Armidale Regional Landfill
Armidale Dumaresq Council
17-Jul-2015

Greenhouse Gas Management Plan

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Client: Armidale Dumaresq Council

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Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
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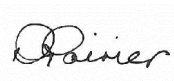
C	17-Jul-15	For Issue to DP&E	Danielle Poirier Associate Director - Environment	

Table of Contents

Abbreviations

CFCs	Chlorofluorocarbons
CH_4	Methane
cm	Centimetres
CO_2-e	Carbon dioxide equivalent
DP&E	NSW Department of Planning & Environment
EPA	NSW Environment Protection Authority
GGMP	Greenhouse Gas Management Plan
GHG	Greenhouse Gas
ha	Hectare
kL	Kilolitre
kWh	Kilowatt-hour
LEMP	Landfill Environmental Management Plan
LEL	Lower Explosive Limit
LFG	Landfill gas
MW	Megawatt
NA	Not applicable
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
t	Tonnes
tCO_2-e	Tonnes of carbon dioxide equivalent
TJ	terajoules
WTS	Waste Transfer Station

1.0 Introduction

1.1 Project Background

Armidale Dumaresq Council (Council) has approval for the construction and operation of a new regional landfill to service the Armidale region. The Armidale Regional Landfill (the project) is located on Waterfall Way, approximately 12 km east of Armidale.

The Planning Assessment Commission, as delegate for the then NSW Minister for Planning and Infrastructure, granted approval for the project under Section 75J of the *Environmental Planning and Assessment Act 1979*, subject to conditions, on 4 July 2012. The project involves construction and operation of a landfill comprising five cells, each cell with a maximum volume of 211,000m^3.

AECOM has been engaged by Council to prepare a Greenhouse Gas Management Plan (GGMP) for the construction and operation of the new landfill.

1.1.1 Consultation

A copy of this Plan was provided to the NSW Environment Protection Authority (EPA) on 1 July 2015 in accordance with consultation requirements under Condition 23 of the Project Approval. The EPA responded on 15 July 2015 confirming it had reviewed this GGMP and will not be providing any further comment (Appendix A). No formal consultation was required with the local community under this condition.

1.2 Purpose and Scope

This GGMP has been prepared in accordance with the Project Approval Conditions (06_0220) issued by the (former) NSW Department of Planning (dated 4 July 2012) and in accordance with the *Environmental Guidelines: Solid Waste Landfills* (1996) Benchmark Techniques set by the EPA. A modification is currently pending approval from the Secretary however would not impact the purpose or scope of this GGMP. Nonetheless, the GGMP has considered the anticipated modified changes where appropriate (for example, consultation requirements with the EPA rather than OEH).

Condition 22/Schedule 4 of the Conditions of Approval requires the implementation of all reasonable and feasible measures to minimise greenhouse gas emissions and energy use for the project.

Condition 23/Schedule 4 of the Conditions of Approval requires the preparation of a Greenhouse Gas Management Plan for the project, in consultation with the EPA and to the satisfaction of the Secretary of the (now) NSW Department of Planning and Environment (DP&E), prior to the commencement of operations.

This GGMP satisfies *Condition 23*. The GGMP identifies feasible and reasonable monitoring and management measures that will be implemented to minimise greenhouse gas (GHG) emissions and energy use during the operation of the project.

1.3 Structure of this Plan

This management plan is structured as follows:

Section 1.0 – Introduction

Section 2.0 – Statutory Requirements

Section 3.0 – Greenhouse Gas Emissions

Section 4.0 – Roles and Responsibilities

Section 5.0 – Management Measures

Section 6.0 – Monitoring Program

Section 7.0 – Reporting

Section 8.0 – Review and Continual Improvement

Section 9.0 – References

This plan forms part of the project's Landfill Environmental Management Plan (LEMP) as shown in Figure 1

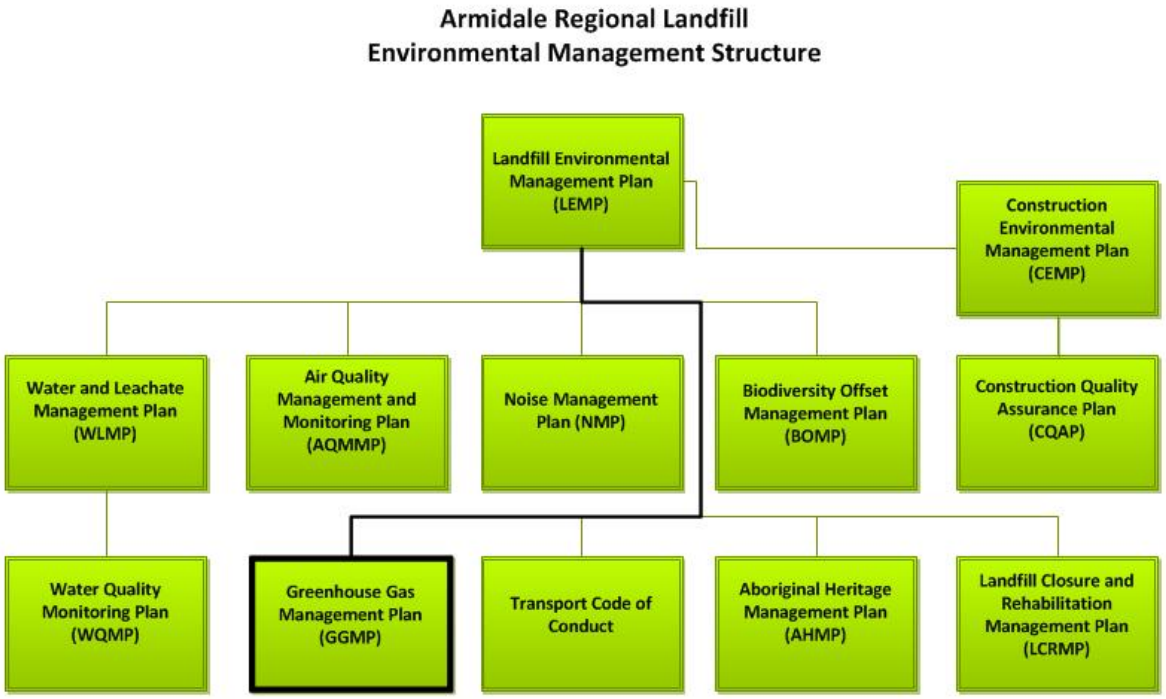


Figure 1 Environmental Management Structure

2.0 Statutory Requirements

2.1 Approval Requirements

Condition 22/Schedule 4 of the Conditions of Approval requires the proponent to implement measures to minimise GHG emissions and energy use.

Condition 22:

The Proponent shall implement all reasonable and feasible measures to minimise:

a) greenhouse gas emissions;

b) energy use.

Condition 23/Schedule 4 of the Conditions of Approval requires the preparation of a GGMP for the project.

Condition 23:

The Proponent shall prepare and implement a Greenhouse Gas Management Plan in consultation with the EPA and to the satisfaction of the Director-General prior to commencement of operations.

Table 1 indicates where each component of the conditions is addresses within this Plan.

Table 1 Management Plan Requirements

Project Approval Conditions	Plan Section
Condition 22/Schedule 4 The Proponent shall implement all reasonable and feasible measures to minimise: a) greenhouse gas emissions; b) energy use.	Section 5.0
Condition 23/Schedule 4 The Proponent shall prepare and implement a Greenhouse Gas Management Plan in consultation with the EPA and to the satisfaction of the Director-General prior to commencement of operations.	This GGMP satisfies Condition 23.

2.2 Licenses and Permits

The operation of the landfill will require an Environment Protection Licence as prescribed under the *Protection of the Environment Operations Act 1997*.

2.3 Relevant Legislation and Guidelines

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes the legislative framework for the reporting of greenhouse gas emissions, energy consumption and energy production by corporations in Australia.

Other additional legislative instruments under the NGER Act provide further detail of GHG and energy reporting obligations. These include:

- *The National Greenhouse and Energy Reporting Regulations 2008.*
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008* and associated amendments. The Measurement Determination is updated annually to reflect improvements in emission estimation methods.

The NGER Scheme legislation is administered by the Clean Energy Regulator, which operates under the *Clean Energy Regulator Act 2011* to reduce national GHG emissions.

Relevant guidelines for the identification, assessment and ongoing reporting of GHG emissions and energy for the project include:

- *The National Greenhouse and Energy Reporting (Measurement) Technical Guidelines* (NGER Technical Guidelines). These guidelines are updated on an annual basis to reflect changes made to the Measurement Determination and updated emissions factors. Chapter 5 of the NGER Technical Guidelines provides for emissions from solid waste disposal on land.
- NSW EPA *Environmental Guidelines: Solid Waste Landfills* (1996).
- NSW EPA *Draft Environmental Guidelines: Solid Waste Landfills*, Second Edition (2015).
- Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories* (2006).
- Life Cycle Assessment (LCA) Australian and New Zealand Standards (AS/NZS ISO 14040 series).
- Australian Standard AS ISO 14064.1:2006 Greenhouse Gas Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals (Standards Australia, 2006).
- World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (2005).

2.4 Reporting Thresholds

Under the NGER legislation, corporations who have operational control of activities or a facility which meets specified GHG emission and energy use/production thresholds are required to register and report emissions to the Clean Energy Regulator on an annual basis. There are two types of thresholds at which corporations are required to apply for registration and to report – 'facility' thresholds and 'corporate' thresholds. The facility threshold applies to the Armidale Regional Landfill.

The current GHG emissions threshold for a facility, which relates to Scope 1 (direct) and Scope 2 (indirect) emissions, is:

- 25,000 tCO_2-e.

The current energy use/production threshold for a facility is:

- 100 terajoules (TJ).

3.0 Greenhouse Gas Emissions

In 2010 AECOM prepared a Greenhouse Gas Inventory for the Armidale Regional Landfill to estimate the GHG emissions associated with the construction and operation of the project. The Greenhouse Gas Inventory was used to inform the project's Environmental Assessment.

The Greenhouse Gas Inventory (AECOM, 2010) provides modelling for GHG emissions under two scenarios. This approach allows for Council's objective to improve waste management procedures to be considered in the modelling.

The following sections provide an overview of the scope and results of the Greenhouse Gas Inventory estimated for the project.

3.1 Scope

The Greenhouse Gas Inventory considered Scope 1, Scope 2 and Scope 3 emissions associated with the construction and operation of the project over its 50 year life. Annual estimates of Scope 1 and Scope 2 emissions were also calculated and the results are presented in the following section.

Activities that would generate GHG emissions during construction and operation of the project were considered to those sources presented in Table 2.

Table 2 Sources of Emissions by Scope

Scope 1 – Direct Emissions	Scope 2 – Indirect Emissions	Scope 3 – Upstream Indirect Emissions
• The onsite use of fuel by construction plant/ equipment • The vegetation permanently cleared • Landfill gas (methane) emissions	• The onsite use of electricity purchased from the grid	• The onsite use of fuel by construction plant/ equipment • Use of fuel for the transportation of construction materials and staff to/ from site • The onsite use of electricity purchased from the grid • The use of construction materials

Landfill gas is the gaseous component of the various bi-products of the breakdown of organic wastes and other matter, over time, within a landfill mass. Landfill gas is made up a number of odourous and non-odourous gases, but mainly comprises methane (CH_4). Methane is an odourless, colourless gas which may be burned as a fuel source, if collected in sufficient quantities. Methane is a significant GHG which, if produced in any significant quantities, would need to be managed appropriately in order to reduce the landfill's GHG emissions.

The Armidale Regional Landfill is designed to accept up to 15,000 tonnes per annum (tpa) of general solid waste, up to a total capacity of 750,000 tonnes over the proposed landfill's life span of approximately 50 years.

The amount of landfill gas which will be generated will be dependent upon the fraction of putrescible materials within the waste stream. The landfill will be classed as a General Solid Waste (putrescibles) landfill. It is Council's longer term objective, however, to begin operating the landfill, as soon as possible in the future (and then until final closure) only as a General Solid Waste (non-putrescible) facility, when appropriate additional offsite sorting and/or treatment technologies are able to be procured and successfully employed. To account for this, the following waste stream scenarios were modelled:

- Scenario 1: General Solid Waste (putrescibles) landfill operating for 50 years.
- Scenario 2: General Solid Waste (putrescibles) landfill operating from years 1-10, General Solid Waste (non-putrescible) landfill operating from years 11-50.

Scenario 2 assumes that from year 11 onwards the waste landfilled will be pre-treated at an alternative waste treatment facility and that this facility will successfully remove 85% of the following materials from the waste stream:

- Food;
- Paper and paper board;
- Green waste;

- Wood and wood waste; and
- Nappies (not including compostable nappies).

It is noted that move to a non-putrescible landfill is subject to cost-effective available technology. Council have already been implementing a number of waste programs and actions in order to reduce waste to landfill (refer Section 5.1.2) with recent audits showing effective results.

3.2 Results

3.2.1 Construction and Operational GHG Emissions

The construction and 50 year operation of the project will generate approximately 693,871 tCO_2-e for Scenario 1 (i.e. if the putrescible materials and recyclables are not removed from the general waste prior to landfilling). The construction and 50 year operation of the project will generate approximately 279,381 tCO_2-e for Scenario 2 (i.e. if the putrescible materials and recyclables are removed from the general waste prior to landfilling from years 11 onwards). The breakdown of GHG emissions from the project is shown in Table 3.

Table 3 Estimated Total Greenhouse Gas Emissions – Construction and Operation (50 year period)

Emissions Source	Quantity	Units	GHG Emissions (t CO_2 –e)			Total GHG Emissions (t CO_2 –e)
			Scope 1	Scope 2	Scope 3	
Diesel Fuel Use						
Transport of Construction Materials	1,999	kL	5,394	-	409	5,804
Construction Equipment Onsite	11,856	kL	31,989	-	2,426	34,415
Transport of Waste to Landfill	1,452	kL	3,917	-	297	4,214
Landfill Gases						
Landfill Gas Emissions – Scenario 1*	750,000	t of waste	641,622	-	-	641,622
Landfill Gas Emissions – Scenario 2*	750,000	t of waste	227,132	-	-	227,132
Land Use Change						
Cleared vegetation	12.7	ha	4,572	-	-	4,572
Electricity Use						
Purchased Electricity	680,940	kWh	-	606	123	729
Use of Construction Materials						
Clay	338,831	t	-	-	678	678
Gravel	128,472	t	-	-	899	899
HDPE (liner)	167	t	-	-	363	363
Soil	308,459	t	-	-	463	463
Cover Material	75,960	t	-	-	114	114
Total – Scenario 1			**687,494**	**606**	**5,771**	**693,871**
Total – Scenario 2			**273,004**	**606**	**5,771**	**279,381**

The total estimated quantities of fuel, waste disposed, vegetation removed, electricity and construction materials used during the 50 year operation of the project are shown in column 2 of Table 3.

The results show that the majority of GHG emissions are associated with Scope 1 direct emissions, specifically the methane generated as the waste decomposes in the landfill.

The breakdown of the annual Scope 1 and Scope 2 GHG emissions associated with the project is provided in the following section.

3.2.2 Annual Scope 1 and Scope 2 Emissions

For Scenario 1 the project will generate approximately 13,671 tCO_2-e per annum. For Scenario 2 the project will generate approximately 5,381 tCO_2-e per annum. The breakdown of annual Scope 1 and Scope 2 emissions is provided in Table 4.

Table 4 Annual Scope 1 and Scope 2 GHG Emissions

Emissions Source	Quantity	Units	GHG Emissions (tCO_2 –e)		Total GHG Emissions (tCO_2 –e)
			Scope 1	Scope 2	
Fuel Use					
Transport of Construction Materials	237	kL	640	-	640
Construction Equipment Onsite	40	kL	108	-	108
Transport of Waste to Landfill	29	kL	78	-	78
Landfill Gases					
Landfill Gas Emissions – Scenario 1*	15,000	t of waste	12,832	-	12,832
Landfill Gas Emissions – Scenario 2*	15,000	t of waste	4,543	-	4,543
Electricity Use					
Purchased Electricity	13,619	kWh	-	12	12
Total – Scenario 1			**13,658**	**12**	**13,671**
Total – Scenario 2			**5,369**	**12**	**5,381**

For Scenario 1 the project will generate approximately 13,658 tCO_2-e of Scope 1 emissions per annum. For Scenario 2, where the landfill is transitioned to a General Solid Waste (non-putrescible) landfill, the project will generate approximately 5,369 tCO_2-e of Scope 1 emissions per annum. In line with the total emissions estimate for the project, the highest source of emissions per annum is attributed to the generation of methane as the waste decomposes in the landfill. For Scenarios 1 and 2, the project will generate approximately 12 tCO_2-e of Scope 2 emissions per annum.

The most recently published Australian National Greenhouse Accounts estimate NSW's annual GHG emissions to be 154.7 million tCO_2-e for the year 2011 to 2012, of which 3.8 million tCO_2-e is attributed to the waste sector (Department of the Environment, 2014). The estimated annual Scope 1 and Scope 2 emissions from the project would therefore contribute approximately 0.36 percent and 0.14 percent of the State's annual waste sector emissions for Scenarios 1 and 2 respectively.

The GHG Inventory results do not indicate that the thresholds for reporting under the NGER Act, as discussed in Section 2.4, will be exceeded. However, during operation of the landfill, GHG emissions would be monitored to track emissions and energy use against these thresholds to ensure any reporting requirements are met in future, if required. GHG reporting obligations are discussed further in Section 7.0.

4.0 Roles and Responsibilities

Roles and responsibilities for the implementation of the GGMP, consistent with the overarching LEMP (ARLF-LEMP-RP-0001), are summarised in Table 5.

Table 5 Summary of Roles and Responsibilities

Responsibility	Action
Waste Manager	- Overall implementation of the GGMP. - Authorise and confirm the implementation of management measures. - Ensure staffing and training requirements for environmentally responsible and safe management of the landfill are undertaken in line with Benchmark Technique Number 39: Staffing and Training Requirements.
Site Environmental Officer/ Waste Super Intendant	- Coordinate landfill gas monitoring and compile data. - Maintain internal records of landfill gas monitoring, waste tracking data and other emissions source data. - Assess GHG emissions and prepare an internal GHG report, in consultation with a qualified GHG Specialist if required, on an annual basis. - Review results of annual GHG report and assess need for additional management measures. - Collate and maintain records of complaints, respond to complainants. - Identify any landfill gas emission non-conformances and notify Waste Manager. - Ensure staffing and training requirements for environmentally responsible and safe management of the landfill, including accurate data recording and management procedures, are undertaken in line with Benchmark Technique Number 39: Staffing and Training Requirements.

5.0 Management Measures

The results of the Greenhouse Gas Inventory (AECOM, 2010), summarised in Section 3.0, indicates that the emission of landfill gas (methane) is the most significant source of GHG emissions for the project for both Scenario 1 and Scenario 2. This is largely due to the nature of methane, which has a global warming potential of 21 times the carbon dioxide equivalent.

Measures to reduce the amount of putrescible materials in the waste stream, in line with Council's objectives for waste management of the landfill, will therefore have the greatest impact on reducing the landfill's GHG emissions. Similarly, although to a lesser extent, measures to reduce energy and resource requirements during construction and operation of the landfill will also reduce GHG emissions.

The approach to identifying management measures was undertaken in line with the EPA's *Environmental Guidelines: Solid Waste Landfills* (1996) and the principles of sustainable resource management. The following hierarchy was used to develop the management measures:

- Avoid.
- Reduce.
- Abate.
- Offset.

The following sections outline the management measures that will be implemented to reduce/offset GHG emissions associated with the project.

5.1 Management of Landfill Gas Emissions

The management of landfill gas emissions for the project would be undertaken in accordance with the Environmental Goals set out in the EPA's *Environmental Guidelines: Solid Waste Landfills* (1996), which include:

1) Preventing landfill gas emissions, including minimising GHG emissions;
2) Detecting landfill gas emissions; and
3) Remediating landfill gas emissions.

The following sections outline measures incorporated into the landfill design and operation to meet these Environmental Goals.

5.1.1 Council Waste Reduction Strategy

The amount of landfill gas which would be generated by the project is primarily dependent upon the fraction of putrescible materials within the waste stream. Reducing the amount of putrescible waste landfilled at the proposed new landfill would therefore have the greatest impact on reducing the landfill's GHG emissions.

It is Council's objective to begin operating the landfill, as soon as possible in the future (and then until final closure), as a General Solid Waste (non-putrescible) landfill. Council aims to achieve this through the implementation of offsite sorting and/or treatment technologies within its existing waste management processes.

The majority of wastes received at the landfill will originate from the existing Waste Transfer Station on Long Swamp Road. The Waste Transfer Station allows for the source separation of waste for maximum recycling. Only the residual waste from the Waste Transfer Station will be directed to the landfill for disposal.

All green waste collected by Council would continue to be composted or mulched at the existing landfill at the Waste Management Centre on Long Swamp Road and made available for re-use. Green waste will not be disposed of in the Armidale Regional Landfill, except whenever significantly contaminated loads of materials are collected.

Through the implementation of these offsite sorting, treatment and recycling technologies, and the subsequent reduction of waste to landfill, Council anticipates an increase in the expected life of the first cell of the Armidale Regional Landfill from 10 years to 15 years. Examples of additional waste management initiatives implemented by Council are discussed in the following section.

5.1.2 Existing Waste Management Initiatives

In recent years, Council has implemented a number of strategies to reduce the quantities of waste to landfill and decrease the amount of organic material (putrescibles) in the waste stream. These initiatives include:

- **City to Soil:** Council implemented the *City to Soil* program to encourage residents and business to separate kitchen and garden organic wastes. Once collected, these organic wastes are composted and used to support local farmers and improve agricultural soils. Compost material can be purchased from the Waste Transfer Station.
- **Polystyrene Recycling:** Free polystyrene recycling has been implemented at the Waste Transfer Station to separate this material from the waste stream as it takes up valuable space in landfill. The polystyrene collected at the Waste Transfer Station is recycled into new products.
- **Plastic Bag/Film Recycling:** Council collects and separates plastic bags from the waste stream. The material is provided to downstream industry for recycling and reuse in creating new plastic products, preventing waste to landfill and reducing windblown litter at the landfill site.
- **Recycling Crates:** Council operates a recycling crate system to encourage residents to separate recyclables from their waste. The crates are used to separate paper and cardboard from cans, glass, plastic bottles and other recyclable containers to divert these materials from landfill. Council offers unlimited crates to residents to encourage recycling.

5.1.3 Additional Management Options

Additional methods which can be implemented to reduce the generation of landfill gas GHG emissions would be determined once the landfill has commenced operating and the quantity of emissions generated is determined. During the initial operational phase of the project, the landfill's performance with respect to landfill gas production and other associated matters would be assessed and the results discussed with both EPA and DP&E.

Once the filling of Cell 1 is complete, landfill gas monitoring would be conducted to determine if the amount of gas produced requires the installation of a gas extraction/control system (refer to Section 6.0).

Three suitable options to manage landfill gas emissions have been identified for consideration. These options, which are discussed in more detail below, include:

- The application of a methane oxidation cap.
- Passive venting and use of a filter (e.g. activated carbon or the like) to reduce emissions.
- Active collection of the landfill gasses with a landfill gas collection system and flaring of the methane (combustion conversion to CO_2).

The methane oxidation cap is a biological cap (sometimes called a phyto-remediation cap) that is used in preference to the standard compacted clay cap. It relies on a biomass that oxidises methane as the landfill gas permeates through the soil media that constitutes the cap. Extensive research into this type of capping demonstrates a reduction in methane emissions from landfills of up to 10 times over a standard compacted clay cap. The Waste Management Association of Australia is currently undertaking research into the use of alternative caps as part of the Australian Alternative Cover Assessment Program, which would allow more flexibility in national capping requirements for smaller landfills.

Landfill methane can be combusted by open flaring, burning to generate heat, or burning in an internal combustion engine to generate electricity. When anthropogenic methane is burned in air to produce carbon dioxide and water, the carbon dioxide produced is equal to the amount that would have been produced by natural decomposition. The carbon dioxide produced is therefore not considered an anthropogenic GHG emission and does not contribute to the facility's GHG emissions footprint.

Flaring is generally most effective and economically viable where smaller or unreliable quantities of methane are generated. Generation of heat or electricity has an additional benefit of offsetting electricity consumption, which further offsets total GHG emissions. However, these methods are only economically feasible where sufficient quantities of methane can be reliably collected over a long time.

In general, most commercially viable landfill gas to energy operations rely on consistent (i.e. 80 percent operational time) generation of 1MW of electricity for a period of 5-7 years. In order to achieve this, a landfill gas (LFG) flow of about 600m^3/hr is required with a 50 percent methane composition. To achieve this LFG flow, a landfill needs to have approximately 1 million tonnes of waste in place after a period of about 10 years.

The Armidale Regional Landfill will have accumulated approximately 150,000 tonnes of waste after approximately 10 to 15 years of operation, hence generation of electricity from landfill methane is not likely to be commercially viable.

The amount of methane generated after the landfill is operating will be monitored and assessed to determine whether the amount of methane produced is sufficient for either small scale self-generation or commercial scale electricity generation and export.

Monitoring and reporting of land fill gas emissions will be undertaken as part of the ongoing monitoring program and annual GHG reporting, as discussed in Section 6.0 and Section 7.0 of this management plan. The results will be used to assess the need for implementation of additional management measures, as described in this section.

5.2 Management of Other Emissions Sources

GHG emissions reductions are also achieved through sustainable management of other emissions sources including energy and resources. Management measures include:

5.2.1 Fuel

- Assess fuel efficiency of the construction plant/equipment prior to selection and, where practical, use equipment with the highest fuel efficiency or equipment which uses lower GHG intensive fuel such as biofuels (e.g. biodiesel, ethanol).
- Ensure construction equipment and transport vehicles are maintained to reduce energy efficiency losses associated with damaged/unmaintained equipment.
- Consider the distance of construction material suppliers prior to procurement to reduce transport-related emissions.
- Plan construction works to avoid double handling of materials.
- Reuse and recycling of materials at the landfill site where appropriate, to reduce the quantity of materials required to be brought to site.

5.2.2 Construction Materials

- Consider the distance of construction material suppliers prior to procurement to reduce transport-related emissions. For example, where possible, drainage gravel would be won on site or sourced locally.
- Assess the emissions intensity of construction materials specified in the project's detailed design and use purchasing power to drive the use of low emission construction materials.
- Reuse and recycling of materials at the landfill site where appropriate (e.g. crushed concrete aggregate), to reduce the quantity of materials required to be brought to site.

5.2.3 Vegetation Clearance and Sequestration

- Minimise vegetation clearance and undertake revegetation works, where possible.
- Vegetation clearance and management would be undertaken in accordance with the Biodiversity Offset Management Plan (BOMP). Any greenwaste generated on the landfill site will most likely be reused in the Biodiversity Offset Area (e.g. logs), with mulch used for the initial rehabilitation of areas following clearing and grubbing within landfill areas.
- The trees planted and maintained within the proposed Biodiversity Offset Area have the potential to sequester and store carbon, with an average of 360 t CO_2-e/ha (in the vegetation biomass only).

5.2.4 Energy Efficiency

Energy efficiency and energy reduction measures to be implemented at the landfill may include:

- Regular maintenance of construction equipment and transport vehicles to reduce energy efficiency losses associated with damaged/unmaintained equipment.
- Installation of solar panels to power monitoring equipment, lights and other site facilities (e.g. site shed). Council proposes to operate the site completely off-grid, using standalone solar power and standby generator to run all systems, including pumps.
- Using purchasing policies that favour energy efficient equipment.
- Enhancing the energy efficiency of buildings on site by using:
    - Energy efficient lighting systems with low energy lights, wide-panel skylights, task lighting, timers, and motion sensors.
    - Natural ventilation.
    - Wood/slow combustion heaters.

6.0 Monitoring Program

6.1 Landfill Gas Monitoring

The gas generated by the landfill would be contained by the leachate barrier system, by the covering of waste and by site capping and revegetation. The installation of a landfill gas extraction system is not considered necessary based on the type and volume of waste to be accepted at the landfill. Nevertheless, during the initial operational phase of the proposed development, the landfill's performance with respect to landfill gas production and other associated matters would be assessed and the results discussed with both EPA and DP&E.

Once the filling of Cell 1 is complete, landfill gas monitoring (surface and subsurface gas testing) would be conducted to determine if gas is being produced and whether the amount of gas produced requires the installation of a gas extraction/control system. The installation of a gas extraction/control system would be required if perimeter well testing shows methane concentrations that exceed 1.25 percent of methane (measured as volume/volume) or 25 percent of the Lower Explosive Limit (LEL).

In accordance with EPA Benchmark Technique Number 15: Subsurface Gas Monitoring Devices, monitoring wells should be installed at intervals sufficiently small to be able to detect any potential offsite migration of landfill gas. Monitoring wells should be installed around the perimeter of the site, to the following specifications:

- At a depth equal to the minimum groundwater level;
- The greatest depth of refuse; or
- Ten metres below underground utilities or manholes within 50 metres of the landfill.

Subsurface gas monitoring at the landfill perimeter would initially utilise the existing network of groundwater monitoring wells to detect whether gas migration is an issue, and whether further well development is required. Monitoring of these perimeter wells will commence following the filling and capping of Cell 1.

Methane generation would be monitored to determine whether there is sufficient methane produced to necessitate collection .The monitoring data would be assessed to consider whether the installation of a retro-fitted landfill gas system, such as those discussed in Section 5.1.3, is required for electricity generation.

In the event there is insufficient landfill gas to generate electricity but there is sufficient volume to warrant collection, the gas would undergo thermal oxidation, via flaring. If flaring is to be undertaken, non-methane organic compounds (NMOC) emissions would be quantified by the landfill operator, in strict accordance with the EPA Benchmark Technique Number 11: Extraction and Disposal of Landfill Gas, prior to and following any flaring activities taking place.

Low volumes of gas are unlikely to warrant collection or flaring and in this instance passive venting would also be investigated as a viable option to manage landfill gas.

6.2 Proposed Monitoring Program

Any gas extraction and/or monitoring would be undertaken in accordance with the EPA's *Environmental Guidelines: Solid Waste Landfills* (1996) and the relevant Environmental Goals, including:

- Benchmark Technique Number 11: Extraction and Disposal of Landfill Gas.
- Benchmark Technique Number 15: Subsurface Gas Monitoring Devices.
- Benchmark Technique Number 16: Subsurface Gas Monitoring Program.
- Benchmark Technique Number 17: Surface Gas Emission Monitoring.
- Benchmark Technique Number 18: Gas Accumulation Monitoring.

The proposed monitoring program provided in Table 6 sets out the frequency and procedure for landfill gas monitoring in accordance with these Benchmark Techniques.

Table 6 Proposed Monitoring Program

Type of Monitoring	Frequency	Procedure
Subsurface Gas Monitoring	Quarterly	- Detection of methane above 1.25% (volume/volume) will require notification to the EPA within 24 hours and an increase in the frequency of monitoring. - Procedures for subsurface sampling should include the flushing of one probe casing volume prior to taking the reading. - Testing for Hydrogen sulfide gas may also need to be undertaken in situ, using a properly maintained, zeroed and calibrated field instrument.
Surface Gas Monitoring	Quarterly / or as otherwise agreed with the EPA	- Testing of the atmosphere 5cm above the ground surface is to be undertaken in areas with immediate or final cover. - A field technician would start at a point 5m from the waste perimeter and walk across the waste parallel to the boundary of the landfill until reaching the opposite side. Repeat this procedure every 25m across the landfill. - This monitoring is to be undertaken in calm weather conditions (winds below 10km per hour). - Depressions in cover material or surface fissures outside of the nominated sampling grid must also be tested for methane emissions. - Monitoring should be conducted using a properly maintained, zeroed and calibrated methane gas detector. - The threshold concentration for closer investigation and potential action is 500 parts per million (volume/volume) of methane at any point on the landfill surface.
Gas Accumulation Monitoring (Buildings)	Quarterly / or as otherwise agreed with the EPA	- All buildings within 250m of deposited waste or areas identified in the LEMP as having potential to have methane concentrations greater than 1.25% (volume/volume) in the subsurface should be tested. - Buildings are not to have gas concentrations exceeding 1.25% (volume/volume). - If methane is detected above this volume, daily testing is required until ventilation or other measures control the methane build-up.

Adapted from *Environmental Guidelines: Solid Waste Landfills* (EPA, 1996)

Any change to the above procedures would require approval from the EPA prior to monitoring. Corrective action would be taken in consultation with the EPA if any monitoring results exceed the thresholds listed in Table 6. Monitoring reports would be maintained onsite and made available for inspection upon request by an authorised EPA officer.

Record keeping, data management and reporting procedures are discussed in Section 7.0.

7.0 Reporting

Greenhouse gas emissions and energy use can be tracked over time to assess the performance of the landfill and to identify the need for additional GHG abatement measures.

GHG monitoring and assessment results for each year will be documented and reported in the Annual Report. Results may also be published in incident reports and independent environmental reviews when relevant.

GHG measurement and reporting tools, such as those discussed in Section 2.3, are amended and updated annually. It is therefore important to ensure that the correct tools are used for each reporting year.

7.1 Data Management and Internal Reporting

The Site Environmental Officer shall establish and maintain a system of records which provides full documentation of all waste tracking data, landfill gas monitoring results and other data relevant to the assessment and reporting of GHG emissions.

The Site Environmental Officer would establish and maintain procedures for the collection, indexing, filing, storage and maintenance of the records. Archived records would be kept in accordance with standard document control procedures.

Benchmark Technique Number 39: Staffing and Training Requirements outlines the level and training of staff required to allow environmentally responsible and safe management of the landfill, and includes the importance of accurate data recording.

To allow the annual reporting of GHG emissions (documenting in the Annual Report), the following data management and internal reporting procedures would be followed:

Waste Tracking

The landfill will accept only approximately 15,000 tpa of waste per annum. A weighbridge will be installed at the landfill site to service commercial and reporting needs. Records of the waste types and weights received by the landfill will then be maintained in order to improve the estimates of the waste being disposed of.

The weighbridge operator will record the following information on the site database (linked via telemetry to the existing Waste Management Facility on Long Swamp Road) for waste tracking:

- Date.
- Time.
- Vehicle Registration.
- Customer.
- Gross weight, tare weight, net payload.
- Waste type.

Note: the tare weight of vehicles used for disposal of waste to the landfill will be known and kept on record.

The EPA *Environmental Guidelines: Solid Waste Landfills* (1996) provides examples of reporting forms in Appendix D of the guideline to assist landfill operators with the collation of data. The procedures for recording waste accepted at the landfill are provided in more detail in the LEMP (ARLF-LEMP-RP-0001).

Reporting of waste received at the Armidale Regional Landfill would be undertaken in accordance with Benchmark Technique Number 23: Recording of the Quantities, Types and Sources of Wastes Received. Data required to be provided to the EPA, which would also be used to assess and report GHG emissions is listed in Table 7.

Table 7 Requirements for Recording of Wastes Received

Type of Record	Frequency	Procedure
Waste acceptance reports	Monthly	- Quantities of waste received each month would be recorded and maintained for inclusion in the annual report to the EPA, or as otherwise requested by the EPA. - Controls would be implemented to prevent vehicles from entering or exiting the site without generating a permanent record.
Survey of the landfill	Annually	- A registered surveyor would undertake a survey of the site to confirm the volume of landfill space consumed in the past 12 months - This information would be provided to the EPA for comparison with monthly waste acceptance reports

Adapted from *Environmental Guidelines: Solid Waste Landfills* (EPA, 1996)

Landfill Gas Monitoring

If a landfill gas collection system is installed at the landfill, the quantity of gas flared or captured would be measured by the inclusion of a gas meter in the collection circuit. Landfill gas monitoring reports would include the following details:

- The locations and results of the monitoring.
- Notes identifying the principal sources of landfill gas.
- A summary of any measurements exceeding the criteria levels, and descriptions of the circumstances causing these exceedances.
- Details of corrective action applicable to criteria exceedances, and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending, and the status of its implementation shall be carried forward to following reports.

The results of the monitoring would be reported in the AEMR and submitted to the EPA.

Procurement and Resource Use

- Records of procurement of resources and energy, such as invoices, would be maintained within the system of records for the landfill.
- Waste tracking records would also be used to determine quantities of fuel used in the transportation of waste to site.
- Records of any vegetation clearance and/or sequestration (re-planting) would also be maintained and updated as necessary.

7.2 Reporting Under the NGER Act

As discussed in Section 2.3, corporations who have operational control of activities or a facility which meets specified GHG emission and energy use/production thresholds are required to register and report emissions under the NGER Act.

Council is the owner and operator of the Armidale Regional Landfill and is also responsible for its management throughout the facility's operational life and subsequent rehabilitation phases.

Reporting under the NGER Act would be triggered if the Armidale Regional Landfill generates GHG emissions equal to or exceeding the threshold of 25,000 tCO_2-e per year. Only Scope 1 (i.e. direct) emissions and Scope 2 (i.e. indirect) emissions as determined by the NGER Act are used to calculate the threshold. This includes direct emissions from the release of methane as well as emissions from fuel combusted on site (e.g. vehicles used on site).

Based on the results of the Greenhouse Gas Inventory (AECOM, 2010), the landfill is not anticipated to meet or exceed this threshold for either Scenario 1 or Scenario 2, with approximately 13,671 tCO_2-e and 5,381 tCO_2-e estimated to be generated per annum, respectively (refer to Section 3.2.2). However, internal GHG assessment and reporting would be undertaken on an annual basis, as discussed in the previous section. Results of internal reporting would be monitored against this threshold to determine if reporting under the NGER Act is required.

Similarly, the reporting threshold for facilities in terms of energy use/production of 100 TJ is unlikely to be met. The generation of electricity from landfill methane is not likely to be commercially viable given the small scale operation of the Armidale Regional Landfill. Energy use and possible generation would be recorded for internal reporting purposes and monitored against NGER Act reporting thresholds, where necessary.

If thresholds are triggered, emissions and energy use/production are required to be reported to the Clean Energy Regulator for each financial year.

8.0 Review and Continual Improvement

Within three months of a report submission to the Secretary, including the annual report, incident report and independent environmental audit, this management plan would be reviewed, and if necessary revised to the satisfaction of the Secretary.

The review would assess all relevant information to the GGMP including but not limited to:

- Historical analytical data;
- Changes in land use; and
- Incidents related to landfill gas emissions or excessive energy use.

The GGMP would be modified to reflect any variation in sampling frequency, addition of new sampling locations or variation in the analytical regime (for example, increased monitoring as a result of exceedances of landfill gas emission thresholds identified on site).

The GGMP would be viewed as a live document and updated as necessary, noting that revision of the GGMP may result in changes to the landfill gas monitoring regime.

The GGMP and associated documents (for example, waste tracking data, landfill gas monitoring reports and GHG emissions reports) would be maintained by Council and be made available for inspection when requested by an authorised EPA officer.

8.1 Non-Compliance Measures

In the event of landfill gas monitoring results exceeding the thresholds listed in Section 6.0, corrective action would be taken in consultation with the EPA, including:

- Notification of the EPA within 24 hours of an identified exceedance;
- Increased frequency of monitoring; and
- Implementation of additional measures to control methane build up and potential offsite migration, as recommended by the EPA.

Any change to the monitoring program and procedures would require approval from the EPA prior to being undertaken.

8.2 Complaints Handling

The procedure for the handling of complaints for the landfill, as detailed in the project's LEMP, is to be followed for all complaints made regarding offsite pollution and operation of the facility (ARLF-LEMP-RP-0001).

In terms of complaints relating to GHG emissions, the Site Environmental Officer would record the following information:

- Details of any complaints regarding GHG or landfill gas emissions, including the complainant's name, address and contact number.
- A summary of the complaint: complainant location, time of day, notes regarding the event and duration of the event.
- Details of the response to complaints (including supplementary monitoring, corrective action, etc.).
- A log of all factors related to the event, i.e. time of the complaint, duration of the event in question, frequency of the event if occurring on multiple occasions, landfilling operation details, weather conditions, etc.

The Site Environmental Officer would record details of all complaints received, which would be kept in an up-to-date log-book to ensure that a response is provided to the complainant within 24 hours. The corrective action may involve supplementary monitoring to identify the source of the non-conformance, and/or may involve modification of construction or operational techniques to avoid any recurrence or minimise its adverse effects. Complaints received in relation to GHG emissions would be updated onto the landfill complaints register on a monthly basis.

The Site Environmental Officer would make available a report on complaints received to the community, Council and relevant government agencies upon request. A summary will be included in the *Annual Report*.

9.0 References

AECOM, February 2010, Greenhouse Gas Inventory, Armidale Regional Landfill Environmental Assessment.

Australian and New Zealand Standards (ISO 14040 series) Life Cycle Assessment.

Australian Standard (AS ISO 14064.1 – 2006) Greenhouse Gases Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

Clean Energy Regulator, April 2015, National Greenhouse and Energy Reporting Scheme, Commonwealth of Australia 2015. http://www.cleanenergyregulator.gov.au/NGER/Pages/default.aspx

Department of the Environment, April 2014, State and Territory Greenhouse Gas Inventories 2011-12: Australia's National Greenhouse Accounts, Commonwealth of Australia 2014. http://www.environment.gov.au/system/files/resources/255447ab-3c51-412e-9756-921ef23cb8aa/files/state-territory-inventories-11-12.pdf

Department of the Environment, July 2014, The National Greenhouse and Energy Reporting (Measurement) Determination Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (NGER Technical Guidelines), Commonwealth of Australia 2014. http://www.environment.gov.au/system/files/resources/da7bde5c-1be2-43f7-97d7-d7d85bb9ad6c/files/nger-technical-guidelines-2014.pdf

EPA, January 1996, Environmental Guidelines: Solid Waste Landfills. http://www.epa.nsw.gov.au/resources/waste/950085-solid-waste-landfill.pdf

EPA, March 2015, Draft Environmental Guidelines: Solid Waste Landfills, Second Edition 2015. http://www.epa.nsw.gov.au/resources/waste/150111env-guide-solid-waste-landfills.pdf

Waste Management Association of Australia, 2006, Australian Alternative Covers Assessment Program. http://www.wmaa.com.au/aacap/aacap.html

World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI), 2005, The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.

Appendix A

Consultation with EPA on GGMP

Frolich, Alexandra

From: Michael Lewis <Michael.Lewis@epa.nsw.gov.au>
Sent: Wednesday, 15 July 2015 5:02 PM
To: Frolich, Alexandra
Cc: Lindsay Fulloon
Subject: RE: Armidale Regional Landfill - Greenhouse Gas Management Plan

Hi Alex,

Again as you have noted the EPA policy is that it will not endorse site management plans required by project approval conditions. However I can confirm that the EPA have reviewed the supplied GGMP and that it will not be making further comment.

Please don't hesitate to call me if you wish to discuss.

Cheers

Michael Lewis

Acting Head Regional Operations - Armidale | NSW Environment Protection Authority |

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From: Frolich, Alexandra [mailto:Alexandra.Frolich@aecom.com]
Sent: Wednesday, 1 July 2015 1:57 PM
To: EPA RSD Armidale Mailbox
Cc: Price, Duncan
Subject: Armidale Regional Landfill - Greenhouse Gas Management Plan

Good afternoon,

AECOM, on behalf of Armidale Dumaresq Council, wish to consult with the EPA on the attached Greenhouse Gas Management Plan (GGMP) for the Armidale Regional Landfill. The GGMP satisfies Condition 22 and 23 of Schedule 4 of the landfills project approval (PA 06_0220). We note that the EPA does not endorse management plans however we would appreciate any feedback or comment. We would appreciate feedback by 15th July 2015.

If you have any queries please let me know.

Kind regards,

Alex Frolich
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Alexandra.Frolich@aecom.com

AECOM