Centre for Social Responsibility in Mining
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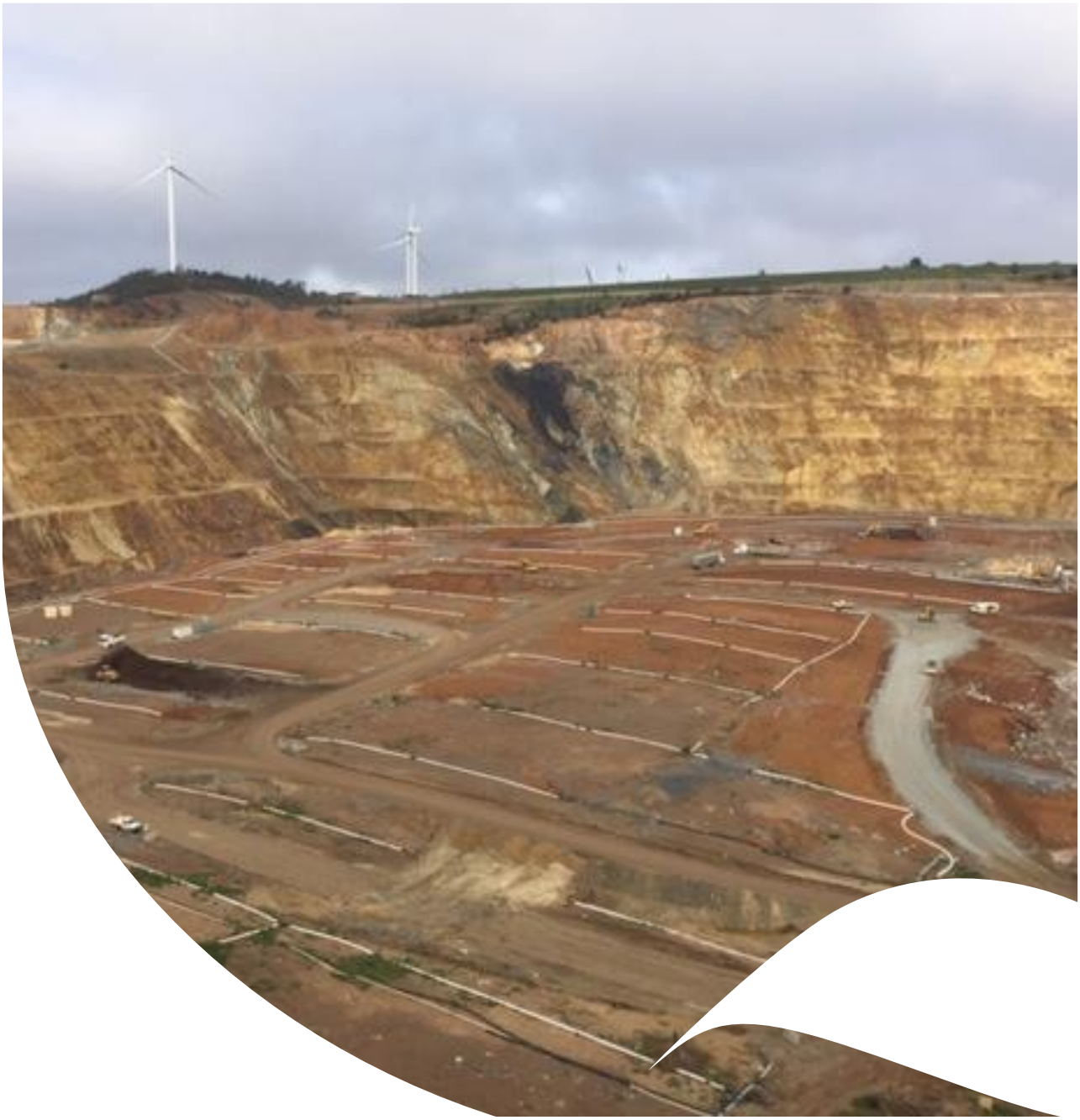
Woodlawn Mine site repurposing: Success factors, enablers and challenges

Report for the Social Aspects of Mine Closure Research Consortium



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Acknowledgements

This project report is part of a broader initiative, the Social Aspects of Mine Closure Research Consortium. Established in 2019, the consortium is a multi-party, industry-university research collaboration challenging accepted industry norms and practices around mine closure and demanding new approaches placing people at the centre of closure. Industry partners in the consortium include: Anglo American, BHP, MMG, Newcrest, Newmont, OceanaGold and Rio Tinto. The initiative falls under the SMI's Transforming Mine Lifecycles cross-cutting program.

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Cover image

The Woodlawn mine pit with the system of biogas extraction pipes and the windfarm in the background. Photo Sarah Holcombe, May 2020.

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[1] QS World University Rankings and Performance Ranking of Scientific Papers for World Universities, 2018.

List of acronyms

Acronym	Term
R&I	Research and innovation
MBT	Mechanical biological treatment plant
SRF	Solid recovered fuel
WOO	Woodlawn organic output
SSI	State significant infrastructure
SSD	State significant development
IMF	Intermodal facility
NSWB	New South Wales Waste Board
CLC	Community Liaison Committee
CCC	Community Consultation Committee
EBIT	Earnings before interest or taxes

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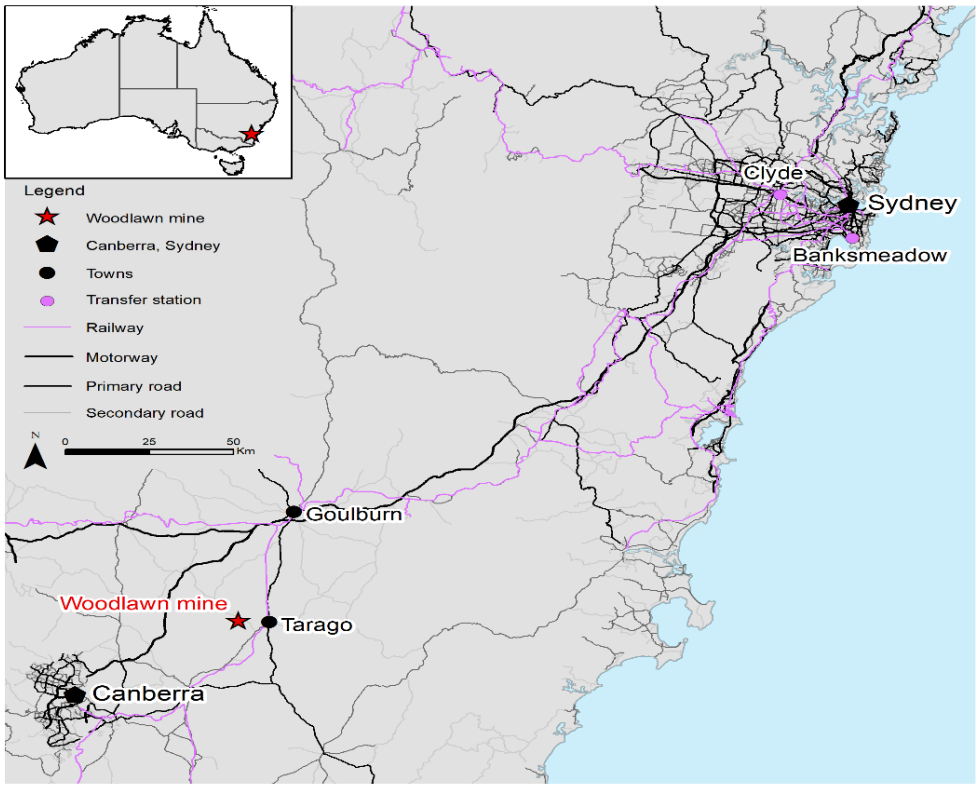
1. Background to the project

This project emerged from the 'Mining as a temporary land use: transitions and repurposing scoping study" as part of the Social Aspects of Mine Closure Consortium. The case study serves as an example of an innovative and sustainable land-use transition in an area once used solely for mining. While this transition was not led or funded by the mining industry, it is a successful contemporary example offering multiple lessons for mining industry-led or funded repurposing.[2]

Starting from around the year 2000, part of the Woodlawn copper, lead, and zinc mine in regional NSW was repurposed into a bioreactor and associated "eco-precinct" over a 10-year period. This example was a brief case study in the *Mine Closure Leading Practice Sustainable Development Program for the Mining Industry* (Australian government 2016: 24-25).[3]

Woodlawn is one of the largest and deepest purpose-built bioreactor landfill projects globally. As at 2019, the site was accepting approximately 40% of Sydney's putrescible waste and is recognised as an example of best practice in the application of landfill technology. The project assists several Sydney Councils to meet their targets for reducing landfill, being located 250km south of Sydney. It has also expanded to take waste from Canberra and Goulburn.



NSW Regional map, produced by Kamila Svobodova.

[2] This particular case study site was also chosen, as there was the ability to visit the operation and interview staff on site, considerations in the current context of air-travel restrictions and social distancing due to Covid-19. Holcombe resides only 1-hour's drive from the operation.

[3] See https://www.industry.gov.au/sites/default/files/2019-05/lpsdp-mine-closure-handbook-english.pdf

Likewise, as the previous mine owners (Denehurst Ltd) left the site in receivership, little rehabilitation had occurred. As a result, site remediation and rehabilitation is also an integral aspect of this repurposing by the new owners – Veolia – over the proposed 60-year lifespan of their operation.[4]

This case study, as an interconnected set of repurposing initiatives, offers a ready vehicle for the development of additional interactive operations maps (via graphical representation), that may be adapted to different case studies. This graphical representation for this case study - visually portraying the evolution of the Eco-precinct - is available at https://www.mineclosure.net/specialprojects/woodlawn/index.html.

A key learning is that massive mine voids are not likely to be rehabilitated by conventional approaches. Unconventional and innovative solutions also need to be considered, and that look beyond the linear economy to embrace the growth in the circular economy and regional economic diversification. The example of this bio-rector is one such innovative solution.

1.1 What does this eco-precinct encompass?

Veolia's eco-precinct operates as a circular economy – with the motto "Let no waste be wasted", to the effect that the precinct undertakes:

- **Waste separation:** Conventional sorting, mechanical-biological sorting/composting.
- **Recycling:** Secondary raw materials recycled (organic and inorganic).
- **Energy recovery:** Energy recovery facility in the form of bio-energy from the methane gas.

The eco-precinct includes a bioreactor landfill, bioenergy facility and a Mechanical Biological Treatment (MBT) plant. The bio-energy (extracting gas and heat from the landfill) contributes to the grid and supplies enough power to support 10,000 households. Supporting the major infrastructure on site are aquaculture (using waste heat from electrical generation activities) and agricultural outputs, a wind farm (powers houses), solar farm (powers the MBT) and a community education centre. Veolia has invested $100 million in technology to extract as much value out of the waste cycle as possible, to ensure it is feasible over the long-haul: the 50 years it is estimated that it will take to fill the mine-void.

1.2 Two major anchor points

The two major anchor points that enabled the project was (i) being able to tap into the existing railway network to transport the Sydney waste to the site and, (ii) the massive open-cut mine void.[5]

The following sections drill down into further detail into each of the elements of the interactive operations map.

2. Major success factors

2.1 Persistence

Persistence from the company (Collex and then Veolia) was an important element in the viability of the project. Though there were early setbacks in terms of finding a site (the first location in the Hunter valley was rejected by community stakeholders), there was a Commission of Inquiry and two significant legal challenges to elements of the infrastructure development, the company persevered.

[4] The Denehurst mine was not long closed, when another operator (Heron) sought to re-open it as an underground mine. For Veolia this has meant that a number of their consent conditions in relation to rehabilitation of the mine site were no longer applicable. However, they are rehabilitating the tailings dams in consultation with Heron and obviously the mine-pit.

[5] Note that these two anchor points are also in place at the Ti-Tree bioreactor in Qld (near Ipswich) that takes waste from Brisbane, and is also run by Veolia with J.J Richards and Sons. It was established from a repurposed coal mine void. See https://titreebioenergy.com.au/about-ti-tree/

2.2 Investment in Research and Innovation (R&I)

Veolia's investment in R&I has led to the development of leading edge technology, such as the MBT. In 2018, as a proportion of the company's profits, Veolia spent around 3.3% on R&I as reinvestment; that equates to $54.2M, of an EBIT (earnings before interest and taxes) of $1,604m.[6]

Veolia has three (3) complimentary R&I pillars focusing on water, waste and energy:[7]

1. An internal research and innovation structure
2. An open innovation approach, and
3. A global scale internal innovation network.

Building on these three complementary pillars, in 2018, Veolia's Research and Innovation activities involved over 200 researchers and technicians in the dedicated structure along with experts from all the Group's entities. Veolia also relies on over two hundred partners worldwide: academic partners recognized for their scientific excellence, and industries or local authorities that are leaders in their respective fields.

The **Veolia Institute** was established in 2001 as a platform that looks to the future and considers challenges relating to the environment and society.[8] It is guided in its work by the **Foresight Committee**, which gives its opinion on the Institute's work and development at an annual meeting. The Institute is an independent space for collective thinking and discussion that calls on a vast network of intellectuals and scientific experts, NGOs, international organizations, universities and research institutions around the world.[9] The Veolia Institute also convenes a **critical friends committee**, which is made up of people from non-profits, institutions and the academic community who are experts in social and environmental problems, and that is unique in its kind; the diversity of backgrounds and experience of its 15 or so members helps inform and support the Group's continuous improvement approach.[10]

It is also of note that sustainability is central to Veolia's business model. They state that "we focus on fostering and supporting sustainable outcomes not only for the company but for our clients and the local communities in which we operate and live. We aim to:

- Provide a range of sustainable resource based solutions to optimise environmental, social and economic efficiency
- Reduce the company's environmental impacts through efficiency, research and innovation
- Contribute to the communities where Veolia operates by providing services and solutions which meet evolving community needs[11]

[6] This figure was provided by Henry Gundry, which he indicated was drawn from this report below: https://www.veolia.com/sites/g/files/dvc2491/files/document/2019/05/2018-Registration-document-and-Annual-Financial-Report.pdf
[7] See https://www.veolia.com/en/veolia-group/innovation and see https://www.livingcircular.veolia.com/en and https://www.veolia.com/sites/g/files/dvc2491/files/document/2020/04/veolia-integrated-report-2019-2020.pdf
[8] See https://www.veolia.com/sites/g/files/dvc2491/files/document/2020/04/veolia-integrated-report-2019-2020.pdf
[9] See Veolia Integrated Report: 2019/2020 P 58. And see https://www.institut.veolia.org/en
[10] IBID
[11] See https://www.veolia.com/anz/sustainability/sustainability/sustainability-veolia

3. Historical catalysts and enablers

The introduction of new state legislation from the mid-1990s and, the associated Sydney regional council waste-to-landfill reduction targets, was a major enabler of this repurposing project. Several years after the NSW Waste Minimisation Act (1995) was introduced, the waste industry was privatised, creating considerable opportunity for industry and the establishment of public/private partnerships.

3.1 Establishment of public/private interdependencies

SSD or SSI: Significant or Essential Development status

In 1999/2000, the Woodlawn bioreactor project development was classified as a State significant development (SSD) (development that is significant for NSW).

The Northern Sydney Waste Board (NSWB) was a major stakeholder in the project at its inception. The Board was one of eight responsible for achieving the State Government's waste reduction targets and was established in 1996 under the State Government's Waste Minimisation and Management Act (1995).[12]

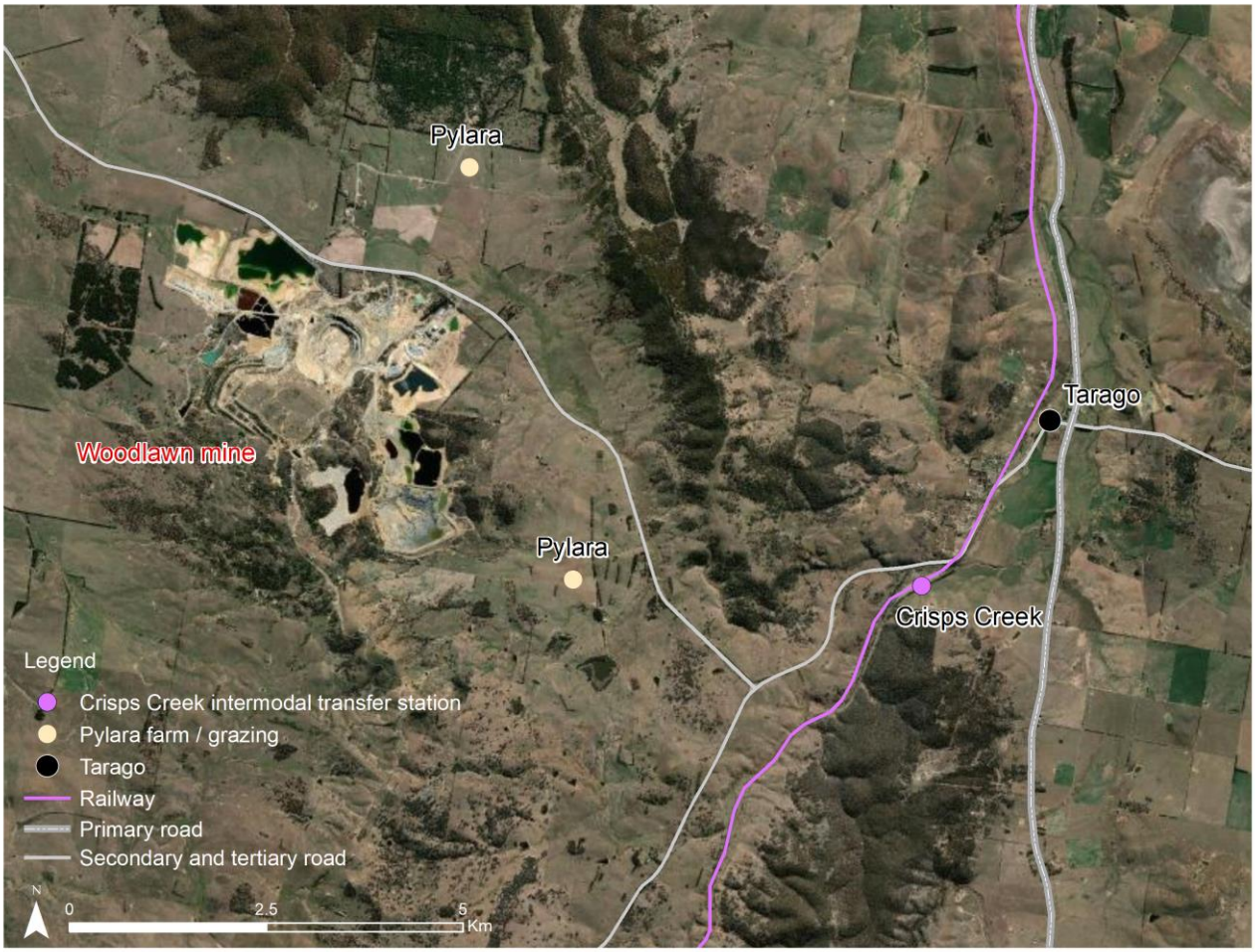
According to a submission from a community stakeholder, Tarago resident Adrien Ellson, Woodlawn is now critical to Sydney's management of its municipal waste, and its importance in the management of the ACT and surrounding local governments' municipal waste is growing.[13] As a result, Veolia's portion of the Woodlawn Eco Precinct has consolidated itself as a State significant infrastructure (SSI), as a project that is important or *essential* for NSW, rather than an SSD.

State government incentives: Paying out workers entitlements and rehabilitation

When the Denehurst mining company went into receivership over the Woodlawn mine, they left millions in unpaid wages and superannuation, little rehabilitation over a vast mining footprint area, considerable environmental issues (AMD, etc.), and an open void 900m wide and more than 200 deep. As part of the project, Collex (now Veolia) agreed to step in and pay out the mine-workers' entitlements and to commit to rehabilitation of the site.

As the media noted at the time, "Collex helped win over locals by offering to pay the miners' entitlements. The last 45 percent will be paid when the first load of rubbish arrives" (2004, SMH).[14]

[12] As far as I can ascertain, this Board does not operate any more. Rather there is a Northern Sydney Regional Organisation of Councils, who now manage the waste contracting as at 2013.
[13] See Adrien Ellson Submission (no 180817 DPE Submission Veolia)
[14] Sydney Morning Herald. 2004 "A complete space of waste". August https://www.smh.com.au/national/a-complete-space-of-waste-20040802-gdjgsn.html



Locality map showing the local township and the intermodal transfer station. Produced by Kamila Svobodova.

4. Threshold points (stakeholder and regulatory)

> "Our biggest hurdle are the community stakeholders – this would probably be the case in any disruptive industry. A Social licence to operate is the single most important matter for any form of industry" (Woodlawn manager, Henry Gundry, May 2020).

Shortly after the SSD application was lodged by Collex (now Veolia), a **Commission of Inquiry** was established in 1999 into the proposal. Two key elements of the conditions of consent was the purchase of the neighbouring sheep and cattle station (Pylara), and constructing an inter-model transfer station at Crisps Creek, so that the waste is not unloaded and transferred from train to truck in the nearby Tarago township; two major threshold issues for local stakeholders.

From the perspective of the previous Denehurst employees, "the [1999 Commission of Inquiry] report provides all the justification needed for a go-ahead of the Woodlawn Bioreactor Waste Facility, which will provide an immediate release of miner's long overdue entitlements", as the union press release (State Secretary Tony Sheldon) stated at the time.

When consent was granted to Woodlawn in 2000, the NSWB and Collex partnership insured a viable commercial relationship between the waste producer and waste service provider regardless of the quantity of waste going to landfill.

4.1 Other regulatory enablers and approvals

Regulatory enablers include the 2001 *Waste Avoidance and Resource Recovery Act* (Waste (landfill) levy, which was progressively increased, plus the Environmental Protection Agency (EPA) "Waste Less, Recycle More" initiative. The regulation and the policy both act as strong incentives for councils to reduce waste. As of September 2020, the landfill levy stands at $146/t, though it started as $10/t.[15]

There is a significant public debate and literature on the role of incentives in the circular economy.[16]

The other key element required for the success of the project was approval for the Clyde Transfer Terminal in Auburn (Western Sydney), so that the waste could be transferred from the Sydney kerbside garbage trucks to rail and onto the Woodlawn facility (about 220 km).

4.2 Legal hurdles and 'technicalities'

Though consent was initially granted for the Clyde Transfer Terminal in 2002, Clyde and Auburn residents formed the No Dump Residents Association Inc. and concertedly opposed it. In early 2003, the case went to a Land and Environment Court Hearing, which subsequently overturned the development approval.

This was followed in December 2003 by the Carr NSW government passing the *Clyde Waste Transfer Terminal (Special Provisions) Act (2003)*: development essential for Sydney waste transfer via train to Woodlawn. As stated at the time, "the fundamental issue that this bill addresses is to provide a measure of certainty to the future sustainable management of Sydney's waste. As lawmakers, we have an obligation to ensure that Sydney's waste needs are met. This integrated proposal will strengthen Sydney's waste management infrastructure and assist in achieving long term sustainable outcomes" (NSW Hansard 2003).

This was, again, subsequently opposed by the No Dump Residents Association Inc. (through the Environmental Defenders Office), and the Act was repealed in 2004. Again, Collex took the case to the NSW Land and Environment Court. In 2005, the court ruled in favour of them and the "four year battle" by the Residents Association was over.[17] A spokesman for Collex stated at the time that "it is a relief to have overcome this latest series of legal technicalities about issues and operations which are delivering a positive benefit for the environment…The transport of waste by rail to Woodlawn is removing and reducing the running distances of up to 60,000 waste truck movements on Sydney's roads."[18]

4.3 Ongoing stakeholder challenges

A complaints register for odour was established in 2010 for Tarago and surrounding residents. As a wet waste treatment facility, there have been ongoing issues with odour wafting into residents homes and there have been several fines from the EPA.[19] In 2019, a new leachate treatment plant was installed – as a condition of the EPA consent – which treats the additional waste and has, according to discussions with stakeholders, reduced the odour.

Another challenge has been impact on the roads and traffic through the number of trucks transporting the waste. Though use of the rail line from Sydney significantly reduces the number of waste trucks on the local and regional roads, the expansion of Woodlawn's waste collection to include the Canberra and Goulburn regions has increased the truck numbers.

According to Henry Gundry (Woodlawn Manager), Veolia has a commitment of $3m to improving local and regional roads in the two regional Councils (Queanbeyan Palerang Regional Council and the Goulbourn

[15] Thanks for Henry Gundry for this figure.
[16] See https://www.climate-kic.org/insights/the-role-of-fiscal-incentives-in-the-transition-to-a-circular-economy-the-case-of-regione-emilia-romagna/ and
https://circular-impacts.eu/policy-changes/tax-and-other-economic-incentives?page=9
and the report from the European Union "Policy Instruments and Incentives for Circular Economy: Final Report. 2020. See https://eitrawmaterials.eu/wp-content/uploads/2020/07/EIT-RawMaterials-project-POLICE-Final-report.pdf
[17] See Goulburn Post April 5, 2005. *Residents lose case: Collex in the Clear*. And
See The Guardian Dec 2003. *No Dump in Auburn*
[18] See Goulburn Post April 5, 2005. "Residents lose case: Collex in the Clear"
[19] See the Goulburn Post, Sept 29, 2017 "Woodlawn Bioreactor plans new $10m treatment plant"

Mulwaree Council). However, according to Tarago stakeholders, this funding is spread too thinly and they are increasingly concerned about traffic safety issues. Some stakeholders also recognise, however, that for SSI and SSD projects – some responsibility for road maintenance also rests with the state government.[20]

According to Henry Gundry, "our social licence to operate is $1 million per year into the Goulburn – Mulwaree trust. Now $12 million in there". Though, according to community stakeholders, initially the trust money was given to Mulwaree local government – but in 2008, it became part of larger shire and the money is now spread too thinly. Those who can access the funding have expanded to also include those along a considerable length of the transport route.

See also Section 9 on Perception Management.

5. Key EPA approval

In May 2020, the EPA approved use of the Mechanical Biological Treatment (MBT), which though opened in 2017 and operating, the output could not be used. Veolia took its rehabilitation strategy forward to the NSW EPA and its output was given an exemption for use as a remediation material.

The material – recycled compost product – is for the specific use in the bioreactor to cap the landfill and other areas of the degraded mine site. This includes as a capping layer for the neighbouring Sulphidic tailings dams owned by Heron Resources. Woodlawn has named the material WOO - Woodlawn Organic Output".[21]

This approval was described by Woodlawn management as "a massive win from the EPA…currently we're the only one in the state that use the output. The others, who are still trying to pave their way forward, are in limbo."

6. Key infrastructure and expansion

The expansion of the facility to be able to take more waste from Sydney and the region is important, as Woodlawn manager, Henry Gundry noted; "our biggest fear is that we won't fill the mine void" (May 2020). Rehabilitating the void – through the waste as landfill (and from which bio-energy is extracted) – is one of the key goals.

The three core pieces of infrastructure: the Bioreactor and the Intermodal Facility were both completed in September 2003, and the Clyde Transfer Terminal (Sydney) constructed in June 2004.

From **September 2004,** the landfill gas collection system was installed at the base of the mine void and the first waste load was delivered to the site, followed by the first stage of gas extraction system and flaring in mid-2005. The construction of first power generator hub followed six months later. The three landfill gas generators were commissioned between February 2008 and March 2010, all of which were necessary for the generation of the bio-power.

The eco-precinct education centre was established in **2004** and hosts around 2,500 visitors per year, made up of community groups, schools and universities.

In **2012,** EPA consent enabled Veolia to expand to take waste beyond Sydney. The initial consent only allowed Collex to take Sydney waste material, as the principal aim of the project. This has now changed, and Veolia provides waste management for numerous regional councils and commercial customers within the region, and including Canberra and Goulburn waste.

[20] See Adrian Ellson Submission (2018) 180817 to the NSW DPE.
[21] See https://www.tarago.org.au/clientfiles/taragotimes-2020-June.pdf

In **2016,** the Banksmeadow waste transfer station opened in addition to the Clyde terminal. This further reduced the number of truck movements on Sydney's roads by an additional 30,000 per annum.[22] As Veolia stated, the Clyde waste transfer is now at capacity and the rail transport solution reduces local truck movements.[23]

The Mechanical and Biological Treatment (MBT) facility was launched in Sept **2017** and is Veolia's largest MBT in the world, capable of processing 240,000 tonnes annually of putrescible waste into an organic material to be used in onsite mine rehabilitation. Veolia has contracts with both the Southern and Northern Sydney Regional Organisations of Councils, though note the three year approval wait from the EPA to use the WOO.

In **2018,** Veolia submitted modification requests seeking approval to construct and operate a resource recovery facility, known as the Solid Recovered Fuel (SRF) facility to process up to 50,000 tonnes per annum of residual general solid waste (non-putrescible) from the MBT facility. The SRF produced at the facility would be transported to the Crisps Creek IMF by road, where it would be railed to Port Botany and utilised either locally or internationally.

This project has yet to get off the ground due to the challenges relating to markets for the material both nationally and internationally. The stance by China and its implementation of the National Sword Policy, which banned the global importation of recycled waste, has significantly impacted the recovery of Australian products.[24]

7. Cumulative rewards: Emissions reduction

There is no direct pricing of greenhouse gas emissions within Australia.[25] However, many of the policy instruments required for direct carbon pricing are in place. This includes the mandatory reporting of facility emissions under the National Greenhouse and Energy Reporting Act 2007.

The current policy framework provides indirect pricing of greenhouse gas emissions through the Emissions Reduction Fund, which is a voluntary scheme in which the Federal Government will purchase lowest cost emissions abatement from producers through a reverse auction process.

At the last Emissions Reduction Fund auction in 2020, the Clean Energy Regulator purchased abatement at an average cost of $16.14 AUD per tonne (Clean Energy Regulator, 2020). Projects, such as Woodlawn's landfill gas and waste to energy project, gain credits through the scheme and other possible avenues are vegetation management to increase net carbon storage in biomass or soil carbon. [26]

8. Diversification

Important elements contributing to the 'eco-precinct' are the windfarm, solar farm, working farm/grazing, and aquaculture. The neighbouring property was purchased as part of the consent conditions. As a result, the site incorporates a working farm that produces meat and wool. Nutrient and grazing rotation are employed with the aim of improving productivity and reducing the impact on soil.[27]

[22] See https://www.veolia.com/anz/about/our-facilities/transfer-stations/banksmeadow-transfer-terminal-nsw
[23] See https://www.veolia.com/anz/our-services/our-facilities/transfer-stations/clyde-transfer-station
[24] See https://www.environment.gov.au/system/files/consultations/bf403fda-b6d7-4476-9c6f-5627502d52a4/files/waste-export-ban-discussion-paper-november-2019.pdf
[25] This section draws on Golev, et al 2020. *Circular Economy Opportunities at Newcrest's Cadia Valley Operations*. Final Report. SMI, University of Qld. (Pp 21-22)
[26] See Protocol for Quantification of Greenhouse Gas Emissions from Waste Management Activities (2013, V. 5), by Veolia and others. https://ghgprotocol.org/sites/default/files/Waste%20Sector%20GHG%20Protocol_Version%205_October%202013_1_0.pdf
[27] See https://www.theswitchreport.com.au/business/ongoing-evolution-veolias-woodlawn-eco-precinct/

In late **2004,** the Development Application and the EIS were lodged for the **Wind Farm** and it was approved the following year. It has been operating since 2010 by Infigen Energy on land leased to them by Veolia. The 23 turbines generate enough power to meet the needs of 29,100 homes (the output of 48.3MW).[28]

In **2009,** a trial **aquaculture** and aquaponics project commenced. This is to make the facility as sustainable as possible and take advantage of every opportunity to turn waste into a resource. Excess heat from the generators was available for use, and Veolia uses the 'waste' heat to create optimal water conditions for fish farming. In **2014,** the fish farm/aquaculture became commercially viable and Veolia now produces 3.5 tonnes of Barramundi to supply the closely located Canberra market.[29]

Most recently in **2020,** the **solar farm** was established to supply energy for MBT operation, which is energy intensive.

9. Perception management and community engagement

Note the language of "waste management facility" (2001 CLC meeting) and "super tip" (SMH 2004) that is often used in the mainstream media, and that used by Veolia of "eco-precinct", and on the "renewable energy trail". As a disruptive industry, perception management often has to catch up with the technology.

According to a 2018 submission by community stakeholder, Ellson, most Governments are reluctant to recognise waste disposal as a form of essential service/infrastructure provided to the public.[30]

According to one community stakeholder, Woodlawn have in the past, gone for long periods without community liaison (CLC) meetings. Though according to another stakeholder, this may be partly due to a lack of community nominations for the Committee. Community stakeholders compared the functioning of the CLC with the re-opened Heron mine (neighbouring Veolia's site) which has meetings that are more consistent. They indicated that this is due to Heron having a "community consultation committee" (CCC), under new legislation.

This CCC has an independent chair appointed and is a more formal and regulated process with guidelines to follow and set meeting dates. Such a model enforces community engagement. This was described by a community stakeholder as a more effective model than that being engaged by Veolia's CLC. According to discussions with community stakeholders, TADPAI in a submission, sought to change Veolia's license to shift to a CCC model to improve community engagement.

The perception from one community stakeholder was that "waste and mining Industries are very different. Mining is more outward looking – and a much older industry, they've had more time to establish community relations systems".

Veolia and the Woodlawn site do not have specific community relations or external relations staff. This appears to be a gap in managing stakeholder relations. However, holding CLCs is an element in Woodlawn's consent, as pointed out by Manager Henry Gundry. The two main avenues for wider community information have been the Tarago Times "Woodlaundry" segment, which started with the mine in the 1990s, and the Tarago Community Newsletter.

Finally, of note Veolia employ approximately 35 staff, including in their aquaculture and farming businesses. Infigen Energy also employs staff for the windfarm on Veolia land. It was not possible to locate employment

[28] See https://www.infigenenergy.com/our-assets/owned-renewable-energy-assets/woodlawn-wind-farm/#:~:text=Woodlawn%20Wind%20Farm%20is%20located%20adjacent%20to%20Infigen's%20Capital%20Wind,approximately%2029%2C100%20homes%20each%20year.

[29] See https://www.theswitchreport.com.au/business/ongoing-evolution-veolias-woodlawn-eco-precinct/. Also note that the farm is producing more than the 2.5 tonnes in the report, as Henry Gundry corrected the figure to 3.5 tonnes in this report draft.

[30] See Adrien Ellson Submission (no 180817 DPE Submission Veolia)

figures from the previous Woodlawn mine, but there was a general perception that the employment numbers for the mine were higher than those at Veolia's operation.

9.1 What is a Disruptive Innovation?

The term "disruptive innovation" has been applied to the Woodlawn circular economy precinct by the site manager. The term was coined by Christensen in 1997 in the book *The Innovators Dilemma*. It refers to a technology whose application significantly affects the way a market or industry functions.[31]

According to Danneels:

> The products based on disruptive technology initially only satisfy the niche market segment only, which values the dimensions of performance on which the disruptive technology does excel. Over time as research and development investments are made and the technology matures, the performance supplied by the disruptive technology improves to the point where it can also satisfy the requirements of the mainstream market.[32]

In the case of Woodlawn – this also includes the expectation that electricity generation is increasingly from sustainable sources and that the economy is moving from a linear to a circular model.

As Danneels continues, "disruptive technologies change the basis of competition because they introduce a dimension of performance along which products did not compete previously" (2004: 249).

[31] See also https://www.investopedia.com/terms/d/disruptive-innovation.asp
[32] Danneels, E. 2004. "Disruptive Technology reconsidered: A Critique and Research Agenda". In the *Journal of Product Innovation Management* Vol 21: 246-258.

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