200HCV

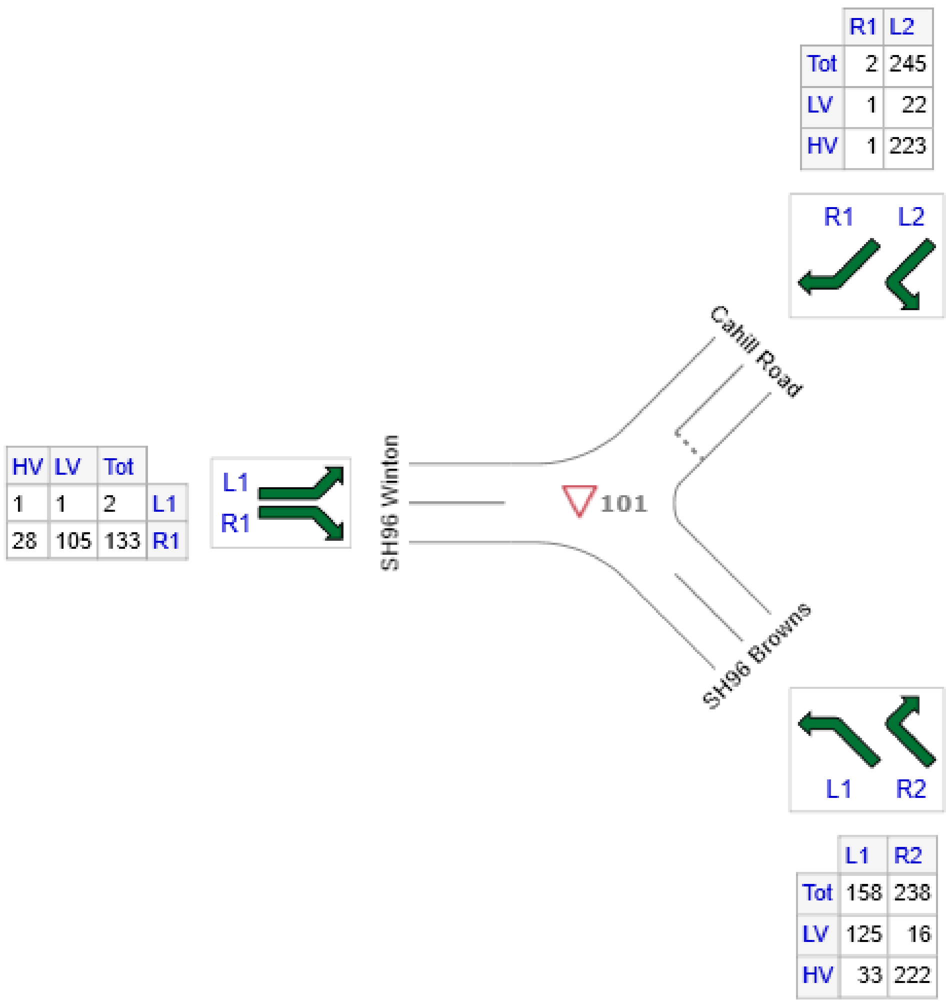
INPUT VOLUMES

Vehicles and pedestrians per 60 minutes

Site: 101 [2055_0%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Volume Display Method: Separate



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
SE: SH96 Browns	396	141	255
NE: Cahill Road	247	23	224
W: SH96 Winton	135	106	29
Total	778	270	508

MOVEMENT SUMMARY

▽ **Site: 101 [2055_0%leftin +200HCV]**

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: SH96 Browns												
21a	L1	166	20.9	0.152	9.0	LOS A	1.1	8.9	0.43	0.38	0.43	65.8
23	R2	251	93.3	0.557	19.2	LOS C	3.7	46.4	0.65	0.99	1.04	45.2
Approach		417	64.4	0.557	15.1	LOS C	3.7	46.4	0.56	0.75	0.80	53.6
NorthEast: Cahill Road												
24	L2	258	91.0	0.278	3.5	LOS A	1.4	16.9	0.37	0.43	0.37	34.7
26a	R1	2	50.0	0.004	4.2	LOS A	0.0	0.1	0.42	0.42	0.42	40.4
Approach		260	90.7	0.278	3.5	LOS A	1.4	16.9	0.37	0.43	0.37	34.8
West: SH96 Winton												
10a	L1	2	50.0	0.002	10.3	LOS B	0.0	0.1	0.44	0.62	0.44	52.5
12a	R1	140	21.1	0.084	7.5	LOS A	0.0	0.0	0.00	0.66	0.00	68.1
Approach		142	21.5	0.084	7.5	LOS A	0.0	0.1	0.01	0.66	0.01	67.9
All Vehicles		819	65.3	0.557	10.1	NA	3.7	46.4	0.41	0.63	0.52	48.8

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
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Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

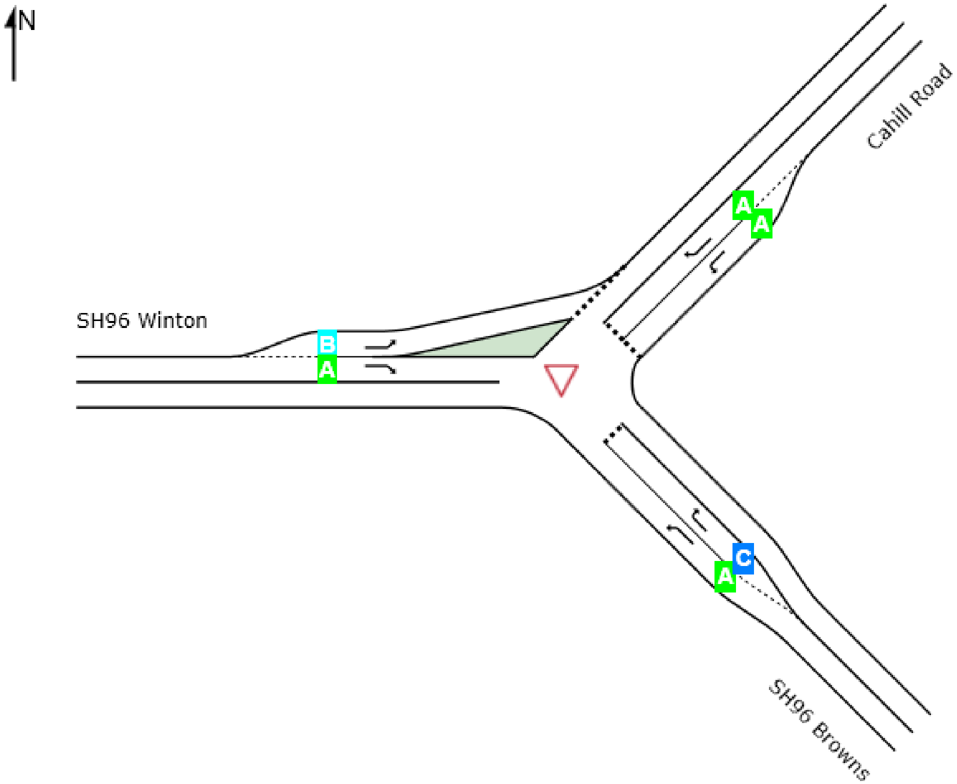
LANE LEVEL OF SERVICE

Lane Level of Service

Site: 101 [2055_0%leftin +200HCV]

SH96 / Cahill Rd
Background traffic (SH96 traffic factored up by 35 years), turning traffic not changed
Site Category: (None)
Giveway / Yield (Two-Way)

	Approaches			Intersection
	Southeast	Northeast	West	
LOS	C	A	A	NA



Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
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SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

AB Lime Limited Resource Consent Application

Preliminary Site Investigation

IZ000400-LFC-NG-RPT-0002 | 1

29 May 2020

AB Lime Limited

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	22 May 2020	Draft Issue	Kate Murray	Charlie Watts	Kevin Tearney	Vince Pace
1	29 May 2020	Final	Kate Murray	Charlie Watts	Kevin Tearney	Vince Pace

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments
0	22 May 2020	22 May 2002	SDC and ES	Draft Issue
1	29 May 2020	29 May 2020	SDC and ES	Final for Lodgement

AB Lime Limited Landfill Resource Consent Application

Project No:	IZ000400
Document Title:	Preliminary Site Investigation
Document No.:	IZ000400-LFC-NG-RPT-0002
Revision:	1
Document Status:	Final
Date:	29 May 2020
Client Name:	AB Lime Limited
Project Manager:	Katrina Jensen
Author:	Kate Murray
File Name:	Preliminary Site Investigation

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Contents

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for landfill management to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

It is imperative to note that the report only considers the likelihood of the presence of contaminants in soil at the site at the date of the assessment. Any decisions based on the findings of the report must consider any subsequent changes in site conditions and/or developments in legislative and regulatory requirements. Jacobs accepts no liability to the Client or any third party for any loss and/or damage incurred as a result of a change in the site conditions and/or regulatory/legislative framework since the date of the report.

Executive Summary

AB Lime Limited have engaged Jacobs New Zealand Limited (Jacobs) to undertake and prepare a resource consent application to expand and increase the accepted tonnage rate associated with landfill operations. The site is located at 10-20 Kings Bend, Winton on land legally described as Part Section 71 and Sections 70, 75, 76, 77 and 78, Block VIII, Winton Hundred and comprises of an operational landfill and active lime quarry.

The purpose of the preliminary site investigation (PSI) is to inform the resource consent application as to whether the newly constructed landfill cell in Area 15, considered to be a *piece of land* defined by the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS), has been or is being subject to an activity or industry described in the Hazardous Activities and Industries List (HAIL) held by Ministry for the Environment (MfE) and therefore subject to the NESCS.

The scope of work for the PSI comprised the following:

- A desktop review of readily available information including historic aerial imagery, Certificates of Title, available Council property files and existing available geological and hydrogeological information, to assess previous and current land uses and the environmental setting;
- Site walkover by a Contaminated Land Specialist (CLS) to view the current site condition and the surrounding environment, and to conduct interviews with relevant personnel to provide anecdotal information about land uses and processes occurring on site;
- Preparation of this PSI report.

A site walkover and review of historical aerial images, the site history and operations documented in this PSI indicate the following:

- The AB Lime site was in agricultural use until 1947 when the limestone quarry was developed
- The current waste disposal operations within former quarried voids commenced in 2004 and continue in conjunction with quarry operations.
- The quarry and landfill site have been operated in accordance with the relevant legislative requirements to the satisfaction of Environment Southland.
- The AB Lime site is identified as HAIL G3 - Landfill sites by Southland Regional Council.
- Area 15, the location of current expansion of the landfill, was formerly quarried and has remained as an open void since excavation ceased in 2018.
- There has been no apparent change to the soil conditions of the *piece of land* that is to be developed as Area 15 as the ground has not come into contact with the landfill waste body, its leachate or its stormwater runoff.

It is therefore considered unlikely that the Area 15 *piece of land* has been subject to an activity or industry described in the HAIL resulting in soil contamination and it is more likely than not that the *piece of land* is not HAIL G3. As such a resource consent under the NESCS is not required.

No significant effect on the health of workers undertaking ground works from soil contamination within the proposed redevelopment area is anticipated and no further contaminated land investigations are considered to be necessary.

1. Introduction

1.1 Background

This report has been prepared for AB Lime Limited (AB Lime) by Jacobs New Zealand Limited (Jacobs). It presents a Preliminary Site Investigation (PSI) to support the resource consent application associated with expanding the current landfill operations at 10-20 Kings Bend, Winton (the site).

1.2 Purpose

The purpose of the PSI is to inform the resource consent application as to whether the newly constructed landfill cell in Area 15, considered to be a *piece of land* defined by the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NESCS), has been or is being subject to an activity or industry described in the Hazardous Activities and Industries List (HAIL) held by Ministry for the Environment (MfE), and therefore subject to the NESCS.

1.3 Scope of Work

The scope of work for the PSI comprised the following:

- A desktop review of readily available information including historic aerial imagery, Certificates of Title, available Council property files and existing available geological and hydrogeological information, to assess previous and current land uses and the environmental setting;
- Site walkover by a Contaminated Land Specialist (CLS) to view the current site condition and the surrounding environment, and to conduct discussions with relevant personnel to provide anecdotal information about land uses and processes occurring on site;
- Preparation of this PSI report.

2. Statutory Context

2.1 Contaminated Land Management Guidelines

The Ministry for the Environment (MfE) has prepared a series of guideline documents to reach a uniform approach to contaminated land management in New Zealand. This PSI report and the methodologies used within it have been undertaken in general accordance with the most recent version of the MfE Contaminated Land Management Guidelines (CLMG) No. 1 – Reporting on Contaminated Sites in New Zealand and CLMG No.5 - Site Investigation and Analysis of Soils.

2.2 Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011

The objective of the (NESCS) is to ensure that land affected/potentially affected by contaminants in soil which may have an adverse effect on human health, is appropriately identified and assessed when soil disturbance and/or a change in land use occurs. This includes, where appropriate, the requirement that contaminants are contained, or the land remediated to make the land safe for human use.

The NESCS applies to specific activities on HAIL sites including sampling, investigating, remediating or disturbing a *piece of land* and changing the use of a *piece of land*. The NESCS contains definitions of several key terms and consenting requirements relevant to this contamination investigation report which are outlined in Attachment 1.

3. Site Description

3.1 Site Location

The site is located at 10-20 Kings Bend, on the corner of Bend Road and Cahill Road, 4km east of the Winton township and approximately 4.5 km north-west from the town of Browns. To the west of the site Bend Road runs north-south, and directly south lies Cahill Road and State Highway 96. The entire site covers an area of approximately 152 hectares at an average elevation downgradient of the quarry site of approximately 80 m above mean sea level (m AMSL). Flanking hills vary between 80 m and 150 m to a maximum elevation of approximately 230 m AMSL.

Limestone quarry operations at the site commenced in 1947, followed by waste disposal into quarried voids commencing in 2004. As shown in Figure 1, the site currently comprises of a capped landfill (Areas 1-12 and part of Area 13) in the southern area of the site, the active landfill (Area 14) and the newly constructed cell (Area 15) in the centre of the site and the active lime quarry in the north. A plan (IZ000400-1000-NG-DRG-1013) is provided in Attachment 2, which shows the layout of the various landfill areas.

The land use surrounding the site is predominantly rural in nature which is characterized rolling agricultural pasture and some plantation forests.

Figure 1: Site Location

3.2 Environmental Setting

3.2.1 Geology and Hydrogeology

According to an Assessment of Environmental Effects report compiled by Sinclair Knight Merz Ltd (2002) the site overlies Oligocene to Miocene age limestone of the Forest Hill Formation. The limestone is considered to have distinctly variable hydraulic characteristics with depth. Above the groundwater table and within approximately 20 m of the ground surface, there is evidence of high secondary permeability through solution cavities and sinkholes. Below the water table, permeability is low and dominated by the matrix properties of the rock mass. The hydraulic characteristics of the underlying siltstone of the Chatton Formation are considered to be similar to that of the overlying non-karst (deep) limestone.

3.2.2 Site Catchment

The site is situated at the south-west base of Winton Hill in a small group of limestone hills located approximately 6 km east of the Oreti River towards the northern end of the Southland Plains. Winton Hill and adjacent hills rise between 80 and 130 m AMSL. Several karstic springs are found in the lime hills, discharging to lowland drains that traverse farmland downstream of the site. These drains join larger streams that are tributaries of the Winton Stream and eventually the Oreti River. The surface drainage on the plains to the south of Winton Hill comprises a dendritic network of shallow drains and natural streams flowing predominantly to the southwest.

3.3 Area 15 Development

Area 15 is 15,543 m^2 in extent and has been under construction since December 2018 to May 2020. Figure 2 shows Area 15 construction progress as at week of the 06/04/2020.

Figure 2: Area 15 construction progress as at week of the 06/04/2020

4. Desktop Investigation

4.1 Certificate of Title

Historic Search Copy and Certificate of Title documentation was obtained on the 21st of April 2020. The documents are provided in Attachment 3 AB Lime Limited have acquired a lot of land surrounding the site since 1914 to allow for a buffer zone for the landfill, with the main site having been solely owned by AB Lime Limited since 1914.

4.1.1 Council Site Records

Southland Regional Council maintains a Contaminated Sites Register to record HAIL information. According to their publicly available information (see Figure 3) the entire site has been identified as HAIL G3, Landfill sites[1].

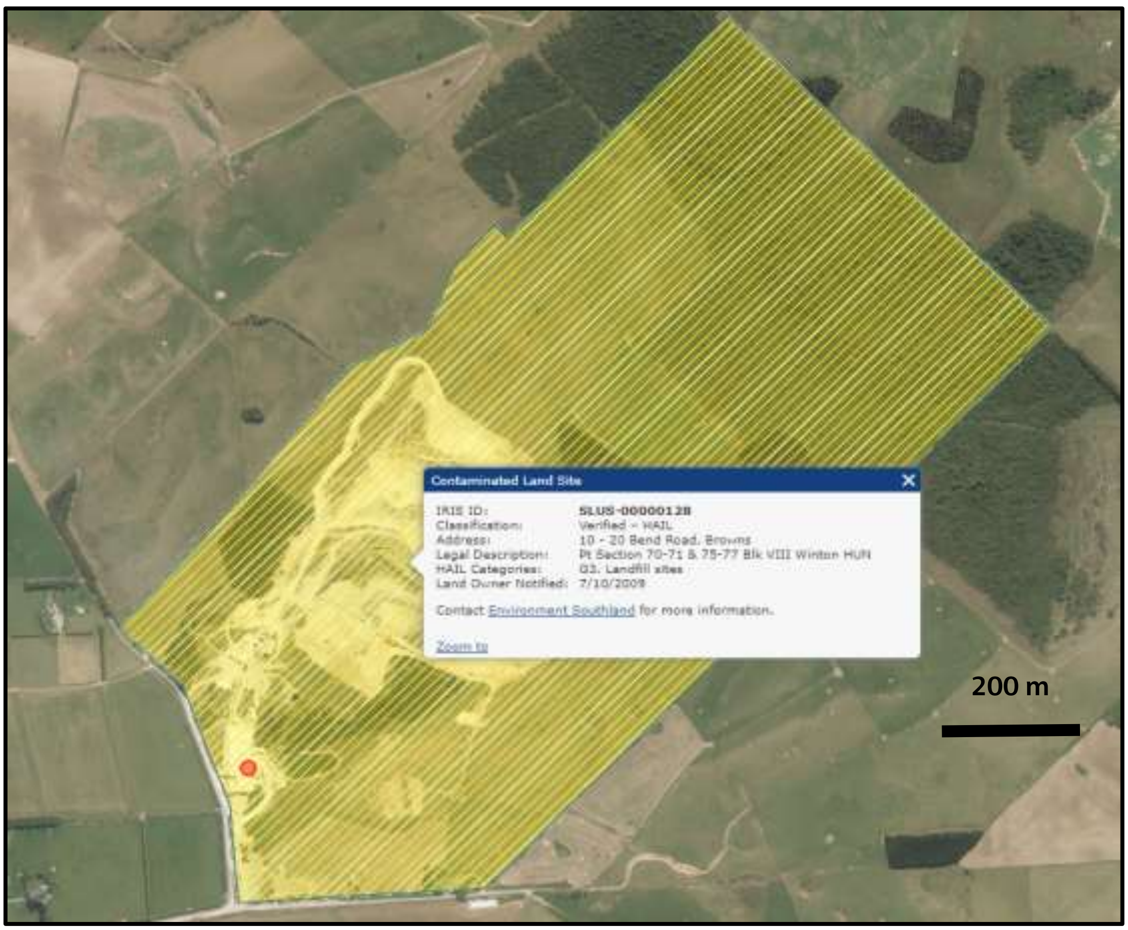


Figure 3: Overall AB Lime site identified as HAIL

[1] http://gis.es.govt.nz/index.aspx?app=contaminated-sites-register

4.2 Site History

Jacobs has undertaken various aspects of technical work for AB Lime since the early 2000s, including obtaining the original consent for the landfill operation. Accordingly, Jacobs holds knowledge of the overall site history and the way the site has been developed and operated which was further substantiated during the site walkover by the CLS.

Current activities on site include the operation of a limestone quarry, processing of limestone and fertiliser and operation of a landfill.

The current quarry began production in 1947. AB Lime obtained consent in the early 2000s to operate a landfill facility and quarry limestone at the site, and waste disposal on site commenced on 1 July 2004.

Table 1 below provides a summary of the development of the site since 2004[2].

Table 1: Summary of events at the AB Lime Landfill

Period	Areas of Waste Placement	Other events
May 2004 – April 2005	Stage 1	• Installment of ground water drainage, compacted clay liner, GCL and HDPE liner
April 2005 – May 2006	Stage 2 – Phase 1	• Leachate reticulation trial – eastern end of stage 1
May 2006 – May 2007	Area 8 – Stage 2	• Installment of leachate recirculation field – south-east corner of site • Two landfill gas collection wells installed
May 2007 – July 2008	Phase 1 – to raise fill to final cover level	• Stormwater bund and pond system constructed – northeast of the landfill • Alternative cover (existing cover 150 mm of clay) consisting of a paper pulp and polymer spray system was implemented
July 2008 – May 2009	Phase 1 – to raise fill to final cover level	• Two areas of capping placed as a trial

[2] AB Lime Landfill Peer Review – Site Inspection Annual Reports 2005-2013, URS New Zealand Limited
AB Lime Landfill – Peer Review Inspection Reports 2017-2019, AECOM Consulting Services (NZ) Ltd
AB Lime Landfill Independent Peer Review Annual Reports 2018 & 2019, John Cocks Limited

June 2009 – April 2010	Area 10 and Phase 1 – to raise fill to final cover level	• Stormwater bund and pond constructed around Area 11 • Permanent gas flare commissioned
April 2010 – May 2011	Area 10 and 11	• Clay and HDPE liner and leachate collection drains completed in Area 11
May 2011 – May 2012	Areas 10, 11 and 12	• Liner and leachate collection system completed in Area 12 • Landfill gas wells completed in Area 10 • First strip of capping on Stage 1 cells completed • Second strip of capping on Stage 1 cells commenced
May 2012 – May 2013	Areas 10, 11 and 12	• Commenced surface landfill gas monitoring • Placed second lift on strip 2 of the final capping
April 2014 – March 2015	Areas 10, 11, 12 and 13	• Stormwater bund for Area 13 completed • Area 13, Stage 1 leachate system completed • Alternative base liner design proposed • Stormwater storage within Area 15
March 2015 – April 2016	Areas 12 and 13	• Area 13, Stage 2 liner and leachate system completed
March 2016 – April 2017	Areas 13 and 14	• Area 14 liner and leachate collection system completed • Temporary separation bund between Area 14 and Area 15 completed (see Area 14 inspection report attached as Attachment 4)
May 2017 – April 2018	Areas 13 and 14	• Stormwater concept design completed for extending the stormwater system to Areas 15 and 16

May 2018 – April 2019	Area 14	• Blinding layer for Area 15 inspected and signed off in January 2019 (see inspection report attached as Attachment 5) • Groundwater collection channels under construction
Dec 2018		• Construction of the centre section of Area 15 commences
January 2020		• Construction of the edge section of Area 15 commences

As evidenced in the aerial photographs attached in Attachment 6, Area 15 was part of the active quarry until 2015 when part of the Area was then used for the storage of clean stormwater for a period until 2018, following which the blinding layer for the area was prepared and completed in 2019 and construction of the new Area 15 commenced in January 2020.

4.3 Site Contamination Mitigation

Landfill operations may present risks to groundwater, surface waters and land. Leachate and surface runoff pose the primary risks of contamination by landfills to surface waters and groundwater that can potentially contaminate land. Sections 4.3.1 to 4.3.4 provide a brief summary of the site contamination mitigation measures for further detail please refer to the following documents:

- Site Stormwater Technical Memo (IZ000400-LFC-NW-RPT-0001);
- Landfill Leachate Technical Memo (IZ000400-LFC-NG-RPT-0008);
- Groundwater Quality Technical Memo (IZ000400-LFC-NW-RPT-0003); and
- Landfill Geotechnical Engineering Technical Memo (IZ000400-LFC-CG-RPT-0001).

4.3.1 Stormwater Management

Within the landfill area there is separation of areas with waste and 'clean' areas. All rainwater collected on lined areas, with any waste already placed, is treated as leachate and drained via the leachate collection system to the leachate pond. Any lined areas that have not been required for immediate waste placement have been separated from the active area by a 500mm bund. Rainwater from these 'clean' areas is drained to the stormwater system.

The quarry stormwater is discharged to an open channel which drains to the stormwater pond. All stormwater from the quarry and the 'clean' landfill working areas drain to the stormwater pond.

4.3.2 Leachate management

As rainfall or surface water passes through the landfill, either through the current tipping area or capped areas, it extracts substances from the waste and becomes leachate. Leachate contains a number of organic and inorganic contaminants, which, if not contained and treated, will pollute waterways.

A leachate collection layer is laid above the landfill liner. A series of perforated and solid pipes laid within the layer will drain leachate by gravity, out of the landfill to a lined leachate storage pond.

A groundwater drainage system is also installed under the liner to relieve groundwater pressure under the liner and act as a leak detection system.

Pipes that collect the groundwater drainage from beneath the landfill drain to the stormwater pond. In the unlikely event that groundwater becomes contaminated then it can be diverted to the leachate pond.

4.3.3 The Liner System

The lining system at the base of the landfill consists of multiple layers to minimise the risk of leachate leaking from the site. Figure 4 below shows the current liner design for Areas 14 and 15 and a photograph taken in 2017 for the AECOM Peer Review report, shows the liner system installation with the lined bund between Areas 14 and 15 being evident (Figure 5).

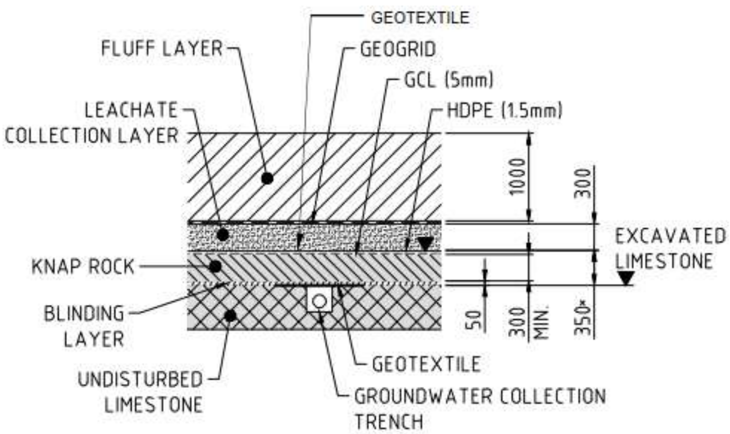


Figure 4: Approved liner design

Figure 5: Historic photo of the view looking west across Areas 13, 14 and 15 showing the liner and bund between Area 14 and 15

4.3.4 Monitoring

Regular monitoring of groundwater and surface water quality is conducted and reported on to assess the effects on the surrounding environment and to ensure that the landfill performs in accordance with the design, operational practices and regulatory requirements. Monitoring reports for the past 5 years have confirmed that there have been no reported environmental incidents including groundwater contamination.

5. HAIL Status of the Site

Since the quarrying of Area 15 or the *piece of land* where the expansion of the current landfill operations is proposed the piece of land has remained as natural ground until preparation for construction of the Area 15 landfill cell began in 2018.

Stormwater bunds along the edges of Area 14 of the landfill have been in existence since the area was developed and stormwater from the existing landfill cells for the duration of the site operation has been channeled, captured and contained in such a way that it does not run off into any of the working cell surrounds. Thus, migration of contamination to the south-west of Area 14 or other areas of the landfill to Area 15 is unlikely.

Monitoring reports for the past five years have confirmed that there have been no reported environmental incidents or migration of contamination.

Whilst the entire site is considered to be a HAIL site under category G3 – Landfill sites, the *piece of land* comprising Area 15 is natural ground. It is unlikely that Area 15 has been subject to an activity or industry described in the HAIL resulting in soil contamination. It is therefore more likely than not that the *piece of land* is not HAIL G3.

On this basis, no resource consent is required under the NESCS.

6. Summary and Conclusions

A site walkover and review of historical aerial images, the site history and operations documented in this PSI indicate the following:

1) The AB Lime site was in agricultural use until 1947 when the limestone quarry was developed
2) The current waste disposal operations within former quarried voids commenced in 2004 and continue in conjunction with quarry operations.
3) The quarry and landfill site have been operated in accordance with the relevant legislative requirements to the satisfaction of Environment Southland.
4) The AB Lime site is identified as HAIL G3 - Landfill sites by Southland Regional Council.
5) Area15, the location of current expansion of the landfill, was formerly quarried and has remained as an open void since excavation ceased in 2018.
6) There has been no apparent change to the soil conditions of the *piece of land* that is to be developed as Area 15, as the ground has not come into contact with the landfill waste body, its leachate or its contaminated stormwater runoff.

It is therefore considered unlikely that the Area 15 *piece of land* has been subject to an activity or industry that could result in soil contamination and it is more likely than not that the *piece of land* is not HAIL G3. As such a resource consent under the NESCS is not required.

No significant effect on the health of workers undertaking ground works from soil contamination within the proposed redevelopment area is anticipated and no further contaminated land investigations are considered to be necessary

Attachment 1. National Environmental Standards for Assessing & Managing Contaminants in Soil to Protect Human Health

As outlined in Section 2.2 the NESCS contains definitions of several key terms and consenting requirements. These key terms and consenting requirements are outlined below.

Regulation 3 - Interpretation

HAIL *means the current edition of the MfE Hazardous Industries and Activities List, Wellington, Ministry for the Environment.*

It is noted that the HAIL currently comprises 53 activities and industries that are considered to have a potential to result in contamination to land due to the hazardous substance use, storage or disposal.

Preliminary site investigation *means an investigation that—*

(a) is done by a suitably qualified and experienced practitioner; and

(b) is reported on in accordance with the current edition of Contaminated Land Management Guidelines No. 1–Reporting on Contaminated Sites in New Zealand, Wellington, Ministry for the Environment; and

(c) results in a report that is certified by the practitioner.

Regulation 5 – Application

(1) These regulations—

(a) apply when a person wants to do an activity described in any of subclauses (2) to (6) on a piece of land described in subclause (7) or (8):

(b) do not apply when a person wants to do an activity described in any of subclauses (2) to (6) on a piece of land described in subclause (9).

Activities

(2) An activity is removing a fuel storage system from the piece of land or replacing a fuel storage system in or on the piece of land, which means—

(a) doing any of the following:

(i) removing or replacing the whole system:

(ii) removing or replacing an underground part of the system:

(iii) taking away or putting back soil associated with the removal or replacement of the system or the part:

(b) doing any of the following for purposes associated with removing or replacing the whole system or part of the system:

(i) sampling the soil of the piece of land:

(ii) investigating the piece of land:

(iii) remediating the piece of land:

(iv) validating the piece of land:

(v) managing the piece of land.

(3) An activity is sampling the soil of the piece of land, which means sampling it to determine whether or not it is contaminated and, if it is, the amount and kind of contamination.

(4) An activity is disturbing the soil of the piece of land, which—

(a) means disturbing the soil of the piece of land for a particular purpose:

(b) does not include disturbing the soil of the piece of land, whatever the purpose, if the land is land to which regulation 33(9) or 36 of the Resource Management (National Environmental Standard for Electricity Transmission Activities) Regulations 2009 applies.

(5) An activity is subdividing land, which means subdividing land—

(a) that has boundaries that are identical with the boundaries of the piece of land; or

(b) that has all the piece of land within its boundaries; or

(c) that has part of the piece of land within its boundaries.

(6) An activity is changing the use of the piece of land, which means changing it to a use that, because the land is as described in subclause (7), is reasonably likely to harm human health.

Land covered

(7) The piece of land is a piece of land that is described by 1 of the following:

(a) an activity or industry described in the HAIL is being undertaken on it:

(b) an activity or industry described in the HAIL has been undertaken on it:

(c) it is more likely than not that an activity or industry described in the HAIL is being or has been undertaken on it.

(8) If a piece of land described in subclause (7) is production land, these regulations apply if the person wants to—

(a) remove a fuel storage system from the piece of land or replace a fuel storage system in or on the piece of land:

(b) sample or disturb—

(i) soil under existing residential buildings on the piece of land:

(ii) soil used for the farmhouse garden or other residential purposes in the immediate vicinity of existing residential buildings:

(iii) soil that would be under proposed residential buildings on the piece of land:

(iv) soil that would be used for the farmhouse garden or other residential purposes in the immediate vicinity of proposed residential buildings:

(c) subdivide land in a way that causes the piece of land to stop being production land:

(d) change the use of the piece of land in a way that causes the piece of land to stop being production land.

Land not covered

(9) These regulations do not apply to a piece of land described in subclause (7) or (8) about which a detailed site investigation exists that demonstrates that any contaminants in or on the piece of land are at, or below, background concentrations.

<u>Regulation 6 – Methods</u>

(1) Subclauses (2) and (3) prescribe the only 2 methods that the person may use for establishing whether or not a piece of land is as described in regulation 5(7).

(2) One method is by using information that is the most up-to-date information about the area where the piece of land is located that the territorial authority—

(a) holds on its dangerous goods files, property files, or resource consent database or relevant registers; or

(b) has available to it from the regional council.

(3) The other method is by relying on the report of a preliminary site investigation—

(a) stating that an activity or industry described in the HAIL is, or is not, being undertaken on the piece of land; or

(b) stating that an activity or industry described in the HAIL has, or has not, been undertaken on the piece of land; or

(c) stating the likelihood of an activity or industry described in the HAIL being undertaken, or having been undertaken, on the piece of land.

(4) The person must—

(a) choose which of the 2 methods to use; and

(b) meet all the costs involved in using the method that the person has chosen.

<u>Regulation 7(1) – Land Use</u>

(1) In this regulation,—

***land use** means—*

(a) the current use, if the activity the person wants to do is—

(i) to remove a fuel storage system from the piece of land or replace a fuel storage system in or on the piece of land:

(ii) to sample the soil of the piece of land:

(iii) to disturb the soil of the piece of land:

(b) the intended use, if the activity the person wants to do is—

(i) to subdivide land:

(ii) to change the use of the piece of land

Regulation 8 – Permitted Activities

Regulation 8 describes a number of permitted activities associated with the NESCS. Regulation 8(3) and 8(4) are relevant to this PSI report.

Disturbing soil

(3) Disturbing the soil of the piece of land is a permitted activity while the following requirements are met:

(a) controls to minimise the exposure of humans to mobilised contaminants must—

(i) be in place when the activity begins:

(ii) be effective while the activity is done:

(iii) be effective until the soil is reinstated to an erosion-resistant state:

(b) the soil must be reinstated to an erosion-resistant state within 1 month after the serving of the purpose for which the activity was done:

(c) the volume of the disturbance of the soil of the piece of land must be no more than 25 m^3 *per 500* m^2*:*

(d) soil must not be taken away in the course of the activity, except that,—

(i) for the purpose of laboratory analysis, any amount of soil may be taken away as samples:

(ii) for all other purposes combined, a maximum of 5 m^3 *per 500* m^2 *of soil may be taken away per year:*

(e) soil taken away in the course of the activity must be disposed of at a facility authorised to receive soil of that kind:

(f) the duration of the activity must be no longer than 2 months:

(g) the integrity of a structure designed to contain contaminated soil or other contaminated materials must not be compromised."

Regulation 8(4)

Regulation 8(4) is a permitted activity for subdividing or changing the use of the land as follows:

Subdividing or changing use

(4) Subdividing land or changing the use of the piece of land is a permitted activity while the following requirements are met

(a) a preliminary site investigation of the land or piece of land must exist:

(b) the report on the preliminary site investigation must state that it is highly unlikely that there will be a risk to human health if the activity is done to the piece of land:

(c) the report must be accompanied by a relevant site plan to which the report is referenced:

(d) the consent authority must have the report and the plan

Regulation 9 – Controlled Activities

Regulation 9 describes a number of controlled activities associated with the NESCS. Regulation 9(1) and 9(2) are relevant to this PSI report.

Removing or replacing fuel storage system, sampling soil, or disturbing soil

(1) If a requirement described in any of regulation 8(1) to (3) is not met, the activity is a controlled activity while the following requirements are met:

(a) a detailed site investigation of the piece of land must exist:

(b) the report on the detailed site investigation must state that the soil contamination does not exceed the applicable standard in regulation 7:

(c) the consent authority must have the report:

(d) conditions arising from the application of subclause (2), if there are any, must be complied with.

(2) The matters over which control is reserved are as follows:

(a) the adequacy of the detailed site investigation, including—

(i) site sampling:

(ii) laboratory analysis:

(iii) risk assessment:

(b) how the activity must be—

(i) managed, which may include the requirement of a site management plan:

(ii) monitored:

(iii) *reported on:*

(c) *the transport, disposal, and tracking of soil and other materials taken away in the course of the activity:*

(d) *the timing and nature of the review of the conditions in the resource consent:*

(e) *the duration of the resource consent.*

Regulation 10

Regulation 10 describes the restricted discretionary activities associated with the NESCS. Regulation 10(2) and 10(3) are relevant to this PSI report.

(2) *The activity is a restricted discretionary activity while the following requirements are met:*

(a) *a detailed site investigation of the piece of land must exist:*

(b) *the report on the detailed site investigation must state that the soil contamination exceeds the applicable standard in regulation 7:*

(c) *the consent authority must have the report:*

(d) *conditions arising from the application of subclause (3), if there are any, must be complied with.*

(3) *The matters over which discretion is restricted are as follows:*

(a) *the adequacy of the detailed site investigation, including—*

(i) *site sampling:*

(ii) *laboratory analysis:*

(iii) *risk assessment:*

(b) *the suitability of the piece of land for the proposed activity, given the amount and kind of soil contamination:*

(c) *the approach to the remediation or ongoing management of the piece of land, including—*

(i) *the remediation or management methods to address the risk posed by the contaminants to human health:*

(ii) *the timing of the remediation:*

(iii) *the standard of the remediation on completion:*

(iv) *the mitigation methods to address the risk posed by the contaminants to human health:*

(v) *the mitigation measures for the piece of land, including the frequency and location of monitoring of specified contaminants:*

(d) *the adequacy of the site management plan or the site validation report or both, as applicable:*

(e) *the transport, disposal, and tracking of soil and other materials taken away in the course of the activity:*

(f) *the requirement for and conditions of a financial bond:*

(g) *the timing and nature of the review of the conditions in the resource consent:*

(h) *the duration of the resource consent.*

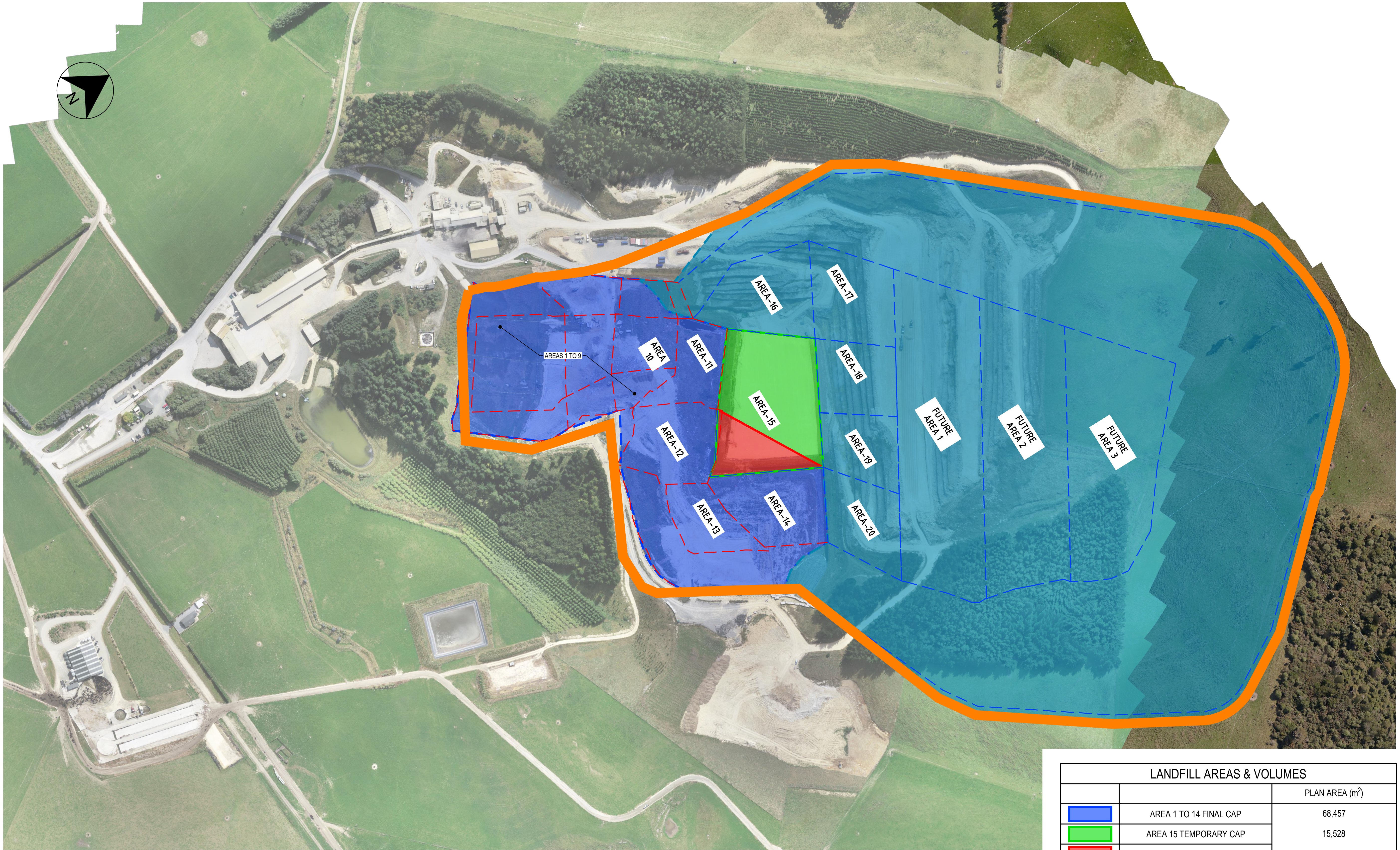
Regulation 11

Regulation 11 describes the discretionary activities associated with the NESCS. Regulation 11 is relevant to this PSI report.

(1) This regulation applies to an activity described in any of regulation 5(2) to (6) on a piece of land described in regulation 5(7) or (8) that is not a permitted activity, controlled activity, or restricted discretionary activity.

(2) The activity is a discretionary activity.

Attachment 2. Drawing



LANDFILL AREAS & VOLUMES

		PLAN AREA (m^2)
(blue)	AREA 1 TO 14 FINAL CAP	68,457
(green)	AREA 15 TEMPORARY CAP	15,528
(red)	AREA 15 WORKING AREA	3,882
(light blue, dashed)	AREA 16 TO FUTURE AREA 3 LANDFILL	296,157

CONSENT ISSUE

REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

AB LIME

Jacobs

Level 2, Wynn Williams Building
47 Hereford Street
CHRISTCHURCH CENTRAL 8013
NEW ZEALAND

Tel: +64 3 940 4900
Fax: +64 3 940 4901
Web: www.jacobs.com

CLIENT: AB LIME LTD.

PROJECT: LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
NBL	KJ	CW	VP
DESIGNED: WS	DESIGN REVIEW: BC	DATE 29.05.20	DATE 29.05.20

TITLE: LANDFILL CAPPING STATUS WHEN AREA 15 IS ACTIVE PLAN

SCALE: AS SHOWN
DRAWING No: IZ000400-1000-NG-DRG-1013
REV: A

A1

Attachment 3. Historic Search Copy and Certificate of Title documentation

RECORD OF TITLE
UNDER LAND TRANSFER ACT 2017
FREEHOLD
Search Copy

R.W. Muir
Registrar-General
of Land

Identifier	**SL102/10**
Land Registration District	**Southland**
Date Issued	24 November 1914

Prior References
SLPR30/151 WA 386

Estate	Fee Simple
Area	88.3884 hectares more or less
Legal Description	Section 70 Block VIII Winton Hundred

Registered Owners
A B Lime Limited

Interests

255248.1 CERTIFICATE UNDER SECTION 37 BUILDING ACT 1991 (AFFECTS CT SLB1/1451) - 14.1.1998 AT 9.12 AM

6021217.1 Bond pursuant to Section 108(2)(b) Resource Management Act 1991 - 27.5.2004 at 9:00 am

6100224.1 Encumbrance to The Gore District Council, The Southland District Council and The Invercargill City Council - 2.8.2004 at 9:00 am

9747831.4 Mortgage to Westpac New Zealand Limited - 2.7.2014 at 9:04 am

10079000.3 Variation of Mortgage 9747831.4 - 2.6.2015 at 3:34 pm

Transaction Id *Search Copy Dated 21/04/20 5:05 pm, Page 1 of 2*
Client Reference *IZ000400, A.P4.EV.LFC* *Register Only*

Attachment 4. Area 14 Inspection Report

Phase 4 Quality Control and Quality Assurance Standard

JACOBS

INSPECTION FORM

Project: Area 14

Project No.:

Report No.: A14-011

Contract Title: A14 - Building Temp Bund

Contract No.:

Contractor/Supplier: Area 14/15 ABLime

Inspection Requested by: Fiona Smith.

Date of Inspection: 27-02-17

Time: (in 24 hrs)

ITP Activity No./Feature description: Temporary Bund Instalation between Areas 14+15

Drawing No:

Feature Location: Between Prepared site 14 and Unprepared site 15

Reason for Inspection: Correct construction and completion.

Inspection Report:

- leachate pipe installation ✓ as per AE 03541.18-ECC-DG0222 (attached)
- Bund Material (old Bund between Area 13/14 + Knap)
- Survey of leachate pipes ✓ True South (attached)
- Lined as per diagram detail AE 03541.18-ECC-DG0222 attached.
- Photos attached.

Work Passed: Passed

Work to be re-inspected: No

Photographic Evidence-Film No: attached.

Samples/Evidence Collected: as attached

Photo Nos: Photos on dropbox

Recommendations: Signoff.

NOTE: This is an inspection report only and does not authorise a Contract Variation or Extension of Time to the Contract. Any claims or extensions of time shall be made in accordance with the terms of the contract.

Inspected by: Fiona Smith

Date: 27-02-17.

WHO	REQUESTED ACTION	SIGN/DATE

28

Attachment 5. Area 15 blinding layer inspection report

Quality Assurance and Quality Control Standard

JACOBS

INSPECTION FORM

Project: Area 15 Landfill
Project No.:
Report No.: Area 15/02

Contract Title: Area 15 - Blinding Layer
Contract No.:

Contractor/ Supplier: ABLime

Inspection Requested by: Fiona Smith
Date of Inspection:
Time: (in 24 hrs)

ITP Activity No./ Feature description: Blinding Layer Inspection & Signoff

Drawing No.:

Feature Location: Area 15 Blinding Layer - ~ 10,000 m²

Reason for Inspection: Ensure layer proof rolled & meets QA/tech specs.

Inspection Report: 11/01/2019: Jim Bowman present to test compaction
NDM results = mean value over 21 sites = 100.2% (All ≥95%).
MC results = 12.1% average (hot dry day when rolling & testing)
Clegg results (optional) = clegg not available due to calibration hold up @ Geotech:

TrueSouth to survey blinding layer - results attached.
- minimum 50mm deep. 14/01/19
± 20mm variance for GPS.

Work Passed: NDM - passed ≥95% (attached).
MC - N/A as per structural fill testing requirements
depth - average 65mm depth.

Work to be re-inspected:
No.

Photographic Evidence- Film No:
Photo Nos: Photos Taken by contractors and attached.

Samples/Evidence Collected: Photos on file Dropbox: Construction Photos/Area 15/2. BlindingLayer.

Recommendations:

NOTE: This is an inspection report only and does not authorise a Contract Variation or Extension of Time to the Contract. Any claims or extensions of time shall be made in accordance with the terms of the contract.

Inspected by: Fiona Smith. Date:

WHO	REQUESTED ACTION	SIGN/DATE

Distribution: Contractor ☐ Client/AB Lime ☐ Project File ☐ Site ☐ Form 4035

Sent to Jacobs: Louise Wilson on

Attachment 6. Aerial Photographs

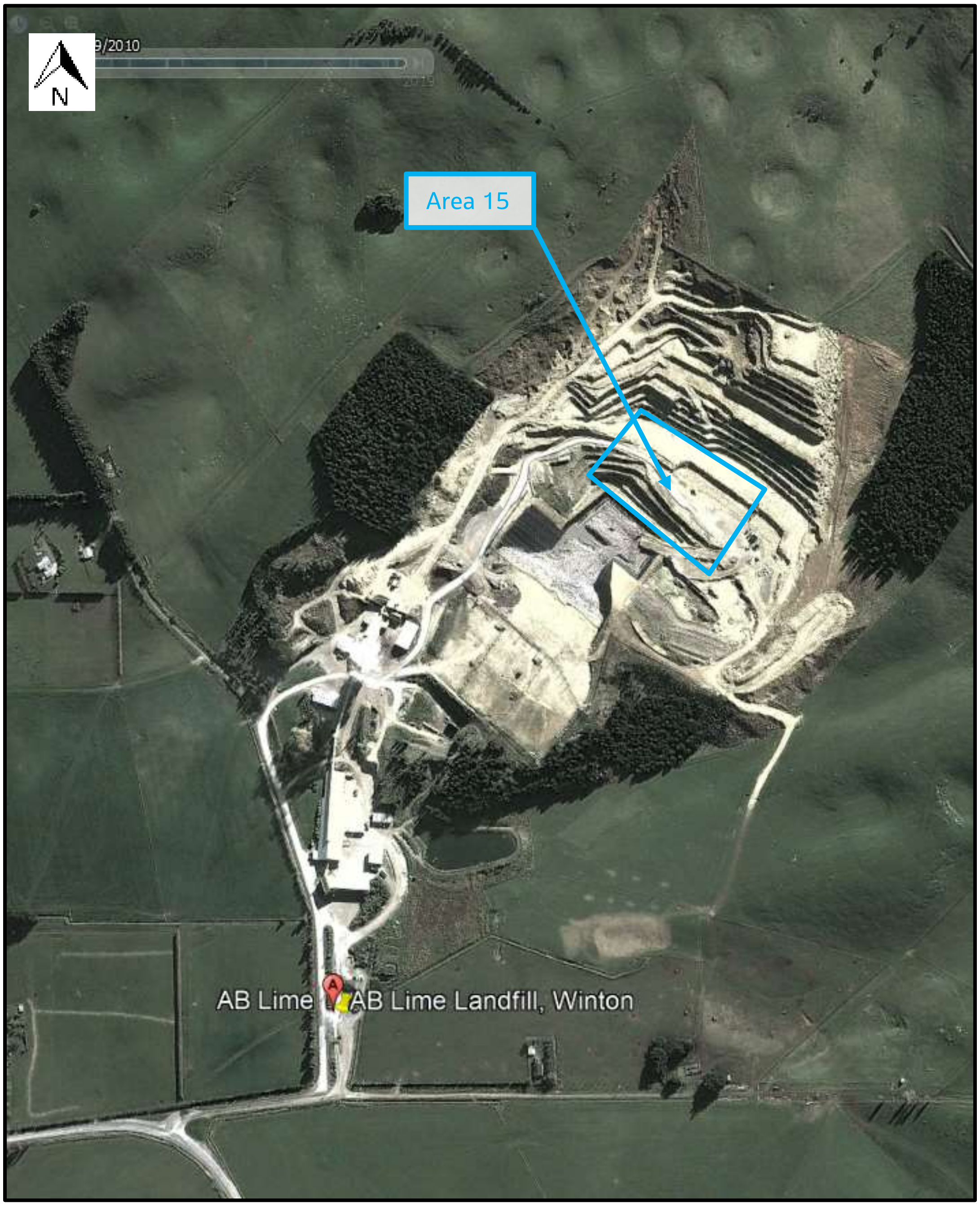


Photo 1: Aerial photograph of the site in 2010 (Google Earth)

Photo 2: Aerial photograph of the site in 2012 (Google Earth)

Photo 3: Aerial photograph of the site in 2013 (Google Earth)

Photo 4: Aerial photograph of the site in 2015 (Google Earth)

Photo 5: Aerial photograph of the site in 2018 (Google Earth)

Photo 6: Aerial photograph of the site in 2018 (Google Earth)

Photo 7: Aerial photograph of the site in 2019 (Google Earth)

AB Lime Limited Resource Consent Application

Predicted Lifespan and Capacity of the AB Lime Landfill

IZ000400-LFC-NG-RPT-0004 | 1

29 May 2020

AB Lime Limited

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	22 May 2020	Draft Issue	Kate MacDonald & Donné Wallace-Hunter	Ryan McCone	Charlie Watts	Vince Pace
1	29 May 2020	Final	Kate MacDonald & Donné Wallace-Hunter	Ryan McCone	Charlie Watts	Vince Pace

Distribution of copies

Revision	Issue approved	Date issued	Issued to	Comments
0	22 May 2020	22 May 2020	SDC and ES	Draft Issue
1	29 May 2020	29 May 2020	SDC and ES	Final for Lodgement

AB Lime Limited Resource Consent Application

Project No:	IZ000400
Document Title:	Predicted Lifespan and Capacity of the AB Lime Landfill
Document No.:	IZ000400-LFC-NG-RPT-0004
Revision:	1
Document Status:	Final
Date:	29 May 2020
Client Name:	AB Lime Limited
Project Manager:	Katrina Jensen
Author:	Kate MacDonald
File Name:	Landfill Capacity and Lifespan Technical Memo

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Contents

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for landfill management to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Executive Summary

Having successfully operated the landfill since 2004, AB Lime now wish to expand their ability to accept waste in order to become the premier landfill for the southern regions of the South Island. The overarching objective is to future proof the landfill so that it is well positioned to accept waste from a wider range of locations and in a majority of circumstances.

Importantly, AB Lime would like to provide for the inclusion of waste acceptance in emergency response scenarios as New Zealand works towards having fewer but better managed landfills. The proposal seeks a change to the current 100,000 tonne discharge limit of accepted landfill waste per year and establishes an environmental management framework as a catalyst for managing the potential and actual effects on the environment from landfill operations. It is important to note that AB Lime is not proposing to change the footprint, the final area, or capacity of the landfill. The changes to be effected through this consent will allow the landfill to be filled at an increased rate, should there be a need to do so.

From June 2004 to the end of 2019, AB Lime has accepted 839,100 t of waste, averaging 52,445 tonne per year (t/yr). The landfill itself has a total of 24.9 million m^3 capacity, of which 956,281 m^3 has already been filled. In order to provide for future land management planning, the lifespan of the landfill needs to be investigated to determine the different rate it could fill up given difference waste acceptance scenarios.

This report will analyse the projected lifespan of the landfill under three different scenarios:

1. Continued acceptance of waste with projected growth

    A) without a 100,000 t waste acceptance limit; and

    B) with a 100,000 t waste acceptance limit.

2. Acceptance of waste from all of the lower South Island with no waste acceptance limit

The results of this report determined the approximate lifespan of the landfills under different waste acceptance scenarios. The findings are summarised as follows:

- **Scenario 1a:** Based on current acceptance data, when projected into the future waste acceptance is likely to exceed the current consent limit of 100,000 t/yr by 2065. Without a waste acceptance limit, in this scenario the landfill is likely to reach capacity by 2190.

- **Scenario 1b:** Based on current acceptance data and consent conditions, when projected into the future and a maximum of 100,000 t/yr is accepted from 2065 onwards, the landfill is likely to reach full capacity around 2255.

- **Scenario 2:** When projecting waste acceptance from the lower South Island with no waste acceptance limit, the landfill is likely to be filled by 2061. Under this scenario, from 2021 onwards the waste acceptance would exceed the current consent conditions of 100,000 t/yr.

1. Purpose of this Report

AB Lime Limited propose to become the premier landfill for the southern regions of the South Island with an overarching objective to future proof the landfill to be well positioned to accept waste in a majority of circumstances. Importantly, AB Lime would like to provide for the inclusion of waste acceptance for crisis and emergency response scenarios as New Zealand works towards having fewer but better managed landfills.

From June 2004 to the end of 2019, AB Lime has accepted 839,100 t of waste, averaging 52,445 tonnes per year (t/yr). The landfill itself has a total of 24.9 million m^3 capacity, of which 956,281 m^3 has already been filled. In order to provide for future land management planning, the lifespan of the landfill needs to be investigated to determine the different rate it could fill up given difference waste acceptance scenarios.

This report will analyse the projected lifespan of the landfill under three different scenarios:

1. Continued acceptance of waste with projected growth

   A) without a 100,000 t waste acceptance limit

   B) with a 100,000 t waste acceptance limit

2. Acceptance of waste from all of the lower South Island with no waste acceptance limit

The three scenarios represent a continued 'business as usual' approach both with and without the removal of the current 100,000 t per year waste acceptance limit; and a 'worst case' scenario which demonstrates the likely shortest lifespan possible by accepting all waste from the lower South Island. These projections are based on current waste acceptance and population data, and have been projected forward excluding and crisis situations or emergency responses. The calculation of lifespan also accounts for the conversion of Tonnage to m^3, in which compaction of the waste in the landfill is accounted for.

The report structure is as follows:

- Section 2 will present an overview of the methods used to project future waste acceptance and lifespans of the landfill;
- Section 3 will present the results of Scenarios 1 and 2; and
- Section 4 will summarise the findings of this report.

2. Methods

The following outlines the methods used to determine the lifespan of the landfill under two different waste acceptance scenarios:

1. Continued acceptance of waste with projected growth

   A) without a 100,000 t waste acceptance limit

   B) with a 100,000 t waste acceptance limit

2. Acceptance of waste from all of the lower South Island with no waste acceptance limit

2.1 Waste Density

The density of waste is calculated in order to determine how much volume on the landfill is being filled by the waste tonnage previously accepted. This was determined using waste acceptance data from AB Lime (tonnage) and comparing it to the amount of volume currently filled (as of 12 March 2020). Key parameters used to determine the waste density are outlined below in Table 1. The current waste density based on the acceptance data and current volume in the landfill is 0.94 t/m^3. This value includes 5% to account for the volume of the daily cover, which will be denser than the waste.

An annotated diagram with further visual explanation of these parameters is attached in Attachment 1.

Table 1: Key Parameters of Landfill Void Space Volumes and Waste Acceptance to Date to Determine the Density of Waste at AB Lime.

Parameter	Calculated
Accepted Waste	
Total tonnage accepted over the weigh bridge between 2004 and end of 2018, as per AB Lime Annual Report No. 5	770,300 tonnes
Assumed tonnage received at landfill between Jan 2019 and March 2020 (Drone survey 12 March 2020)	85,000 tonnes
Total tonnage of 'weigh bridge' waste	855,300 tonnes
Landfill	
Total Landfill volume (Pre-settlement)	24.9 million m^3
Available Volume (Pre-settlement)	23.9 million m^3
Filled: Total m^3 in Areas 1-14 less 1m thick cap	956,281 m^3
Available Limestone	8.7 million m^3
Overburden and waste ratio	1.2
Density	
Density of Waste	0.94 t/m^3

2.2 Waste Acceptance Data and Projection

2.2.1 Scenario 1: Continued acceptance of waste with projected growth.

Waste acceptance data was provided by AB Lime from June 2004 to December 2019, which recorded the tonnage of waste accepted into the landfill since operations begun. This data is presented below in Table 2.

Table 2: AB Lime Annual Waste Tonnages from June 2004 to 2019.

Year	Annual Totals (t)	Accumulative Tonnage (t)	Year	Annual Totals (t)	Accumulative Tonnage (t)
2004 (from June)	27,914	27,914	2012	50,463	450,593
2005	51,763	79,677	2013	47,974	498,567
2006	54,608	134,285	2014	47,823	546,390
2007	62,753	197,038	2015	58,173	604,563
2008	55,826	252,864	2016	50,505	655,069
2009	49,573	302,436	2017	53,671	708,739
2010	48,648	351,084	2018	61,560	770,299
2011	49,046	400,130	2019	68,799	839,098
Total	**839,098**				
Average	**52,444**				

As can be seen from the table, on average 52,443 t of waste has been accepted per year since operations at the landfill begun in June 2004. A total of 839,098 t of waste has been accepted into the landfill in total on record. Overall, past acceptance of waste has been in the order of 50,000 – 70,000 tonnes per year.

The data indicates that acceptance of waste is likely to increase over the next 35 years. At the time of this report, data for 2020 was not available, and therefore for projection purposes an estimate of 60,000 t was assumed for this year.

Based on the current waste acceptance data, acceptance rates were projected forward to determine the lifespan of the landfill. These projections were based on the following linear relationships:

$$Tonnes:\quad Y = 922.32X + 44604$$

$$Volume\ (m^3):\quad Y = 678.2X + 32797$$

2.2.2 Scenario 2: Acceptance of all waste from the lower South Island

The second waste acceptance scenario considered in this report is the acceptance of waste from the lower South Island (south of and including Timaru), as shown in Figure 1 below. The population of the shaded blue area is 378,033 people[1] which equates to 8% of the New Zealand population. NZ total waste acceptance in Class 1 landfills[2] was used to determine the projected waste acceptance if the landfill was to accept all waste from the lower South Island.

Over the 10 years between 2009-2019, total accepted waste at Class 1 landfills across New Zealand increased in the order to 45% from 2.5 million tonnes to 3.6 million tonnes. When considering the total waste in the lower South Island in relation to this data and assuming a constant 8% population value over this time period, waste in the lower South Island has increased from 200,000 t/yr to 240,000 t/yr.

[1] 2018 New Zealand Census data from www.stats.govt.nz
[2] Ministry for the Environment (2019) Reducing waste: A more effective landfill levy consultation document.

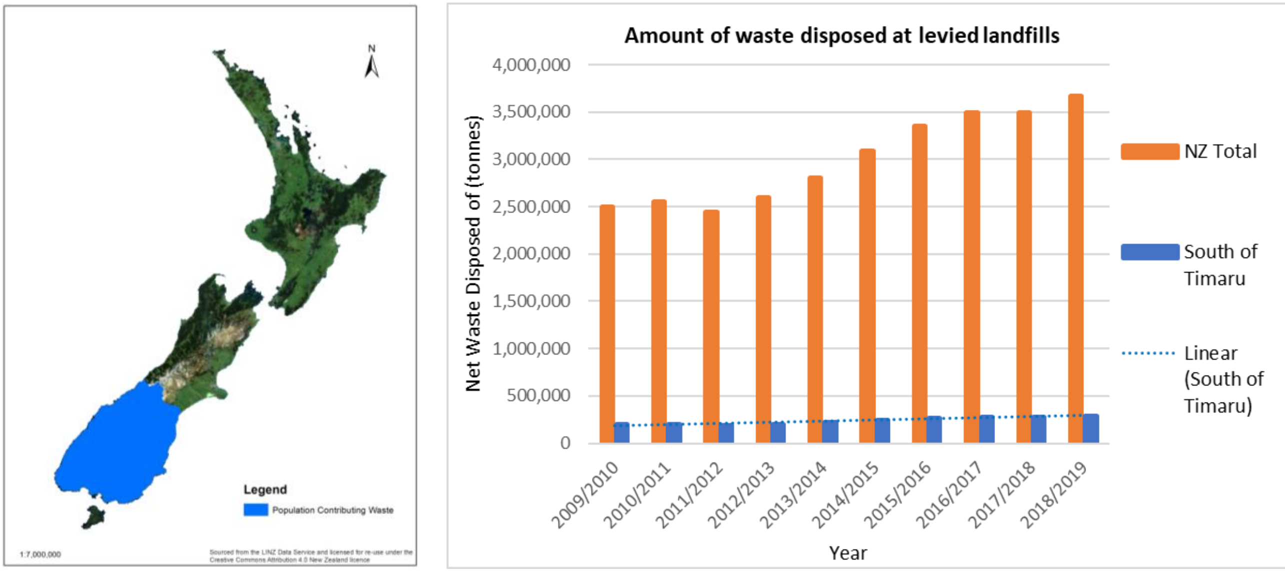


Figure 1 Area Considered in Scenario Two as the Lower South Island (left) and Total Amounts of Waste Disposed at Class 1 Landfills in NZ Compared to the 8% Totals for the Lower South Island (right).

Based on these assumptions, projected waste acceptance for the lower South Island was determined using the following linear relationships:

$$Tonnes: \quad Y = 12069X + 173843$$

$$Volume\ (m^3): \quad Y = 8874.6X + 127825$$

A summary of the scenario projections is presented in 10 yearly intervals until 2200 or until capacity is reached is presented in Attachment 2.

3. Landfill Lifespans

3.1 Scenario 1a: Continued acceptance of waste based on current data with no waste acceptance limit

Waste Acceptance

Scenario 1a is the continued acceptance of waste based on current data which is projected forward with no 100,000 t limit. Figure 2 below shows the projected future waste acceptance based on this data. Waste acceptance in this scenario is likely to exceed the current 100,000 t acceptance limit around 2065. By 2150, waste acceptance is likely to be in the order of 180,000 t/yr.

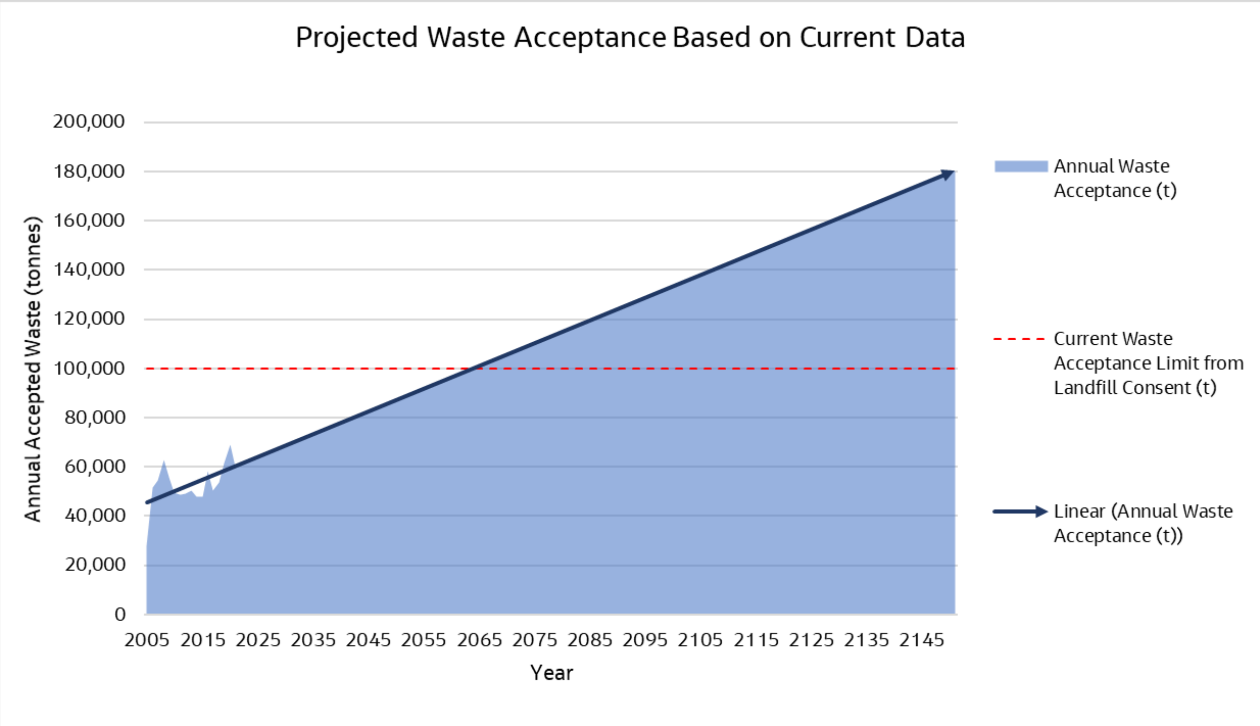


Figure 2 Projected Waste Acceptance Based on the Trend of AB Lime Waste Acceptance Data from 2004-2019. (The red dotted line represents the current landfill consent in which the landfill can accept 100,000 t/yr of waste)

Landfill Lifespan

The lifespan of the landfill under Scenario 1a is presented in blue in Figure 3 below. The projection shows that the landfill is likely to be filled by 2190 assuming there is no future limit of waste accepted. In this scenario, waste acceptance exceeds 100,000 t/yr by 2065 and reaches 200,000 t/yr by 2172.

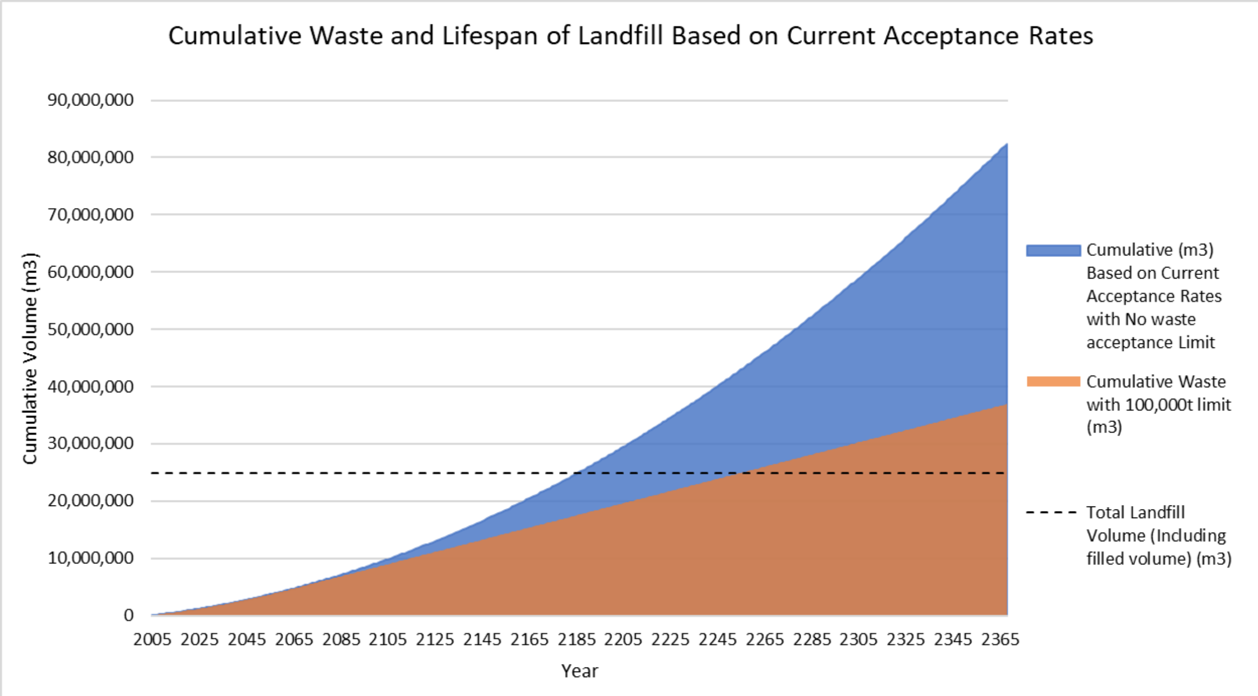


Figure 3 Lifespan of the Landfill Based on Current Waste Acceptance Data. (The blue area shows continued acceptance of waste with no waste acceptance limit, which fills the landfill by 2190. The orange area shows continued acceptance based on the current data but reaches a 100,000 t acceptance limit and only accepts 100,000 t from then onwards. The landfill reaches capacity at 2255 in this scenario)

3.2 Scenario 1b: Continued acceptance of waste based on current data with 100,000 t waste acceptance limit

Waste Acceptance

Scenario 1b is the continued acceptance of waste based on current data which is projected forward with the current 100,000 t limit. As demonstrated in Figure 2, the projected data shows annual waste acceptance will exceed 100,00 t around 2065. In this scenario, at 2065 waste acceptance limits are capped at 100,000 t/yr until the landfill has reached full capacity.

Landfill Lifespan

The lifespan of the landfill under Scenario 1b is presented in Figure 3 above. Continued filling of that landfill at 100,000 t from 2065 onwards will result in the landfill reaching full capacity around 2255.

3.3 Scenario 2: Acceptance of all waste from the lower South Island with no waste acceptance limit

Waste Acceptance

The projected waste acceptance in Scenario 2 calculated using the methods outlined in Section 2.2.2 is presented below in Figure 4. The projected waste from the lower South Island instantly exceeds the 100,000 t current consent limit in 2021. It is possible that in 2021 waste acceptance could be in the order of 320,000 t/yr, which increases to 670,000 t/yr by 2050.

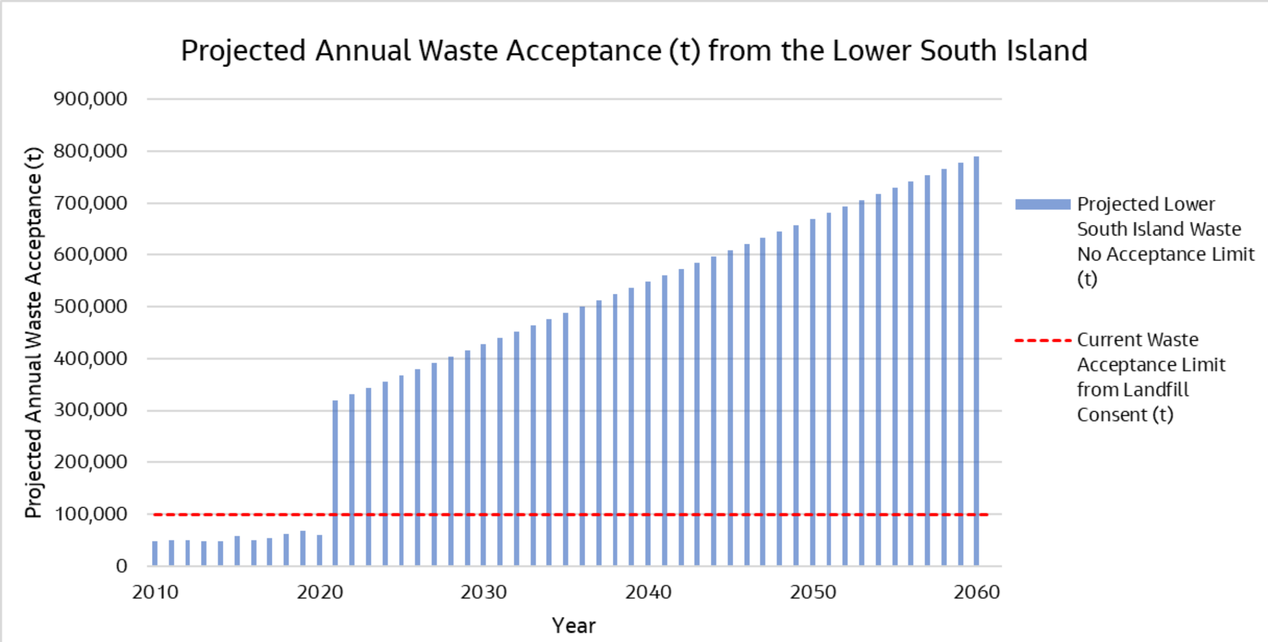


Figure 4 Projected Annual Waste Acceptance Based on an Increase from Accepting all Waste from the Lower South Island (8% of NZ population). (The red dotted line shows the current 100,000t limit for waste acceptance)

Landfill Lifespan

The projected lifespan of the landfill when accepting all waste from the lower South Island with no waste acceptance limit is presented below in Figure 5. In this scenario, it shows that the landfill is likely to completely filled by 2061.

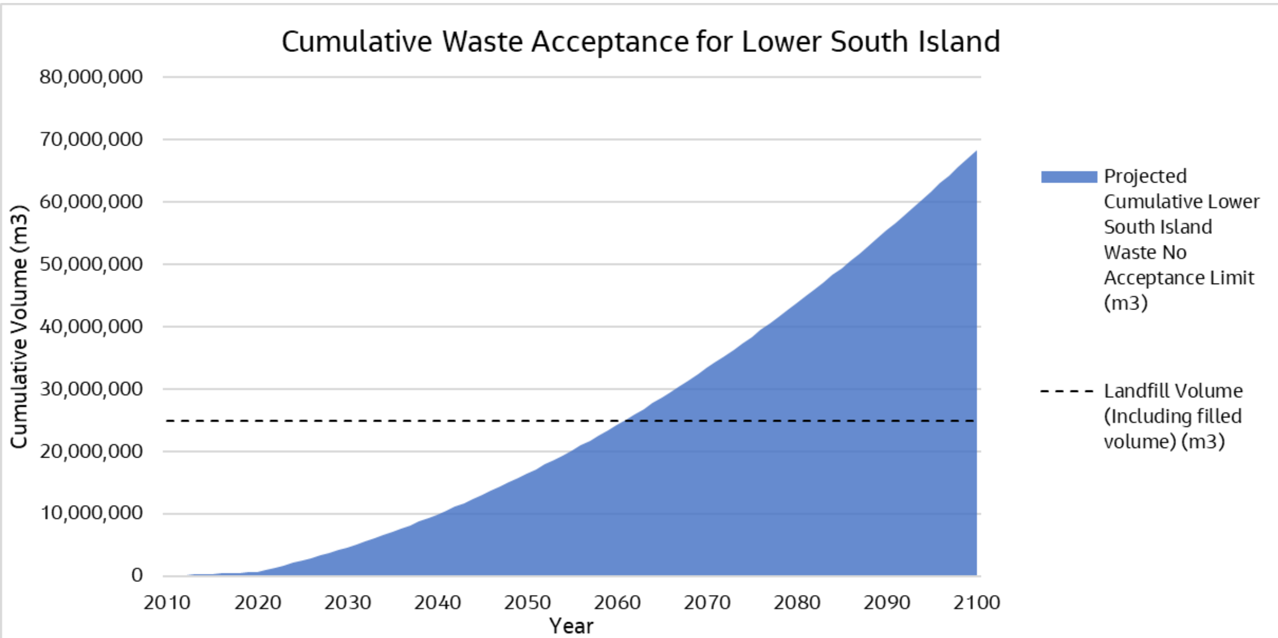


Figure 5 Cumulative Waste Projections when Accepting All Waste from the Lower South Island with no Limits on Waste Acceptance

4. Landfill and Lime Quarry Operations

4.1 Scenario 1a

The extraction of limestone could potentially impact the volume of accepted waste into the landfill during the current consented period of the lime quarry (up until 2038). This impact was investigated by identifying stages of limestone excavation and filling of waste within the landfill. These stages are depicted in Attachment 3, where the stages with 'A' at the end (i.e. 1A) indicate filling and the stages without indicate excavation of limestone. The excavation rate was assumed to be the average lime tonnage over the weighbridge per year from 2008-2019 multiplied by an overburden ratio. The filling rate was varied to reflect the predicted increase in waste accepted over time. Acceptance rates were selected from the results of Scenario 1a above (see Section 3.1).

The excavation of limestone and filling of refuse results are shown in Table 3 and Table 4 respectively. The average lime extraction rate used was 209,179 t/year at the weighbridge, which equates to the excavation of 101,243 m^3/year of limestone including an overburden ratio of 1.2.

Table 3. Scenario 1a staged limestone extraction results

Stage	Volume (m^3)	No. years to excavate	Start of excavation	Completion of excavation
1	716,165	7.1	2020	2028
2	1,141,515	11.3	2029	2040
3	1,579,395	15.6	2041	2057

Table 4. Scenario 1a staged waste filling results

Stage	Volume (m^3)	Average Acceptance Rate (t/year)	No. years to fill	Start of filling	Completion of filling
1A	3,826,214	80,000	45	2020	2065
2A	1,517,426	108,000	13	2066	2079
3A	1,643,307	122,000	13	2080	2093

The completion of excavation for each stage occurs before filling begins. Therefore, up until the end of the consented period (2038) of the lime quarry, the extraction of limestone is not considered to be a constraint on the acceptance of waste.

4.2 Scenario 2

The above approach was also considered for the case where landfill is accepted from the lower South Island. The excavation rate was assumed to be 350,000 t/year at the weighbridge, which equates to the excavation of 169,400 m^3/year including an overburden ratio of 1.2. Again, the filling rate was varied, with the acceptance rates selected from the results of Scenario 2 (see Section 3.3).

The results from for the excavation of limestone and the filling of refuse are shown in Table 5 and Table 6 respectively.

Table 5. Scenario 2 staged excavation results

Stage	Volume (m^3)	No. years to excavate	Start of excavation	Completion of excavation
1	716,165	4.2	2020	2025
2	1,141,515	6.7	2026	2033

Table 6. Scenario 2 staged waste filling results

Stage	Volume (m^3)	Average Acceptance Rate (t/year)	No. years to fill	Start of filling	Completion of filling
1A	3,826,214	300,000	12	2020	2032
2A	1,517,426	422,000	4	2033	2037

Up until 2037, the completion of excavation for each stage occurs before filling begins. Therefore, the excavation of limestone is not considered to be a constraint on the acceptance of waste, even in this unlikely projection.

5. Conclusions

This report has identified three future waste acceptance scenarios for the AB Lime landfill and has determined what the lifespan of the landfill will be under various future projections. The results are as follows:

- **Scenario 1a:** Based on current acceptance data, when projected into the future waste acceptance is likely to exceed the current consent limit of 100,000 t/yr by 2065. Without a waste acceptance limit, in this scenario the landfill is likely to reach capacity by 2190.
- **Scenario 1b:** Based on current acceptance data and consent conditions, when projected into the future and a maximum of 100,000 t/yr is accepted from 2065 onwards, the landfill is likely to reach full capacity around 2255.
- **Scenario 2:** When projecting waste acceptance from the lower South Island with no waste acceptance limit, the landfill is likely to be filled by 2061. Under this scenario, from 2021 onwards the waste acceptance would exceed the current consent conditions of 100,000 t/yr.

Landfill and Lime Quarry Operations

The extraction of limestone could potentially impact the volume of accepted waste into the landfill. Staged excavation of limestone and filling of waste for Scenario 1a indicates that excavation for each stage is completed prior to filling. This means that during the current lime quarry consented period (up to 2038), the filling of the landfill is not believed to be constrained by the excavation of limestone.

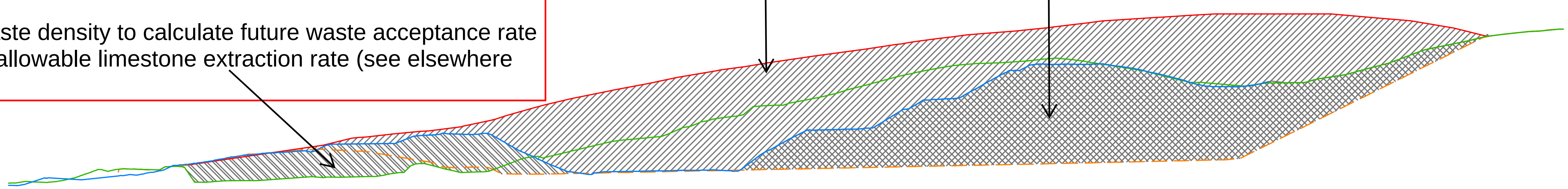
For the Scenario 2, the staged excavation and filling shows that the excavation is finished before filling begins. Therefore, for this scenario the acceptance of waste is not believed to be impacted by the excavation of limestone.

Attachment 1. Annotated Diagram for Maximum Accepted Waste

Future landfill air void volume = 23.9 Mm3.
NOTE; this whole void is not immediately available, need to excavate the limestone rock first.

1. Total void filled in Areas 1-14 is 1,024,738 m3.
2. Total landfill cap area from Drone survey in March 2020 = 68,457 m2.
3. Assume average landfill cap thickness in Area 1-14 = 1 m.
4. Total volume of 'waste + daily cover' (less cap volume) = 956,281 m3.
5. Total tonnage of waste accepted over weighbridge between 2004 and Jan 2020 = 846,120 ton.
6. Assume Feb 2020 and Mar 2020 waste tonnage added so total tonnage over weighbridge between 2004 - Mar 2020 = 855,000 ton.
7. Therefore average 'in-situ waste density' for Areas 1-14 = 855,000 tonnes / 956,281 m3 = 0.89 ton/m3.
8. Increase in-situ waste density by 5% as the total volume includes the volume of the daily capping which will be denser than the waste = 0.89 x 1.05 = 0.94
9. Use this in-situ waste density to calculate future waste acceptance rate based on maximum allowable limestone extraction rate (see elsewhere on drawing)

Volume rock to be excavated = 8.68 Mm3.



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Datum 65.000

	0.000	50.000	100.000	150.000	200.000	250.000	300.000	350.000	400.000	450.000	500.000	550.000
EXISTING LEVELS	72.703	76.800	81.778	91.322	96.658	102.367	108.609	105.448	82.413	82.836	83.697	102.178
FINISHED LEVELS				90.521	97.824	106.987	111.702	120.902	134.315	144.231	153.766	161.457
ORIGINAL LEVELS	74.350	79.141	83.974	75.726	77.802	78.905	87.397	85.693	96.919	106.274	119.347	129.965
CHAINAGE	0.000	50.000	100.000	150.000	200.000	250.000	300.000	350.000	400.000	450.000	500.000	550.000

	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1050.000	1100.000	1108.075
EXISTING LEVELS	112.784	132.406	147.681	159.138	156.432	144.175						
FINISHED LEVELS	168.520	175.805	181.405	186.375	191.319	194.463	195.000	194.337	189.932	179.935		
ORIGINAL LEVELS	141.481	153.879	159.933	163.205	155.861	146.158	145.765	151.295	166.035	178.176	183.650	184.114
CHAINAGE	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1050.000	1100.000	1108.075

1. Volume rock to be excavated = 8.68 Mm3.
2. Quarry consent: max extraction 350,000 ton/yr.
3. Assume limestone density = 2.5 ton/m3.
4. Quarry limestone extraction is 140,000 m3/yr.
5. Overburden and waste ratio, say 1.2.

Pre-Settlement

6. Topo ratio = (Available volume - capping)/Limestone available = (23,918,619-310,654)/8,682,611 = 2.72
7. Total ratio = Topo ratio x Overburden ratio = 2.72 x 1.2 = 3.29
8. Excavated void volume = 140,000 m3/yr x 3.29 = 461,211 m3/yr
9. Incoming waste that can be accepted = 461,211 x 0.94 = 430,000 t/year

Post-Settlement

6. Topo ratio = (Available volume - capping)/Limestone available = (17,929,547-310,654)/8,682,611 = 2.03
7. Total ratio = Topo ratio x Overburden ratio = 2.03 x 1.2 = 2.46
8. Excavated void volume = 140,000 m3/yr x 2.46 = 344,207 m3/yr
9. Incoming waste that can be accepted = 344,207 x 0.94 = 320,000 t/year

LEGEND

- ORIGINAL SURFACE
- EXISTING SURFACE
- PERMANENT CAP SURFACE
- LANDFILL FLOOR
- LIMESTONE TO EXCAVATE
- BOTTOM OF LANDFILL TO FINAL CAP
- CURRENT FILL - ORIGINAL FLOOR TO EXISTING SURFACE

PRELIMINARY ISSUE

REV	DATE	APP'D	REVISION

SCALES AT A1

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CLIENT: AB LIME LTD.
PROJECT: LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DESIGNED	DESIGN REVIEW	DATE	DATE

TITLE: LANDFILL VOLUMES LONG SECTION

SCALE: AS SHOWN
DRAWING No: IZ000400-1000-CG-DRG-1003
REV: A
A1

DATE: 5/05/2020 5:27:42 PM NAME: LOCKE, NEIL

Attachment 2. Projections in 10-year intervals

Table 1: Scenario 1a projections to full capacity

Year	Waste (t)	Cumulative (t)	Waste (m^3)	Cumulative (m^3)
2010	48,648	351,084	51,753	373,494
2020	60,000	899,098	63,830	899,098
2030	69,507	1,552,660	73,943	1,651,766
2040	78,730	2,298,454	83,755	2,445,164
2050	87,953	3,136,480	93,567	3,336,681
2060	97,176	4,066,738	103,379	4,326,317
2070	106,399	5,089,228	113,191	5,414,073
2080	115,623	6,203,950	123,003	6,559,947
2090	124,846	7,410,904	132,815	7,883,941
2100	134,069	8,710,090	142,627	9,266,053
2110	143,292	10,101,508	152,439	10,746,285
2120	152,515	11,585,158	162,250	12,324,636
2130	161,739	13,161,040	172,062	14,001,107
2140	170,962	14,829,154	181,874	15,775,696
2150	180,185	16,589,500	191,686	17,648,404
2160	189,408	18,442,078	201,498	19,619,232
2170	198,631	20,386,888	211,310	21,688,179
2180	**207,855**	**22,423,930**	**221,122**	**23,855,245**
2190	**217,078**	**24,553,204**	**230,934**	**26,120,430**

Table 2: Scenario 1b Projections until 2370

Year	Waste (t)	Cumulative (t)	Waste (m^3)	Cumulative (m^3)
2010	48,648	351,084	51,753	373,494
2020	31,202	870,300	33,194	925,851
2030	69,507	1,523,862	73,943	1,621,130
2040	78,730	2,269,656	83,755	2,414,528
2050	87,953	3,107,682	93,567	3,306,045
2060	97,176	4,037,940	103,379	4,295,681
2070	100,000	5,035,003	71,942	5,356,386
2080	100,000	6,035,003	71,942	6,420,216
2090	100,000	7,035,003	71,942	7,484,046
2100	100,000	8,035,003	71,942	8,547,875
2110	100,000	9,035,003	71,942	9,611,705
2120	100,000	10,035,003	71,942	10,675,535
2130	100,000	11,035,003	71,942	11,739,365
2140	100,000	12,035,003	71,942	12,803,195
2150	100,000	13,035,003	71,942	13,867,024
2160	100,000	14,035,003	71,942	14,930,854
2170	100,000	15,035,003	71,942	15,994,684
2180	100,000	16,035,003	71,942	17,058,514
2190	100,000	17,035,003	71,942	18,122,343
2200	100,000	18,035,003	71,942	19,186,173
2210	100,000	19,035,003	71,942	20,250,003
2220	100,000	20,035,003	71,942	21,313,833
2230	100,000	21,035,003	71,942	22,377,663
2240	100,000	22,035,003	71,942	23,441,492
2250	**100,000**	**23,035,003**	**71,942**	**24,505,322**
2260	**100,000**	**24,035,003**	**71,942**	**25,569,152**

Table 3: Scenario 2 projections to full capacity

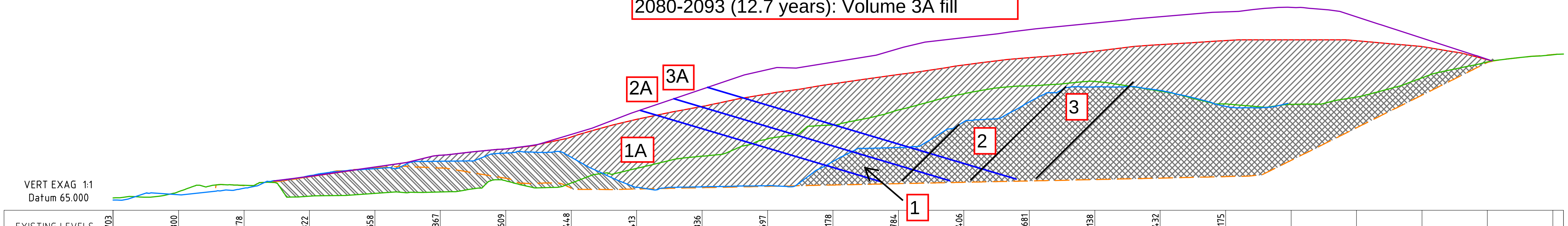
Year	Waste (t)	Cumulative (t)	Waste (m^3)	Cumulative (m^3)
2010	48,648	48,648	51,753	51,753
2020	60,000	596,662	63,830	634,747
2030	427,292	4,326,477	454,566	4,602,635
2040	547,982	9,263,192	582,960	9,854,459
2050	668,672	15,406,807	711,353	16,390,220
2060	**789,362**	**22,757,322**	**839,747**	**24,209,917**
2070	**910,052**	**31,314,737**	**968,140**	**33,313,550**

Attachment 3. Excavation and Filling Stages

Assume:
a) Varied ton/yr waste filling rate to reflect predicted increase in waste, using 0.94 ton/m3
b) 209,179 ton/yr limestone and overburden excavation ratio (1.2) for Scenario 1a
350,000 ton/yr limestone and overburden excavation ratio (1.2) for Scenario 2
c) Always keep 10 m buffer distance between rock excavation and landfill

Scenario 1a
2020-2028 (7.1 years): Volume 1 excavate 2029-2040 (11.3 years): Volume 2 excavate 2041-2057 (15.6 years): Volume 3 excavate
2020-2065 (44.4 years): Volume 1A fill 2066-2079 (12.2 years): Volume 2A fill 2080-2093 (12.7 years): Volume 3A fill

Scenario 2
2020-2025 (4.2 years): Volume 1 excavate 2026-2033 (6.7 years): Volume 2 excavate
2020-2032 (12 years): Volume 1A fill 2033-2037 (4 years): Volume 2A fill



EXISTING LEVELS	72.703	76.800	81.778	91.322	96.658	102.367	108.609	105.448	82.413	82.836	83.697	102.178	112.784	132.406	147.681	159.138	156.432	144.175						
FINISHED LEVELS				90.521	97.824	106.987	111.702	120.902	134.315	144.231	153.766	161.457	168.520	175.805	181.405	186.375	191.319	194.463	195.000	194.337	189.932	179.935		
ORIGINAL LEVELS	74.350	79.141	83.974	75.726	77.802	78.905	87.397	85.693	96.919	106.274	119.347	129.965	141.481	153.879	159.933	163.205	155.861	146.158	145.765	151.295	166.035	178.176	183.650	184.114
CHAINAGE	0.000	50.000	100.000	150.000	200.000	250.000	300.000	350.000	400.000	450.000	500.000	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1050.000	1100.000	1108.075

SECTION 1
SCALE N.T.S. CI-DRG-1006

LEGEND

- ORIGINAL SURFACE
- EXISTING SURFACE
- PERMANENT CAP SURFACE
- PRE-SETTLEMENT CAP SURFACE
- LANDFILL FLOOR
- LIMESTONE TO EXCAVATE
- CURRENT FILL - ORIGINAL FLOOR TO EXISTING SURFACE

PRELIMINARY ISSUE

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SCALES AT A1

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CLIENT AB LIME LTD.
PROJECT LANDFILL INVESTIGATION

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
DESIGNED	DESIGN REVIEW	DATE	DATE

TITLE LANDFILL VOLUMES
LONG SECTION

SCALE AS SHOWN | DRAWING No IZ000400-1000-CG-DRG-1003 | REV A

A1

AB Lime Ltd

AB Lime Ltd Environmental Management Plan

IZ000400-LFC-NP-RPT-0002 | 1

29 May 2020

AB Lime Ltd

Draft for Consenting Purposes

AB Lime Ltd

Project No: IZ000400
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Document No.: IZ000400-LFC-NP-RPT-0002
Revision: 1
Date: 29 May 2020
Client Name: AB Lime Ltd
Project Manager: Katrina Jensen
Author: Ryan McCone
File Name: Environmental Management Plan

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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	22/05/2020	Draft for Comment	Ryan McCone	Craig Redmond	Andrew Henderson	
1	29/05/2020	Final Draft for Consenting Purposes	Craig Redmond	Ryan McCone	Andrew Henderson	Vince Pace

Contents

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs (on behalf of AB Lime Limited) is to provide a technical report for landfill management to assist with a resource consent application to increase the activities at AB Lime Landfill at 10-20 Kings Bend, Winton, in accordance with the scope of services set out in the contract between Jacobs and AB Lime (the Client).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Background

1.1 Purpose/Objective of the Environmental Management Plan

This Environmental Management Plan is for the operation of the AB Lime Ltd landfill and quarry. The purpose of the Environmental Management Plan provides details of the practices and procedures to operate the landfill and quarry in compliance with the Resource Management Act.

The scope of the Environmental Management Plan is to:

- Capture and address the environmental and social effects generated by the operation of the landfill and quarry;
- Identify the compliance requirements for the operation of the entire site;
- Set a framework for the management of the environmental effects identified; and
- Enable compliance with all environmental legislation, particularly the resource consent conditions.

All activities on site will operate in accordance with this plan for the duration of the resource consents requiring it. The Environmental Management Plan is designed to achieve the following objectives:

- To operate in full compliance with the resource consent requirements and demonstrate this through reporting procedures to Consent Authorities;
- To liaise closely with neighbours and the local community, including iwi representatives, regarding landfill operational issues;
- To provide a safe working environment for people on the site;
- To maintain an independent review process for the design, construction, operation and aftercare of the landfill to confirm the work is undertaken by appropriately qualified personnel in accordance with good practice;
- To identify operational responsibilities, the management structure and staffing;
- To facilitate the effective training of staff;
- To facilitate accurate record keeping;
- To maintain community involvement including details of complaints procedures;
- To appropriately manage site access, fencing and security; and
- To manage site infrastructure and site amenities.

1.1.1 Description

AB Lime own and operate the Class A Southern Regional Landfill facility at Winton. It is the primary accepter of waste for the Southland region, as well as accepting waste from other regions in the lower half of the South Island. AB Lime also operate a lime quarry, cutting and processing limestone on site to produce high quality lime and fertiliser blends.

1.1.2 Location

The landfill is located on the eastern fringe of Winton, at 10-20 Bend Road, Kings Bend Figure 1 shows the location of the landfill and quarrying operations within the context of Winton, and Figure 2 shows a close up of the AB Lime Ltd landfill and quarry operations.

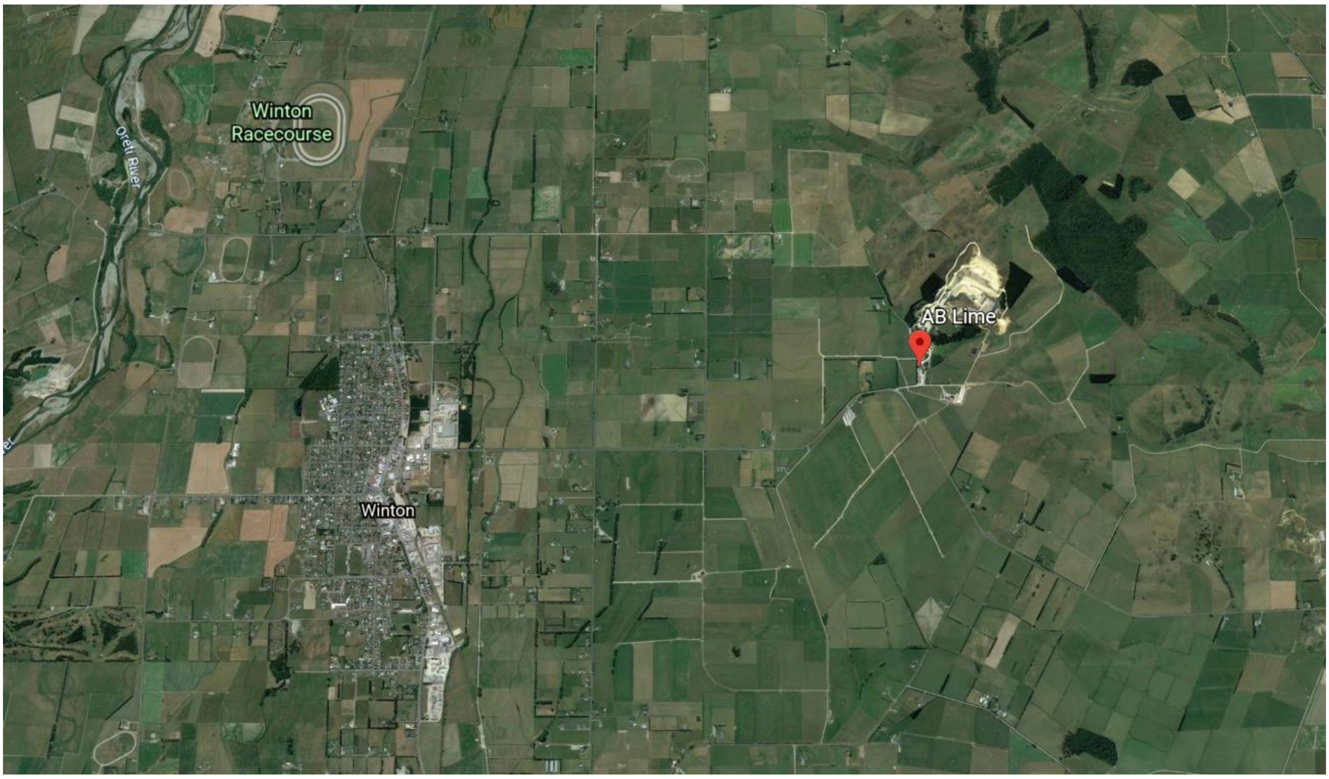

Figure 1 Local Context of AB Lime Landfill and Quarry

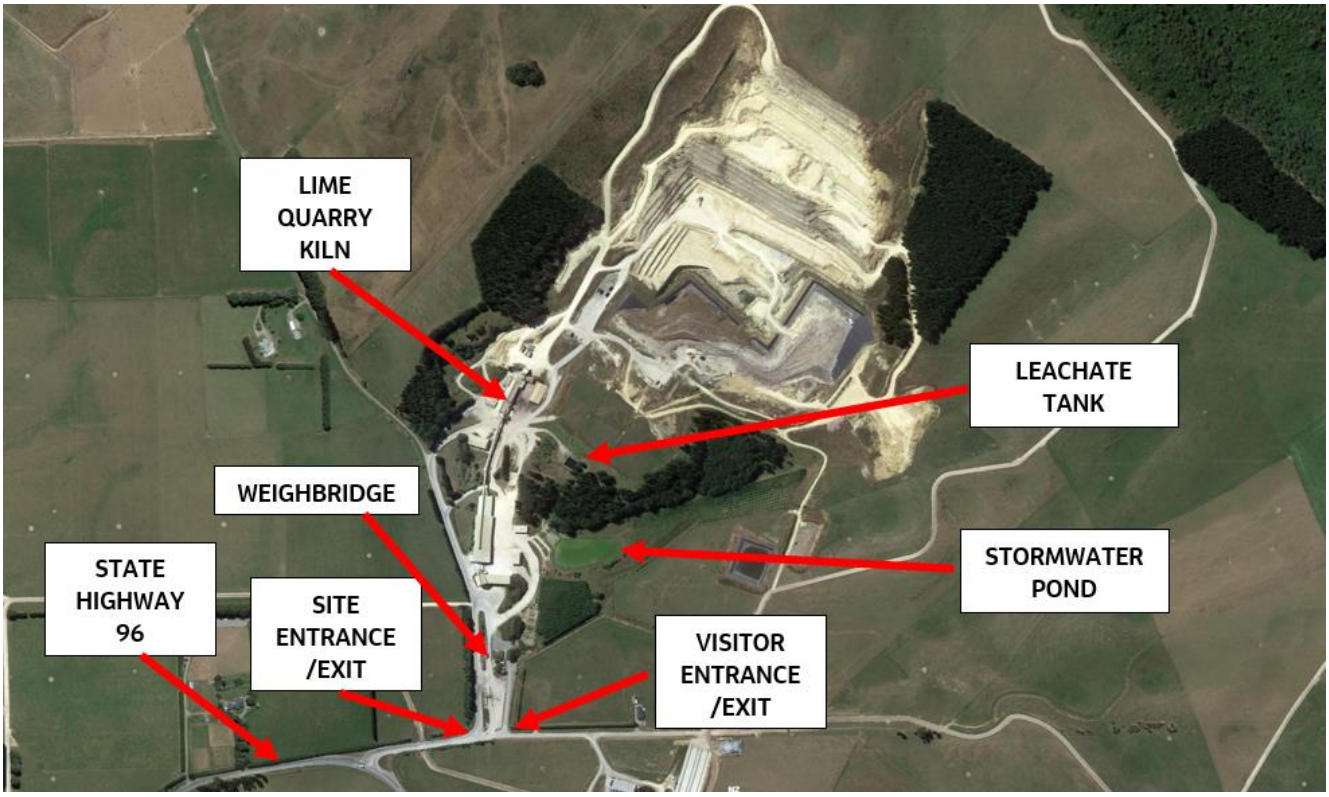

Figure 2 Close up of the AB Lime Landfill and Quarry

1.1.3 Management Plan Framework

The operation of AB Lime landfill and quarry requires a suite of environmental management and mitigation plans to operate the site. The Environmental Management Plan sets the overall framework for the operation of the site and is supported by a series of sub management plans focusing on specialist environmental areas to effectively run the landfill and quarry.

Figure 3 below illustrates the relationship between the Environmental Management Plan and the sub environmental management and mitigation plans.

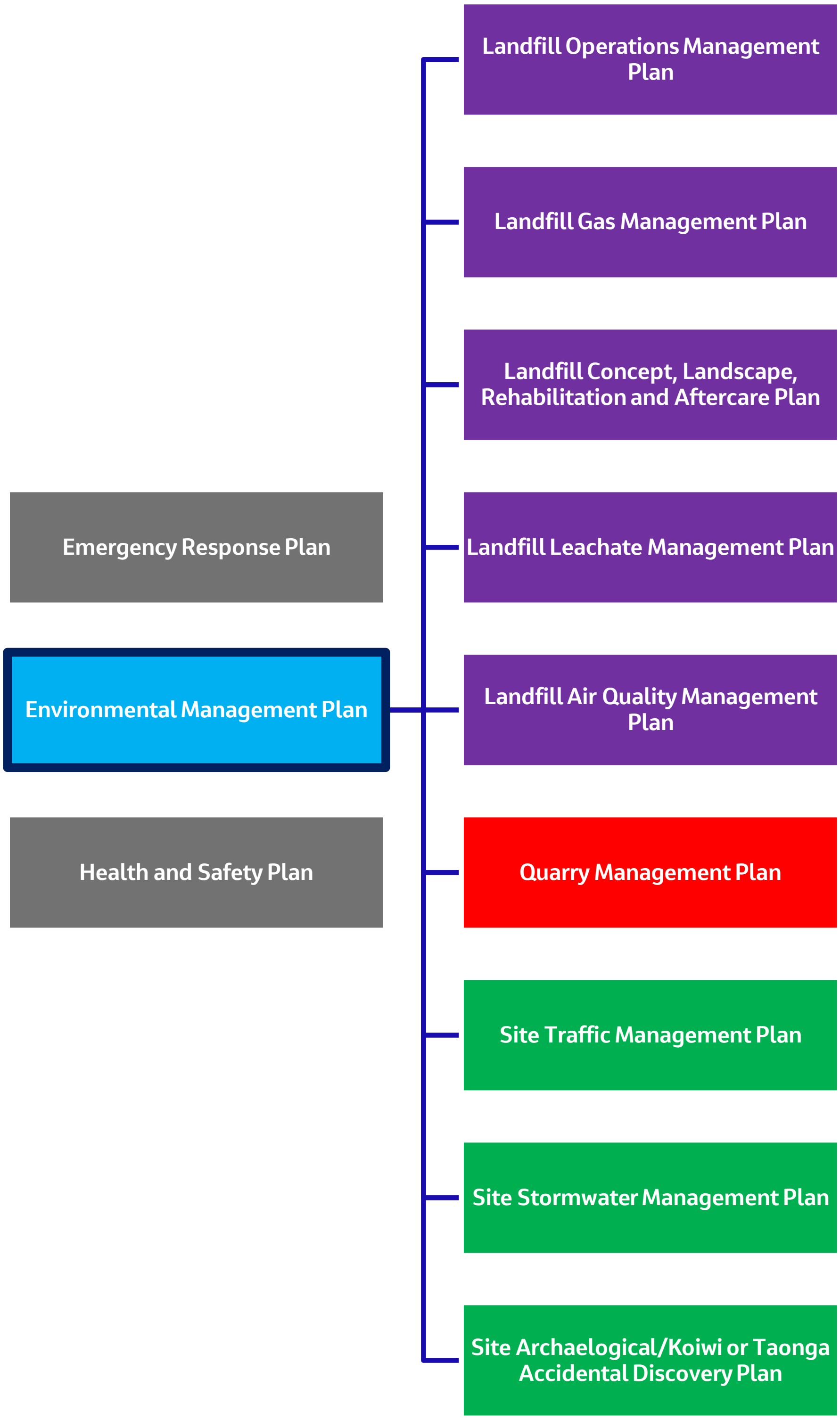

Figure 3 AB Lime Limited Management Plan Structure

Key:

1.2 Plan Preparation and Process

AB Lime have an environmental management plan framework to coordinate the efficient and effective environmental management of the landfill and quarry. This plan and all the sub plans are live documents that provide an adaptive management framework that will be updated as the site operations and industry guidance evolve. Updates and reviews to this plan will be carried out in accordance with section 4.6 of this plan.

1.2.1 Minimum Contents of Each Plan

Each management plan for the AB Lime landfill and quarry will specify:

- The purpose and objectives of the management plan;
- The legislative requirements and specific consent conditions the plan is designed to assist with implementing;
- How the site will give effect to the purpose, objectives and legislative requirements; and
- Monitoring and reporting the performance of the management plan in ensuring that conditions of consent are complied with.

1.2.2 Certification and Submission Process

All of the environmental management plans require certification and Environment Southland and/or Southland District Council require the following plans to be independently certified.

Table 1 List of Appointed Independent Reviewers/Certifier for Each Plan

Management Plan	Independent Reviewer/Certifier	Certifier
Environment Management Plan	To be appointed	Environment Southland/Southland District Council
Landfill Operations Management Plan	To be appointed	Environment Southland/Southland District Council
Landfill Gas Management Plan	To be appointed	Environment Southland
Landfill Concept, Landscape Rehabilitation and Aftercare Plan	To be appointed	Environment Southland/Southland District Council
Landfill Leachate Management Plan	To be appointed	Environment Southland
Landfill Air Quality Management Plan	To be appointed	Environment Southland
Quarry Management Plan	To be appointed	Southland District Council
Site Traffic Management Plan	To be appointed	Southland District Council
Site Stormwater Management Plan	To be appointed	Environment Southland
Site Archaeological/Koiwi or Taonga Accidental Discovery Plan	To be appointed	Environment Southland/Southland District Council

1.2.3 Certification Process

All AB Lime management plans that fit under the management plan structure identified in Table 1 are required to be independently certified. The EMP is required to be independently certified by the Southland Regional Council and the Southland District Council. The resource consent conditions in Land Use Consent

60/3/02/138/1 and Schedule 1 to the Environment Southland Consents for the AB Lime Landfill outline the process for certification and review for all management plans. The independent certification or reviewer process outlined in Figure 4 is used when first certifying the plans with the respective councils or when the plans are updated.

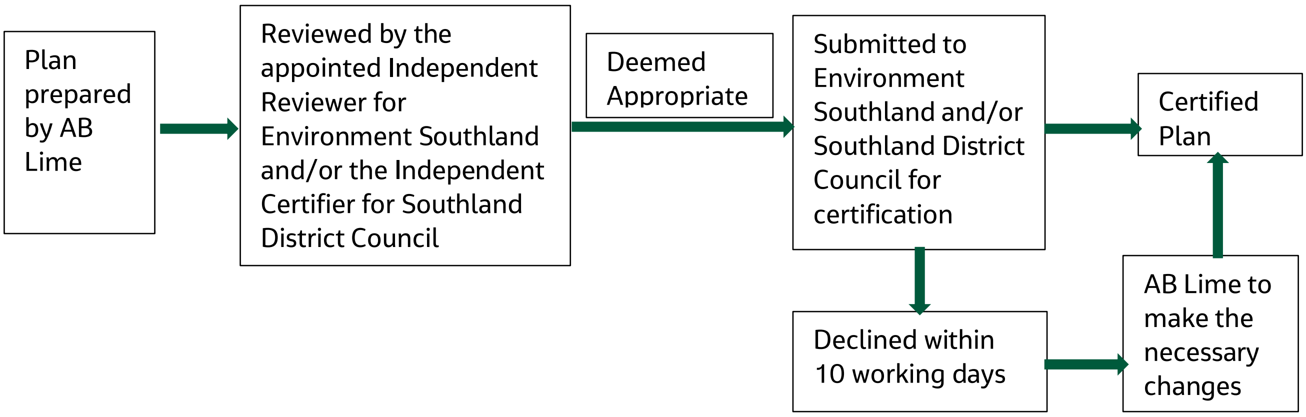

Figure 4 Management Plan Certification Process

1.3 Roles and Responsibilities

The listed site personnel in **Error! Reference source not found.** will be required to ensure that the activities on-s ite are managed, and the management plans are given effect to in accordance with conditions of resource consents.

Roles and responsibilities for the implementation of this Plan are provided in Table 2 below. Everyone involved at AB Lime Ltd has a role in the implementation of the Environmental Management Plan. The roles listed are key proponents to ensuring the delivery of the Environmental Management Plan.

Table 2 Plan Implementation - Roles and Responsibilities

Name	Role	Contact Details	Key Responsibilities in Relation to this Plan
Steve Smith	AB Lime Landfill Manager and General Manager		▪ Implement appropriate training measures for all staff to familiarise with the EMP
Fiona Smith	AB Lime Environmental Manager		▪ Ensure that a copy of all consents and management plans are kept on site; ▪ Document control; ▪ Monitoring and reporting; and ▪ Liaison with regulatory authorities and Independent Peer Review Panel; ▪ Manage the entire disposal process associated with emergency waste
Craig Owen-Cooper	Landfill Supervisor		▪ Facilitate with landfill operators to ensure they are familiar with and apply all relevant components of the EMP in daily practise; ▪ Train and upskill new staff in landfill matters relating to the EMP;

Name	Role	Contact Details	Key Responsibilities in Relation to this Plan
			▪ Implement requirements that fall to the responsibility of the landfill supervisor under all relevant sub-management plans
TBC	Quarry Manager		▪ Facilitate with quarry maintenance and production staff to ensure they are familiar with and apply all relevant components of the EMP in daily practise; ▪ Train and upskill new staff in quarry matters relating to the EMP

1.4 Management Structure

The AB Lime organisational chart for the landfill and quarry is shown below in Figure 5.

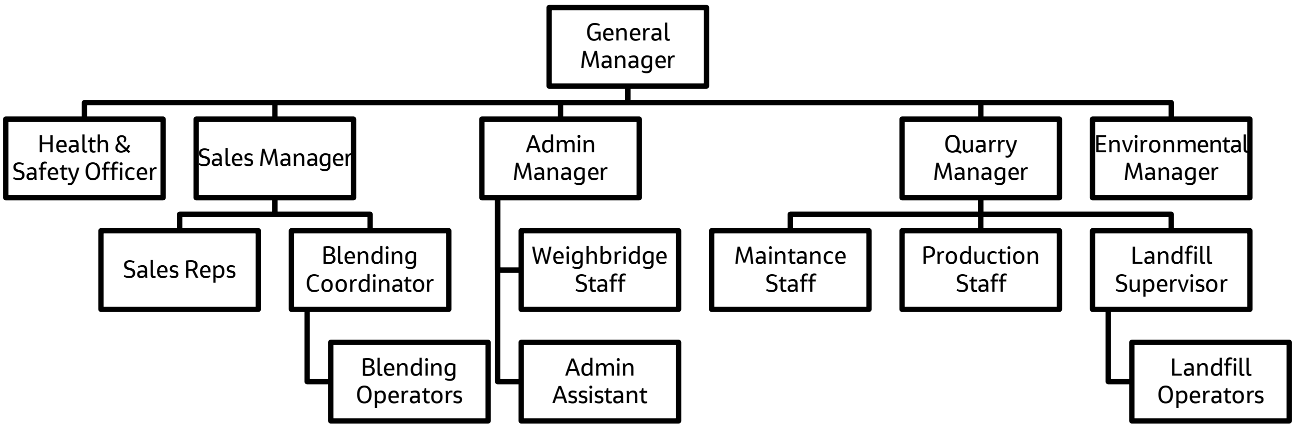

Figure 5 Organisational Chart - AB Lime Quarry and Landfill

2. Environmental and Social Management

2.1 Environmental and Social Impacts

2.1.1 Environmental Impacts

The potential environmental impacts for the operation of the landfill include:

- Noise;
- Litter;
- Vermin;
- Surface water;
- Groundwater;
- Leachate;
- Landfill gas;
- Air quality; and
- Ecology

The management plan framework created considers the sensitivity of the receiving environment to adverse effects. Landfill operations that utilise this management plan framework have minor impacts on the wider environment.

2.1.2 Social Impacts

The social impact of the operation of the landfill is considered to be substantially less when compared to the development of a new landfill at a new location. It is considered that any adjustment to property values in the vicinity of the landfill have already occurred as the landfill now forms an integrated part of the existing environment.

While there is acceptance of a continued need for a regional Class A landfill, it is considered to remain of concern to neighbours, who identify potential adverse effects that could impact on their current amenity. Issues that could affect current amenity of neighbours include:

- Odour;
- Landfill gas emissions;
- Noise;
- Traffic volumes;
- Road safety effects;
- Vermin and litter management;
- Dust; and
- Litter spread.

The perceptions of and stigma attached to landfills is an important matter requiring consideration. Whether or not all perceived effects actually materialise, recognition of these potential effects remains an important consideration as they can have a real effect on community wellbeing. AB Lime identify the need for continued open and transparent communication as a key mechanism to manage perceptions in the community.

The following mitigation measures are recommended to continue to ensure any perceived negative social effects are minimised:

- Ongoing consultation and interaction with the general public, local residents and local community groups through the Community Liaison Committee;
- AB Lime continue to play a role in the education of the waste minimisation and provide an understanding of the waste cycle;
- Provide improved management and mechanisms for neighbours and relevant authorities to manage complaints, particularly related to odour; and
- Remain accessible to neighbours and affected parties to maintain transparent and open communication channels .

2.2 Legislative Requirements

The legislative requirements of this Environmental Management Plan outline the consent conditions that this plan is designed to assist with implementing.

The Resource Management Act approvals listed in Table 3 apply to this site.

Table 3 Current Resource Management Act Approvals (to be completed once consent application is granted)

Granter	Authority number	Consent type	Purpose	Expiry

2.3 Resource Consent Requirements

The conditions relevant to the Environmental Management plan are compiled in Table 4.

Table 4 Relevant Conditions for Consents related to Environmental Management Plan

Condition Number	Condition	Reference
Land Use Consent 60/3/02/138/1		
Management Plans		
2.4	The solid waste disposal facility and associated operations shall operate in accordance with an Environmental Management Plan (EMP) for the duration of this consent.	Section 1.1

Condition Number	Condition	Reference
2.5	The EMP shall incorporate or refer to the following management plans, described in later conditions of this consent: a) Landfill Operations Management Plan; b) Landfill Gas Management Plan; c) Landfill Concept, Landscape, Rehabilitation and Aftercare Plan; d) Landfill Leachate Management Plan; e) Landfill Air Quality Management Plan; f) Quarry Management Plan g) Site Traffic Management Plan h) Site Stormwater Management Plan i) Site Archaeological/Koiwi or Taonga Accidental Discovery Plan In the event of an inconsistency between the management plans and a condition of this consent, these conditions shall prevail. ***Advice Note (i):*** *For completeness all sub-management plans are identified in condition (2.5). The sub-management plans relevant to this consent include the Landfill Operations Management Plan, the Landfill Concept, Landscape, Rehabilitation and Aftercare Plan, the Site Traffic Management Plan, and the Site Archaeological/Koiwi or Taonga Accidental Discovery Plan.* ***Advice Note (ii):*** *The objectives for each sub-management plan relevant to this consent are identified in consent conditions (2.12)-(2.16). There are also other objectives within these sub-management plans not relevant to this consent that are managed by the Regional Authority.*	Section 3.1
Appointment of Certifiers		
2.6	Within one month of giving effect to this resource consent the Consent Holder shall confirm the appointment of independent, suitably qualified and experienced person(s) to certify the management plans required by this consent, and provide information to the Southland District Council to demonstrate that the proposed certifier(s) is independent, suitably qualified and experienced. ***Advice Note:*** *If the Southland District Council does not approve the person(s) proposed by the Consent Holder, reasons must be provided in writing to indicate why the person(s) is not considered to be suitable.*	Section 1.5.1
2.7	Certification of the plans shall not proceed until the Southland District Council confirms in writing that the Certifier meets these requirements.	Section 1.5.1
2.8	The independent certifier may be changed at any stage during operations, however, the new certifier must be confirmed as being appropriate by the Southland District Council in accordance with condition (2.6)	Section 1.5.1
Certification Process		

Condition Number	Condition	Reference
2.9	If changes to the relevant plan are requested by the certifier, in alignment with conditions (2.11)-(2.14) these changes shall be made before the certification is confirmed by the Southland District Council.	Section 1.2
2.10	This resource consent and a copy of the Southland District Council certified versions of all the management plans required by this consent shall be kept on site at all times, and the consent holder shall ensure all personnel are made aware of each plan's contents, where the plan relates to activities that those personnel are responsible for.	Section 1.2
Review Process		
2.11	The consent holder may make amendments to the final management plans that may change how any adverse effect is managed at any time subject to the certification of Southland District Council.	Section 1.2
2.12	All amendments shall be consistent with the objectives and performance requirements of the management plan and these consent conditions.	Section 1.2
2.13	a) In event of an amendment to a management plan under Condition (2.11), the consent holder must submit the amendment to Southland District Council for certification 10 working days before the commencement of the relevant works. Certification shall confirm that the amendment is in accordance with condition (2.3) and meets the objectives and performance requirements of the management plan. b) Southland District Council shall be requested, no later than 10 working days of the receipt of the amendment, to confirm to the consent holder that the amendment is either certified or declined. If no response is received, approval is deemed to have been given as set out in condition (2.14). c) Should Southland District Council decline to certify the amendment or request the incorporation of changes to the amendment the consent holder may then resubmit a revised amendment to the management plan(s) following the procedures set out in Condition 2.13(a)-(b)	Section 1.2
2.14	If no confirmation of the Plan's suitability is received from Southland District Council within 10 working days of submission of any plan or other information provided for certification, the submitted information shall be deemed to have been approved.	Section 1.2
Environmental Management Plan		
2.15	The overall purpose of the EMP is to provide details of the practices and procedures to operate the landfill in compliance with the conditions of consent. The EMP shall comply with the relevant consent conditions and achieve the following objectives:	Section 1.1
	i. To operate in full compliance with the resource consent requirements and demonstrate this through reporting procedures to Consent Authorities.	Section 2.3
	ii. To liaise closely with neighbours and the local community, including iwi representatives, regarding landfill operational issues.	Section 3.2
	iii. To provide a safe working environment for people on the site.	Section 3.3.3

Condition Number	Condition	Reference
	iv. To maintain an independent review process for the design, construction, operation and aftercare of the landfill to confirm the work is undertaken by appropriately qualified personnel in accordance with good practice	Section 1.5
	v. To identify operational responsibilities, the management structure and staffing	Section 1.3 and Section 1.4
	vi. To facilitate the effective training of staff:	Section 4.2
	vii. To facilitate accurate record keeping	Section 4.6
	viii. To maintain community involvement including details of complaints procedures	Section 5.5
	ix. To appropriately manage site access, fencing and security	Section 3.3
	x. To manage site infrastructure and site amenities	Section 3.3
Operational Conditions		
2.20	That the solid waste disposal facility shall not accept any waste delivered to the site by the general public. Solid waste shall be delivered to the site only in vehicles which have been given prior authorisation to access the site by the consent holder.	Section 3.3
2.21	That the solid waste disposal facility shall be permitted to receive solid waste only between the hours of 8.00 am and 6.00 pm 7 days per week.	Section 3.3
2.23	Vehicles transporting refuse cover and/or construction material to and from the site shall not enter the site prior to 7.45 am or leave after 6.15 pm on any day. Other solid waste disposal operations (such as placing of cover and maintenance etc) may be undertaken between 7.00 am and 6.15 pm on any day.	Section 3.3
2.36	That the consent holder shall establish a “AB Lime Landfill Community Liaison Committee” (CLC) in accordance with the following requirements: d) The purpose of the CLC shall include, but no be limited to, the following: To engage on an ongoing and regular basis about matters associated with the operation of the landfill where those matters affect the community and are of mutual interest to the representative parties. To promote the free flow of information between the local community and the consent holder so as to, wherever possible, address any issues that may arise. a) The CLC shall initially comprise up to two representatives of the consent holder and the consent holder shall invite one representative from each of the following to be represented:: i. All adjoining landowners/occupiers whose properties bound on to the site of this consent and not owned by the consent holder. Te Ao Marama Incorporated. Southland District Council.	Section 3.2

Condition Number	Condition	Reference
	Environment Southland. Public Health South. Winton Community Board. ***Advice Note (i):*** *This condition only governs initial membership for the purposes of convening the first meeting of the CLC. Ongoing membership will be determined by the CLC.* e) The AB Lime CLC has the ability to set its own terms of engagement. ***Advice note (ii):*** *In the event that it is not possible to establish a CLC or convene meetings though lack of interest to participate from the local community, then such failure to do so shall not be deemed a breach of these conditions. Should the local community wish to re-establish meetings after a period of inactivity then the conditions above continue to apply.*	
2.37	That in all signage relating to the solid waste disposal facility, the facility shall be referred to as the "AB Lime Landfill" or the "AB Lime Solid Waste Disposal Facility" with no direct reference in the name of the facility to Kings Bend or Winton.	Section 3.3.6
Schedule 1 – General Conditions AUTH 201346, 201347, 201348, 201349, 201350, 201351		
Management Plans		
3.	The solid waste disposal facility and associated operations shall operate in accordance with an Environmental Management Plan (EMP) for the duration of this consent.	Section 1.1
4.	The EMP shall incorporate or refer to the following management plans, each of which is described in later conditions of this consent: a) Landfill Operations Management Plan; b) Landfill Gas Management Plan; c) Landfill Concept, Landscape, Rehabilitation and Aftercare Plan; d) Landfill Leachate Management Plan; e) Landfill Air Quality Management Plan; f) Quarry Management Plan g) Site Traffic Management Plan h) Site Stormwater Management Plan i) Site Archaeological/Koiwi or Taonga Accidental Discovery Plan In the event of an inconsistency between the management plans and a condition of this consent, these conditions shall prevail.	Section 3.1

Condition Number	Condition	Reference
	Advice Note (i): *For completeness all sub-management plans are identified in condition (4). The sub-management plans relevant to these consents include the Landfill Operations Management Plan, the Landfill Gas Management Plan, the Landfill Concept, Landscape, Rehabilitation and Aftercare Plan, the Landfill Leachate Management Plan, the Landfill Air Quality Plan, the Site Stormwater Management Plan and the Site Archaeological/Koiwi or Taonga Accidental Discovery Plan.* ***Advice Note (ii):*** *The objectives for each sub-management plan relevant to this consent are identified in consent conditions (21)-(28). There are also other objectives within these sub-management plans not relevant to these consents that are managed by the District Authority.*	
Appointment of Certifiers		
5.	Within one month of giving effect to this resource consent the Consent Holder shall confirm the appointment of independent, suitably qualified and experienced person(s) to certify the management plans required by this consent, and provide information to the Southland Regional Council to demonstrate that the proposed certifier(s) is independent, suitably qualified and experienced. ***Advice Note:*** *If the Southland Regional Council does not approve the person(s) proposed by the Consent Holder, reasons must be provided in writing to indicate why the person(s) is not considered to be suitable.*	Section 1.5.1
6.	Certification of the plans shall not proceed until the Southland Regional Council confirms in writing that the Certifier meets these requirements.	Section 1.5.1
7.	The independent certifier may be changed at any stage during operations, however, the new certifier must be confirmed as being appropriate by the Southland Regional Council in accordance with condition (5).	Section 1.5.1
Certification Process		
8.	Once the EMP and sub management plans have been reviewed and deemed appropriate by the independent reviewer(s), in accordance with conditions (16)-(20) the plan shall be provided to the Southland District Council for certification.	Section 1.5.1
9.	Southland Regional Council shall be requested, no later than 10 working days of the receipt of the management plan, to confirm to the consent holder that the plan is either certified or declined. If no response is received, approval is deemed to have been given as set out in condition (15)	Section 1.5.1
10.	If changes to the relevant plan are requested by the certifier, in alignment with conditions (12)-(15) these changes shall be made before the certification is confirmed by the Southland Regional Council.	Section 1.5.1
11.	This resource consent and a copy of the Southland Regional Council certified versions of all the management plans required by this consent shall be kept on site at all times, and the consent holder shall ensure all personnel are	Section 1.3

Condition Number	Condition	Reference
	made aware of each plan's contents, where the plan relates to activities that those personnel are responsible for.	
Review Process		
12.	The consent holder may make amendments to the final management plans that may change how any adverse effect is managed at any time subject to the certification of Southland Regional Council.	Section 1.2
13.	All amendments shall be consistent with the objectives and performance requirements of the management plan and these consent conditions.	Section 1.2
14.	a) In event of an amendment to a management plan under Condition (11), the consent holder must submit the amendment to Southland Regional Council for certification 10 working days before the commencement of the relevant works. Certification shall confirm that the amendment is in accordance with condition (2) and meets the objectives and performance requirements of the management plan. b) Southland Regional Council shall be requested, no later than 10 working days of the receipt of the amendment, to confirm to the consent holder that the amendment is either certified or declined. If no response is received, approval is deemed to have been given as set out in condition (14). Should Southland Regional Council decline to certify the amendment or request the incorporation of changes to the amendment the consent holder may then resubmit a revised amendment to the management plan(s) following the procedures set out in Condition (13)(a)-(b)	Section 1.2
15.	If no confirmation of the Plan's suitability is received from Southland Regional Council within 20 working days of submission of any plan or other information provided for certification, the submitted information shall be deemed to have been approved.	Section 1.2
Independent Peer Review Process		
16.	Within one month of giving effect to this resource consent the Consent Holder shall confirm the appointment of independent peer reviewer(s), suitably qualified and experienced person(s) to review conditions and the management plans required by this consent, and provide information to the Southland Regional Council to demonstrate that the proposed certifier(s) is independent, suitably qualified and experienced. ***Advice Note:*** *If the Southland Regional Council does not approve the person(s) proposed by the Consent Holder, reasons must be provided in writing to indicate why the person(s) is not considered to be suitable.*	Section 1.2
17.	The Independent Peer Review process shall not proceed until the Southland Regional Council confirms in writing that the Independent Peer Reviewer(s) meets these requirements.	Section 1.2
18.	The Independent Peer Reviewer(s) may be changed at any stage during operations, however, the new Independent Peer Reviewer(s) must be	Section 1.2

Condition Number	Condition	Reference
	confirmed as being appropriate by the Southland Regional Council in accordance with condition (15).	
19.	The consent holder shall engage, at its own cost, an Independent Peer Reviewer(s), to review the design, construction, operation, maintenance and monitoring of the landfill and to assess whether or not the work is undertaken by appropriately qualified personnel in accordance with good practice. The Independent Peer Reviewer(s) shall produce an annual report on the following matters by 1 May every year: ▪ site preparation, including hydrogeological and geotechnical issues; ▪ liner, leachate collection and stormwater system detailed design (including calculations), construction and quality control and use of on-site materials; ▪ landfill operations management; ▪ water control, including groundwater, stormwater and leachate management; ▪ compaction, including method and degree; ▪ waste acceptance; ▪ cover material used; ▪ landfill gas management; ▪ monitoring, modelling and records; ▪ site rehabilitation. Preparation of each annual report shall include at least one site inspection. In addition, the Independent Peer Reviewer may report, in writing, to the Southland Regional Council on any matter that he/she considers should be brought to the attention of the Council in respect of the landfill and its operation. Copies of all reports shall be sent to the consent holder and the Southland Regional Council. A Terms of Reference, to guide and direct the Independent Peer Reviewer, shall be established, in consultation with the Southland Regional Council.	Section 4.4.2
20.	Following independent peer review (as per condition 19 of this Schedule), detailed designs of all works, , shall be updated and included in the Environmental Management Plan and relevant sub management plan(s) and forwarded to the Southland Regional Council for acceptance in writing prior to works commencing. All works shall be carried out in accordance with the designs as accepted by the Southland Regional Council.	Section 4.4.2
Environmental Management Plan		
21.	The overall purpose of the EMP is to provide details of the practices and procedures to operate the landfill in compliance with the conditions of	Section 1.1

Condition Number	Condition	Reference
	consent. The EMP shall comply with the relevant consent conditions and achieve the following objectives:	
	i. To operate in full compliance with the resource consent requirements and demonstrate this through reporting procedures to Consent Authorities.	Section 2.3
	ii. To liaise closely with neighbours and the local community, including iwi representatives, regarding landfill operational issues.	Section 3.2
	iii. To provide a safe working environment for people on the site.	Section 3.3.3
	iv. To maintain an independent review process for the design, construction, operation and aftercare of the landfill to confirm the work is undertaken by appropriately qualified personnel in accordance with good practice	Section 1.2
	v. To identify operational responsibilities, the management structure and staffing	Section 1.3 and Section 1.4
	vi. To facilitate the effective training of staff:	Section 3.4
	vii. To facilitate accurate record keeping	Section 4.1
	viii. To maintain community involvement including details of complaints procedures	Section 4.3
	ix. To appropriately manage site access, fencing and security	Section 3.3
	x. To manage site infrastructure and site amenities	Section 3.3

2.4 Monitoring and Reporting the Performance of the Environmental Management Plan

Table 5 Monitoring and Reporting Requirements Related to the Environmental Management Plan

Condition	Requirement	Relevant Regulatory Authority	Frequency	Date	Responsibility	Reference
Land Use Consent 60/3/02/138/1						
2.28	The Southland District Council may, on 1 May each year, commence a review of the Environmental Management Plan to ensure that management practices continue to result in compliance with the conditions of this consent. Any costs inherent in this review shall be borne by the consent holder.	Southland District Council	Annually	1 May	Southland District Council Compliance Officer	N/A
Schedule 1 – General Conditions AUTH 201346, 201347, 201348, 201349, 201350, 201351						

Condition	Requirement	Relevant Regulatory Authority	Frequency	Date	Responsibility	Reference
29.	The EMP and sub-management plans (where applicable) shall include monitoring with respect to surface water, groundwater, leachate, landfill gas and nuisance. Each monitoring element shall include: ii. Monitoring locations; iii. Monitoring parameters; iv. Monitoring frequency; v. Detection limits; vi. Reporting; Trigger levels (for each monitoring location) for implementing contingency/remedial actions	Environment Southland	Refer to sub-management plans	Refer to sub-management plans	AB Lime Environmental Manager	Section 4

2.4.1 Interaction Between Legislative Requirements and Management Plans

If there is conflict between the management plan and the corresponding legislative requirements, including consent conditions, then the legislative requirements must prevail.

3. Implementation and Operation

This section of the plan outlines how the identified environmental and social requirements in section 2 will be managed to achieve the commitments outlined in section 1.1.

3.1 Environmental Management Plans

The conditions require a number of sub management plans to be developed and certified to support the Environmental Management Plan. The purpose of each plan is detailed in Table 6 and form the overall environmental management system for the site.

Table 6 Environmental Sub-Management Plans and Purpose

Plan	Purpose
Landfill Operations Management Plan	The Landfill Operations Management Plan sets out how operations of the landfill will be undertaken and managed to mitigate any adverse impact on sensitive receptors.
Landfill Gas Management Plan	The Landfill Gas Management Plan sets out how landfill gas systems will be designed and operated to appropriately manage the effects of landfill gas on the landfill site.
Landfill Concept, Landscape Rehabilitation and Aftercare Plan	The Landfill Concept, Landscape Rehabilitation and Aftercare Plan demonstrates how the effects of post-landfill management are mitigated or avoided for final contouring, landscaping activities, planting programmes and aftercare.
Landfill Leachate Management Plan	The Landfill Leachate Management Plan sets out how the effects of landfill leachate are managed, mitigated and avoided through leachate design, leachate treatment and disposal and leachate recirculation.
Landfill Air Quality Management Plan	The Landfill Air Quality Management Plan sets out how odour and emissions will be managed and treated at the landfill to mitigate and avoid any adverse effects on sensitive receptors and ensure compliance with consent conditions.
Quarry Management Plan	The Quarry Management Plan sets out how operations of the quarry will be undertaken and managed to mitigate any adverse impact on sensitive receptors.
Site Traffic Management Plan	The Site Traffic Management Plan sets out how traffic operations are designed and implemented on site.
Stormwater Management Plan	The Stormwater Management Plan sets out how to manage the effects of landfill and quarry stormwater in accordance with conditions of consent to manage and mitigate any adverse impact on the receiving environment
Site Archaeological/Koiwi or Taonga Accidental Discovery Plan	The Site Archaeological/Koiwi or Taonga Accidental Discovery Plan sets out how to manage Taonga and artefact discovery at the landfill and quarry.

3.2 AB Lime Landfill Community Liaison Committee

The following parties have been identified as important community pillars to remain involved in the operation of the landfill:

- All adjoining landowners/occupiers whose residential dwellings are in close proximity to the site of this consent and not owned by the consent holder;
- Te Ao Marama Incorporated;
- Southland District Council;
- Environment Southland;
- Public Health South; and
- Winton Community Board.

The objectives of the CLC are:

- To engage on an ongoing and regular basis about matters associated with the operation of the landfill, where those matters affect the community and are of mutual interest to the representative parties.
- To promote the free flow of information between the local community and the consent holder so as to, wherever possible, address any issues that may arise.

Importantly, given the fluid nature of the requirements to meet to discuss these issues it is recommended that the CLC have the ability to set their own terms of engagement. The condition of consent governs the initial membership of the purposes of convening the first meeting of the CLC and ongoing membership can be determined by the CLC.

In the event that it is not possible to establish or convene CLC meetings through lack of interest to participate from the local community, then such a failure to do so does not constitute a breach of the condition of consent. Should the local community wish to re-establish meetings after a period of inactivity then the conditions above continue to apply.

3.3 Site Provisions

3.3.1 Operating Hours

The landfill is normally open for waste acceptance during the following times:

- **Monday to Saturday 8am to 6pm**

Hours may be shortened over the winter period (May to October). Vehicles transporting refuse, cover and or construction material to and from the site do not enter the site prior to 7.45 am or leave after 6.15 pm on any day.

Other landfilling operations (such as placing cover, maintenance etc.) are undertaken during operating days between 7.00 am and 6.15 pm.

Gates are locked after hours.

3.3.2 Right of Access

There is no direct access to the landfill by the public and there are no recycling or composting facilities on site. A fence restricts vehicles from the site and there is a gate that is locked outside operating hours.

3.3.3 Safe Working Environment

The landfill operation complies with regulations under the Health and Safety at Work Act 2015.

A site Health and Safety Plan is in operation for landfill and quarrying activities (refer to section 1.1.3), and is adhered to by the site operator, contractors or any other persons entering the site. There is no direct public access to the landfill site.

Management, the workforce, contractors and visitors are made fully aware of the existence of the site safety regulations and know to observe them at all times. These regulations include instructions on:

- Speed limits;
- Personal protection clothing;
- The risk of overturning if vehicles attempt to discharge their loads on uneven surfaces;
- Fire hazards (no smoking or naked lights within the landfill area);
- No fires anywhere;
- Personal hygiene;
- Tetanus and hepatitis vaccination;
- Access to confined spaces;
- Reporting accidents and incidents;
- Personal noise exposure;
- Substances hazardous to health; and
- Emergency responses procedures

Access to leachate manholes or any underground chamber or trench is restricted to staff and contractors who are fully trained with appropriate health and safety procedures.

Prior to any work taking place in confined spaces, the work requires a Job Safety Analysis (JSA). All JSA must be signed off by the Quarry Manager before work can commence.

3.3.4 Fencing

- A fence is provided around the landfill site, and the gate to the landfill is locked outside normal operating hours;
- Security fences are erected around the gas flare compound.

3.3.5 Security

It is critical to control where and when people access the landfill. Unauthorised entry can lead to waste dumping, fires and vandalism of pollution control devices as well as loss of amenity. Salvaging / scavenging is prohibited as the practice is dangerous and interferes with the efficient operation of the landfill.

Site security includes controlling access onto the site and supervising the activities of all persons on-site.

Site security includes:

- Fencing of the perimeter of the site with one gate through which all vehicles and persons enter and leave
- The employment of appropriately trained staff to control access to the site by vehicular traffic
- Maintenance of physical access control
- Surveillance and control of visitors, users and employees

a) Inspection monitoring and maintenance

Site fence is to be inspected on a monthly basis by the Landfill Operations Manager and recorded in a monthly site inspection checklist. Illegal dumping, damage or vandalism either within the property or to perimeter fencing is to be reported.

b) Contingency Plan

Dependent on the nature of breach in site security, AB Lime has identified specific responses. Evidence of unauthorised disposal of waste will require the following actions:

Contingency triggering event	Response guidelines
Evidence of unauthorised disposal of waste	▪ Advise Site Management immediately ▪ Segregate wastes from approved wastes ▪ Notify Environment Southland ▪ Dispose of material in an approved location ▪ Breach to be recorded in incident register
Site security breach that results in damage to property	▪ Landfill Operations Manager to handle the breach work with the local police and property insurance company

3.3.6 Site Infrastructure and Amenities

The landfill shares the following facilities with the quarry:

- Weighbridge;
- Weighbridge office;
- Administration office;
- Parking;
- Wheel wash;
- Workshops; and
- Internal roading

The location of the landfill facilities is shown in Attachment 1.

3.3.6.1 Landfill Facilities

- The weighbridge office at the site entrance operates as a control office for acceptance of refuse and checking of documentation;
- A small portable office at the landfill is provided for record keeping, storage of monitoring equipment and may be used for staff training;
- Radio telephone contact is maintained between the weighbridge office and landfill operating area. The Landfill Supervisor is also contactable by cell phone; and
- The existing quarry workshop is used for maintenance of mobile plant and equipment.

3.3.6.2 Personnel Welfare Facilities

Welfare facilities include:

- Personal Effects Storage;
- Storage for safety equipment;
- Adequately heated and lighted staff room;
- Facilities for heating food and providing hot water;
- First aid equipment room;
- Washbasin with hot and cold water;

- Shower facilities; and
- Lavatories for both employees and visitors.

3.3.6.3 Hazardous Substances Storage

The following methodology is adopted for hazardous substances on site:

- A suitable storage area is provided for potentially harmful substances such as insecticides and weed killers in the AB Lime Dairy Farm Chemical Shed. This facility is clearly labelled and is locked with access only to authorised staff;
- For non-complying hazardous wastes delivered to site, contingency plans and temporary storage protocols are described in the appropriate sub-management plans; and
- Diesel fuel for mobile and static plant, operated on the landfill and quarry, is stored in a bunded tank. Fuel tanks are clearly labelled.

3.3.6.4 Wheel Wash

Vehicle wheel wash facilities are provided. The wheel wash facilities are used by all vehicles, as required, after depositing waste at the landfill to minimise the tracking of particulate matter off site. Waste water is drained to a settling pond before being recycled by the plant.

3.3.6.5 Signs and Lighting

A sign at the site entrance near the weighbridge displays that only authorised users may proceed to the weighbridge, and all other site visitors are to report to the office.

All signs are maintained during the operation of the landfill. All signs relevant to the naming of the landfill are required to have the title "AB Lime Landfill" or "AB Lime Solid Waste Disposal Facility'. There is to be no direct reference in any naming signage to Kings Bend or Winton.

A sign is located at the landfill which details the following:

- Prohibiting unauthorised vehicles;
- No smoking;
- Travel and tipping instructions;
- Safety Instructions; and
- Types of waste prohibited.

All exterior lighting is directed away from adjacent residence to minimise the potential for adverse effects from light spill in adjacent residents and to achieve compliance with Rule Rural.7(1) of the Operative Southland District Plan 2018.

3.4 Training

Part of the AB Lime Health and Safety Officers' duties is the training and development of all landfill staff. All staff have the opportunity to attend external training courses to ensure best practice is maintained.

All site staff are required to have an understanding of the principles of landfill management and the requirements of the consent conditions and all management plans.

Training programs are prepared for site staff where appropriate to maintain their skills in the follow areas:

- Health and safety policy for contractors, visitors and transport operators;
- Emergency response procedures;
- Effective use of personal protection equipment;

- Hazardous waste identification;
- Waste acceptance procedures;
- Action plan, contingency and implementation for accidental hazardous waste acceptance;
- Hazard identification and reporting procedures;
- The effective use of litter fences;
- Rodent, cat and bird control;
- Entry into confined spaces;
- Refuelling procedures;
- Leachate management;
- Odour control;
- Plant and equipment maintenance and operation;
- Landfill gas risks and operational procedures;
- Dust control and suppression; and
- Wheel washing and general control of mud/dust.

All equipment and plant on-site will be operated and maintained by appropriately trained staff and in accordance with the manufacturer's instructions.

3.5 Emergency Contacts and Response

An Emergency Response Plan is in operation for landfill and quarrying activities. A current emergency contact list is displayed at the Landfill Office and Main Office as part of AB Lime Health and Safety policies.

Contact	Telephone Number
FIRE, AMBULANCE or POLICE EMERGENCY	111
Winton Medical Centre	(03) 236 7444
Regional Ambulance Centre	0800 100 776
Winton Police Station	(03) 236 6060
Winton Fire brigade (unattended)	(03) 236 7118
Browns Fire brigade (unattended)	(03) 236 4018
Power Net Ltd	(03) 217 1899
Power Services	(03) 236 9072
National Poison Centre	0800 764 766
Jodi Baylis – H & S Coordinator	027 531 3786
Steve Smith – General Manager	Home: (03) 236 9923 or Cell: 027 681 8881
Craig Owen-Cooper – Quarry Manager	Cell: 027 283 4585

4. Monitoring and Review

4.1 Record Keeping

All records are legible and stored either as paper copy in an appropriate file and/or as computer files. Records are maintained and backed up in accordance with AB Lime documented administrative procedures.

Monitoring information is compared to compliance requirements and trigger levels. Trends are monitored and explanations provided where possible.

The landfill operator maintains operational records including:

- Wastes accepted by type and weight;
- Waste inspections undertaken and any rejected loads;
- Daily record of areas used for waste disposal;
- Vehicle movements;
- 3-D disposal locations of treated hazardous wastes and special wastes;
- Any actions to control vermin;
- Complaints;
- Design and construction records, including as-built drawing; and
- Environmental Monitoring data as per the appropriate sub-management plans.

4.1.1 Onsite Documentation

The following information is documented and generated onto a computer system on the arrival of all waste consignments. Most of the data below is generated automatically:

- Date and time generated by computer;
- Container identification;
- Type of vehicle;
- Net weight;
- Vehicle registration number;
- Order number ;
- Truck ID;
- Client and source codes;
- Description of waste as per waste code and special permit numbers; and
- Drivers signature of waste docket book.

In the event that a consignment of waste that is considered unacceptable for disposal at the landfill due to hazardous content, procedures are followed as per the Landfill Operations Management Plan. Information recorded is documented on a waste inspection sheet and a copy sent to Environment Southland via email or fax. The original sheet is filed.

The results of one in fifty (50) random inspections are carried out every month and are recorded on Waste Inspection Sheets and transferred to an electronic spreadsheet. If during these random inspections hazardous waste is discovered, copies of the inspection sheets are sent to Environment Southland along with a description of the action taken.

Records of vehicle movements are supplied to Southland District Council every 6 months in accordance with the Site Traffic Management Plan.

4.2 Compliance Monitoring

The monitoring requirements and parameters are extrapolated under each relevant sub-management plan. For ease of reference and completeness all monitoring requirements related to the operation of the landfill are summarised in Table 7 below.

Table 7 Compliance Monitoring (table to be updated upon the consents being granted)

Environmental Aspect	Requirement	Relevant Regulatory Authority	Frequency	Management Plan with the Detailed Monitoring Requirements
Landfill Operations/ Groundwater	Annual noise monitoring survey	Southland District Council	Annually	Landfill Operations Management Plan
	Report of the waste types and quantities received	Environment Southland	Annually	
	Notification of any vehicles turned away for not meeting the waste acceptance criteria		As required	
	Report on the water level of each downgradient groundwater monitoring well		Monthly recording, quarterly reporting	
	Report on the groundwater composition for a range of parameters at each downgradient groundwater monitoring well		Quarterly and reduced to 6 Monthly	
	Report on the volatile organic compounds and semi-volatile organic compounds at each downgradient groundwater monitoring well		Annually - February	
	Report on the inspection of the landfill cap following storm events greater than 50% AEP or at least every 6 months.		As required post storm events or at least every 6 months	
	Report on the quantity of the groundwater taken from the groundwater underdrainage system		Continuous monthly recording, annual reporting	
	Report on daily water usage and pumping logs		Daily recording, annual reporting	
	Report produced by an appropriately experienced person on the operation of the landfill.		Annual report	
Landfill Gas	Record of weekly landfill inspection for evidence of possible gas leaks	Environment Southland	Weekly recording, remediation as required	Landfill Gas Management Plan

Environmental Aspect	Requirement	Relevant Regulatory Authority	Frequency	Management Plan with the Detailed Monitoring Requirements
	Record the methane concentrations at least once each month in at least 7 monitoring probes outside the landfill footprint		Monthly recording	
	Record for a range of parameters the landfill gas at each gas extraction well head		Monthly recording	
	Record continuously a range of parameters at the permanent landfill gas flare		Continuous recording	
	Record weekly the gas composition (ppm carbon monoxide) at the permanent landfill gas flare		Weekly recording	
	Record weekly the hydrogen sulphide concentration at the permanent landfill gas flare		Monthly recording	
	Record weekly the concentration of total non-methane organic compounds at the permanent landfill gas flare		Annual recording	
Landfill Landscape	Report on the progress and forward works relating to site rehabilitation	Southland District Council	5 Yearly	Landfill Concept, Landscape, Rehabilitation and Aftercare Plan
Landfill Leachate	Report the daily leachate volume withdrawn from the landfill, the leachate volumes discharged onto or into the landfill and the level of leachate in the landfill	Environment Southland	Daily recording, Annual reporting	Landfill Leachate Management Plan
	Report on the daily recorded dissolved oxygen levels leachate storage pond		Daily recording (2 readings between 8am and 10am each week), 6 monthly reporting	
	Report the inflow of the leachate composition for a range of parameters		6 monthly samples and reporting	
Landfill Air Quality	Record hourly wind velocity and direction, barometric pressure, rainfall and temperature.	Environment Southland	Hourly recording	Landfill Air Quality Management Plan
	Record boundary odour observations once a week during winds blowing from the north, northeast and east (winds		Weekly recording	

Environmental Aspect	Requirement	Relevant Regulatory Authority	Frequency	Management Plan with the Detailed Monitoring Requirements
	blowing from 0 - 90 degrees azimuth), or during still cold air drainage conditions.			
	Record H_2S continuously at two monitors along the south western boundary		Continuous monitoring	
Site Traffic	Report on the daily weigh bridge logs	Southland District Council	Daily recording, 6 monthly reporting	Site Traffic Management Plan and Environmental Management Plan
Stormwater	Report on the monthly rainfall at the rain gauge at Site 8	Environment Southland	Continuous monthly recording, annual reporting	Site Stormwater Management Plan
	Report on the continuous monitoring of stormwater discharge at Site 5 and 9		Continuous monthly recording, annual reporting	
	Report on the pH, conductivity, dissolved oxygen and turbidity in the stormwater discharge at Site 5 and 9		Continuous recording, quarterly reporting	
	Report on the stormwater composition for a range of parameters at Site 5 and 9		Quarterly reporting	
	Report on the volatile organic compounds and semi-volatile organic compounds in stormwater discharge at Site 5 and 9		Annual reporting	
	Report on stream sediments upstream and downstream of the site surface water discharge		2 yearly samples and reporting	
	Report on the flow and water quality of groundwater at Site 13.		Monthly recording, annual reporting	

4.3 Complaints and Feedback Procedure

A comprehensive analysis of complaints and mitigation measures is also provided in the Landfill Air Quality Management Plan.

4.3.1 Receiving Complaints and Feedback

If a complaint or feedback is received by post or fax or email, it is to be brought to the attention of the Environmental Manager as soon as possible and within 4 hours of receipt during normal working hours, dependant on the nature of the complaint.

If a complaint or feedback is received by phone, the call will be directed to the Environmental Manager, and if unavailable, to the General Manager. Failing that calls can be directed to the Quarry Manager.

The following details (when relevant) of all complaints or feedback are to be taken and recorded in the site register:

- Name, address and telephone number of complainant(s);
- Nature of complaint and effect detected;
- Time and day of occurrence that gave rise to the complaint;
- Location of the source of the effect;
- Weather, wind direction and rainfall at the time the effect was detected;
- Most likely cause of effect;
- Response made; and
- Corrective action taken or proposed to avoid, remedy or mitigate the effect

If the Environmental Manager is to be out of contact for more than 4 hours after receiving the complaint or feedback, with the General Manager or Quarry Manager will respond to the complaint or feedback.

4.3.2 Response to Complaints and Feedback

The Environmental Manager will contact the complainant by telephone, or if this is not possible by sending a letter, or email on the same day as the complaint or feedback is received.

If the cause of the complaint is identifiable, measures will be put in place to avoid a recurrence will be provided. If there is uncertainty as to the nature or cause of the complaint or feedback the Environmental Manager will seek clarification. A meeting may be required to discuss the complaint or feedback and if possible, will be arranged as soon as is practicable:

- All complaints and feedback will be responded to in writing, and in some cases this may be after clarification;
- Copies of the written responses will be filed with the complaints and feedback register;
- All complaints and feedback will be reported to Environment Southland as soon as possible and no longer than one working day after the complaint is received;
- Should investigation of odour complaints or feedback indicate that discharges from the landfill are causing objectionable or offensive effect beyond the boundary, a systematic odour diary will be instigated in accordance with the Air Quality Management Plan.

4.3.3 Ongoing Complaints

If a complainant is dissatisfied with a response to a complaint, every reasonable attempt is made to find a satisfactory solution. If all reasonable measures are rejected, the complainant will be referred to Environment Southland and Southland District Council. Details of the measures offered will be sent to the regulatory authority at the same time as being offered to the complainant or if offered verbally as soon afterwards as is practical.

4.3.4 Access to Complaints and Feedback Register

The register of complaints and feedback will be provided to Environment Southland annually and be available for inspection by Environment Southland and Southland District Council at all reasonable times.

4.4 Audits

4.4.1 Internal Audits

Internal audits will be undertaken periodically (at as a minimum annually) by the Environmental Manager with the objective to determine if the environmental management requirements are being implemented and maintained, assess the effectiveness of the environmental controls being applied, and identify areas of non-compliance or improvement opportunities so that corrective actions can be taken.

4.4.2 Independent Peer Reviewer Annual Report

Conditions 19 and 20 in Schedule 1 of the consents held with Environment Southland, which applies to all consents issued by Environment Southland and describes the process for review of the following:

- Management and Monitoring Plans;
- Site preparation;
- Liner design and construction;
- The use of on-site materials;
- Water control – including stormwater and leachate management;
- Compaction;
- Waste acceptance;
- Cover material used;
- Monitoring, modelling and records; and
- Rehabilitation.

Following Independent Peer Review detailed designs of all works shall be updated and included in the Environmental Management Plan and relevant sub management plan(s).

4.5 Corrective and Preventive Action

Corrective and preventative actions will be identified through compliance monitoring, audits, and complaints/feedback processes. The actions and response will be recorded in the Corrective and Preventive Action Register held by the Environmental Manager. The actions assessed and when relevant discussed with Environment Southland/Southland District Council. The Environmental Management Plan and the sub management and mitigation plans will be updated as required.

4.6 Management Review

Annually (or when any major changes to legislation or policy occurs), a management review of the Environmental Management Plan and the sub management plans will be undertaken. This review will be led by the General Manager and will include the Environmental Manager. The review will focus on how environmental compliance is being managed and achieved and identifying areas of improvement.

Attachment 1. Site Drawing

DATE: 29/05/2020 12:04:40 PM NAME: HOBDAY, MAI
LOCATION: C:\users\hobdaym\appdata\local\projectwise\jacobs_anz_ie\d0213192\IZ000400-1000-NG-DRG-1002.dwg

LEGEND

- CONSENTED LANDFILL FOOTPRINT
- CELL DEVELOPMENT OF LANDFILL
- CELL DEVELOPMENT OF FUTURE LANDFILL
- CADASTRAL BOUNDARY
- BUILDING
- TREE

NOTES

1. THE HORIZOTNAL COORDINATE SYSTEM FOR THE SITE IS NEW ZEALAND MAP GRID 1949.
2. THE LATEST SURVEY FOR THE SITE WAS PERFORMED BY DRONE SURVEY, FLOWN ON 12/03/2020.

SCALE 1:2000 (A1)

0 40 80 120 160 200m

40 20

CONSENT ISSUE

REV	DATE	APP'D	REVISION
A	29.05.20	VP	CONSENT ISSUE

SCALES AT A1

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CLIENT AB LIME LTD.

PROJECT LANDFILL INVESTIGATION KING'S BEND SITE

DRAWN	DRAWING CHECK	REVIEWED	APPROVED
MH	JK	CW	VP
DESIGNED	DESIGN REVIEW	DATE 29.05.20	DATE 29.05.20
KJ	LJ		

TITLE LANDFILL FOOTPRINT AND SITE INFRASTRUCTURE

SCALE 1:10000 (A1)

DRAWING No IZ000400-1000-NG-DRG-1002

REV A

A1