# BERRIMA CEMENT WORKS

## Solid Waste Derived Fuels & Delivery Variation Project
## Greenhouse Gas Assessment

Prepared for:

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SLR

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# BASIS OF REPORT



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# 1 INTRODUCTION

## 1.1 Background – History of Site Approvals

The Boral Cement Works ("the Site") operates under two development consents originally issued by the Department of Planning and Environment (DPE), now the Department of Planning, Industry, and Environment (DPIE), being DA 401-11-2002-i (Kiln 6) and DA 85-4-2005-i (Kiln 7).

DA 401-11-2002-i for Kiln 6 has been modified several times, the latest being Modification 13 (MOD 13) – refer Table 1 - which allowed for the establishment of a chloride bypass system at the kiln.

Table 1 Berrima Cement Works DA 401-11-2002-I Modification History

| Reference | Description | Date Modified |
|---|---|---|
| MOD 2-1-2004-i | Non-Standard Fuels | 26 September 2005 |
| MOD 109-9-2006-i | Remove prohibition of hazardous wastes | 22 September 2006 |
| MOD 12-2-2007-i | Trial use of tyre chips | 13 February 2007 |
| MOD 4 | Variation to usage rate of coke fines | 24 April 2008 |
| MOD 5 | Coal deliveries by rail | 31 August 2009 |
| MOD 6 | Coal stockpiling for sale | 20 June 2012 |
| MOD 7 | GBFS processing | 16 April 2012 |
| MOD 8 | Approval / EPL Consistency | 5 August 2012 |
| MOD 9 | Use of Waste Derived Fuels | 5 October 2016 |
| MOD 10 | Fuel storage shed amendments | 11 April 2019 |
| MOD 11 | Use of Hi Cal 50 | 25 October 2019 |
| MOD 12 | Use of Isotainers and Site Wide Noise Limit | 7 March 2020 |
| MOD 13 | Chloride Bypass System and Use of Woodchips | 31 May 2021 |

## 1.2 Summary of the Proposed Modification 14 at the Site

Boral proposes a further modification to the consent (Modification 14) to:

- increase the consumption of SWDF materials within the kiln;
- construct an alternative haulage access route through the Site;
- expand the current storage and handling facilities at the Site;
- supplement existing kiln feeding infrastructure; and
- increase the truck deliveries and permissible delivery hours at the Site.

## 1.3 Aspects of the Proposed Modification 14 Relevant to GHG

Of specific interest to the GHG (Greenhouse Gas) emissions from the Site, Modification 14 would reduce the Site's reliance on coal for the purposes of firing the cement kiln, divert waste from landfill and divert trucks off a local residential street, Taylor Avenue, and instead access the Old Hume Highway and Hume Motorway via a new internal haulage route, thereby allowing raw material delivery to bypass nearby residential receivers.

In conjunction with the above significant environmental benefits, Modification 14 will assist in ensuring that Boral's operation at Berrima remains sustainably and economically viable into the future.

Key metrics associated with Modification 14 are listed in Table 2.

Table 2 Modification 14 – Key Operational Changes Proposed

| Item | Current ( Approved under MOD 13 ) | Proposed ( MOD 14 ) |
|---|---|---|
| Site Personnel | 150 | NO change |
| Cement Production | 1.56 million tonnes per annum (Mtpa) | |
| Hours of Operation | 24 hours/day, 7 days/week | |
| Raw Materials | 357,000 tpa / 17,850 trucks per annum | |
| FUEL – COAL | 170,000 tpa / 6,285 trucks per annum<br>22 trucks per day ( typical ) | 56,700 tpa / 2,100 trucks per annum<br>12 trucks per day ( typical ) |
| FUEL – SWDF | 100,000 tpa / 4,166 trucks per annum<br>16 trucks per day ( typical ) | 250,000 tpa / 10,415 trucks per annum<br>39 trucks per day ( typical ) |
| FUEL – AKF5 [1] | 30,000 tpa / 1,250 trucks per annum | 30,000 tpa / 1,250 trucks per annum |
| SWDF Deliveries | 6:00am - 6:00pm Monday to Friday<br>7:00am - 1:00 pm Saturday | 24 hours/day, 7 days/week |
| Total Trucks / Day | 317 trucks per day<br>. All trucks via existing access | 330 trucks per day<br>. 128 trucks via existing access<br>. 202 trucks via NEW access |

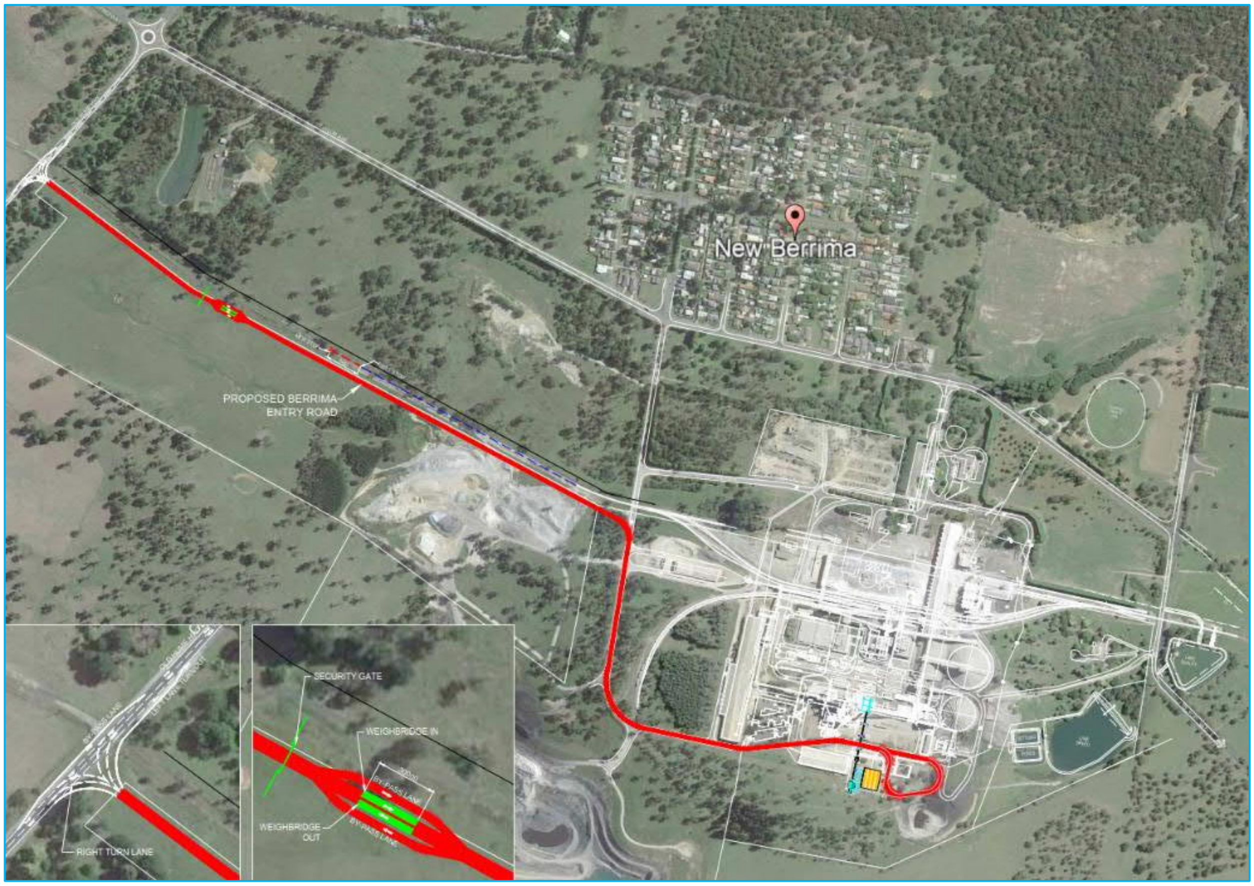
Note 1 AKF5 (30ktpa) is currently licensed as part of the 100ktpa SWDF; in MOD14 it would be a "stand-alone" item

## 1.4 Site Context

A locality plan for the Site is provided in Figure 1, which also shows the new Haul Route proposed for the Site.

The new Storage Sheds proposed for the Site are shown in Figure 2.

## Figure 1 Location Plan and Proposed New Haul Route




## Figure 2 Concept Design for Proposed New Storage Sheds

## 1.5 Objective of this Report

The Environmental Assessment Requirements for Modification 14 were issued 6 August 2021 and included the following regarding GHG (Greenhouse Gases) and Energy Efficiency.

> - **Greenhouse Gas and Energy Efficiency** - an assessment of the energy use of the proposal and all reasonable and feasible measures that would be implemented on site to minimise the proposal's greenhouse gas emissions.

This report addresses the above requirement.

Specifically, the purpose of this report is to undertake a GHG Assessment that addresses Scope 1, Scope 2 and Scope 3 emissions relating to Modification 14. In carrying out the GHG Assessment, key Energy Efficiency aspects are noted and recommendations made where cost-effective improvements are identified for further consideration.

The remainder of this report is structured as follows:

- Section 2 describes the Assessment Methodology used in this study;
- Section 3 details the GHG Calculations used in this study
- Section 4 discusses the GHG emission outcomes for MOD14
- Section 5 present recommendations for further energy efficiency initiatives
- Section 6 Conclusions

# 2 ASSESSMENT METHODOLOGY

## 2.1 Background to the Greenhouse Effect and Greenhouse Gases

The greenhouse effect is a naturally occurring process that aids in heating the Earth's surface and atmosphere. It results from the fact that atmospheric gases, such as carbon dioxide, water vapor, and methane, are able to change the energy balance of the planet by absorbing longwave radiation emitted from the Earth's surface. Without the greenhouse effect, life on this planet would probably not exist as we know it, as the average temperature of the Earth would be around -18°C, rather than the present 15°C.

Human activities, however, are changing (enhancing) the natural greenhouse effect.

The key gases involved in the human-caused enhancement of the greenhouse effect include:

- Carbon dioxide ($CO_2$): In addition to natural processes such as respiration and volcanic eruptions, $CO_2$ is released through human activities such as deforestation, land use changes, and burning fossil fuels. Humans have increased the atmospheric $CO_2$ concentrations by almost 50% since the Industrial Revolution began. This is the most important long-lived 'forcing' of climate change.
- Methane ($CH_4$): $CH_4$ is produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture (especially rice cultivation), as well as ruminant digestion and manure management associated with domestic livestock.
- Nitrous oxide ($N_2O$): $N_2O$ is a powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilisers, but also (in lesser amounts) from fossil fuel combustion, nitric acid production, and biomass burning.
- Sulphur hexafluoride ($SF_6$): $SF_6$ is a colourless, odourless, synthetic gas used as an insulating material for medium and high-voltage electrical installations to prevent electrical accidents and fires. It is emitted via leakages in industrial complexes, power stations, electrical sub-stations, etc.
- Chlorofluorocarbons (CFCs): CFCs are synthetic compounds, entirely of industrial origin, used in a number of applications, but now largely regulated under the Montreal Protocol to prevent the destruction of the planet's ozone layer. They are also greenhouse gases.

Global Warming Potential

For comparative purposes, non-$CO_2$ greenhouse gases are awarded a "$CO_2$-equivalence" ($CO_2$-e) based on their relative enhancement of the greenhouse effect. This is calculated via their Global Warming Potential (GWP), defined and periodically updated by the Intergovernmental Panel on Climate Change (IPCC)

The following 100-year equivalent warming GWPs of greenhouse gases relevant to the Project, as taken from Australian National Greenhouse Accounts (NGA) Factors workbook (DISER, 2020), have been used to estimate emissions from the Project:

- $CO_2$ = 1
- $CH_4$ = 28
- $N_2O$ = 265
- $SF_6$ = 23,500
- CFCs = refer Table 30 NGA Factors (2020) for individual substances

## 2.2 Background Regulatory Requirements

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Australia has made commitments to manage its Greenhouse Gas (GHG) emissions, track progress towards those commitments, and report each year on Australia's GHG emissions.

Specifically, under the two key UNFCCC international climate agreements (the Kyoto Protocol and the Paris Agreement), Australia has had the following GHG emission targets.

- Under the Kyoto Protocol, Australia appeared to successfully meet its target of limiting the increase in net GHG emissions to 108% of its 1990 levels from 2008 to 2012.
- The Paris Agreement came into effect from 4 November 2016. Australia is currently committed to reducing GHG emissions by 26% to 28% below 2005 levels by 2030.
- Finally, at the recent Glasgow COP26, Australia committed to reducing GHG emissions to zero by 2050.

Australia fulfils its international greenhouse gas inventory reporting commitments by submitting annual National Inventory Reports to the UNFCCC. Emission estimates are compiled consistent with the following:

National Greenhouse and Energy Reporting (NGER) Act (2007): The NGER Act establishes a single, national system for reporting GHG emissions, abatement actions, and energy consumption and production by corporations, taking effect in July 2008. Under the NGER Act, entities are required to register and report GHG emissions, energy production and energy consumption information if specific requirements are met (either at a facility or corporate group level). The methods and criteria for calculating GHG emissions and energy data under the NGER Act are detailed in the NGER (Measurement) Determination 2008 and its Amendment (2020 Update) Determination 2020.

National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule (2015) [SGM]: The SGM provides a framework for Australia's largest emitters (facilities with Scope 1 emissions of more than 100,000 t $CO_2$-e per year) to measure, report and manage their emissions by them to keep their emissions at or below emissions baselines set by the Clean Energy Regulator.

National Greenhouse Accounts (NGA) Factors (2020) Australian National Greenhouse Accounts: The NGA Factors was prepared by the Commonwealth Department of Industry, Science, Energy and Resources and designed to estimate GHG emissions. Unless otherwise stated, the NFA Factors methodologies are "Method 1" from the NGER (Measurement) Determination 2008 and NGER (Measurement) Amendment (2020 Update) Determination 2020.

## 2.3 International Guidelines

The Equator Principles: The Equator Principles (Equator Principles Association, 2006) are applied by financial institutions globally across all industry sectors to all new project financings with project capital costs of US$10 million or more. For a project to be eligible for a loan through an Equator Principle Financial Institution (EPFI) it must conform to a set of nine principles. In relation to GHG emissions, Performance Standard 3 requires that:

> "The client will promote the reduction of project-related greenhouse gas emissions in a manner appropriate to the nature and scale of project operations and impacts.
>
> During the development or operation of projects that are expected to or currently produce significant quantities of GHG's, the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary and indirect emissions associated with the off-site production of power used by the project."

The Greenhouse Gas Protocol Initiative: GHG accounting and reporting principles are intended to underpin all aspects of GHG accounting and reporting. The five principles outlined below are consistent with the World Resources Institute / World Business Council for Sustainable Development (WRI/WBCSD) GHG Protocol, (a globally adopted and leading GHG accounting strategy), and ISO 14064-1, 2, and 3 GHG guidelines (which are internationally accepted best practice).

The following outlines the basic requirements of any GHG assessment, as defined by the five WRI/WBCSD principles. All of these apply to the present assessment.

Relevance

The relevance of a company's GHG report relates to the information which it contains. The information should allow stakeholders, both internal and external to the organisation, to make informed decisions about GHG management. An important aspect of relevance is the selection of appropriate boundary conditions which reflect the reality of the company's operations. The operation of the company, the purpose of the information and the needs of users will all inform the choice of the inventory boundary. In choosing the inventory boundary, a number of factors should be considered:

- organisational structure (control, ownership etc.)
- operational boundaries (on and off-site activities, services, impacts)
- business context (geographical locations, nature of activities, industry sector, purpose and users of information).

Completeness

All relevant emission sources within the chosen inventory boundary need to be accounted for so that a comprehensive and meaningful inventory is compiled. WRI (2004) states that no materiality threshold (or minimum emissions accounting threshold) should be defined as this is not in line with the principle of completeness. However, if emissions are not able to be estimated or estimated at a sufficient level of quality, then these should be transparently documented and justified.

Consistency

Consistency in an emissions inventory allows stakeholders to compare GHG emissions performance from year to year. This consistency also allows trends to be identified and performance against objectives and targets to be tracked. Any changes in the inventory (accounting approaches, boundaries, calculation methods) need to be transparently documented and justified.

Transparency

All processes, procedures, assumptions and limitations of an inventory should be presented clearly and accurately. Information needs to be recorded, compiled and analysed in a way that enables internal reviewers and external auditors to verify the credibility of the inventory. Specific exclusions and inclusions are to be documented and justified, assumptions disclosed and appropriate references provided for the calculation methods applied and the data sources used. Transparency is essential in the production of a credible GHG inventory.

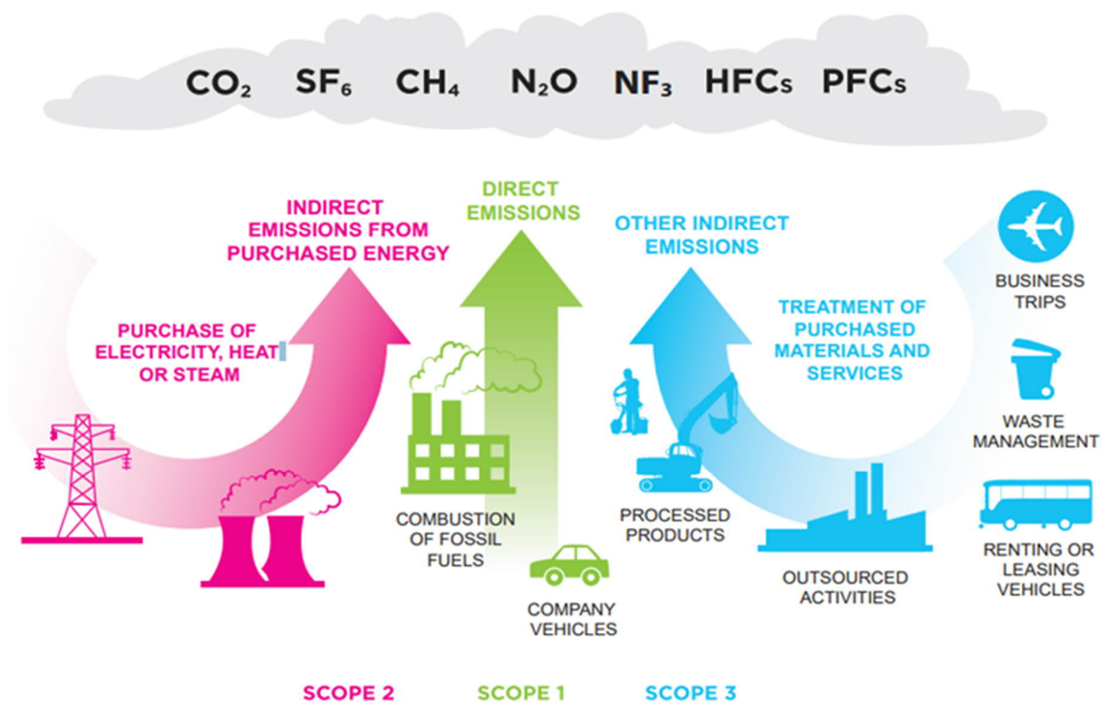
Accuracy

Accuracy describes how close the estimates of GHG emissions are to the 'true' value. The accuracy of a GHG inventory should be sufficient for stakeholders to make decisions with reasonable assurance of the integrity of the reported information. Quality management measures should be implemented to maximise inventory accuracy.

## 2.4 Emission Scope Definitions

GHG emissions are normally divided into Scope 1, Scope 2 and Scope 3 emissions, or alternatively, 'direct' or 'indirect' emissions - refer Figure 3.

Figure 3 Scope 1, 2 and 3 GHG Emissions as per the GHG Protocol Initiative




Source: WRI (2004)

Scope 1 (Direct) Emissions:

Direct GHG emissions are termed Scope 1 emissions and are produced from sources within the boundary of the Project and as a result of the Project's activities. These direct emissions may include:

- Transportation of materials, products, waste or people.
- Generation of electricity, heat and/or steam via combustion of fossil fuels.
- Fugitive emissions, both intentional and unintentional (eg venting of natural gas during maintenance activities and plant upsets at petrochemical facilities, leakage of SF6 from switchgear, land clearing, etc).
- Vegetation clearing (loss of bio-sequestration).
- On-site waste management, eg solid and liquid waste management through landfilling, incineration and sewage treatment plant(s).

Scope 2 (Indirect) emissions:

- Indirect GHG emissions are generated in the wider economy as a consequence of an organisation's activities but are physically produced by the activities of another organisation.
- The most important category of indirect emissions is from the consumption of purchased electricity. Scope 2 emissions invariably relate to the GHG emissions from the generation of purchased electricity consumed within the boundary of the organisation and as a result of the organisation's activities.

Scope 3 (Indirect) emissions:

Other indirect emissions fall into the category of Scope 3 emissions and may include, for example, the extraction and production of purchased materials and fuels; transportation of purchased materials and goods (including fuels), products and waste; employee business travel and commuting; and outsourced activities, such as waste disposal by third parties.

Scope 3 emissions are normally divided into upstream and downstream emissions, based on the financial transactions of the company:

- Upstream emissions are indirect GHG emissions related to purchased materials and services.
- Downstream emissions are indirect GHG emissions related to sold materials and services.

Scope 3 GHG emissions are also classified in 15 distinct categories including:

Upstream

- Purchased goods and services.
- Capital goods.
- Fuel and energy related activities.
- Transportation and distribution.
- Waste generation in operations.
- Business travel.
- Employee commuting.
- Leased assets.

Downstream

- Transportation and distribution.
- Processing of sold products for example iron ore, bauxite and alumina, titanium dioxide feedstock, copper concentrate etc.
- Use of sold products.
- End of life treatment of sold products.
- leased assets.
- Franchises.
- Investments.

GHG Emission Reporting Inclusions / Exclusions:

Scope 3 GHG emissions are sometimes not reported, because these emissions are under another entity's control and should therefore be accounted for as Scope 1 emissions by those relevant entities.

It is also noted that Scope 3 GHG emissions are not formally reported under the Australian NGER scheme.

However, for completeness, Scope 3 emissions have been included in this assessment.

# 3 CALCULATIONS

## 3.1 GHG Emission Sources for the Proposed Modification

As noted previously, this assessment considers Scope 1, Scope 2 and key Scope 3 emissions associated with the proposed MOD 14, and specifically related to operational emissions.

Construction phase GHG emissions associated with the proposed modification were not considered within the present assessment on the basis of the following:

- GHG emissions are expected to be modest in relation to the total GHG emissions associated with the modification in the context of the overall lifetime of the Site.
- The above is based on an expected moderate construction timeframe for the modification, modest use of construction plant and equipment, and relatively simple design of the newly proposed haul route into, and storage sheds at, the Site.
- 5% is a commonly used threshold for materiality in GHG Accounting. The NGER Act 2007 includes a threshold for reporting of energy consumption at 5%.

Scope Boundary Definition

The boundary for the proposed modification was determined to be the geographical boundary of the Site for Scope 1 and Scope 2 GHG emissions. Scope 3 emissions associated with the transport of products and materials to and from the Site as part of general operations were also considered within the broader reporting boundary.

Emissions Sources

The main emissions sources identified for the assessment are listed in Table

Particular emphasis has been placed on identifying (i) changes to Site operations that impact on its GHG emissions, and (ii) areas where improvements may be made in the future.

Table 3 MOD 14 GHG Emission Sources

| Scope | Activity | Source |
|---|---|---|
| Scope 1 | On-Site Usage – Transport Activities | Diesel Fuel for Vehicles |
| | On-Site Usage – Stationary Activities | Diesel Fuel for Plant & Equipment |
| | On-Site Usage – Stationary Activities | Fuel Oil for Plant & Equipment |
| | Kiln Combustion | Sub-bituminous Coal |
| | Kiln Combustion | Coking Coal |
| | Kiln Combustion | Waste Derived Fuel |
| Scope 2 | On-Site Power Usage | Electricity |
| Scope 3 | Material Transport | Diesel Fuel for Vehicles |
| | Material Diverted from Landfill | SWDF: Wood Waste & RDF |

## 3.2 GHG Emission Inputs

Aggregated emission inputs have been compiled based on information provided by Boral in relation to its existing operations and projections based on the operations envisaged for MOD14 – refer Table 4.

A "Benchmark" scenario has also been included highlighting the overall strategy that has been pursued by Boral in reducing, where practical, the use of coal for combustion at the Berrima site.

Table 4 Aggregate GHG Emission Inputs for Current and Proposed MOD14 Operations

| Emission Sources | | | | | |
|---|---|---|---|---|---|
| Category | Units | Quantity | | | Comment |
| | | "Benchmark" | Existing Licensed Operations | Proposed MOD14 Operations | |
| On-Site Diesel Fuel - Transport | kL | 178 | 178 | 178 | No additional fuel used on site as material is delivered straight to shed |
| On-Site Diesel Fuel - Stationary | kL | 193 | 193 | 193 | no change |
| On-Site Fuel Oil | kL | 465 | 465 | 465 | no change |
| On-Site Electricity Use | MWh | 135,000 | 140,474 | 150,000 | Additional 9.5 MWh based on new sheds and material handling (ie tyres or fuel in the front of the kiln) at ~3 kwh/t clinker |
| Sub-Bituminous Coal for Combustion | t | 260,000 | 170,000 | 56,700 | planned decrease |
| HiCal50 for Combustion | t | 0 | 10,000 | 10,000 | no change |
| AKF1 for Combustion | t | 0 | 20,000 | 20,000 | no change |
| SWDF for Combustion | t | 0 | 100,000 | 250,000 | planned increase |
| AKF5 for Combustion [2] | t | 0 | 30,000 [2] | 30,000 | planned increase |
| Clinker & Cement Products | t | 1,560,000 | 1,560,000 | 1,560,000 | no change |
| Scope 3 Transport Fuel | kL | 5,840 | 6,000 | 6,246 | MOD14 based on a proposed increase of 317 trucks/day to 330 trucks/day |
| Scope 3 Diverted Landfill Waste | t | 250,000 | 150,000 | 0 | Potential maximum diversion |

Note 1 The "Benchmark" scenario assumes that the fuel for combustion at the plant is handled solely with coal

Note 2 The 30ktpa allowance for AKF5 is currently licensed within the total SWDF of 100ktpa. In MOD14, it would be counted as a stand-alone amount, ie not part of the proposed 250ktpa SWDF.

## 3.3 Emission Factors

Fuel Consumption

According to the most recent NGA Factors (DISER, 2020), estimates of emissions from the combustion of individual fuel types are made by multiplying a (physical) quantity of fuel combusted by a fuel-specific energy content factor and a fuel-specific emission factor. This is performed for each relevant GHG: $CO_2$,$CH_4$, $N_2O$. Separate calculations should be carried out for each fuel type. Total GHG emissions are calculated by summing the emissions of each fuel type and each greenhouse gas.

Fuels used for transport purposes produce slightly different methane and nitrous oxide emissions than if the same fuels were used for stationary energy purposes. Therefore, separate emission factors are provided for calculation.

The following formula can be used to estimate GHG gas emissions from the combustion of each type of fuel used for either transportation or stationary energy purposes.

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000}$$

where:

- $E_{ij}$ is the emissions of gas type "j", ($CO_2$,$CH_4$, $N_2O$) from fuel type "i" ($CO_2$-e tonnes)
- $Q_i$ is the quantity of fuel type "i" (kL)
- $EC_i$ is the energy content factor of fuel type "i" (GJ/kL)
- $EF_{ijoxec}$ is the emission factor for each gas type "j" (which includes the effect of an oxidation factor) for fuel type "i" (kg $CO_2$-e per GJ)

Emission Factors (as per NGA Factors, 2020) for the fuel types of relevance to this study are provided in Table 5 for stationary use activities and Table 6 for transport use activities.

Table 5 Fuel Consumption Emission Factors – Stationary Use Activities

| Fuel Combusted | Energy Content Factor ( GJ/t or GJ/kL ) | Emission Factor - kg $CO_2$-e/GJ | | |
|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ |
| Sub-Bituminous Coal | 21.0 | 90 | 0.04 | 0.2 |
| Dry Wood | 16.2 | 0 | 0.1 | 1.1 |
| Non-biomass municipal, if recycled and combusted to produce heat or electricity | 10.5 | 87.1 | 0.8 | 1.0 |
| Biomass | 12.2 | 0 | 0.8 | 1.0 |
| Diesel Oil | 38.6 | 69.9 | 0.1 | 0.2 |
| Fuel Oil | 39.7 | 73.6 | 0.04 | 0.2 |
| HiCal50 for Combustion | 26.3 | 81.6 | 0.03 | 0.2 |
| AKF-1 | 26.3 | 81.6 | 0.03 | 0.2 |
| AKF-5 | 26.3 | 81.6 | 0.03 | 0.2 |

Table 6 Fuel Consumption Emission Factors – Transport Use Activities

| Fuel Combusted | Energy Content Factor ( GJ/kL ) | Emission Factor - kg $CO_2$-e/GJ | | |
|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ |
| Diesel Oil – “General” | 38.6 | 69.9 | 0.01 | 0.4 |
| Diesel Oil – “post-2004 Vehicles” | 38.6 | 69.9 | 0.01 | 0.5 |
| Diesel Oil – ( Euro i ) | 38.6 | 69.9 | 0.02 | 0.4 |
| Diesel Oil – ( Euro iii ) | 38.6 | 69.9 | 0.01 | 0.4 |
| Diesel Oil – ( Euro iv+ ) | 38.6 | 69.9 | 0.007 | 0.4 |

Clinker and Cement Products

According to the most recent NGA Factors (DISER, 2020), the following formula can be used to estimate GHG gas emissions from cement clinker production.

$$E_{ij} = \left( EF_{ij} + EF_{toc,j} \right) x \ [A_i + (A_{ckd} \ x \ F_{ckd})]$$

where:

- $E_{ij}$ is the emissions of $CO_2$ from cement clinker production ($CO_2$-e tonnes)
- $EF_{ij}$ is the emission factor for cement clinker (t $CO_2$-e per t clinker)
- $EF_{toc,j}$ is the emission factor for carbon-bearing non-fuel raw material (t $CO_2$-e per t clinker)
- $A_i$ is the quantity of cement clinker produced (t)
- $A_{ckd}$ is the quantity of cement kiln dust (CKD) produced (t)
- $F_{ckd}$ is the degree of calcination of cement kiln dust (0% to 100%: default value is 100%)

Emission Factors (as per NGA Factors, 2020) for the Cement Clinker Production are provided in Table 7.

Table 7 Fuel Consumption Emission Factors – Stationary Use Activities

| Fuel Combusted | Energy Content Factor ( GJ/kL ) | Emission Factor - kg $CO_2$-e/GJ | | |
|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ |
| Cement Clinker | 21.0 | 0.534 | na | na |
| Carbon-Bearing Non-Fuel Raw Material | 10.4 | 0.010 | na | na |

#### Purchased and/or Lost Electricity

According to the most recent NGA Factors (DISER, 2020), the emission factor shown in Table 8 can be used to estimate GHG gas emissions associated with the consumption of purchased electricity from the main grid, or loss of electricity from a facility, the operation of which is characterised by an electricity transmission network or distribution network that is, or is part of, the main grid (hereinafter "or loss of electricity").

Table 8 Emission Factor for Purchased/Lost Electricity

| State | Emission Factor - kg $CO_2$-e / kWh |
|---|---|
| New South Wales and Australian Capital Territory | 0.81 |

#### Landfill Waste

The NGA Factors (DISER, 2020) handbook provides broad emission factors shown in Table 9 for waste disposed to landfill. Organisations that have data on their own waste streams and waste mix can use that data. In the present instance, a conservative estimate of the SWDF used at the Site has been used.

Table 9 Waste Emission Factors for Total Waste Disposed to Landfill by Broad Waste Streams

| Category | Emission Factor - kg $CO_2$-e / t Waste |
|---|---|
| Municipal Solid Waste | 1.6 |
| Commercial & Industrial Waste | 1.3 |
| Construction & Demolition Waste | 0.2 |
| SWDF typically being sourced for the Berrima Cement Works Site | 0.5 |

## 3.4 Calculated GHG Emissions

Based on the previous tables and assumed inputs, the following tables provide the "Benchmark", "Existing" and Modification 14 projected GHG emissions as well as the total Energy values for the Site.

It is noted that the actual GHG emissions at the Site will depend on the precise combination of fuels sourced each calendar year which may vary from the "licensed" quantities listed in Table 4 and used in the following computations. As a result, actual reported GHG emissions (eg for NGER reporting purposes) may vary (modestly) from the following "Benchmark", "Existing" and Modification 14 calculated GHG emissions.

## Table 10 GHG Input Quantities

| Category | Emission Sources & Quantities | | | | Comment |
|---|---|---|---|---|---|
| | units | quantity | | | |
| | | "Benchmark" | Existing License | Proposed MOD14 | |
| On-Site Diesel Fuel - Transport | kL | 178 | 178 | 178 | no change |
| On-Site Diesel Fuel - Stationary | kL | 193 | 193 | 193 | no change |
| On-Site Fuel Oil | kL | 465 | 465 | 465 | no change |
| Sub-Bitumenous Coal for Combustion | t | 260,000 | 170,000 | 56,700 | proposed decrease |
| SWDF for Combustion | t | 0 | 100,000 | 250,000 | proposed increase ( note: SWDF 38.5% wood waste + 61.5% RDF with RDF = 90% biomass & 10% non-biomass ) |
| HiCal50 (spent carbon anode fuel) | t | 0 | 10,000 | 10,000 | no change |
| AKF1 for combustion (recovered oil) | t | 0 | 20,000 | 20,000 | no change |
| AKF5 for Combustion (tyres) | t | 0 | 30,000 | 30,000 | no change ( note: "Existing License" 30ktpa is part of the "Existing License" 100ktpa "Combined SWDF" ) |
| Clinker & Cement Products | t | 1,560,000 | 1,560,000 | 1,560,000 | no change |
| Carbon-Bearing Non-Fuel Raw Material | t | 0 | 0 | 0 | assumes no change in 0% degree of calcination |
| Scope 3 Transport Fuel | kL | 5,840 | 6,000 | 6,079 | based on proposed increase of 317 trucks/day to 330 trucks/day |
| Potential SWDF Diverted from Landfill | t | 250,000 | 150,000 | 0 | under the Existing license, 100ktpa is diverted; under MOD14, 250ktpa would be potentially diverted |
| On-Site Electricity Use | MWh | 135,000 | 140,474 | 150,000 | based on increased electricity usage for proposed storage sheds & material handling |

## Table 11 Energy Conversion Factors and Energy for "Benchmark", Existing and MOD 14

| Category | Energy Content Factors | | Energy Values | | |
|---|---|---|---|---|---|
| | Units | Conversion Factor | "Benchmark" | Existing License | Proposed MOD14 |
| On-Site Diesel Fuel - Transport | kL | 38.6 | 6,880 | 6,880 | 6,880 |
| On-Site Diesel Fuel - Stationary | kL | 38.6 | 7,430 | 7,430 | 7,430 |
| On-Site Fuel Oil | kL | 39.7 | 18,450 | 18,450 | 18,450 |
| Sub-Bitumenous Coal for Combustion | GJ / t | 21.0 | 5,460,000 | 2,892,230 | 1,012,070 |
| SWDF for Combustion [2] | GJ / t | 14.32 | 0 | 1,158,520 | 3,038,680 |
| HiCal50 (spent carbon anode fuel) | GJ / t | 22.1 | 0 | 183,420 | 183,420 |
| AKF1 for combustion (recovered oil) | GJ / t | 34.4 | 0 | 571,000 | 571,000 |
| AKF5 for Combustion (tyres) | GJ / t | 26.3 | 0 | 654,830 | 654,830 |
| Clinker & Cement Products | na | na | na | na | na |
| Carbon-Bearing Non-Fuel Raw Material | na | na | na | na | na |
| Scope 3 Transport Fuel | kL | 38.6 | 225,420 | 231,600 | 234,670 |
| Potential SWDF Diverted from Landfill | na | na | na | na | na |
| On-Site Electricity Use | na | na | na | na | na |

Note 1: Energy requirement used to produce 1,560,000 t Clinker & Cement remains constant at 5,460,000 GJ
Percentage of input fuels for combustion for "Existing" and "MOD14" is assumed to be in proportion to license limits

Note 2: Emission Factors for SWDF based on 38.5% wood waste, 55.5% RDF:Biomass, 6% RDF:Non-Biomass

## Table 12 GHG Emission Factors

| Category | Emission Factors | | | |
|---|---|---|---|---|
| | units | quantity | | |
| | | $CO_2$ | $CH_4$ | $N_2O$ |
| On-Site Diesel Fuel - Transport | kL | 69.9 | 0.10 | 0.50 |
| On-Site Diesel Fuel - Stationary | kL | 69.9 | 0.10 | 0.20 |
| On-Site Fuel Oil | kL | 73.6 | 0.04 | 0.20 |
| Sub-Bitumenous Coal for Combustion | kg CO2-e / GJ | 90.0 | 0.04 | 0.20 |
| SWDF for Combustion [1] | kg CO2-e / GJ | 5.2 | 0.4 | 1.1 |
| HiCal50 (spent carbon anode fuel) | kg CO2-e / GJ | 95.0 | 0.08 | 0.20 |
| AKF1 for combustion (recovered oil) | kg CO2-e / GJ | 69.8 | 0.02 | 0.10 |
| AKF5 for Combustion (tyres) | kg CO2-e / GJ | 81.6 | 0.03 | 0.20 |
| Clinker & Cement Products | t | 0.534 | 0.000 | 0.000 |
| Carbon-Bearing Non-Fuel Raw Material | t CO2-e per t | 0.010 | 0.000 | 0.000 |
| Scope 3 Transport Fuel | kL | 69.9 | 0.10 | 0.50 |
| Potential SWDF Diverted from Landfill | t CO2-e per t | 0.50 | | |
| On-Site Electricity Use | t CO2-e / MWh | 0.81 | | |
| Note 1: Emission Factors for SWDF based on 38.5% wood waste, 55.5% RDF:Biomass, 6% RDF:Non-Biomass | | | | |

## Table 13 GHG Emissions: Benchmark, Existing and Proposed MOD14

| Category | BENCHMARK: GHG Emissions t CO2-e | | | EXISTING: GHG Emissions t CO2-e | | | PROPOSED MOD14: GHG Emissions t CO2-e | | |
|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| On-Site Diesel Fuel - Transport | 481 | 1 | 3 | 481 | 1 | 3 | 481 | 1 | 3 |
| On-Site Diesel Fuel - Stationary | 519 | 1 | 1 | 519 | 1 | 1 | 519 | 1 | 1 |
| On-Site Fuel Oil | 1,358 | 1 | 4 | 1,358 | 1 | 4 | 1,358 | 1 | 4 |
| Sub-Bitumenous Coal for Combustion | 491,400 | 218 | 1,092 | 260,301 | 116 | 578 | 91,086 | 40 | 202 |
| SWDF for Combustion | 0 | 0 | 0 | 6,054 | 477 | 1,223 | 15,880 | 1,250 | 3,207 |
| HiCal50 (spent carbon anode fuel) | 0 | 0 | 0 | 17,425 | 15 | 37 | 17,425 | 15 | 37 |
| AKF1 for combustion (recovered oil) | 0 | 0 | 0 | 39,856 | 11 | 57 | 39,856 | 11 | 57 |
| AKF5 for Combustion (tyres) | 0 | 0 | 0 | 53,434 | 20 | 131 | 53,434 | 20 | 131 |
| Clinker & Cement Products | 833,040 | 0 | 0 | 833,040 | 0 | 0 | 833,040 | 0 | 0 |
| Carbon-Bearing Non-Fuel Raw Material | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Scope 3 Transport Fuel | 15,757 | 23 | 113 | 16,189 | 23 | 116 | 16,403 | 23 | 117 |
| Potential SWDF Diverted from Landfill | 125000 | | | 75,000 | | | 0 | | |
| On-Site Electricity Use | 109,350 | | | 113,784 | | | 121,500 | | |

## Table 14 GHG Emissions: Changes in Emissions with Proposed MOD14

| Category | Change: Benchmark --> Existing t CO2-e | | | Change: Benchmark --> MOD14 t CO2-e | | |
|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| On-Site Diesel Fuel - Transport | 0 | 0 | 0 | 0 | 0 | 0 |
| On-Site Diesel Fuel - Stationary | 0 | 0 | 0 | 0 | 0 | 0 |
| On-Site Fuel Oil | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub-Bitumenous Coal for Combustion | -231,099 | -103 | -514 | -400,314 | -178 | -890 |
| SWDF for Combustion | 6,054 | 477 | 1,223 | 15,880 | 1,250 | 3,207 |
| HiCal50 (spent carbon anode fuel) | 17,425 | 15 | 37 | 17,425 | 15 | 37 |
| AKF1 for combustion (recovered oil) | 39,856 | 11 | 57 | 39,856 | 11 | 57 |
| AKF5 for Combustion (tyres) | 53,434 | 20 | 131 | 53,434 | 20 | 131 |
| Clinker & Cement Products | 0 | 0 | 0 | 0 | 0 | 0 |
| Carbon-Bearing Non-Fuel Raw Material | 0 | 0 | 0 | 0 | 0 | 0 |
| Scope 3 Transport Fuel | 432 | 1 | 3 | 647 | 1 | 5 |
| Potential SWDF Diverted from Landfill | -50,000 | | | -125,000 | | |
| On-Site Electricity Use | 4,434 | | | 12,150 | | |

# 4 DISCUSSION

## 4.1 Scope 1 Emissions

Table 13 shows that:

- There is a significant decrease in on-site combustion-related GHG emissions resulting from the decreased us of coal with the proposed MOD14 operation.
- There is a minimal increase in on-site GHG emissions from the increased use of SWDF for combustion

The net DECREASE in Scope 1 GHG emissions is … 157,000 t $CO_2$-e per annum.
( comparing the proposed MOD14 operations to the Existing operations )

## 4.2 Scope 2 Emissions

Table 13 shows that:

- There is a slight increase in electricity consumption at the Site associated with the newly proposed storage sheds

The net INCREASE in Scope 2 GHG emissions is … 7,700 t CO2-e per annum.
( comparing the proposed MOD14 operations to the Existing operations )

## 4.3 Scope 3 Emissions

Table 13 shows that:

- There is a minimal increase in transport-related GHG emissions associated with the increase in quantity of SWDF material compared to the coal being replaced.
- There is potentially a significant decrease in Scope 3 GHG emissions from the diversion of SWDF from landfill to the Site.

The net DECREASE in Scope 3 GHG emissions is potentially … 74,800 t CO2-e per annum.

## 4.4 All Scope Emissions

The net DECREASE in Scope 1, 2 and 3 GHG emissions is … 224,000 t CO2-e per annum.

The decrease of ~224,000 t $CO_2$-e per represents an overall decrease of almost 16%.

This is a very significant achievement in the overall context of the site and is even greater than the approximately 10% reduction in Scope 1, 2 and 3 GHG emissions comparing the "Benchmark" to the Existing scenarios.

# 5 RECOMMENDATIONS FOR FUTURE ENERGY INITIATIVES

While the proposed Modification 14 operations have the potential to significantly decrease GHG emission at the Site, the history of the Berrima Cement Works indicates a willingness from the Client to continue to look for further opportunities to decrease GHG reductions.

## 5.1 Boral's Long-Term Sustainability Commitments

Boral's Sustainability commitments are outlined in the 2021 Boral Sustainability Report.

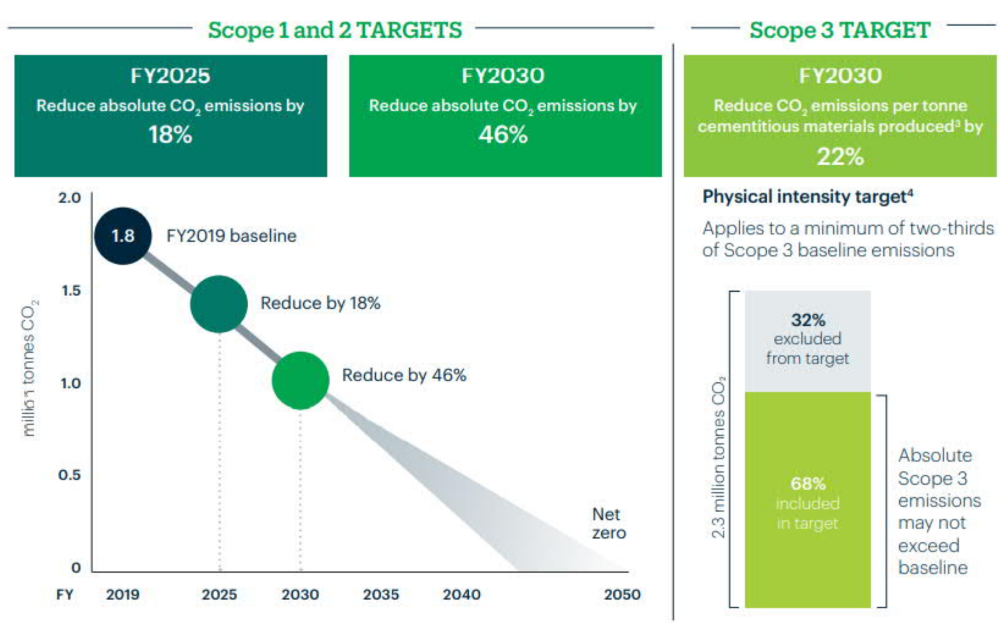
- Refer … https://www.boral.com/news/annual-reports

Boral has committed to the following objectives:

- Boral will utilise science-based climate targets to reach net-zero emissions from all operations by no later than 2050, in line with the most ambitious aim of the Paris Agreement to limit global warming to 1.5°C.
- Boral has joined the SBTi Business Ambition for 1.5°C and UNFCCC Race to Zero.
- Boral has submitted its FY2030 Scope 1 and 2, and Scope 3 targets for validation to SBTi.2.
- Boral is working on numerous new and emerging technologies to help achieve its 2050 ambitions.

The targets relating to FY2025 and FY2030 aligned with the above commitments are shown graphically in Figure 4.

Figure 4 FY2025 and FY2030 Scope 1, 2 and 3 GHG Targets – 2021 Boral Sustainability Report



The 2021 Boral Sustainability Report includes the following decarbonisation strategies that will help achieve its net zero target.

- Continue to explore alternative fuels to replace coal for kiln use.
- Source electricity from renewable sources
- Drive all aspects of operations to maximise energy efficiency
- Continue to optimise kiln feed and cementitious intensity
- Optimise supply chain related emissions, including both Boral's and Contractor fleets
- Give priority to lower $CO_2$ intensity suppliers
- Explore Carbon Capture, Use and Storage (CCUS) opportunities

The proposed Modification 14 at Boral's Berrima operations
provide a clear example of Boral's overall Sustainability commitments
and would have a measurable impact on its GHG emissions.

## 5.2 Additional Recommendations

ION the context of the overarching commitments discussed in Section 5.1, the following energy mitigation and management measures are recommended for consideration.

Vehicle Management

- Turn off vehicles and plant and machinery when not in use
- Ensure vehicle and plant and equipment are regularly serviced
- Use fuel-efficient fuel for all on-site vehicles

Electricity

- Offset current electricity with green power
- Continue to source high efficiency plant and equipment, wherever feasible
- Continue to source high efficiency site-wide lighting, sensor-triggered lighting and avoid over-lighting

Combustion Management

- Continue to carry out R&D on alternative combustion fuel sources, as has been done now for many years, to further minimise coal combustion use on the Site.

Clinker Substitution

- Continue to carry out R&D and work with Industry Stakeholders and Industry Bodies to explore replacement options for portions of clinker with alternative cementitious materials that can result in a lowering of GHG emissions.
- Recent research suggests that mineral additions beyond the 7.5% allowed under AS 3972-2010 may not significantly impact the performance of the resulting blended cement, say to ~12%.

CCSU

- Carbon Capture, Storage and Utilisation (CCSU) remains a complex, capital intensive and largely unproven technology at-scale at the present time.

- Nevertheless, cement plants could potentially be suited to carbon capture due to the high $CO_2$ concentration of the flue gas.
- The Australian Government is currently pursuing initiatives in this area, backed by significant funding – eg recent announcement to supplement CEFC funding by $0.5Bn aimed at developing viable CCSU techniques.

# 6 CONCLUSION

The Boral Cement Works ("the Site") operates under two development consents originally issued by the Department of Planning and Environment (DPE), now the Department of Planning, Industry, and Environment (DPIE), being DA 401-11-2002-i (Kiln 6) and DA 85-4-2005-i (Kiln 7).

DA 401-11-2002-i for Kiln 6 has been modified several times, the latest being Modification 13 (MOD 13) – refer Table 1 - which allowed for the establishment of a chloride bypass system at the kiln.

Boral proposes a further modification to the consent (Modification 14) to:

- increase the consumption of SWDF materials within the kiln; construct an alternative haulage access route through the Site; expand the current storage and handling facilities at the Site; supplement existing kiln feeding infrastructure; and increase the truck deliveries and permissible delivery hours at the Site.

SLR has been engaged to undertake a Greenhouse Gas (GHG) emissions study to address the Environmental Assessment Requirements for the proposed Modification 14 (issued 6 August 2021).

The present GHG Assessment has addressed Scope 1, Scope 2 and Scope 3 emissions relating to Modification 14.

In carrying out the GHG Assessment, key Energy Efficiency aspects were noted and recommendations made where cost-effective improvements are identified for further consideration.

The present study has found that the Scope 1, 2 and 3 GHG emissions from the proposed Modification 14 would results in a net decrease of 224,000 t $CO_2$-e compared to the existing operations at the site, representing a reduction of almost 16%.

This is a very significant achievement in the overall context of the site.

It is noted that Modification 14 is only the latest of a series of continuous improvements that have been made at the site over the past several decades, with ongoing work in all energy-related areas likely to lead to even further GHG emission reductions in the future.

# APPENDIX A

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