ARCADIS Design & Consultancy for natural and built assets

WEST NOWRA LANDFILL EXTENSION

Greenhouse Gas Assessment

30 JULY 2018

Incorporating Hyder

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SHOALHAVEN CITY COUNCIL

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Greenhouse Gas Assessment

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REVISIONS

Revision	Date	Description	Prepared by	Approved by
01	19/04/2018	Draft Greenhouse Gas Assessment	DH	ZW
02	4/06/2018	Final Greenhouse Gas Assessment	DH	ZW
03	19/06/2018	Revised Final GHG report – updates to text on emissions reduction from generator	DH	ZW
04	30/07/2018	Revised Final GHG report – updates from SCC to text on emissions reduction from generator	DH	ZW

CONTENTS

LIST OF ACRONYMNS

Acronymn	Term
BAU	Business as usual
C&D	Construction and demolition waste
C&I	Commercial and Industrial waste
CH_4	Methane
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide Equivalent
DA	Development Application
DoEE	Department of Environment and Energy
DP&E	NSW Department of Planning and Environment
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	New South Wales Environment Protection Authority
EPL	Environment Protection Licence
EP&A Act	Environmental Planning and Assessment Act 1979
GHG	Greenhouse Gas
GWP	Global Warming Potential
LEMP	Landfill Environmental Management Plan
LGA	Local government area
Mt	Mega tonnes
MSW	Municipal solid waste
N_2O	Nitrous Oxide
NGA	National Greenhouse Accounts
NGER	*National Greenhouse and Energy Reporting Act 2007*
NSW	New South Wales
LEMP	Landfill Environmental Management Plan
SCC	Shoalhaven City Council

Acronymn	Term
SSD	State Significant Development
t	tonnes
tpa	tonnes per annum
WNRWF	West Nowra Recycling and Waste Facility
WRI/WBCSD	The World Resources Institute/World Business Council for Sustainable Development

EXECUTIVE SUMMARY

Shoalhaven City Council (SCC) as part of waste management planning for the Shoalhaven region, is proposing to extend the current landfilling area at the West Nowra Recycling and Waste Facility (WNRWF) at 120 Flatrock Road, Mundamia (the Proposal). The Proposal would commence operation from approximately 2026 and would provide capacity to 2034 under a worst-case scenario (minimum of eight years) (SCC, 2017). SCC commissioned Arcadis to prepare a greenhouse gas (GHG) assessment to support a State Significant Development Environmental Impact Statement (EIS) under *Part 4, Division 4.1 of the Environmental Planning and Assessment Act 1979* for the Proposal.

GHG emissions from the Proposal are expected to peak at approximately 41,441 t CO_2-e at its highest emitting point for the collective GHG sources (putrescible waste decomposition, transportation, machinery and vegetation clearing). However, average yearly emissions from the Proposal are estimated to be only 20,767 t CO_2-e. The largest GHG source are those generated from the landfilled putrescible waste decomposition. Peak GHG emissions from the Proposal represent 0.48 per cent of Australia's solid-waste-sector GHG emissions or just 0.01 per cent of Australia's total annual GHG emissions (as at 2016).

The Proposal will see a gradual increase in the total emissions from the WNRWF. Installation of a landfill gas generator and gas flare system at the site in 2002 has reduced the gas emissions from the site, with the system operating at about 71 per cent efficiency. As additional gas is produced by the Proposal, it will be captured up to 71 per cent. Despite this, emissions from the WNRWF are predicted exceeding the 25kt of CO_2-e National Greenhouse and Energy Reporting (NGER) threshold in the years between 2029 to 2038.

As noted, putrescible waste decomposition forms the largest contributor to overall GHG emissions. Future organic diversion measures, such as the proposed processing of red bin waste through an alternative waste processing facility, alternatively implementing a kerbside green bin (GO or FOGO) collection system to reduce organics from the residual stream, or educational activities to encourage greater organic diversion, could have a significant effect on overall emissions. Likewise, broader waste minimisation and avoidance measures across the region, to divert waste from landfill could contribute to reducing overall GHG emissions from the Proposal.

The projected tonnes to landfill are considered conservative, with year on year growth assumed for population and waste generation. In practice, the volume of waste to landfill may be less than projected due to lower than predicted growth rates and the effect of various waste minimisation activities. Additionally, historical waste tonnes to landfill for the site indicate that there are natural fluctuations and variances, which have an immediate effect on landfill gas emissions. However, the reported modelling does not account for any of these potential improvements and therefore is considered a conservative result. Therefore, under the current emissions profile operational mitigation measures should include:

- Ensure that the final capping layer meets the requirements outlined in the Landfill Environmental Management Plan (LEMP) prepared by SLR. A review of best practice standards, methodologies and technologies at the time of capping, should be undertaken to ensure that an optimal solution is achieved. To maximise natural oxidisation through the final capping layer and reduce emissions, the capping layer should be maintained in good condition (i.e. thick layer of topsoil with healthy vegetation). The design and implementation should be reviewed at the time of capping.
- Undertake project planning to ensure that on-site vehicle movements and construction activities are efficient, avoid double handling of materials and avoid unnecessary fuel use.
- Considering use of alternative fuels which are less carbon intensive, such as operating machinery and construction activity vehicles which use bio-diesel fuels.
- Review the GHG emissions profile of the landfill based on recorded waste volumes four years[1] after landfilling commences in Stage 4 to:

[1] The selection of the date of four years post opening is because the landfill is predicted to open in 2026 and the NGER reporting threshold is predicted to be breached in 2031 (5 years later). Hence the timing would inform a decision on whether they are required to report.

  - Confirm the emissions projections reported herein and the need for reporting under the NGER scheme, and
  - Identify opportunities to optimise existing landfill gas management strategies, including existing landfill gas infrastructure.
- Provide a separate report to DPE summarising the findings of the GHG emissions review and outlining any additional reduction and/or management strategies to be implemented.

1 INTRODUCTION

Shoalhaven City Council (SCC), as part of waste management planning for the Shoalhaven region, is proposing to extend the current landfilling area at the West Nowra Recycling and Waste Facility (WNRWF) at 120 Flatrock Road, Mundamia (the Proposal).

1.1 Proposal overview

The Proposal would involve the progressive construction, operation and rehabilitation of the Stage 4 landfill extension at the WNRWF. The landfill extension and associated areas (including access roads, sediment basins, fire trails and a conservation area) would occur on Lot 1 DP 1104402, Lot 1 DP 870268 and Lot 1 DP 847203, with the leachate management system extending into Lot 1 DP 1018193. The location of the Proposal is shown on Figure 1-1 with the Proposal Site boundary shown on Figure 1-2. The Proposal Site is owned by SCC.

The Proposal Site is predominantly set within undeveloped bushland. The Shoalhaven River is located approximately 1 km north of the Proposal Site, with two tributary creeks, Sandy Creek and Cabbage Tree Creek, within 500 m to the west and east of the Proposal Site respectively. Semi-rural properties are located to the south and south-east of the Facility. The main township of Nowra is located approximately 3.8 km to the east of the Proposal Site.

The Proposal Site is approximately 14.52ha and is on land appropriately zoned SP2 Infrastructure–Waste/Resource Management Facilities. The Proposal would be managed under Council's existing and varied Environmental Protection Licence (No 5877) conditions.

SCC considered a range of waste generation and disposal scenarios to develop landfill life expectancy estimates[2]. Under the worst-case scenario, the current operational landfill (Stage 3) would reach capacity in approximately 2026.

The Proposal would commence operation from approximately 2026 and would provide capacity to 2034 under a worst-case scenario (minimum of eight years) (SCC, 2017). The preparatory and completion works for the landfill extension (e.g. landfill cell construction, construction of leachate barrier systems, and final rehabilitation) may commence/conclude up to two years before/after these timeframes. The filling rates and landfill capacity would be reviewed on an ongoing basis. The final landfill capacity would be approximately 1.38 million cubic metres upon completion, with an approximate design elevation of RL 59 m.

Approval is sought for the Proposal in the form of a Development Application (DA) under Part 4, Division 4.1 of the EP&A Act. SCC submitted a request for the Secretary's Environmental Assessment Requirements (SEARs) for the Proposal on 22 July 2015. SEARs were issued on 19 August 2015 (Reference SSD 15_7187) and were subsequently updated on 11 July 2017. An extension to the SEARs was granted on 22 September 2017.

The Proposal would receive waste from all areas within the SCC local government area (LGA). Waste would include general solid waste (i.e. putrescible and non-putrescible materials) and asbestos from domestic and commercial and industrial (C&I) sources.

The key works for which approval is sought include:

- Progressive landfill cell construction, operation and rehabilitation of the Stage 4 landfill extension including:
  - Clearing of 9.87 ha of existing vegetation
  - Construction of access tracks and fire trails

[2] Scenarios included: provision of the existing Stage 3 landfill only (i.e. no landfill extension or resource recovery park (RRP)); provision of the existing landfill and a RRP adjacent to the site; provision of the existing landfill, the RRP and the Stage 4 extension; and the "worst case scenario" adopted herein, being the landfill extension without the provision of the RRP.

  - Earthworks for cell formation including extraction and stockpiling of materials and the reapplication to form the leachate barrier (cell liner) as well as for daily, intermediate and final cover
  - Installation of leachate management structures including the leachate barrier, collection, storage and disposal system (including construction of a rising main to transfer leachate to the existing leachate collection dam within the WNRWF)
  - Installation of a surface water management system, including sediment dams, sediment erosion control measures and surface diversion bunds/swale drains
  - Progressively increasing the annual waste acceptance rate at the landfill
  - Signage and other ancillary works
  - Rehabilitation of closed sub-cells
- Delineation and ongoing management of a conservation area along the southern and eastern boundary of the Proposal Site.

The Proposal is expected to receive a total of approximately 1.38 million m^3 of waste over the life of the landfill extension and would be developed in sub-cells.

The existing landfill consists of three stages: Stages 1 and 2 are closed and capped; Stage 3 is currently operational. Stages 1 to 3 are already approved and therefore do not form part of the Proposal, however the GHG emissions from those stages ('legacy emissions') have been considered within this assessment. Inclusion of Stages 1 to 3 acknowledges the lag times associated with GHG generation, and the potential to manage legacy emissions from Stages 1 to 3 collectively with the emissions from Stage 4. This represents a proactive management approach by SCC in addressing the emissions from the entire landfill.

The landfill would continue to operate during the following hours:

- Monday to Sunday: 8am – 5pm, closed Public Holidays

Site management activities, such as waste covering operations, may continue one hour after closure. The concept design for the Proposal has generally been developed in accordance with the Environmental Guidelines: Solid Waste Landfills, Second Edition, 2016 (EPA, 2016) (Landfill Guidelines).

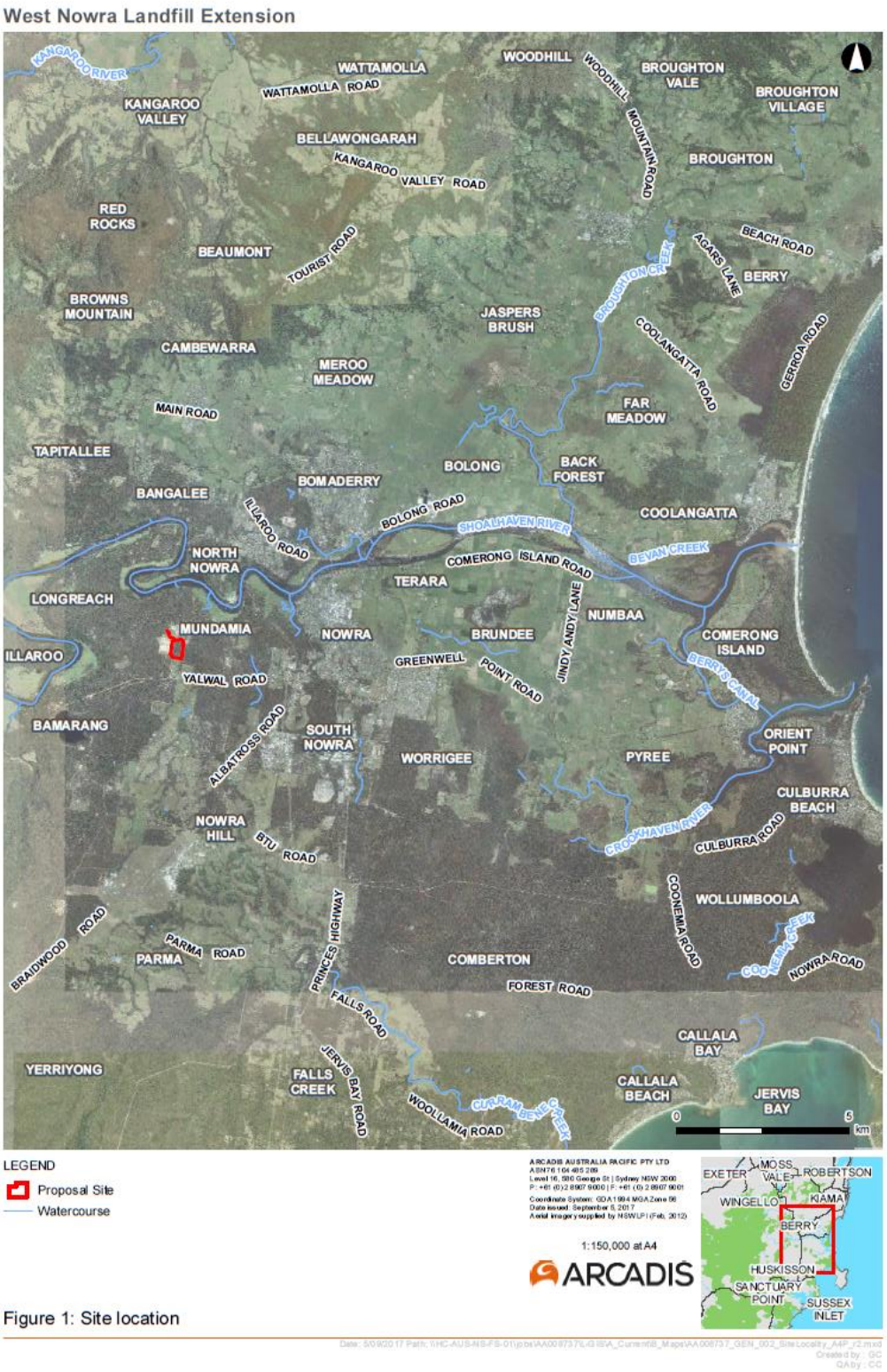

Figure 1: Site location

Figure 1-1 Proposal Site location

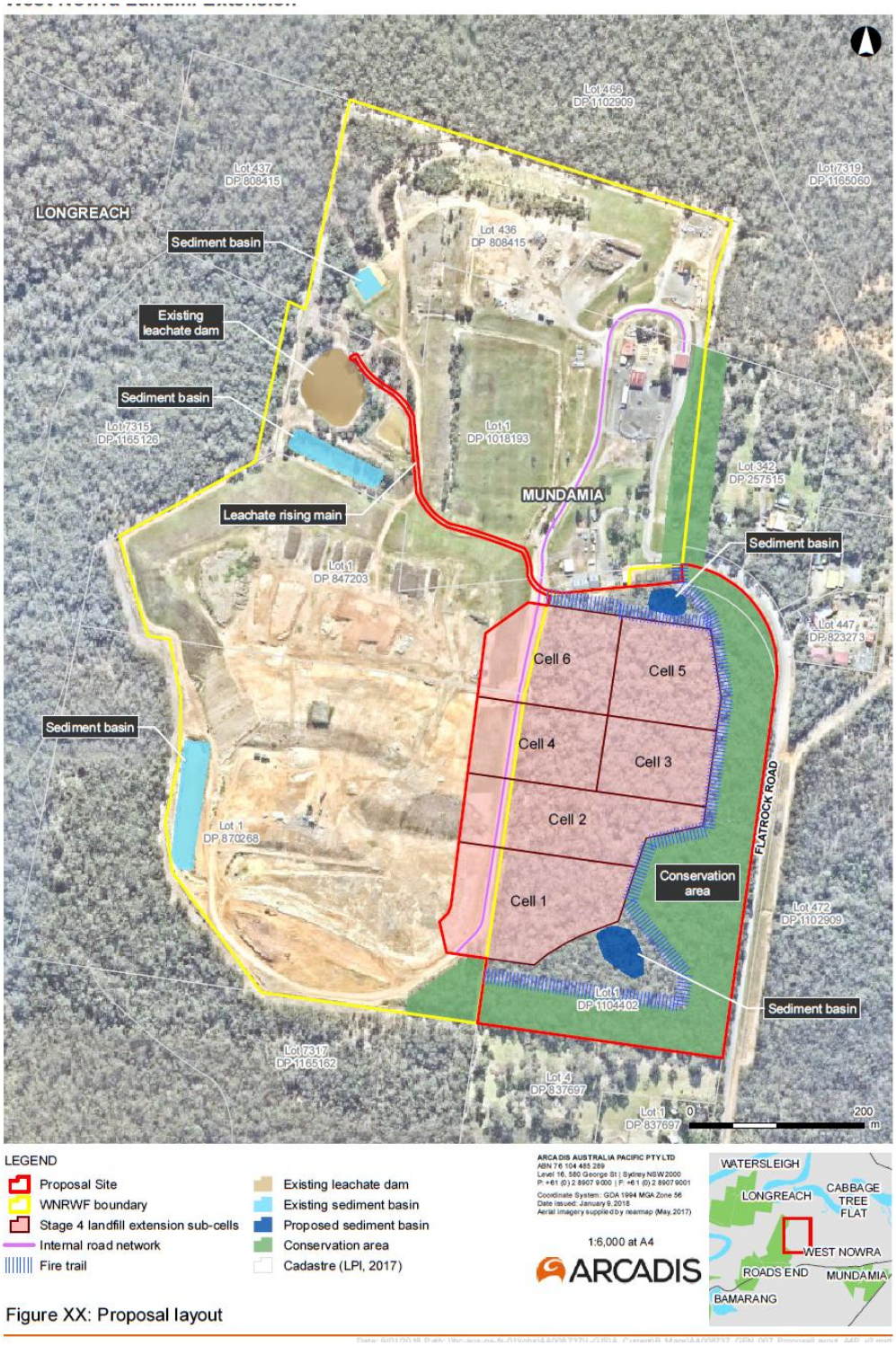

Figure 1-2 Proposal Site boundary and Proposal Site layout

1.2 Purpose and scope of this assessment

This report supports the EIS for the Proposal and has been prepared as part of a SSD Application for which approval is sought under *Part 4, Division 4.1 of the EP&A Act*.

This report has been prepared to address:

- The Secretary's Environmental Assessment Requirements (SEARs) (SSD 7187) for the Proposal, issued by NSW DP&E on 19 August 2015 and extended on 22 September 2017.

The SEARs relevant to this study, and the section of this report where they have been addressed are provided in Table 1-1

Table 1-1 Secretary's Environmental Assessment Requirements relevant to this study

Section	Environmental Assessment Requirement	Where addressed
Greenhouse Gas	- a quantitative assessment of the scope 1, 2 and 3 greenhouse gas emissions of the project; - a detailed description of the measures that would be implemented to minimise the methane emissions of the proposed landfill operations and ensure that the project is energy efficient.	This report

1.3 Structure of report

This report is structured according to the following:

- Section 1 provides the introduction
- Section 2 documents the GHG emissions estimation approach
- Section 3 provides a summary of the existing environment including an emissions profile for Australia and NSW within the waste sector
- Section 4 and Section 5 outline and summarise the expected emissions from the Proposal's contrition and operational activities
- Section 6 documents a number of mitigation strategies to minimise GHG emissions at the Proposal Site.

2 GHG EMISSIONS ESTIMATION APPROACH

This section outlines the GHG emission estimation approach, policy framework, methodology and assessment boundary for the Proposal.

2.1 Policy framework

In September 2013, the Intergovernmental Panel on Climate Change (IPCC) Working Group 1 released its Fifth Assessment Report (AR5) on climate change. The AR5 stated that warming of the climate system is unequivocal and, since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and oceans have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Furthermore, the AR5 stated that it is extremely likely (95 to 100 per cent confidence) that human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2014).

In Australia, there are a number of regulations, policies and targets which have been developed to manage and reduce GHG emissions and these are outline in Table 2-1.

Table 2-1 Australian regulatory and policy context for GHG emissions and climate change

Level	Type	Name	Description
Commonwealth Government	Agreement	Paris Agreement	A global climate change mitigation agreement, adopted by 195 countries including Australia in December 2015, that aims to limit the increase in global temperatures to 1.5ºC above pre-industrial levels.
	Regulation	*The National Greenhouse and Energy Reporting Act 2007*	The National Greenhouse and Energy Report Act 2007 (NGER Act) establishes the legislative framework for the NGER Scheme. Introduced in 2007, the Scheme requires corporations to register and report emissions, energy consumption or production that meets certain thresholds every year. There are two types of thresholds that determine which companies have an obligation under the Act: • Facility Thresholds: 25,000 tonnes/pa or more of greenhouse gases CO_2-e (Scope 1 and Scope 2 emissions) • Corporate Thresholds: 50,000 tonnes/pa or more of greenhouse gases CO_2-e (Scope 1 and Scope 2 emissions) In 2014, an amendment was passed which establishes a framework for the safeguard mechanism, a core element of the Emissions Reduction Fund. The safeguard mechanism requires Australia's largest emitters (more than 100,000 t CO_2-e per year) to keep emissions at or below baseline levels. It ensures that emissions reductions purchased through the ERF are not offset by significant increases in emissions above business-as-usual levels elsewhere in the economy. This took effect from 1 July 2016.

Level	Type	Name	Description
NSW Government	Framework	NSW Climate Change Policy Framework	This framework was introduced in 2016 and: • Defines the NSW Government's role in reducing carbon emissions and adapting to the impacts of climate change • Sets policy directions to guide implementation of the framework • Commits NSW to achieving aspirational long-term objectives of net-zero emissions by 2050 and to help NSW become more resilient to a changing climate. In November 2016, the NSW Government released a Draft Climate Change Fund Strategic Plan and a Draft Plan to Save NSW Energy and Money. These draft plans are the first step towards implementing the Framework and achieving the government's objectives.
	Legislation	*Environmental Planning & Assessment Act 1979*	The EP&A Act contains a general requirement to address environmentally sustainable principles, including climate change, within development applications.
	Target	NSW State Plan 2021	The NSW Plan 2021 has goals and targets towards climate change including: • 20 per cent renewable energy by 2020 • Assistance for businesses and households to realise annual energy savings of 16,000 gigawatt-hours by 2020 compared with 'business as usual' trends • Support for 220,000 low-income households to reduce their energy use by up to 20 per cent by June 2014 • An increase in the share of commuter trips made by public transport, including increasing the proportion of total journeys to work by public transport in the Sydney Metropolitan Region to 28 per cent by 2016 • Targets to increase walking and cycling • Planning policy to encourage job growth in centres close to where people live and to provide access by public transport.

2.2 Assessment methodology

The scoping processes used for the assessment of GHG emissions for the Proposal are based on the following guidelines and regulations:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition (WRI/WBCSD, 2004)
- National Greenhouse Accounts (NGA) Factors, Department of Energy and Environment (DoEE, 2017a).
- National Greenhouse and Energy Reporting System Measurement: Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia, Department of Energy and Environment (DoEE, 2017b)

Under 'The Greenhouse Gas Protocol' (WRI/WBCSD, 2004), a Proposal's direct and indirect emissions sources can be delineated into three 'scopes' (Scope 1, Scope 2 and Scope 3) for GHG accounting and reporting purposes. These scopes are associated within an organisations operational boundaries as shown in Figure 2-1.

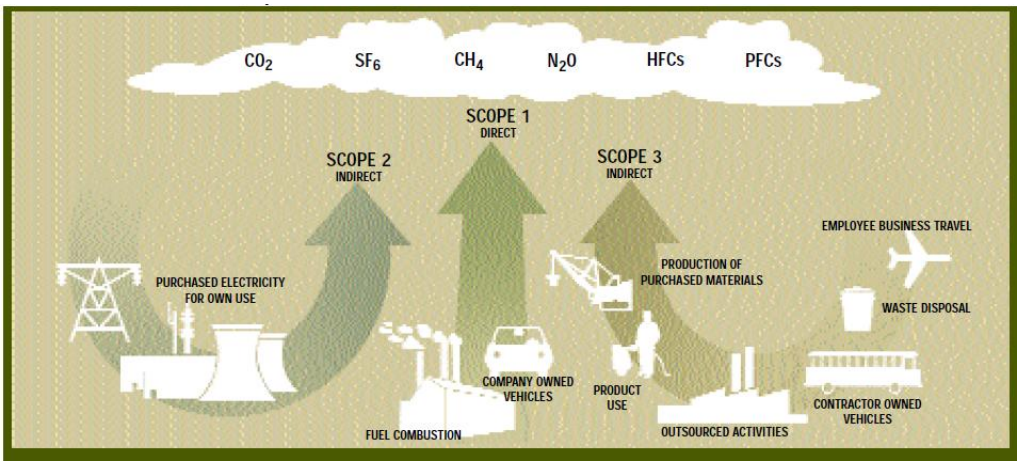

Figure 2-1 Overview of scopes and GHG emissions sources (WRI/WBCSD, 2004)

Further details of GHG operational scopes are outlined below:

- **Scope 1: direct greenhouse gas emissions -** Scope 1 emissions are direct GHG emissions from sources that are owned or controlled by SCC. Scope 1 can include direct emissions sources such as fuel consumption within machinery used during construction and operation.
- **Scope 2: electricity indirect greenhouse gas emissions -** These account for GHG emissions arising from purchased electricity consumed on-site. Scope 2 emissions are considered indirect as they occur at an off-site facility where electricity is generated. There are no Scope 2 emissions associated with the Proposal (i.e. the landfill extension will not be serviced by any electricity supply).
- **Scope 3: other indirect greenhouse gas emissions -** Scope 3 emissions are those that are a consequence of SCC, but occur outside the site operational boundary and are not under SCC control, such as waste delivery vehicles. Scope 3 emissions also include the upstream and downstream emissions associated with the production of fuel. Scope 3 emissions are an optional reporting category that allows for the treatment of all other indirect emissions.

Quantification of potential emissions from the Proposal has been undertaken in relation to carbon dioxide (CO_2) and other non-CO_2 GHG emissions, including methane (CH_4) and nitrous oxide (N_2O). To report these emissions, they are converted to carbon dioxide equivalents (CO_2-e) as specified under the Kyoto Protocol. The Global Warming Potential (GWP) adopted for each GHG is as follows: carbon dioxide GWP of 1; methane GWP of 25; and nitrous oxide GWP of 298, as detailed in the NGA Factors (DoEE, 2017).

This assessment has been undertaken using the best available current and historical data. Assumptions have been outlined, where appropriate, to maintain transparency.

2.3 Assessment approach

This assessment identifies emissions associated with the Proposal (construction and operation of Stage 4) and provides a summary of the highest average annual emissions. 'Legacy emissions' or emissions originating from waste disposal during Stages 1 to 3 of the landfill (already approved) have also been considered to assess SCC's potential *National Greenhouse and Energy Reporting Act 2007* (NGER) reporting liability.

Potential Scope 1 and Scope 3 emissions sources have been identified. Scope 2 emissions are not considered as the landfill extension will not be serviced by an electricity supply

The key sources of GHG emissions, the assessment boundary and the assumptions underpinning this assessment are discussed below.

2.3.1 Emissions sources

The Proposal would generate emissions from:

- Waste decomposition
  - Decomposition of putrescible waste on-site would be the most substantial emissions source over the life of the Proposal (Stage 4)
  - Note that Stages 1 to 3 are not part of the Proposal. Landfill stages 1 and 2 at the WNRWF are complete, with those areas closed and capped. Stage 3 is currently operational and will reach capacity in 2026. To ensure a complete picture of methane generation is represented, 'legacy emissions' from Stages 1 to 3 are considered as part of this GHG assessment.
- Transportation
  - Movement of waste between the originating location and the Proposal Site
- Machinery used during construction and operation:
  - Fuel consumption within machinery (predominantly excavators, compactors and earthmoving equipment used to construct, compact, fill and close landfill sub-cells)
- Vegetation clearing
  - Loss of carbon sequestration due to 9.87 ha of vegetation clearing
  - Decomposition of vegetation waste.

The most substantial source of emissions within the Proposal would be from decomposition of putrescible waste which generates GHGs (primarily methane).

The Proposal (Stage 4) will commence operation in 2026 and accept waste up to the year 2034 (worst case scenario). Stage 4 is expected to see an approximate average yearly accepted waste of 135,058 tonnes per annum (tpa) and total accepted waste of 1,080,464 tonnes (t).

Construction of the landfill sub-cells, landfilling and capping are expected to occur concurrently within the Stage 4 area (i.e. one sub-cell will be constructed while another is filled, and another is capped).

2.3.2 Assessment boundary

The GHG assessment boundary is illustrated in Figure 2-2. The assumptions considered for the quantum of GHG emissions of the Proposal are explained in the following section.

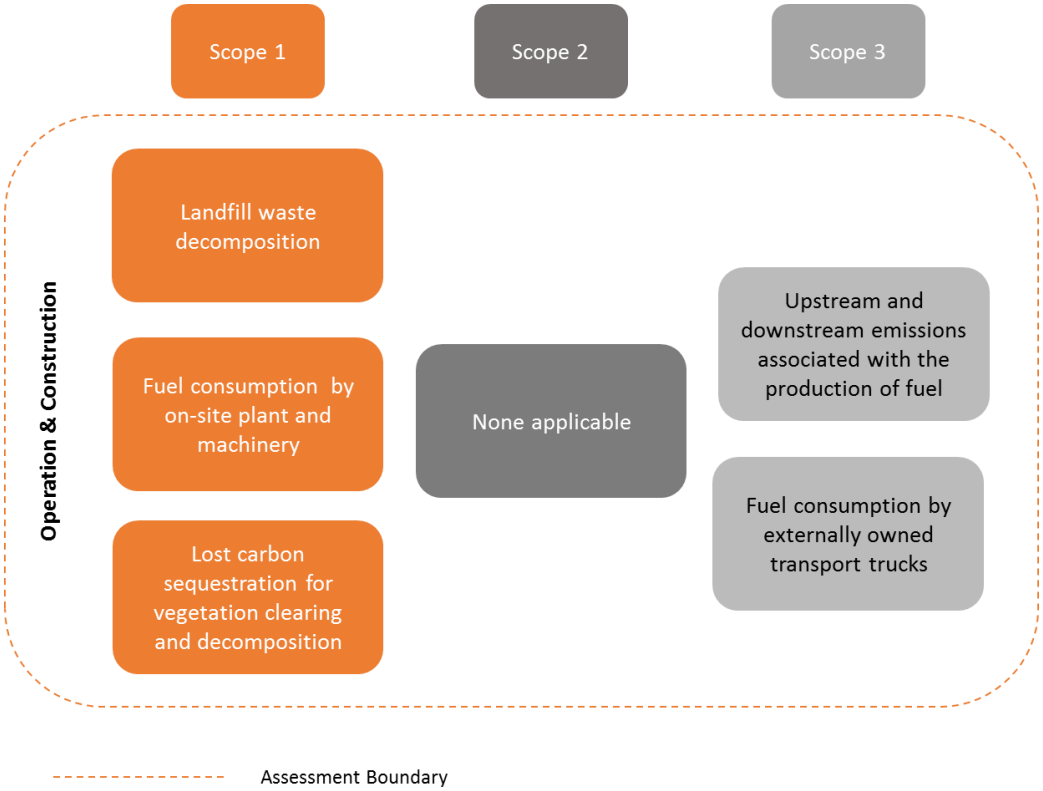

Figure 2-2 GHG assessment boundary

2.3.3 Assumptions

This assessment has been undertaken using the best available data at the time of writing. Assumptions have been outlined where appropriate to maintain transparency.

Where specific assumptions have been made for the calculation of GHG emissions arising from an individual activity, they have been identified within the corresponding section of this report. The following provides a list of the general assumptions used in this assessment:

- Historical waste to landfill data was provided by council (from commencement of landfilling in 1979 to 2016), which was utilised to estimate the historical legacy emissions from Stage 1 to 3.
- Waste flow modelling has been undertaken to estimate the volumes of waste likely to be deposited at the landfill from 2016 to 2026 (the remaining legacy emissions from Stage 3), and from 2026 to 2034 (the Proposal).
- Only plant and machinery that would substantially contribute to CO_2-e emissions were considered in the assessment.
- Scope 2 emissions were not considered as part of this assessment as the landfill extension will not be serviced by any electricity supply.
- Truck movements were assumed to increase at the same rate as the increase in waste to be accepted at the Proposal Site. This is considered conservative as it is likely that as waste volumes increase, larger trucks could be used, increasing the efficiency of transport movements. All vehicles across the operational stage are assumed to be third party owned and operated, and therefore contributing to Scope 3 emissions.

3 EXISTING EMMISSIONS ENVIRONMENT

Existing accounts of greenhouse gases provided by the Commonwealth Department of the Environment and Energy (DoEE) estimate that approximately 537.9 Mega tonnes (Mt) CO_2-e were emitted in Australia during the 2015-16 financial year (DoEE, 2016). Table 3-1 presents a breakdown of the individual State and Territory GHG emissions contribution.

Table 3-1 Australia State and Territory GHG emissions (DoE, 2016)

State or Territory	Total Emissions ($MtCO_2$-e)	Percentage of Total Australian Emissions
New South Wales	133.3	24.8
Victoria	119.4	22.2
Queensland	152.0	28.2
Western Australia	86.4	16.1
South Australia	30.1	5.6
Tasmania	2.3	0.4
Australian Capital Territory	1.6	0.3
Northern Territory	12.8	2.4
External Territories	0.0	0.0
Total	**537.9**	**100.0**

As reported within Australia's Greenhouse Gas Inventory (Ageis.climatechange.gov.au, 2014), solid waste disposal forms a sub-sector of the waste disposal sector. The combined waste disposal subsectors (including solid waste disposal) were the second smallest generators of GHG sector emissions in Australia in 2015, comprising just 2.1 per cent of Australia's total emissions (537.9 $MtCO_2$-e) (DoE, 2016).

The solid waste disposal sector accounted for 1.6 per cent (8.4 $MtCO_2$-e) of Australia's GHG emissions in 2015 and 1.5 per cent of total GHG emissions in NSW (DoEE, 2016). Approximately 74.1 per cent of emissions produced by the waste sector are attributable to the solid waste disposal subsector. Further, trend analysis of the sector shows that since 1990 net GHG emissions from the NSW waste sector have declined by 56 per cent while nationally emissions have dropped by 42 per cent.

4 GHG EMISSIONS ASSESSMENT

The Proposal would be undertaken over a period of approximately eight years. Construction and operation would occur concurrently and would include construction, landfilling, capping and closure of the Stage 4 works. These activities require the use of fuels, vegetation clearing, transportation and waste storage which would result in associated GHG emissions. This section reports the GHG emissions for the Proposal based on the source of the emissions.

Emissions were calculated by estimating fuel use and waste decomposition rates using available data. Emissions in tonnes CO_2-e were calculated using factors and methods from the *Australian Government National Greenhouse Accounts Factors – July 2017* (DoEE, 2017). Specific assumptions were made regarding fuel use, consumption, construction schedule, material quantities, waste transport and waste decomposition. For the purposes of consistency, the emissions of on-site machinery have been reported on an average yearly basis. The emissions from transportation and decomposing waste have been reported as both an annual average and highest emitting year to provide greater clarity on the largest emissions sources across the Proposal. Emissions from vegetation removal associated with the Proposal has been reported as the total emissions amount in one year (i.e. worst case), however, vegetation is likely to be cleared progressively as one sub-cell nears completion and the next is cleared for landfilling.

4.1 Waste decomposition

An estimate of possible emissions from decomposing putrescible waste was generated using best practice GHG modelling, as per the guidelines detailed in Section 2.2 of this report. The numbers incorporate the reduction in emission from the landfill gas generator and flare system installed on site and natural oxidisation that is expected to occur through the final capping layer. All waste decomposition would occur on-site and is therefore regarded as a source of Scope 1 emissions.

Legacy emissions have been included in the calculations to ensure a complete picture of methane generation is presented, even though waste generated during Stages 1 to 3 has already been approved and therefore does not form part of this Proposal. SCC records of historical waste to landfill were used to estimate the likely emissions generated since operations commenced, alongside general assumptions on the composition of typical waste to landfill to generate a decomposition profile for each waste stream.

The assumptions adopted to predict tonnes of waste that would be placed in the Stage 4 landfill are the same as those adopted for the landfill life expectancy modelling undertaken for the Proposal and used throughout the EIS (i.e. a population growth rate of two percent per annum[3] and a waste generation growth rate of three percent per annum[4]). This is considered to be a conservative estimate of waste generation as both population and waste growth may be slower.

Arcadis notes that tonnes of waste delivered to WNRWF appear to have declined across a period of time, from 2006-07 to 2016, as shown in Figure 4-1. Data suggests the site reduced intake of commercial and industrial (C&I) and construction and demolition (C&D) quantities during this period. In particular, a notable decline in waste to landfill is apparent from 2006 to 2012.

[3] Adopted from the SCC Waste Strategy, 2014 / 2015.
[4] Assumed as per the annual waste generation medium-growth rate of 3% in the National Waste Report 2010.

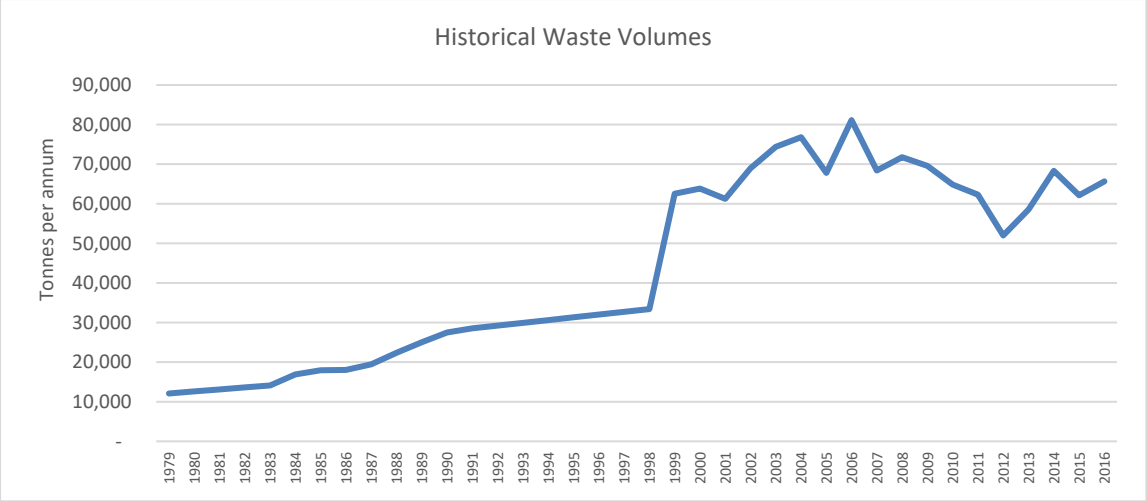

Figure 4-1 Historical total waste volumes (Municipal solid waste (MSW), C&I and C&D)) to WNRWF (1979 to 2016)

As shown in Table 4-1 and Figure 4-2, GHG emissions from waste decomposition would steadily increase as the yearly volume of waste accepted also increases. The peak in GHG emissions would be in 2035, the year after which the landfill will stop receiving waste. This is due to the profile of methane emissions, as materials decay there is a lag between when waste is deposited and when it peaks in methane generation.

MSW is expected to be the largest source of methane emissions within the Proposal. Annual waste emissions are predicted to increase as the Proposal progresses in its lifecycle. Table 4-1 shows that total waste emissions would be expected to peak at 35,115 tCO_2-e in 2035 (from Legacy and Proposal emissions), when the landfill has closed.

It should be noted that this estimation takes into account the emission reduction through the landfill gas generator and flare system installed on site in 2002, which is expected to continue to be operational at the current gas capture rate of 71 per cent[5], and has been assumed to operate throughout the life of the landfill and its post-closure stage indefinitely. While the generator may be decommissioned at some stage post-closure, accurately determining when this may occur is difficult, and the impact on total emissions would be relatively immaterial at that stage, as the methane flow rate slows every year onward from the last year of landfilling.

[5] Estimated efficiency rate provided by SCC and the operator.

Table 4-1 GHG emissions from waste decomposition over Proposal lifespan

Emitting year	Waste decomposition emissions (tCO_2-e)			
	Scope 1	Scope 2	Scope 3	Per cent of emissions from legacy waste (%)
Lowest - 2026	22,154	-	-	83%
Highest - 2035	35,115	-	-	23%

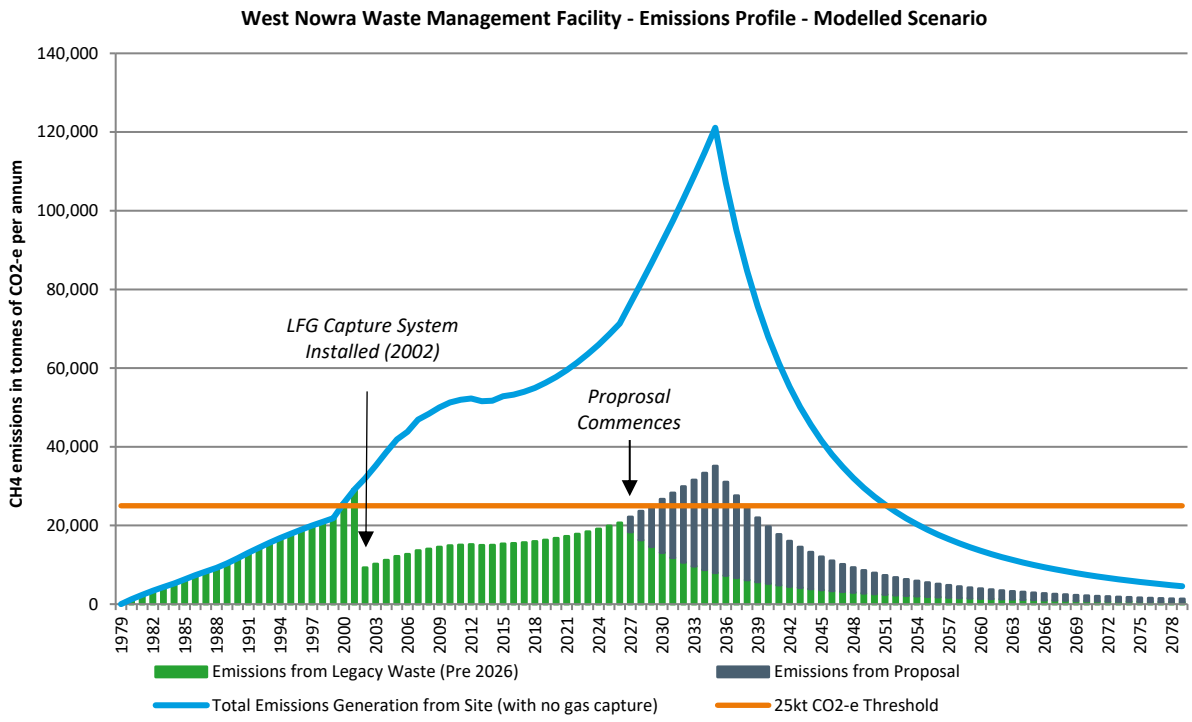

Figure 4-2 Landfill emissions profile for the Proposal, including legacy emissions

Figure 4-2 shows the historical and expected emissions profile for the site. The following are noted in relation to the profile:

- The orange line represents the facility threshold *(*25kt or more of greenhouse gases CO_2-e per annum (Scope 1 and Scope 2 emissions)), which determines whether an entity has an obligation to report emissions under the NGER Act
- The blue line represents the total net emissions generation from the site, with no gas capture
- The green columns represent the net emissions generation from the site, originating from legacy waste disposal (Stage 1, 2 and 3)
- The grey columns represent the net emissions generation from the site, originating from waste disposed for this Proposal (Stage 4).

The total emissions generation from the site (blue line) and emissions from legacy waste (green columns) are equal until 2002, where a significant drop is observed. This is due to the landfill gas generator and flare system and highlights the importance it plays in reducing overall landfill gas emissions from this site.

From its implementation in 2002 to the current year of 2018, the emissions from the site were modelled to amount to 810,581 tonnes of CO_2-e (excluding natural emissions reduction from oxidation through cap). Based on the reported capture rate of the gas generator and flare system of 71 per cent, the emission are estimated to have reduced to 235,068 tonnes of CO_2-e.

The implementation of the system has ensured that the site is emitting below the NGERs threshold and will continue to until the year 2029, at which point the NGERs threshold of 25,000 tCO_2-e per year for a facility is triggered. It should be noted, that the threshold being triggered for the nine years between 2029 and 2038, is based on the assumption that the landfill ceases to receive waste from 2034 onwards (i.e. the landfill is at capacity). This is a function of a number of assumptions used in the modelling, including expected waste generation and population growth rates. Should the landfill continue to form a component of the SCC Regional Waste Management Strategy, or if waste reduction measures are implemented that impact these assumptions, the years where the threshold are triggered or whether the threshold will be triggered at all could change. Therefore, the emission profile should be reconciled with accurate, actual data if possible, to assess the validity of the assumptions and ensure the site is in compliance with NGER reporting requirements.

4.1 Transportation

Historical data on the number of vehicles depositing waste at the WNRWF was provided by Council for the year 2012-13. The data provides information on light vehicles (cars, trailers) and heavy vehicles (trucks). However, the light vehicles accessing the WNRWF site would not access the tip-face and therefore have been excluded from consideration of transportation emission associated with the Proposal. The data indicates that in 2012-13, approximately 26 heavy vehicles transported waste to the tip-face daily. A population and waste generation growth rate of five per cent per annum[6] was applied to the traffic data to generate traffic volumes for the Proposal. Based on this growth rate, heavy vehicle numbers are expected to peak in the final year of operation (2034), with 68 vehicles transporting waste to the tip-face daily. Waste collection would predominantly be undertaken by third party contractors, and therefore represents a Scope 3 emissions source. It has been assumed that the majority (95 per cent) of vehicles will be diesel operated, as is typical with waste collection vehicles, with 5 per cent of vehicles assumed to be fuelled by petrol.

It is likely that as waste volumes increase over time, vehicle movements could be consolidated and larger trucks than those modelled in this assessment could be utilised. Furthermore, the growth assumptions applied are considered conservative and waste reduction initiatives may result in lowered vehicle movements to the facility. Therefore, this assessment represents a conservative outcome.

Based on these assumptions, the Proposal would generate on average approximately 555 tCO_2-e of Scope 3 emissions across the eight years, which includes emissions from both fuel combustion and upstream emissions generated from fuel production. In the lowest emitting year for Stage 4 (2026), the Proposal would generate approximately 307 tCO_2-e of Scope 3 emissions and in the highest year (2034), the Proposal would generate approximately 802 tCO_2-e of Scope 3 emissions.

[6] This is the same growth rate applied to the waste tonnages for estimating landfill life expectancy and is therefore consistent with the assumptions used in the EIS.

Table 4-2 Summary of waste collection vehicles emissions (tCO_2-e)

Emitting year	Waste collection vehicle emissions (tCO_2-e)		
	Scope 1	Scope 2	Scope 3
Lowest - 2026	-	-	307
Highest - 2034	-	-	802

4.2 Machinery emissions

Table 4-3 provides a list of indicative machineries that are expected to be used and their likely uses, noting that this is subject to change over the course of operations.

Table 4-3 Indicative machinery for the Proposal

Type	Model	Size	No. on site	Used for
Excavator	Bulldozer Liebherr	30 t	3	Excavation
	Bobcat	E35 (1.3t)	1	Excavation
Diesel compactor	TANA	450	1	Waste compaction
Water cart	Rapid Spray	2500 L	1	Dust suppression
Bogie Tipper	Bogie	8 t	1	Fuel for excavator and compactor and other transportation
Diesel pump	Hatz	1D5OZ	1	Leachate management
	Ruggerini	MD 191	1	Pumping water into water cart.
Generator	Himoinsa	HYW-35	1	Diesel Generator
Material Handler	Lieberr Handler	316	1	Handling construction material
Mulcher	John Deer Mowing Cart	1445	1	Vegetation removal

The use of machinery on-site would generate Scope 1 GHG emissions from fuel combustion (diesel). Additionally, the upstream and downstream emissions associated with the production of fuel would be incurred by the operation of the above machinery. This would represent a Scope 3 GHG emission for the Proposal.

Scope 1 emissions generated from Stage 4 machinery would be approximately 312 tCO_2-e per annum over the eight-year stage lifecycle. As shown in Table 4-4 an additional 16 tCO_2-e per annum of Scope 3 emissions would be produced as a result of the up and downstream production of the fuel required for operational machinery.

Table 4-4 Summary of Stage 1 annual GHG emissions generated from the operation of on-site machinery

Emissions source	Stage 4 emissions from on-site machinery (tCO2-e/yr)		
	Scope 1	Scope 2	Scope 3
Excavators	169	-	9
Diesel compactor	100	-	6
Bogie Tipper	4	-	0

Emissions source	Stage 4 emissions from on-site machinery (tCO2-e/yr)		
	Scope 1	Scope 2	Scope 3
Diesel pumps	7	-	0
Generator	2	-	0
Material Handler	7	-	0
Mulcher	23	-	1
TOTAL	**312**	**-**	**16**

4.3 Vegetation clearing

Vegetation clearing would generate emissions from a number of potential sources including the loss of carbon sequestration, diesel consumption in machinery used for clearing and mulching (assessed above), and vegetation decomposition.

Approximately 9.87 ha of vegetation would need to be cleared for the Proposal. Clearing would commence in approximately 2025 to enable commencement of landfilling in Stage 4 in 2026.

The loss of carbon sequestration, while not a true GHG emission, would result in less carbon dioxide being removed from the atmosphere. The net effect would therefore be that a greater amount of carbon dioxide would remain. Consequently, the loss of sequestration has been assessed as a Scope 1 source of emissions. Different vegetation types characteristically sequester carbon at different rates and to a different extent. Based on the vegetation types, the likely tonnes of dry vegetation per hectare, and the average emissions factor have been used to determine the loss of sequestration (TAGG, 2013). Loss of sequestration has included all carbon pools including woody, non-woody, debris and soil.

The vegetation being cleared is in Plant Community Type (PCT) Red Bloodwood – Hard-leaved Scribbly Gum – Silvertop Ash heathy open forest on sandstone plateaux of the lower Shoalhaven Valley, Sydney Basin Bioregion. The equivalent Major Vegetation Group (MVG) is Eucalypt Tall Open Forest and is considered a class 4 coverage.

Total emissions from vegetation clearing throughout the life of the Proposal (8-year period) are estimated to be 5,196 tCO_2-e as shown in Table 4-5, under the assumption that cleared vegetation will be mulched on-site.

Table 4-5 Summary of GHG emissions (tCO_2-e) arising from cleared vegetation throughout the life of Proposal (8-year period)

Emissions source	Total emissions due to vegetation clearing (tCO2-e)		
	Scope 1	Scope 2	Scope 3
Loss of carbon sequestration	5,144	-	-
Emissions from vegetation decomposition	52	-	-
TOTAL	**5,196**	**-**	**-**

5 SUMMARY OF TOTAL GHG EMISSIONS FROM THE PROPOSAL

This section summarises the GHG emissions that would be generated by the Proposal. The single largest contributor to GHG emissions would be methane gas generated from landfill waste decomposition.

As shown in Table 5-1, overall GHG emissions from the Proposal at its highest emitting point for each GHG source is 41,441 tCO_2-e. This represents approximately 0.01 per cent of Australia's total annual GHG emissions (as at 2016) and 0.03 per cent of NSW's total emissions.

Table 5-1 Overall GHG emissions from the Proposal (at highest emitting year)

Emissions source	Highest emitting year	Overall GHG emissions at highest emitting year (tCO_2-e)			
		Scope 1	Scope 2	Scope 3	Total
Putrescible waste decomposition	2035	35,115	-	-	35,115
Transportation	2034		--	802	802
Machinery	2034	312	-	16	328
Vegetation clearing	Approx. 2025	5,196	-	-	5,196
GHG emissions		**40,623**	**-**	**818**	**41,441**

Table 5-2 summarises the average annual estimated emissions for the Proposal, broken down by emissions source.

Table 5-2 Average annual estimated GHG emissions

Emissions source		Average annual emissions summary (tCO_2-e)			
		Scope 1	Scope 2	Scope 3	Total
Putrescible waste decomposition	Average	14,688	-	-	14,688
Transportation	Average			555	555
Machinery	Average	312	-	16	328
Vegetation clearing	Total	5,196	-	-	5,196
Average GHG emissions over the life of the Proposal		**20,196**	**0**	**571**	**20,767**

6 GHG MITIGATION STRATEGIES

The carbon management principles (shown in Figure 6-1) provide a robust framework for the management and reduction of GHG emissions.

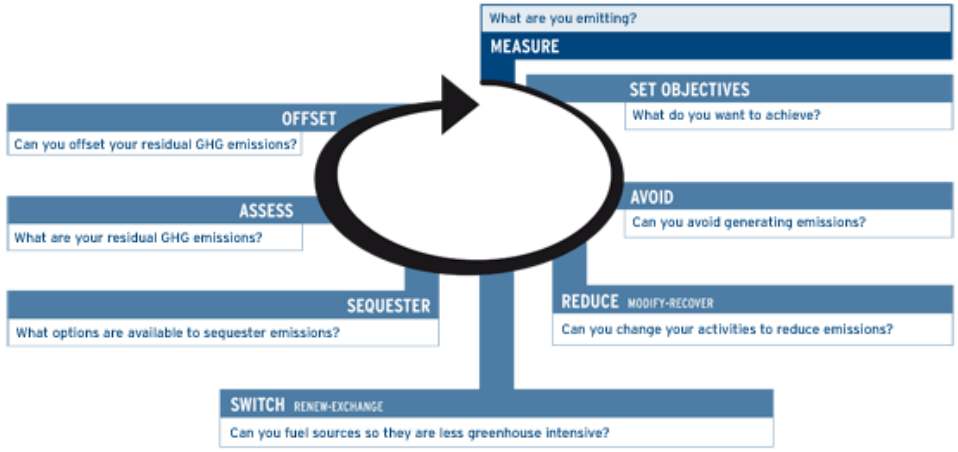

Figure 6-1 Carbon management principles for GHG emissions reduction (EPA Victoria, 2012)

The earlier sections in this assessment represent the “measure” and “set objectives” components of the carbon management principles. GHG emissions reduction actions should ideally be prioritised according to the carbon management principles as illustrated in Table 6-1.

Table 6-1 Carbon management principles

Management principle	Description
Avoid	Actions which avoid emissions, in the first instance, should be considered as a priority
Reduce	Actions which result in a reduction of emissions should be considered next
Switch	Actions which switch energy sources to reduce emissions should be the next considered
Sequester	Actions which sequester or capture GHG emissions. While they do not reduce emissions, they do store them and result in a net reduction in GHG emissions
Offset	Equalising emissions through the purchase of offsets. This should be considered as a last resort.

6.1 Mitigation measures

The WNRWF has successfully managed to reduce landfill gas emissions by a substantial amount, through the installation of a landfill gas generator and flare system. It has also resulted in the site's emissions falling below the facility threshold for reporting under the NGER Act.

The Proposal will see a gradual increase in the total emissions from the WNRWF. Installation of a landfill gas generator and gas flare system at the site in 2002 successfully reduced the gas emissions from the site, with the system operating at about 71 per cent efficiency. Despite this, emissions from the WNRWF are predicted to exceed the 25kt of CO_2-e National Greenhouse and Energy Reporting (NGER) threshold from 2029 to 2038.

The key mitigation measure that would see a step reduction in the emissions from modelled results would be either a significant reduction in waste volumes to landfill across the lifespan of the Proposal, or changes in the composition of the waste being received, such that there is a significant reduction in the organic fraction. Both of these factors are measures that SCC may look to implement, such as source separated garden and food organic wastes delivered to the WNRWF by customers, the introduction of waste processing of the contents red lidded bin (kerbside waste collection) or alternatively introducing a third green bin (GO or FOGO) to reduce organics in the MSW residual stream. Likewise, any significant campaigns to reduce waste generation through the greater council area, or reduction in waste acceptance at the landfill, would see a decline in emissions.

Given the current profile operational mitigation measures should include:

- Ensure that the final capping layer meets the requirements outlined in the Landfill Environmental Management Plan (LEMP) prepared by SLR for the site. A review of best practice standards, methodologies and technologies at the time of capping, should be undertaken to ensure that an optimal solution is achieved. To maximise natural oxidisation through the final capping layer and reduce emissions, the capping layer should be maintained in good condition (i.e. thick layer of topsoil with healthy vegetation). The design and implementation should be reviewed at the time of capping.
- Undertake project planning to ensure that on-site vehicle movements and construction activities are efficient, avoid double handling of materials and avoid unnecessary fuel use.
- Considering use of alternative fuels which are less carbon intensive, such as operating machinery and construction activity vehicles which use bio-diesel fuels.
- Review the GHG emissions profile of the landfill based on recorded waste volumes four years[7] after landfilling commences in Stage 4 to:
  - Confirm the emissions projections reported herein and the need for reporting under the NGER scheme, and
  - Identify opportunities to optimise existing landfill gas management strategies, including existing landfill gas infrastructure.
- Provide a separate report to DPE summarising the findings of the GHG emissions review and outlining any additional reduction and/or management strategies to be implemented.

[7] The selection of the date of four years post opening is because the landfill is predicted to open in 2026 and the NGER reporting threshold is predicted to be breached in 2031 (5 years later). Hence the timing would inform a decision on whether they are required to report.

7 CONCLUSION

Shoalhaven City Council (SCC) as part of waste management planning for the Shoalhaven region, is proposing to extend the current landfilling area at the West Nowra Recycling and Waste Facility (WNRWF) at 120 Flatrock Road, Mundamia (the Proposal). The Proposal would commence operation from approximately 2026 and would provide capacity to 2034 under a worst-case scenario (minimum of eight years) (SCC, 2017). SCC commissioned Arcadis to prepare a greenhouse gas (GHG) assessment to support a State Significant Development Environmental Impact Statement (EIS) under *Part 4, Division 4.1 of the Environmental Planning and Assessment Act 1979* for the Proposal.

GHG emissions from the Proposal are expected to peak at approximately 41,441 tCO_2-e at its highest emitting point for the collective GHG sources (putrescible waste decomposition, transportation, machinery and vegetation clearing). However, average yearly emissions from the Proposal are estimated to be only 20,767 t CO_2-e. The largest GHG source are those generated from the landfilled putrescible waste decomposition. Peak GHG emissions from the Proposal represent 0.48 per cent of Australia's solid-waste-sector GHG emissions or just 0.01 per cent of Australia's total annual GHG emissions (as at 2016).

The Proposal will see a gradual increase in the total emissions from the WNRWF. Installation of a landfill gas generator and gas flare system at the site in 2002 successfully reduced the gas emissions from the site, with the system operating at about 71 per cent efficiency. Despite this, emissions from the WNRWF are predicted to exceed the 25kt of CO_2-e National Greenhouse and Energy Reporting (NGER) threshold from 2029 to 2038.As noted, putrescible waste decomposition forms the largest contributor to overall GHG emissions. Future organic diversion measures, such as the proposed processing of red bin waste through an alternative waste processing facility, alternatively implementing a kerbside green bin (GO or FOGO) collection system to reduce organics from the residual stream, or educational activities to encourage greater organic diversion, could have a significant effect on overall emissions. Likewise, broader waste minimisation and avoidance measures across the region, to divert waste from landfill could contribute to reducing overall GHG emissions from the Proposal.

The projected tonnes to landfill are considered conservative, with year on year growth assumed for population and waste generation. In practice, the volume of waste to landfill may be less than projected due to lower than predicted growth rates and the effect of various waste minimisation activities. Additionally, historical waste tonnes to landfill for the site indicate that there are natural fluctuations and variances, which have an immediate effect on landfill gas emissions. However, the reported modelling does not account for any of these potential improvements and therefore is considered a conservative result.

Therefore, under the current profile, potential operational mitigation measures should include:

- Ensure that the final capping layer meets the requirements outlined in the Landfill Environmental Management Plan (LEMP) prepared by SLR for the site. A review of best practice standards, methodologies and technologies at the time of capping, should be undertaken to ensure that an optimal solution is achieved. To maximise natural oxidisation through the final capping layer and reduce emissions, the capping layer should be maintained in good condition (i.e. thick layer of topsoil with healthy vegetation). The design and implementation should be reviewed at the time of capping.
- Undertake project planning to ensure that on-site vehicle movements and construction activities are efficient, avoid double handling of materials and avoid unnecessary fuel use.
- Considering use of alternative fuels which are less carbon intensive, such as operating machinery and construction activity vehicles which use bio-diesel fuels.
- Review the GHG emissions profile of the landfill based on recorded waste volumes four years[1] after landfilling commences in Stage 4 to:
  - Confirm the emissions projections reported herein and the need for reporting under the NGER scheme, and
  - Identify opportunities to optimise existing landfill gas management strategies, including existing landfill gas infrastructure.

- Provide a separate report to DPE summarising the findings of the GHG emissions review and outlining any additional reduction and/or management strategies to be implemented.

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