



22 November 2019

Attention: Stephen O'Donoghue
Director
Department of Planning, Industry and Environment
Email: [REDACTED]

Dear Stephen

Re: Eraring Power Station Long Term Ash Management Strategy

Please find attached the 2019 update of the Origin Eraring Power Station Long Term Ash Management Strategy (LTAMS).

If you would like to discuss the information contained within, please do not hesitate to contact Lauren Barnaby, on [REDACTED] or the undersigned.

Yours Sincerely,

A handwritten signature in black ink, appearing to read "Fernanda M. Kemeid".

Fernanda Maluly Kemeid
Ash Strategy and Management Lead
Origin Eraring Power Station



Long Term Ash Management Strategy (LTAMS)

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Please see document control section for more information.

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1 Introduction

1.1 General Introduction

Origin Energy Eraring (Origin) operates Eraring Power Station (EPS) as part of an asset portfolio which generates electricity for the National Electricity Market. EPS is a coal fired power station consisting of four 720 megawatt (MW) units. Over recent years, Origin has embarked on a program of upgrades to EPS to accommodate the projected future demands for electricity in the market.

These upgrades have included the expansion of the existing Coal Combustion Product (ash) storage facility (ash dam) to accommodate EPS' ash (ash) management needs. Ash is a by-product of electricity generation produced by burning of coal. Whilst a proportion of ash generated by EPS is reused, the remainder is stored in the ash dam located north east of EPS.

Origin is proposing to augment the ash dam using an alternative placement strategy and landform design to maintain operational flexibility and extend the storage life of the facility in the short to mid-term whilst continuing to support long term ash placement strategies towards 2032. An application has been submitted to the Department of Planning and Environment (DP&E) under the former Section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act) to modify the existing Project Approval (07_0084). The application is currently in the assessment phase.

Origin is also in the planning stages of additional and upgraded onsite ash recycling facilities and continues to pursue new market opportunities and drive the development of new reuse streams through innovation and product development.

1.2 Purpose

This Long-Term Ash Management Strategy (LTAMS) represents a commitment by Origin to improve the efficiency of, and reduce environmental impacts associated with, the operation of EPS and the ash dam. The LTAMS is a tool for both Origin and Government agencies to guide significant reductions in ash storage at EPS through an increase in recycling and development of new technologies in ash management. The LTAMS is used as a management tool to allow for progress in these areas to be measured and monitored on a regular basis and reported back to the relevant stakeholders.

The LTAMS is a dynamic document which undergoes regular review subject to developments in available and preferred ash management practices. The Ash Strategy and Management Lead at Origin maintains overall responsibility for the implementation of the actions and strategies contained in the document and for the revision of these actions and strategies where appropriate. Over the past year, Origin has considerably expanded the Ash Management Team to ensure these strategies are implemented in a timely & optimal manner.

The key goal of the LTAMS is to develop and implement strategies that maximise the reuse potential of fly ash (both classified and unclassified) and bottom ash produced at EPS.

The objectives of the LTAMS are to:

- Work towards a change in the perception of ash from a waste product to a commodity.
- Establish and develop new markets for ash across a variety of industry sectors.
- Foster partnerships between Origin, local industry, local industry associations, the State and local Government and the local community to work towards the use and recycling of ash.
- Improve the efficiency and reduce the environmental impact of ash management at EPS.
- Set benchmarks for environmental best practice in ash management across Australia.

This document is the October 2019 update of the LTAMS.

1.3 LTAMS Requirements

The Long-Term Ash Management Strategy (LTAMS) for ash was initially prepared in accordance with Condition 3.1 of the Concept Approval for the upgrade of the existing ash storage facility at EPS (Project Number 05_0138). The Department of Planning Industry and Environment (DPIE) subsequently approved the LTAMS on the condition that the LTAMS be updated within one month of the issue of Project Approval and reviewed periodically until 2015. A revised LTAMS was subsequently prepared in accordance with this requirement and submitted to DP&E in June 2008. Typically, the LTAMS has been reviewed and submitted to DP&E on an annual basis.

DPIE intend to include the following condition in the Project Approval (07_0084) modification (MOD1):

4A LONG-TERM ASH MANAGEMENT STRATEGY

4A.1 The Proponent shall prepare and submit for the approval of the Planning Secretary, a Long-Term Ash Management Strategy for the site. The Strategy shall be developed in consultation with the EPA and Council, and shall include, but not necessarily be limited to:

- a) a stipulated goal of 80% reuse or recycling of ash from the Eraring Power Station by 31 December 2021. This goal may only be altered with the prior written agreement of the Planning Secretary, based on a demonstration by the Proponent that market conditions reasonably preclude this goal being achieved;*
- b) a program for the investigation of alternative ash management measures over time, with a particular focus on the minimisation of ash disposal on site and beneficial reuse of ash;*
- c) a framework for the identification and assessment of alternative ash management measures from time to time, having regard to the operational needs of the Eraring Power Station, and social, economic and environmental implications of those measures;*
- d) a staging strategy for the implementation of works the subject of this approval;*
- e) a strategic management framework for the optimisation of ash disposal capacity on the site, and periodic review of ash management practices to achieve this outcome;*
- f) an environmental management framework for the on-going management of ash disposal and ash management measures on site, consistent with contemporary best environmental practice;*
- g) a rehabilitation strategy that outlines proposed rehabilitation, with consideration of the ash reuse potential, including:
 - a description of techniques to restore the area;*
 - a timetable for the progressive staging of the rehabilitation program; and*
 - a monitoring and auditing program; and**
- h) a strategy for the reconciliation of the generating life of the Eraring Power Station and the availability and management of ash produced by the Power Station.*

In respect to a), if reuse options are slow to emerge, or they are not feasible on economic environmental, or industrial reliability criteria, the timeframe goal may be extended with the agreement of the Planning Secretary, in consultation with the EPA. Extension of the goal shall be subject to the Proponent providing to the satisfaction of the Secretary information on available reuse options, justification of why these cannot be – or have not been - adopted, and a description of what measures will be implemented to facilitate the reuse of all ash generated on the premises for a beneficial purpose. After reviewing this information, the Planning Secretary in consultation with the EPA, may approve a modified timeframe goal(s), and may require the Proponent to carry out further investigations or works into reuse of all ash generated on the premises for a beneficial purpose.

4A.2 By the end of October each year, or other timeframe agreed by the Planning Secretary, a report shall be submitted to the Department to demonstrate annual progress of reuse and recycling of ash, to the satisfaction of the Planning Secretary.

Clause 4A.1g shown in red text is a new condition proposed by DPIE and it replaces a similar Condition 2.2 in the existing Project Approval (07_0084). This was agreed with the DPIE as rehabilitation of the ash dam is progressive and integrated with ash recycling initiatives, and as such is consistent with the objectives of the LTAMS.

2 Ash Use Identification and Assessment Framework

2.1 Overview

This section of the LTAMS outlines the framework by which ash use opportunities are identified and assessed.

Origin has developed a detailed program for the investigation and development of alternatives to ash storage at the existing storage facility through possible ash use and recycling options. A number of key opportunities have been identified to form the initial focus of the reuse strategy, detailed below. New opportunities will be added and tracked through regular reviews of the LTAMS in accordance with approval conditions. Origin Energy Eraring is currently active in the ash use market and is proactively attempting to stimulate current opportunities while consistently seeking new opportunities.

Origin's commitment to the ash recycling target can be evidenced by the following:

- Origin continues to monitor developments in ash management and opportunities within the building/construction and allied sectors and assist in changing the image of ash from a waste product to a commodity.
- Origin has implemented and maintained monthly reporting to site and senior management with updates on progress with new opportunities identified to be incorporated into the LTAMS. Origin also reports back to the Secretary of DPIE with updated LTAMS on an annual basis.
- Origin is an active member of the Ash Development Association of Australia (ADAA) in its attempts to investigate and create new markets through increasing users', stakeholders' and regulators' awareness of the benefits of effective ash utilisation.
- Origin continues educating and marketing to potential customers about the new streamlined processes available for ash under The Coal Ash Exemption 2014.
- Origin commits to working with regulatory authorities to streamline approval processes and avoid exposure to regulatory risk associated with the use of ash.
- Origin will continue its efforts to increase the use of ash in existing markets through new agreements and those currently in place.
- Origin holds regular meetings and contact with key people within relevant State and Local Government departments to facilitate access to key opportunities for ash use in government projects.
- Origin will continue its efforts to progress new markets in ash reuse through the expansion of research and development opportunities, and through the implementation of proven technologies for the use of fly ash.
- Origin will further develop technical data sheets and associated information for the use of ash as required.

2.2 Ash Markets

The market for the utilisation of ash is broad. A range of potential applications are briefly outlined in this section. These applications span from cementitious uses through to bulk fills and agriculture products, as well as a variety of niche applications employing new technologies.

The following ash markets exist – source: <http://www.adaa.asn.au/resource-utilisation/application-and-uses>.

2.2.1 Cement and Concrete

The use of ash in the manufacture of cement and concrete products currently represents the largest sector for EPS Ash utilisation.

EPS Ash is used in the production of cement powder via:

- Its input as a supplementary cementitious material blended with cement powder to produce products termed blended cements.

Fly ash concretes form the benchmark for 'Normal Class Concrete' types described in Australian Standards AS3600 and AS1379 and supplied to most major projects.

2.2.2 Aggregates

Emerging opportunities for producing manufactured aggregates for use in concrete, pavements and the general construction industry are increasing due to the continued development of the production technology and the improved economics of production versus the traditional quarried products. In addition, there is a greater push for construction projects to utilise recycled products as opposed to less sustainable traditionally quarried materials.

Origin is currently carrying out R&D activities both internally and with third party entities for the production of light weight manufactured aggregates. Origin is further exploring the technologies and patents available to ensure the optimal manufacturing process and market opportunity is identified.

2.2.3 Pavements (Roads, Hardstands)

The term "pavement" is used to refer to the entire structure of the pavement, from foundations through to the top surface. Pavements are not just limited to roads, they can include such hardstands as carparks, walkways and building foundations.

The construction of ultra-high volume fly ash pavements, containing more than 90% fly ash, represents a significant sustainable benefit to pavement construction against the more traditional concrete pavements. In addition, increased ash use percentage in foundation layers of a pavement also provide for a significant sustainable economic outcome for the construction industry.

Ash can be utilised for a number of purposes in pavement works, often with only a limited amount of processing required, these include:

- As a base and sub-base material when stabilised.
- As a component of a stabilising agent.
- In concrete for rigid pavements.
- As a filler and/or binder in asphalt.

The major benefits demonstrated with the use of Ash in pavements include:

- Increases in pavement performance.
- A technically viable alternative to conventional road building materials.
- Potential cost advantages compared to natural road building materials

2.2.4 Structural Fills

Structural fills are typically constructed in layers of uniform thickness and compacted to the desired density in a manner to control the compressibility, strength and hydraulic conductivity of the pavement.

The high strength, lightweight, low compressibility and free-draining properties of Ash products make them suitable fill materials for use in road embankments.

2.2.5 Agriculture

The use of ash, particularly fly ash, has significant environmental and crop production benefits arising from its use in amending the structurally weak soil.

Due to the dominance of silt-sized particles and the porous nature of the components, the addition of fly ash can help to increase the water-holding capacity and modify the permeability of otherwise unfavourable soils. The addition of ash to sandy soils, for example, can reduce episodes of moisture deficit, and also aid the retention of nutrients such as nitrate, ammonium and phosphorus in the rooting zone, leading to increases in plant yield and a range of associated economic and environmental benefits. Ash may also be used to increase the porosity and permeability of clay-rich soils, lowering bulk density, providing better water infiltration and increasing the aeration level.

Additionally, alkaline ash can be used to ameliorate low soil pH, providing chemical nutrients otherwise lacking in the soil, making up deficiencies that might arise due to prolonged weathering or extended cropping.

Origin supplies ash to customers in accordance with the NSW Coal Ash Order, 2014. The concentration criteria for some components of coal ash is more stringent when ash is supplied as a soil amendment which includes agricultural purposes. This has limited coal ash being supplied for this purpose in the past.

2.2.6 Mine Rehabilitation

Ash may be used as structural fill in open-cut or underground coal mines for a number of beneficial purposes. These include:

- Void infilling, spoil pile re-contouring or high wall reclamation.
- Grouting or infilling to control subsidence, ground movement or water flow.
- Amelioration of unfavourable water quality (e.g. acid pH) associated with mining.
- Provision of construction materials for mine access and haulage roads.
- Stabilisation of exposed rock, tailings or soil to prevent wind or water erosion.
- Control of contaminant migration, underground fires or spontaneous combustion.
- Improvement of natural or artificial soils in mine-site rehabilitation programs.

2.2.7 Geopolymers

Geopolymers are a class of inorganic polymer formed by the reaction between a strong alkaline solution and an amorphous aluminosilicate feedstock. Fly ash is an excellent feedstock when utilised as geopolymer cement (binder). The hardened material has an amorphous three-dimensional structure similar to that of an aluminosilicate glass. When blended with a conventional aggregate skeleton (stone + sand), a geopolymer concrete is formed, which in general has superior properties to the equivalent conventional concrete.

Artificial rock-like silicate materials produced by synthetic reactions between the ash and the alkaline solution at temperatures below 100°C can be produced from Ash by transforming ash into geopolymer pellets Coarse (gravel-size) and fine (sand-size) aggregates for conventional or geopolymer concrete.

2.2.8 Zeolites

A range of zeolite minerals may be produced by reacting silica, alumina and cations under hydrothermal conditions (pH 10-14, > 100°C), and the abundant aluminosilicate glass component in fly ash provides a potential raw material for zeolite synthesis. Zeolites are used as control release fertilisers, soil conditioners, ion exchange media, and also as detergent builders, pesticide carriers, and animal dietary supplements. Although natural Zeolites are also available, synthetic Zeolites, including materials made from Ash may be tailored more specifically to meet particular market requirements.

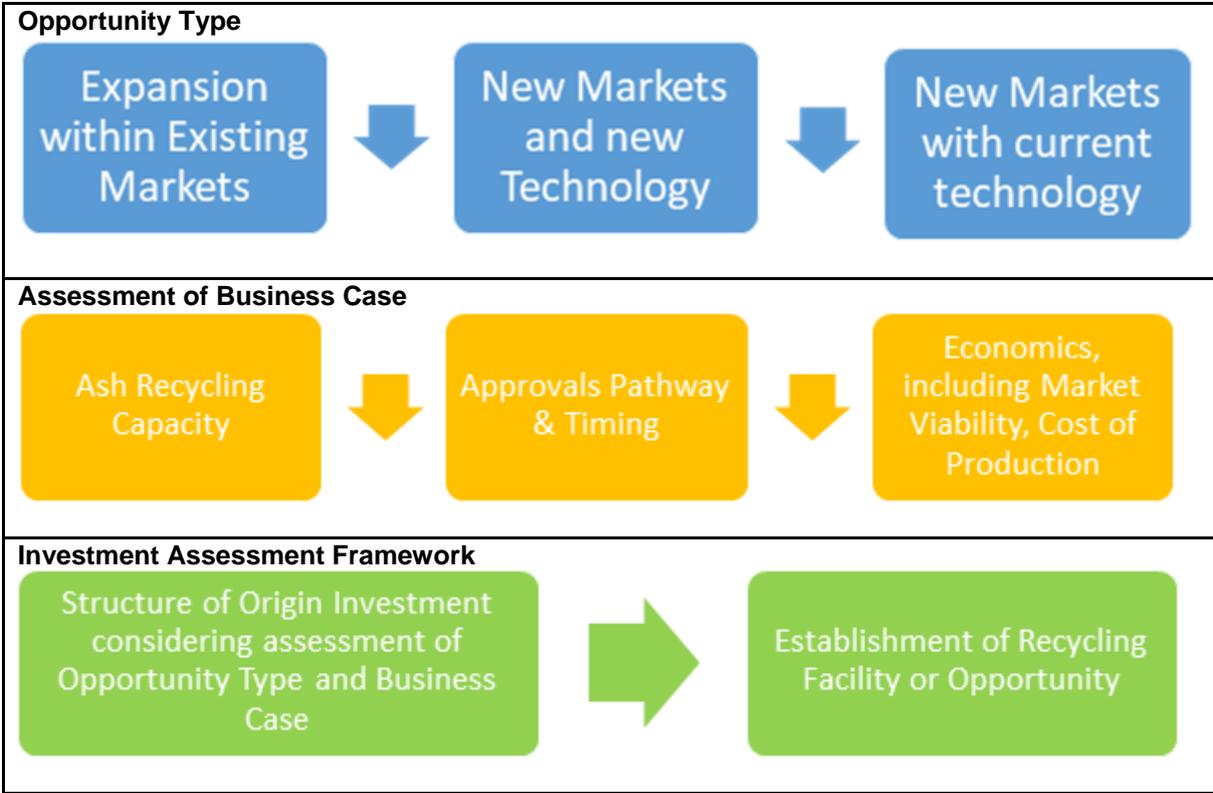
2.3 Barriers to Alternative Ash Use

There are barriers to ash use and recycling and these are considered in the identification and assessment of opportunities. Details market barriers are included in Section 3.3 and Section 4.3.

Origin has worked successfully to reduce barriers to alternative ash use. The Coal Ash Exemption 2014, which commenced on 24 November 2014, introduced changes that have resulted in CCP produced at EPS not being subject to certain licensing and regulatory requirements under the Protection of the Environment Operations Act 1997 (POEO Act) and the Protection of the Environment Operations (Waste) Regulation 2014 (Regulation 2014). This has streamlined the process of storing, transporting and on-selling CCP, making the product more readily available and attractive to potential users.

2.4 Identification and Assessment Framework

Origin has developed a detailed framework for the identification, investigation and development of alternatives to ash storage at the existing ash dam through possible ash use and recycling options. An overview of the framework is set out below.



Our strategy – “Origin is the supplier of Eraring ash direct to market”

The framework includes existing markets and how we continue to optimise ash use with existing customers and increase the supply to these customers. Additionally, we continue to assess new markets for ash use across the areas identified in Section 2.2.

New opportunities are added and tracked through regular reviews of the LTAMS in accordance with approval conditions. Origin is proactively attempting to stimulate current opportunities while consistently seeking new opportunities.

3 Progress to 2021 Goal of 80% Ash Reuse or Recycling

3.1 Overview

This section of the LTAMS sets out Origin's historic ash recycling to date.

3.2 Historic Performance

Origin currently has agreements in place for ash to be used in the production of cement and concrete which is supplied to building and construction industries. In the 2018/2019 period this amounted to more than 602,500 tonnes or approximately 34.8% of ash produced during this period at EPS. Origin's progress towards achieving a goal of 80% reuse is therefore heavily influenced by demand generated by the building and construction industries.

Additionally, at EPS ash products are sold to fly ash wholesalers and end users active in the cement/concrete and grouting industries.

Ash recycling rates have varied from the lowest (27.6% - 2016/2017) through to the highest (46.9% 2012/13). Recycling tonnages have typically been greater than 400ktpa with the exception of 2016/2017 which involved a significant period of ash unavailability due to unforeseen Plant outages. Actual ash reuse rates are provided in **Table 1** (on a Financial Year basis).

The, 2018/19 period reported the largest quantities of ash produced in recent years driven by national energy demands. With recycling tonnages of 602,580 tonnes and a rate of approximately 35%, 2018/19 also had the highest quantity of ash recycled since 2005/06.

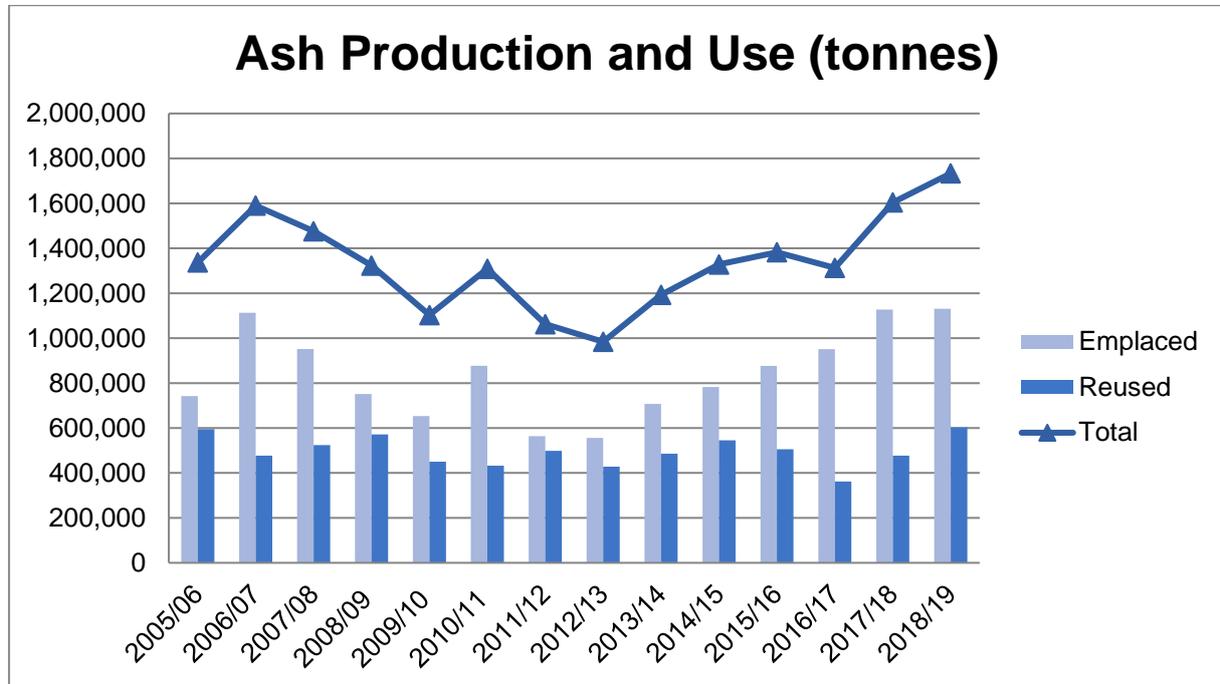
In addition to ash demand Origin puts this down to the focussed effort of the recycling business unit and senior management drive to achieve the 2021, 80% target.

Table 1 Rates of Reuse for ash Produced at Eraring Power Station

Year	Reuse Amounts (tonnes)	Reuse Amounts and Rates
2005/06	595,000	44.5%
2006/07	477,000	30.0%
2007/08	524,000	35.5%
2008/09	571,550	43.2%
2009/10	450,000	40.8%
2010/11	432,000	33.0%
2011/12	498,193	46.9%
2012/13	427,968	43.5%
2013/14	485,659	40.7%
2014/15	545,327	41.1%
2015/16	505,622	36.6%
2016/17	361,839	27.6%
2017/18	477,292	29.8%
2018/19	602,580	34.8%

Historic ash production and use are shown in Figure 1.

Figure 1 Ash Production and Use (tonnes)



It is noted that approximately 90% of all ash is fly ash and 10% is bottom ash. In 2018/19 130% of bottom ash was recycled, that is all of the bottom ash generated in that year was recycled with additional bottom ash removed from the ash dam for recycling sales opportunities.

3.3 Ash Demand Impact on 80% Target

Demand for current ash derived products within the Cement and Concrete sector are primarily governed by the state of the building and construction industries in the Greater Sydney and Hunter regions. These industries are heavily influenced by key state resourced infrastructure projects and the broader construction needs of the region. Therefore, predicted population growth and strategic planning instruments may inform future market conditions and potential demand for ash derived resources.

The population in the Hunter region has grown from around 693,400 people in 2011 to about 732,400 in 2016. While the population for the region is forecast to increase, overall population growth rates are estimated to remain relatively steady and so it is unlikely there will be a significant increase in the demand for cement and concrete products associated with the construction of new dwellings.

Since takeover of the EPS, Origin implemented a new Ash Management Program to enhance the marketability of its ash. In particular, a pneumatic fly ash collection, storage and loading system was constructed as part of the EPS upgrade works to allow for greater separation of the fine and coarse fly ash materials. This has improved opportunities for the sale of fly ash to cement and cement related industries whilst allowing coarse material to be marketed for other reuse opportunities. Since the implementation of the new Ash Management Program, Origin has been active in the market and through proactive business development has been able to take advantage of several opportunities which have resulted in increased ash sales. The opportunities that have been undertaken to date are summarised in **Table 2**.

Table 2 Opportunities Realised to Date & Future Opportunities

Opportunity	Actions Taken by Origin	Result
Continued supply of ash to Industry	Origin established and maintained an ongoing contract with a national fly ash vendor via the installation of a standalone fly ash management facility on EPS.	Ash is selected based on its meeting the Roads and Maritime Services (RMS) specification for fly ash, which is the highest quality ash produced by EPS. The contract currently amounts to the reuse of approximately 310kt of ash during the 2018/2019 period.
	Origin has established an increased sales agreement contract with an additional national fly ash vendor via fly ash supply from Origin's CCP	Ash is sold directly from the CCP Facility. Ash quality is variable and not sold to RMS specification. The contract currently amounts to the reuse of approximately 30kt of ash during the 2018/2019 period with increasing reuse targets over the next 2 years to 150ktpa.
	Origin has established an increased sales agreement contract with a strong regional fly ash vendor.	Ash is sold directly from the CCP Facility. Ash quality is variable and not sold to RMS specification. The contract currently amounts to the reuse of approximately 50kt of ash during the 2018/2019 period with increasing reuse targets over the next two years to 250ktpa.
	Origin has established an increased sales agreement contracts with cement grout companies for supply to the mine void rehabilitation industry.	Ash is sold directly from the CCP Facility. Ash quality is variable and not sold to RMS specification. The contract currently amounts to the reuse of approximately 40kt of ash during the 2018/2019 period with increasing reuse targets over the next two years to 50ktpa.
	Origin has established a 10-year contract in 2018 for the recycling of EPS bottom ash.	The contract currently amounts to the reuse of in excess of 120kt of ash during the 2018/2019 period.
	Origin is investigating the rehabilitation of mine voids beneath the EPS site.	There is potential to grout a significant number of mine voids at EPS.
New supply opportunities to Industry	Origin is in negotiation with a mining company for the use of pond ash for specific mine site rehabilitation projects.	Ash is sold directly from the ash dam to the mine rehabilitation sites. Initial trials are expected to utilize up to 100kt in the 2019/2020 period with increased tonnages expected as a result of the trials.
	Origin established and maintained an ongoing contract with a national fly ash vendor via the installation of a standalone fly ash management facility on EPS.	Ash is selected based on its meeting the RMS specification for fly ash, which is the highest quality ash produced by EPS. The contract currently amounts to the reuse of approximately 310kt of ash during the 2018/2019 period.
	Origin has established an increased sales agreement	Ash is sold directly from the CCP Facility. Ash quality is variable and not sold to RMS

	contract with an additional national fly ash vendor via fly ash supply from Origin's CCP	specification. The contract currently amounts to the reuse of approximately 30kt of ash during the 2018/2019 period with increasing reuse targets over the next 2 years to 150ktpa.
	Origin has established an increased sales agreement contract with a strong regional fly ash vendor.	Ash is sold directly from the CCP Facility. Ash quality is variable and not sold to RMS specification. The contract currently amounts to the reuse of approximately 50kt of ash during the 2018/2019 period with increasing reuse targets over the next two years to 250ktpa.

Reuse rates, as a factor of production, are subject to the demands of the National Electricity Market. During periods where generation demands are consistently high, percentage reuse rates may be negatively impacted, despite reuse tonnages remaining comparatively stable.

Fly ash remains a reusable product post deposition within the ash dam and therefore successful reuse of ash is not necessarily bound to annual production rates, but rather a diverse and multifaceted reuse strategy involving all of EPS ash – including “impounded ash” stored in the ash dam.

4 Alternative Ash Use Measures

4.1 Overview

This section of the LTAMS outlines the ash available for recycling and use, Origin's progress to an 80% recycling target, current and future opportunities to increase ash use and a program for investigation.

Origin continues to investigate opportunities to overhaul and improve the supply chain infrastructure and management to enhance ash sales capacity. In particular, Origin is exploring the ability to provide distinct ash products as per the Australian Standards for fly ash.

Origin's Ash Management Strategy involves the targeted reuse of its ash, those being:

- RMS specification quality fly ash transferred direct to onsite processor facilities;
- Run of Station quality (Australian Standards Grade 1 & 2) fly ash to re-users via the CCP facility;
- Bottom ash to market via a contracted re-user; and
- Pond ash / impounded ash direct to the rehabilitation market and new technology applications.

4.2 Ash Availability for Use

4.2.1 Forecast Future Ash Production and Use

Future ash production is directly related to the energy produced and the type of coal utilised. If the energy production rates and coal type are maintained, the annual ash production will be approximately 1.5 million tonnes per annum (Mtpa). That is 19.5 Mt of additional ash over the 13-year period from 2020 to end 2032. If the ash recycling rate was to stay at 30%, then 5.85 Mt would be recycled, and 13.65 Mt stored in the dam.

An 80 % ash recycling target equates to approximately 1.2 Mt of ash use per annum, and if the target was achieved from 2022 then 13.2 Mt of ash would be recycled of the total 16.5 Mt produced in the 11-year period between 2022 and the end of 2032. As outlined in Section 4.3 to Section 4.6 to follow, Origin is accelerating our efforts with a view to meeting an 80% recycling target in the short-term and plan to sustain ash recycling as high as possible out to the end of power station coal operations planned to occur by 2032.

Ultimately market demand will be a key determinant in the actual rates achieved and the success of the recycling program.

4.3 Market Outlook

4.3.1 Reuse Market Trend

The 2016/2019 current trend analysis as outlined in Section 3.2 reinforces that use of ash is largely driven by demand within the building and construction industry. Actual quantities of ash used remain within long term reporting trends despite lower coal quality and unplanned maintenance causing temporary interruptions in production during the 2016/2018 period. Importantly over the past three years ash use has increased year on year.

The use and sale of ash is dynamic and may vary depending on the economic climate and available markets at the time. Even with increases to population growth or infrastructure projects, it cannot be assumed this would result in greater ash sales. While there are many potential benefits in the use of ash in aggregate substances, they are not always the preferred option for cement and concrete products. Government and regulator advocacy continue to play a key role in driving demand for ash and has a direct impact on Origin's ability to supply ash as a reuse material. Demand for ash materials may be increased through government incentives aimed at encouraging businesses to source ash products for use in cement and concrete.

Origin will continue to work with industry to identify new market opportunities and drive the development of new ash use streams through innovation and product development. Past work with the Australian Technical Infrastructure Committee to develop technical specifications for ash use and the introduction of the Coal Ash Exemption regulation are examples of how Origin's continued engagement with industry and government regulators continues to drive sustainable use of ash.

4.3.2 80% Reuse Target December 2021.

Through the implementation of the existing and future Ash use initiatives and the innovative new products and technology opportunities, Origin continues to track towards the ash recycling target of 80% by the end of 2021.

4.4 EPS Ash Use Alternatives

4.4.1 Existing Ash Use

Origin proactively engages with vendors dealing with all ash products to increase the use of ash in the cement, concrete and other allied industries. Origin continues to work with potential vendors to develop methods to increase reuse of fly ash in the cement and concrete industries by investigating and developing new products based on blending and chemical composition.

Origin has several existing commercial agreements for the sale of fly ash (both classified and unclassified) and bottom ash as detailed above in Table 2.

Origin's Ash Management Strategy involves the targeted reuse of all ash products, those being:

- RMS specification quality Fly Ash transferred direct to onsite processor facilities;
- Run of Station quality (Australian Standards Grade 1 & 2) fly ash to re-users via the CCP facility;
- Bottom ash to market via a contracted re-user; and
- Pond ash / impounded ash direct to the rehabilitation market and new technology applications.

4.4.2 Innovative New Products and Technology Opportunities under Investigation

Ultra-high-volume fly ash pavement

Origin, in partnership with a local consulting firm, is conducting a detailed durability assessment of an ultra-high-volume fly ash pavement constructed on the Coal Haul Road at EPS in 1995. Results to date indicate that the road has outperformed the standard heavy vehicle pavement design. Origin is also committed to the exploration of the enhancement of all pavement components with the addition of fly ash. Full implementation of the opportunity will require engagement with the RMS and local council stakeholders to trial the product and enable the commercial roll out via a change of the relevant RMS Standards for pavements.

Ash amended road base pavements and quarry products

Origin is undertaking a range of product development trials with a regional quarry to incorporate ash products into sub grade, road base and other quarry materials suitable for utilisation in the Lake Macquarie City region. To date this opportunity has identified six potential products, featuring possible improvements on the Plasticity Index, BCR or workability of the products. Origin intends to expand these applications within the local area.

Light weight aggregate manufacturing

Origin is currently in various stages of negotiation with a number of organisations for the construction and operation of an aggregate manufacturing plant at EPS by the third party that would bind CCPs together to produce a range of coarse and fine aggregates for use in concrete and other traditional aggregate applications.

Pre-cast building materials

Origin is currently in various stages of research and negotiation with a number of organisations for the construction and operation of various building material manufacturing plants at EPS by a third party that would bind CCPs together to produce a range of pre-cast building materials including blocks, bricks, pavers and tiles.

Mine Void Rehabilitation

Origin currently reuses up to 50ktpa of Fly Ash for use in mine void rehabilitation projects throughout the Newcastle and Hunter regions. Origin is also developing additional grouting projects at EPS with local mines for the rehabilitation of the former mine workings.

Mine Rehabilitation

The mine rehabilitation ash recycling project involves the transport of ash excavated from the ash dam and transported to a mine site in the Lower Hunter area to be used for rehabilitation purposes within a disused tailings storage facility. The project involves a trial in 2020 where up to 50,000t of fly ash will be transported to the mine site for rehabilitation over a 2-month period. Pending the outcome of the trial there is the potential for up to 1Mt to be exported the site over a 2-year period between FY19/20 and FY21/22

Geopolymers

Origin has been a key joint funder of Geopolymer research via the ADAA to the University of NSW Centre for Low Carbon Living.

4.4.3 Mid and Long-term Opportunities (2-10 years)

In the mid and long-term out to 2032 Origin will continue to supply ash to existing customers and markets as well as continue to develop opportunities for ash recycling. To enable this, Origin has considerably expanded the Ash Management Team to include dedicated Commercial and Planning & Approvals resources.

Key market opportunities in addition to existing ash use include:

- Increased application into Mine void remediation using fly ash grouts.
- Innovative building and road construction industries.
- Eraring pavement construction projects.
- Pond ash / impounded ash mine rehabilitation projects.
- Pond ash / impounded ash innovative building and road construction industries.

4.5 Increased Ash Recycling Ramp Rate

As outlined in Section 3 and Section 0 Origin anticipate an increase in the ash recycling rate over the next few years. This is highlighted in Figure 2.

Figure 2 EPS Estimated Ash Recycling Ramp Rate

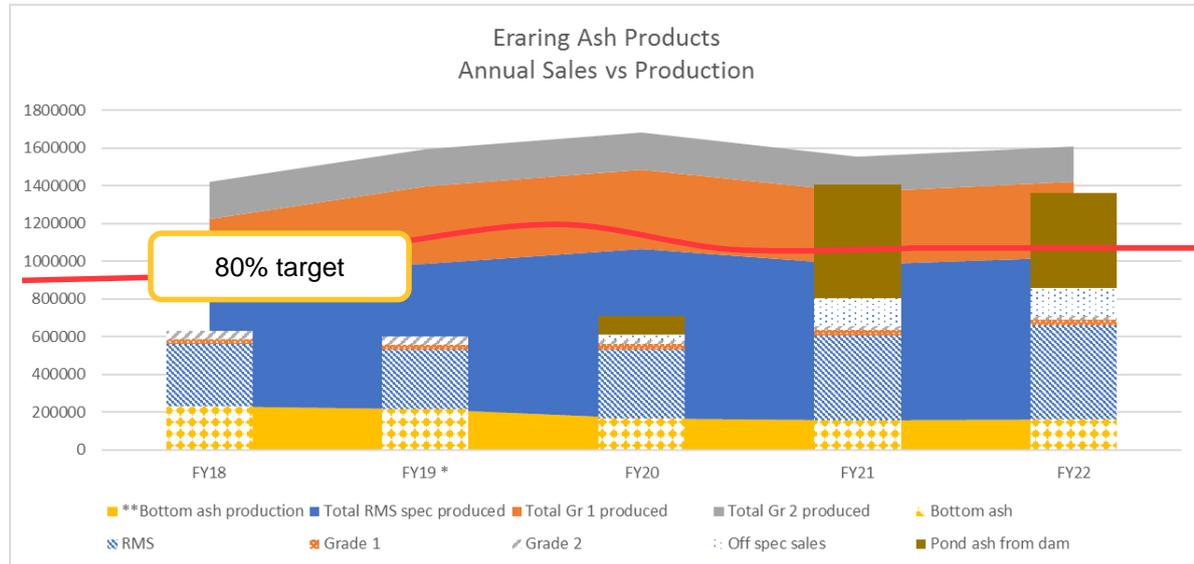


Figure 2 shows the current position where ash recycling in 2019 is approximately 602.5ktpa. In the near term (2020 – 2022) the diversified Run of Station sales and the mine rehabilitation trial project has the potential to significantly increase ash recycling up to a recycling rate from the current 35% to above 50%. Note, the data in Figure 3 assumes a successful Mine Rehabilitation trial, as outlined in Section 4.4.2, which has the potential to develop into a 1Mt standalone rehabilitation project.

4.6 Program for Investigation of Alternate Ash Use

Origin have a team dedicated to the ongoing investigation of alternative ash use. This covers full project lifecycle from opportunity identification including commercial and risk assessment, project design, project execution and management including engaging partners to help construct and deliver the projects.

In each annual update of the LTAMS Origin will update its program of opportunity investigation and project implementation.

5 Staging Strategy for Implementation

5.1 Overview

This section of the LTAMS discusses Origin's historic staging of ash dam development and proposed augmentation (MOD1) as per our conditions of approval. This includes planned staging of ash recycling projects.

5.2 Ash Dam Augmentation

The works required for the progressive augmentation of the existing ash dam at EPS have been staged to reflect the operational needs of EPS in terms of ash management as well as to mitigate and minimise the potential environmental impacts as part of augmentation projects.

Clearing of land required for the of the ash dam commenced prior to the first generating unit being connected to the new dense phase pumping system (August 2009) to allow for commissioning of the dense phase placement process. Details of the staging of proposed and actual clearing works are shown in Table 3. A Habitat Offset Plan (HOP) has been prepared and shows each separate area comprising the total offset area.

Table 3 Schedule of Clearing for Ash Dam Augmentation

Stage	Actions	Timing
Preliminary	Preparation of Habitat Offset Plan for all stages of compensatory habitat.	January 2008 (Complete)
Stage One	Dedication of all compensatory habitat offset area (total 42 ha) of vegetation to be removed (up to 21 ha).	May 2008 (Complete)
	The first stage of land clearing (3.5ha).	October 2008 (Complete)
Stage Two	The second phase of land clearing (approximately 4.5 ha).	June 2010 (Completed)
Stage Three	The third stage of clearing (3 ha) carried out up to around RL 135.	December 2010 (Complete)
Stage Four	The fourth stage of clearing (3 ha to complete 14 ha clearing in total) carried out up to around RL 140 m.	Completed 2017
Stage Five	The fifth stage (8.95 ha) as part of the planned western development of the ash dam (MOD1) which is in the project assessment phase.	Planned for 2020 subject to approval

The following protocol is adopted for each stage of the proposed works:

- Offset areas are offered for the stage requirements before the commencement of any clearing.
- Where possible Origin utilised disturbed areas rather than clear bushland for access to the area of ash placement.

6 Integrated Ash Deposition, Storage and Use

6.1 Overview

This section of the LTAMS outlines forecast ash deposition, storage and use and the potential need for future ash dam projects to meet Life of Facility (LoF) requirements for EPS operations out to 2032 which is the proposed closure date for the power station.

6.2 Forecast Ash Deposition and Storage

6.2.1 No additional ash recycling

As outlined in Section 4.2.1 there is estimated to be 19.5 Mt of additional ash over the 13-year period from 2020 to end 2032. If the ash recycling rate was to stay at 30%, then 5.85 Mt would be recycled, and 13.65 Mt stored in the dam.

This would likely require an increase in capacity of the ash dam including the proposed MOD1 Augmentation Project which will provide an additional 5 Mm³ (or 6 Mt) of storage. This provides adequate storage capacity in the ash dam until approximately 2024 if recycling is maintained at approximately 30%, and the generation demand remains high. At 30% recycling, additional ash dam projects would be required post 2024.

6.2.2 With additional ash recycling

As outlined in Section 4.2.1 an 80 % ash recycling target equates to approximately 1.2 Mt of ash use per annum, and if the target was achieved from 2024 when the existing capacity including the MOD1 Augmentation project is exhausted then 10.8 Mt of a total 13.5 Mt would be recycled over the remaining 9 year life of the power station.

In this situation the ash dam would be required to store 2.7 Mt of ash storage. This is considered a best-case scenario.

6.3 Future Ash Dam Projects

Origin are planning future ash dam projects to ensure there is adequate storage in the ash dam out to the 2032. The planning of these projects considers both the worst-case where there is no increase in ash recycling rates and the best-case where ash recycling is at or above the 80% target.

It is prudent that the worst-case is used when planning future projects. Where the planned increase in ash recycling ramp rate is realised the need for future ash storage projects and the scale of these projects will be revised.

Key projects include:

- Ash Dam Augmentation Project – includes western development of the ash dam for 5 Mm³ (6 Mt), and provides additional storage required until 2024 (currently in the approval phase).
- Life of Facility (LoF) – in preliminary options assessment and design phase, but planned ash dam capacity increase for ash storage between 2024 and 2032.

The scope of the LoF project will continue to be reviewed consistent with Origin's endeavours to increase the rate of ash recycling.

7 Management Framework

7.1 Overview

This section of the LTAMS sets out the approach to ash dam management including environmental management and ash recycling activities.

7.2 EPS Ash Dam Management

This Eraring Power Station Ash Dam Operations and Maintenance Manual (the Manual, October 2018), has been prepared to establish in one primary controlled document (with associated supporting documents) the complete, accurate, current, structure-oriented operating instructions for Eraring Ash Dam and reservoir/decant pond and its related structures. The Manual's purpose is to ensure adherence to the approved operating procedures over long periods of time and during changes in operating personnel.

The Manual contains, as a minimum, information and instructions necessary for the operating personnel to perform their duties. It also contains general information, details of operation, inspection and maintenance procedures and an outline of dam safety and surveillance practices.

Operating procedures must not deviate from those stated in the Manual without appropriate authorisation and must be reviewed and updated regularly.

With respect to ash recycling Origin has adopted the following strategic framework for the management of ash at EPS:

- All ash product quantities reused or recycled are tracked in monthly ash recycling reports sent to site staff and senior management.
- An Origin representative will attend quarterly ADAA meetings with a report back to the Ash Management Steering Committee Meeting following each quarterly meeting.
- Origin is currently a member of the Management Committee of the ADAA. This ensures a positive focus on the development of new markets for the use of both bottom ash and fly ash.

7.3 Environmental Management System (EMS) and Plans (EMPs)

The overall framework for environmental management is governed by the Eraring Power Station Environmental Management Plan (EMP) and subsidiary Land and Biodiversity Management Plan and Water Management Plan. These plans are based on the principals of ISO14001:2015, with a focus on achieving continual improvement in environmental management practices.

Environmental aspects of ash management will be monitored and managed through weekly EPS Ash Management Meetings and the status of action plans resulting from these meetings will be reported to the Ash Steering Committee (held monthly). The meeting agenda shall include:

- Review of progress with regard to ash reused and recycled (both fly ash and bottom ash) and tracking against the 80% reuse goal.
- Tracking the progress of any surface disturbance, revegetation and rehabilitation activities to ensure compliance with the provisions of the EPS Land and Biodiversity Management Plan.
- A review of the implementation of dust and water quality management measures with regard to the Ash Dam Safety and Dust Management Plan and the EPS Water Management Plan.

Environment subject matter experts will also provide input into any Project Specific risk assessments relating to ash management at EPS.

7.4 Reconciliation of EPS Life of Facility and Ash Management

During the 2018/2019 period EPS produced approximately 1.75 Mt of CCP of which more than 1.1 Mt were placed onsite. Market conditions and recycling technology to date have precluded the achievement of the 80% reuse and recycling. As set out in Section 0 significant effort and planning is going into the advancing of opportunities and projects with the aim of achieving the 80% target in the future.

Future expansions to the ash dam may be required to accommodate the ash management needs of EPS within its current design life. Origin is proposing to augment the ash dam using an alternative placement strategy and landform design to maintain operational flexibility and extend the storage life of the Eraring Ash Dam in the short mid-term whilst continuing to support long term ash placement strategies towards 2032.

8 Rehabilitation Strategy

8.1 Overview

This section of the LTAMS sets out Origin's rehabilitation and offsets strategy for the progressive rehabilitation of the ash dam consistent with existing and future ash recycling projects.

8.2 Revegetation and Rehabilitation Management Plan

To the extent necessary to facilitate end use, revegetation and rehabilitation of the ash dam will be undertaken in accordance with the provisions within the EPS Biodiversity and Land Management Plan (BLMP, 2017), which details techniques for primary, secondary and maintenance revegetation and rehabilitation works and defines Key Performance Indicators (KPIs). The EPS BLMP consolidates and supersedes a number of previous plans including:

- Threatened Species Management Plan (HLA ENSR, December 2007); and
- Revegetation and Rehabilitation Management Plan (HLA ENSR, November 2007).

The EPS BLMP also details a monitoring and auditing program for revegetation and rehabilitation activities at the site. Progress against this program will be tracked by the Ash Committee and periodic auditing will occur in line with the provisions of the EPS Environmental Management Plan.

8.3 Provision of Vegetation Offsets and Compensatory Habitat

Condition 2.1 of the Project Approval (07_0084) issued for the 2008 CCP Facility expansion required that a compensatory habitat package be prepared that consisted of no fewer than two hectares of compensatory habitat for each hectare of terrestrial vegetation removed as part of the project. This compensatory habitat package does not apply to clearing undertaken for MOD1 which is currently at the assessment stage, with additional offset requirements outlined in draft Condition 2.1A as follows:

2.1A Within 12 months of commencing construction of MOD1 under this consent, or other timeframe agreed by the Planning Secretary, the Proponent shall retire the biodiversity credits specified in Table 1 to offset the biodiversity impacts of MOD1. The retirement of credits shall be carried out in consultation with BCD and in accordance with the Biodiversity Offsets Scheme of the BC Act, to the satisfaction of the BCT.

Additionally if MOD1 is approved Condition 2.2 of the current approval relating to ash dam rehabilitation will be deleted with rehabilitation provisions moved to Condition 4A.1 relating to the LTAMS (refer to Section 1.3 for specific rehabilitation requirements once MOD1 is approved).

As detailed in Section 1.3 the initial Concept Approval required the project to be staged. The progressive ash dam augmentation to date has thus been delineated into five separate stages as summarised in Table 3. As per the requirements of the 2:1 replacement ratio, 42 ha of compensatory habitat were provided during the staged storage augmentation up to stage 4.

Origin has prepared a Habitat Offset Plan (HOP) for the compensatory habitat areas which have been approved by the OEH. The HOP includes details of compensatory habitat areas for both the 2008 CCP project and the Origin Cooling Water Attenuation Reservoir project. These areas are contiguous in nature.

Origin will update the 2008 Habitat Offset Plan to include offset measures undertaken in accordance with the requirements of MOD1 if project approval is granted.

8.4 Ash Dam Rehabilitation Timetable

Full ash placement in the ash dam will not be completed until towards the end of the life of EPS. This is because a substantial ash storage area would still be required whilst EPS is operational. In addition, future ash reuse and recycling opportunities may necessitate removal of ash from areas of the ash dam. It is therefore likely that the majority of the final rehabilitation works will commence during the last 12 months of EPS's operational life.

Where necessary and feasible, Origin temporarily caps and revegetates areas of the ash dam where ash placement is not currently occurring but may again occur in the longer-term future in order to manage environmental issues such as dust generation. Origin has already undertaken temporary capping and revegetation in several areas of the ash dam in line with the principles of the EPS BLMP. Where temporarily capped areas are reopened for ash placement or recycling, capping materials will be salvaged and stockpiled for future use. To date, Origin has undertaken temporary capping in the south west and south east sections of the dam and is planning to temporarily cap eastern areas of the dam which have recently been reopened once placement in the area is complete. Origin will continue to review opportunities for temporary capping in line with current strategies for ash placement and recycling. Origin may also re-open previously capped areas of the ash dam to recover impounded ash for recycling purposes.

Following decommissioning of EPS it is anticipated that the site will be rehabilitated to a point that will allow further uses, for example: recovery of impounded ash for recycling; industrial and/or community uses. Origin will rehabilitate the final footprint of the CCP management facility in a manner generally consistent with the surrounding landform and the future land use. Any rehabilitation activities would be undertaken in accordance with the current BLMP.

As outlined above if MOD1 is approved Origin will provide an LTAMS update that considers rehabilitation with reference to:

- Proposed ash deposition as outlined in the Augmentation Project (MOD1) EIS.
- Ash recycling including current and future projects.
- Ongoing environmental management of key aspects including:
 - air quality (dust management).
 - water quality (stormwater and sediment control).

Figure 3 Offset Areas



<p>PROJECT ID: 85153157 CREATED BY: TO LAST MODIFIED: TO 23 06 2010</p> <p>AECOM www.aecom.com</p>	<p> Proposed Offset Area Boundary  CCP Expansion Area</p>	<p>Proposed Offset Areas</p>
<p>0  200m</p>	<p>Eraring Energy Long Term Management Strategy - Coal Combustion Products Eraring Power Station Rocky Point Road, Dora Creek</p>	<p>Figure 4</p>

8.5 Monitoring and Auditing Program

Specific aspects of the LTAMS will be subject to regular monitoring and auditing as described throughout this document, with subsequent updates of the LTAMS in accordance with any approval conditions. The monitoring and auditing procedures adopted by Origin in this respect are summarised in *Table 4*.

Table 4 Monitoring and Auditing Procedures

Aspect	Forum/Procedure	Timing	Responsibility
Review of 80% reuse target and evaluation of achievability of reuse goal in current market Conditions	Continual monitoring of national and international market trends in ash reuse and ash sales.	Annual	Operations Support Specialist - Coal Combustion Products
Review and tracking of existing markets for recycling of ash	Continual tracking and follow up of opportunities with review at ash dam steering committee meetings.	Quarterly	Operations Support Specialist - Coal Combustion Products
Review and tracking of new opportunities and markets for recycling of ash	Continual tracking and follow up of opportunities with review at ash dam steering committee meetings.	Quarterly	Head of Operation Services
Level of recycling of ash at EPS	Records kept and tracked at monthly ash recycling report.	Monthly	Operations Support Specialist - Coal Combustion Products
General ash management at EPS	Records kept and reviewed at each ash dam steering committee meeting. To include: <ul style="list-style-type: none"> - Review recycling rates for the period - Confirm recycling targets for following period 	Monthly	Ash Committee Leaders Meeting
Review of ash recycling performance	<ul style="list-style-type: none"> - Review of recycling rates for the period - Trend analysis vs market performance - Consider potential impact on storage capacity and LTAMS recycling goal performance 	Quarterly	Ash Committee Leaders Meeting

Aspect	Forum/Procedure	Timing	Responsibility
Ash rehabilitation areas	The Ash Committee will review opportunities for temporary capping and revegetation, and work towards developing a timetable for final rehabilitation activities. Any revegetation or rehabilitation activities currently underway will be monitored in accordance with the Land and Biodiversity Management Plan.	Monthly	Senior Environmental Business Partner
Update and endorsement of LTAMS	LTAMS to be updated based upon findings of above reviews and tracking, development of new opportunities and progress of ash management and compensatory habitat.	Annually until 2032.	Ash Strategy and Management Lead

9 Document Control

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Review Requirements			
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