# Sustainability options for freight rail
# Recycled materials

Interactive research report

# Foreword

Rhidian Howells
Arup

Dr Mike Shackleton
ARRB

The rail sector has traditionally been seen as an essential contributor to Australia's sustainable growth, with freight rail services generating 16 times less carbon pollution than road freight, delivering improved health and safety outcomes. In 2018, passenger rail supported more than a billion journeys, playing a crucial role in the daily lives of millions of people – with a single commuter train able to take the equivalent of 578 cars off the road, helping to relieve urban congestion and mitigate lost economic productivity.

Rail traditionally accounts for 1% of overall global transport emissions. The climate and biodiversity crises and challenges of the ever-increasing demand for resources and population growth are becoming more acute. Every sector, including rail, will need to accelerate its sustainability practices - working harder to reduce their impact on the environment and contribute toward regenerating and replenishing damaged ecosystems.

Studies by the Ellen MacArthur Foundation have shown that relying solely on energy efficiency and switching to renewable energy will only address 55% of global GHG emissions. However, adopting circular economy (CE) principles can reduce a significant proportion of the remaining 45%. By reusing products and materials, instead of producing new ones, demand for energy used in material extraction and refinement is reduced.

Many considerations and opportunities are available for innovation in rail material selection, extraction and application. These include considering whole-of-life carbon emissions, adopting sustainable procurement practices, normalising and reusing recycled materials, considering the residual impact of material waste particles in local water systems, and introducing material tracking. Asset digitalisation and new 'materials as a service' business models can help transform the rail freight sector as the world moves towards a net zero future.

Reusing materials used in rail, from major project construction to day-to-day operation and maintenance, offers a huge opportunity to reduce waste and the industry's net impact on the environment. The road industry has been practising circular economy principles with road materials for over 50 years, establishing the long-term value of a recycling-intensive strategy. The principle of approach for recycling any materials into infrastructure follows four conditions: (a) that it is safe for people to work with and to use, (b) that it is safe for the environment, (c) that it offers value for money compared to other materials and (d) that it is in itself recyclable to ensure the circularity principles will continue at end-of-life.

Positively recycled and scientifically evaluated materials in rail freight will unlock quality, cost-saving and supply availability opportunities, as well as long-term environmental and social and economic benefits. Supplementary cementing materials (SCMs) in concrete, crushed glass, recycled steel and recycled crushed concrete are now commonly used in construction to replace traditional virgin materials. Opportunities for innovative research and application include ballast reuse and composite sleepers.

Despite proven benefits, there are many barriers to changing the industry's culture toward a 'recycled-first' mentality – obtaining type approval for new materials in a safety critical industry can be a slow process. From government, operators, safety bodies, contractors and infrastructure owners – all industry levels can work together to create recycled material frameworks that will enable more sustainable infrastructure. Educating all sectors of the rail freight industry, from experienced maintenance specialists to cadet and graduate designers, on the potential and importance of recycled material is also crucial to creating cultural change.

As Australasia experiences unprecedented investment in rail freight and infrastructure projects, we must seize the opportunity to build our cities' infrastructure in a modern and more sustainable way, to benefit the future natural environment and our communities.

**How to use the report findings:**
This research report and included options table have been created to provide organisations with more information to support future initiatives and trials of recycled material options in the construction and operation of rail infrastructure.

# Introduction

The Australasian Centre for Rail Innovation (ACRI) has partnered with Arup and the Australian Road Research Board (ARRB) to explore sustainability options for freight rail, focusing on recycled materials. This study explores and highlights material options available for Australasian rail providers to drive their implementation and improve the sustainability of the rail sector.

This research has been undertaken to establish a shared understanding of recycled material options for freight rail and their use to achieve sustainability outcomes. The purpose of this project was to identify the opportunities for material alternatives that provided the greatest value for industry, along with some smaller-scale, accessible starting points, to continue to improve the sustainability of rail networks. Understanding the materials available and their context for use in the construction and maintenance of rail infrastructure will empower the sector to invest in these materials and successfully drive sustainability outcomes.

This report captures many aspects of the project, including a summary of the literature review, detailed findings from the survey, a snapshot of the stakeholder engagement workshop and the options table. Figure 1 shows the project stages from inception to this final report. The research team has engaged with stakeholders and experts across every stage of this project, and these insights have shaped what is discussed in this report.


**Figure 1 - Project stages**

## Glossary:

ACRI – Australasian Centre for Rail Innovation
ARRB – Australian Road Research Board
AU$ – Australian dollars
C&D – Construction and demolition
CE – Circular economy
COAG – Council of Australian Governments
CO2 – Carbon dioxide
GHG – Greenhouse gas
ISCA – Infrastructure Sustainability Council of Australia
MTM – Metro Trains Melbourne
NSW – New South Wales
RCA – Recycled concrete aggregate
R&D – Research and development
SCM – Supplementary cementing materials
TfNSW – Transport for New South Wales
USA – United States of America
UV – Ultraviolet

# Options table

The options table has been developed using findings from all stages of the research project, including a scan of leading literature and stakeholder engagement through surveys and workshops. Additional desktop research was conducted to identify suppliers, indicative pricing, and implementation considerations for each option. The options table represents a snapshot of the industry at the time of publication. Included information, such as indicative costs, may change or be subject to conditions.

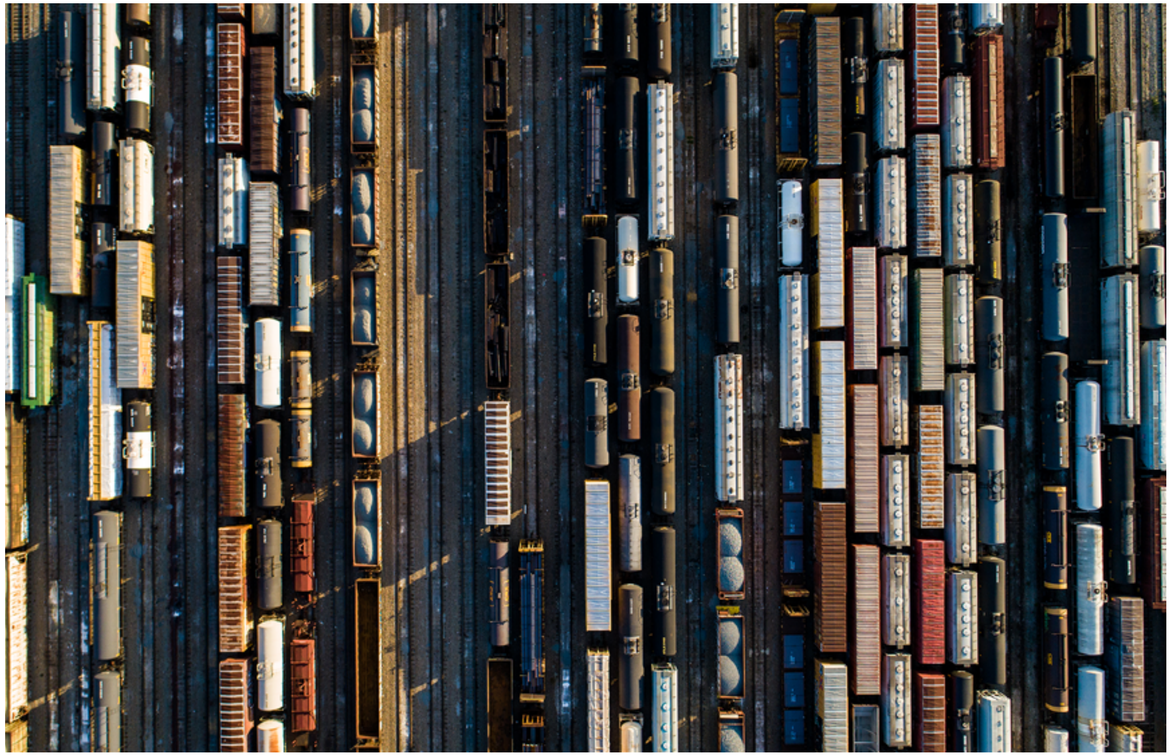
The table is categorised under the nine options. These include recycled plastic, recycled or washed ballast, recycled concrete, supplementary cementing materials, recycled water, recycled rubber, recycled glass, recycled steel and sustainable options for lubricants.

The following sections are included for each option:

- Summary – Providing an overview of the option.
- Context(s) for use in rail – Identifying use cases for the option in the rail context.
- Sustainability benefits – Highlighting the benefits gained by utilising this option for the sustainability of the rail sector.
- Pros and cons – Identifying some of the key benefits and limitations of using the option in a rail context.
- Examples of suppliers and products – A selection of suppliers and their available products.
- Supplier and product details – Further details on each supplier and their product options, which may include indicative costing and implementation considerations for operators.
- Resources – Additional resources to find further information on the options, suppliers, and products.

Local and reputable suppliers and products were prioritised for inclusion in the options table.

The illustration on the following page highlights some of the rail contexts in which each option could be applied.

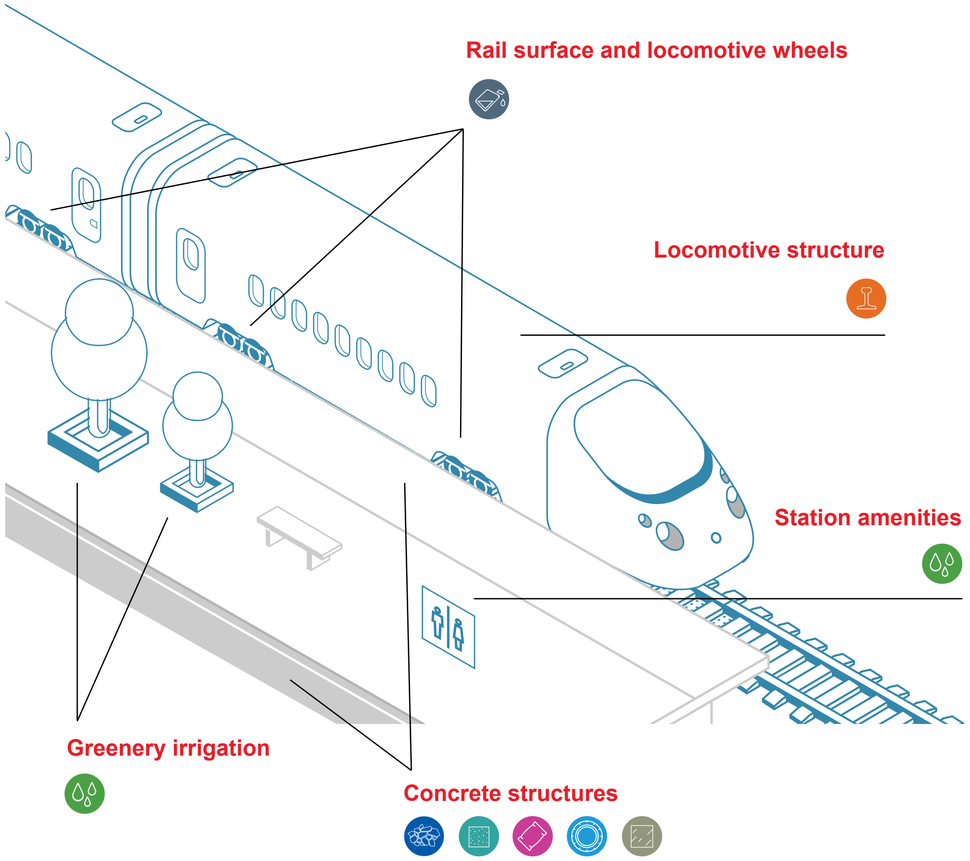


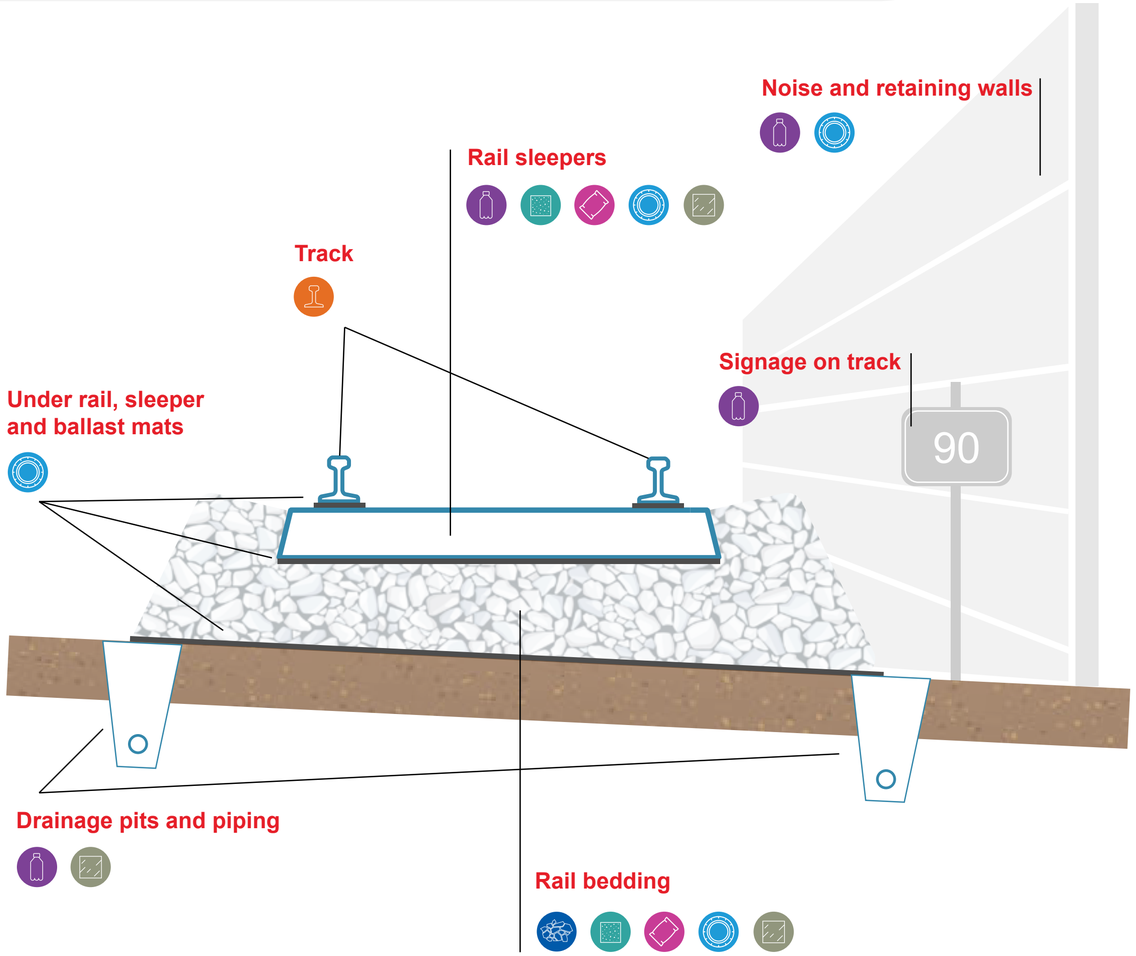
**Options**

- Recycled plastic
- Recycled or washed ballast
- Recycled concrete
- Supplementary cementing materials
- Recycled water
- Recycled rubber
- Recycled glass
- Recycled steel
- Sustainable options for lubricants

# Options

- Recycled plastic
- Recycled or washed ballast
- Recycled concrete
- Supplementary cementing materials
- Recycled water
- Recycled rubber
- Recycled glass
- Recycled steel
- Sustainable options for lubricants



# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled plastic

### Summary

In 2017–18, the annual consumption of plastics in Australia was over 3.4 million tonnes, of which only 9.4% was recycled, with the remainder directed to landfills. On top of that, only about 46% of recycled plastics were reprocessed in Australia. Utilising plastics as an alternative material in rail infrastructure will encourage recycling and reprocessing.

### Contexts for its use in rail

There are several use cases for recycled plastics in rail infrastructure. These include rail sleepers, noise walls, fencing, signage, decking and drainage applications in pipes and pits.

### Sustainability benefits of the option

Recycled plastics offer significant sustainability benefits when used in rail infrastructure. Utilising recycled plastics as an alternative to virgin resources supports industry innovation, and more sustainable infrastructure practices in the construction of sleepers, noise walls, and drainage components.

Using recycled plastics addresses responsible consumption and production by reducing demand for resources such as timber, concrete and steel. Infrastructure made from recycled plastic such as sleepers has the added benefit of being easily recyclable, reducing the impacts of disposal to landfill.

Recycled plastics help to reduce the embodied carbon in rail infrastructure, supporting climate action. For example, concrete and steel materials used in products such as sleepers require at least seven times the amount of energy to produce than sleepers made from recycled plastic.

### Pros

- Unlike most wooden sleepers, recycled plastic sleepers do not require chemical treatment with creosotes, a hazardous substance.
- For each kilometre of track using recycled plastic sleepers, over 54 tonnes of plastic waste are diverted from landfill.
- Using recycled plastics in sleepers could reduce the embodied carbon to as little as 8.9% of what is produced with concrete and steel sleepers.
- Recycled plastic materials have good resistance to chemicals and other forms of corrosion, providing a longer use life. The life span for recycled plastic sleepers is greater than 50 years.
- Recycled plastics do not conduct electricity, making them a safer option in accidental electrical exposure. They also prevent underground metal corrosion due to stray currents.
- Recycled plastics are less susceptible to weather, chemicals, insects, and fungi. They require less maintenance than traditional materials.
- Recycled plastics have a high rate of material recapture because of their ability to be reground and repurposed.

### Cons

- Recycled plastics have a short performance record to compare the environmental and operational factors.
- There is currently a lack of design recommendations and standards for their use in rail.
- Fire performance of these materials may be an issue. Recycled plastics may melt under extreme heat events such as a bushfire.

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled plastic

These extreme changes in temperature may expand or contract the material affecting dimensions and strength.

### Supplier and product options

– Integrated Recycling – Duratrack recycled plastic sleeper

– Sicut – composite sleeper made from recycled plastic and glass

– Delkor Rail & Sekisui Chemical – FFU recycled plastic sleeper

– Axion – Ecotrax recycled plastic sleeper

– Replas – recycled plastic fencing, bollards, deck and signage solutions

– Integrated Recycling – recycled plastic fence, bollard, deck, and rectangular profiles

– Lee Group – recycled plastic noise wall

– Geofabrics Australasia Pty Ltd – recycled panel drain and subsoil drainage

– RPM Pipes – recycled plastic drainage pipe

– Allproof Industries – recycled plastics drainage pits

### Product option details

– Integrated Recycling – Duratrack recycled plastic sleeper

The Duratrack recycled plastic sleeper has been awarded main line type approvals by main line rail operators, including V/Line and Metro Trains Melbourne. This product has also been trialled on main line track by Queensland Rail. Indicative costs for trials of this product were roughly AU$300 per sleeper over several hundred meters of track.

– Sicut – composite sleeper made from recycled plastic and glass

The Sicut composite sleeper, offered by Sicut since 1996, has been awarded provisional type approval (Certificate No. TA00597) by MTM. It has been installed in over 16 countries, has a lifespan of over 50 years, and is impervious to moisture, insects and decay. The installation and handling process is similar to timber sleepers and has the added benefit of reduced noise, vibration, conductivity and maintenance requirements.

– Delkor rail & Sekisui Chemical – FFU recycled plastic sleeper

The Fibre Reinforced Foamed Urethane (FFU) recycled plastic sleeper has been awarded Type Approval by Transport for New South Wales (TfNSW) (Certificate No. TR14/2002). First applied in 1980, in 2015, over 1,400 km of track used this product. These sleepers have been a reliable service for over 40 years and have an expected lifespan of at least 50 years. These sleepers can be manufactured with detailed

precision and allow for detailed customisation. This product has had significant success in Japan and has expanded to European and other global markets.

– Axion – Ecotrax recycled plastic sleeper

The Ecotrax recycled plastic sleeper from Axion outperforms hardwood sleeper options. To manufacture these sleepers, an industrial-grade structural composite that is 100% recycled material, is used to make them nearly impervious to weather impacts and erosion. Extensive testing under different environmental extremes has found the sleepers not to warp, splinter, absorb moisture or leach chemicals into the environment.

– Replas – recycled plastic fencing, bollards, deck and signage solutions

Replas offers a broad range of recycled plastic products that could be used in rail infrastructure. Some of their products include fencing, decking, bollards and signage. They also collaborate with organisations to custom build products made from recycled plastic to suit desired

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled plastic

requirements. In addition, their products are manufactured using at least 90% recycled plastic that has been collected in Australia.

– Integrated Recycling – recycled plastic fence, bollard, deck, and rectangular profiles

Integrated Recycling offers composite recycled plastic products manufactured from recovered plastics, including agricultural films, bottles, pipes and drums combined with organic fibre. Their product range has been independently tested for its environmental and mechanical properties. Their products have applications in rail, including sleepers, drainage, specialty pallets, fencing and signage.

– Lee Group – recycled plastic noise wall

The noise wall manufactured by Lee Group uses up to 70% recycled plastics. The design is versatile to various industrial applications and desired outcomes. These noise walls made from recycled plastics can be re-recycled up to seven times before their end of life.

– Geofabrics Australasia Pty Ltd – recycled panel drain and subsoil drainage

The Megaflo Green drainage system from Geofabrics is made from 100% recycled polymers sourced from and manufactured in Australia. The drainage system can remove water from structures faster than traditional systems, and its shape and structure give it a high crush resistance in either vertical or horizontal positions. Since 2010, Geofabrics have installed and tested thousands of kilometres of their drainage solutions. Their products comply with the local road, rail and landfill specifications.

– RPM Pipes – recycled plastic drainage pipe

RPM Pipes offer piping and irrigation systems made from 100% recycled plastic materials. These piping systems have been tested for reliability for over 20 years. A range of diameters is available, including 315, 400, 450, and 630 mm. The manufacturing of these pipes diverts over 250 tonnes of plastic from landfill every year.

– Allproof Industries – recycled plastics drainage pits

Allproof's square pit drainage range offers a product made from 100% recycled plastic. This range offers three differently sized pits that complement grates offered from the Allproof linear channel ranges.

### Resources

1. Integrated Recycling, Duratrack recycled plastic railway sleeper, Product website, https://bit.ly/3uhUrml
2. Sicut, recycled plastic and glass sleepers, product website, https://bit.ly/3sbhxIx
3. Sicut, recycled plastic and glass sleepers, product brochure, https://bit.ly/3L2nHn7
4. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, product website, https://bit.ly/3rl9s59
5. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, product standard, https://bit.ly/3GlGlCE
6. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, Product brochure, https://bit.ly/35JK6Wb
7. Axion, ECOTRAX composite sleeper, product website, https://bit.ly/342MIhv
8. Axion, ECOTRAX composite sleeper, product brochure, https://bit.ly/3HlRfdf
9. Replas, recycled plastic product range, product website, https://bit.ly/3rhUigW
10. Integrated Recycling, Envire recycled product range, product brochure, https://bit.ly/3GeNkgQ
11. Integrated Recycling, Envire recycled product range, product brochure, https://bit.ly/34va9jj
12. Lee Group, Recycled plastic noise wall, product website, https://bit.ly/3HkV8ih
13. Lee Group, Recycled plastic noise wall, product website, https://bit.ly/3GoxqR0
14. Geofabrics, Recycled drainage products, product website, https://bit.ly/3AY51jJ
15. RPM Pipes, Recycled drainage pipes, product website, https://bit.ly/34m6e8h
16. Allproof Industries, Recycled plastic drainage pits, product website, https://bit.ly/35vPHiz
17. Allproof Industries, Recycled plastic drainage pits, product brochure - https://bit.ly/3AHd6cw

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled or washed ballast

### Summary

Used or degraded rail ballast can be recycled or reused for several applications in the rail sector. Even when damaged or contaminated, some treatment options can offer more sustainable solutions for reusing ballast rather than disposal.

### Contexts for its use in rail

Degraded ballast can be mixed with fresh ballast in quantities up to 30% for use as bedding with no impact on ballast performance. Recycling non-reusable ballast into an aggregate for concrete used in rail applications, including sleepers, drainage pits and decking, is also an option. Fine ballast generated during cleaning processes can be reused in surfacing access roads.

### Sustainability benefits of the option

The primary sustainability benefit of reusing or recycling ballast is reducing the quantity of natural resources extracted to create new ballast. Recycling ballast for uses such as an aggregate in concrete reduces the demand for virgin materials in this secondary process. Keeping this material locally and within the same industry has the benefits of reducing emissions from material transport and allowing a quick turnover of the waste ballast materials for new applications for rail.

### Pros

– Compared to materials such as granite in concrete application, used ballast performs better as an aggregate in providing better strength and resilience to weather erosion.

### Cons

– There are currently no standards written about the use of recycled ballast in Australia. As a result, there has been limited uptake in using degraded ballast as a portion of fresh ballast applications.

### Supplier and product options

– Repurpose It – Reclaimed, washed, and recycled ballast

### Product option details

– Repurpose It – Reclaimed, washed, and recycled ballast

Repurpose It offers a range of tailored rail ballast products produced from washed aggregate. Their reclamation process restores ballast to levels for reuse under demanding environments. They offer a ballast range at an affordable and competitive price compared to virgin ballast. Repurpose It can move and wash over 80,000 cubic meters of ballast ready for reuse within 35 days. They have over 30 years of operation experience delivering ballast re-use solutions for Victoria.

### Resources

18. Repurpose It, Reclaimed and recycled ballast, product website, https://bit.ly/34nBcwO

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled concrete

### Summary

Concrete represents over half of the total construction and demolition waste in Australia. Recycling this concrete into a recycled concrete aggregate (RCA) usually involves crushing and cleaning. RCA is usually composed of about 95% recycled concrete, with the rest being gravel, crushed mortar or cement. In Australia, construction uses RCA mostly as coarse or fine aggregates. About 7 million tonnes of recycled concrete and masonry are available in Australia each year, and this market is growing.

### Contexts for its use in rail

RCA can replace concrete currently used in rail, including sleepers, platforms, beams, drainage pits and bedding.

### Sustainability benefits of the option

Concrete represents a significant volume of materials used in the construction sector. Concrete is also significantly energy intensive to manufacture as a virgin resource. Using RCA up to just 30% volume of natural aggregate for concrete applications (the safest volume of substitution for all applications without compromising strength) presents a significant sustainability benefit for the sector in reduced virgin material use, energy savings and reduced waste sent to landfill.

### Pros

– Recycling concrete as an aggregate provides significant benefits over virgin sourced materials. Making RCA will still involve crushing, washing, and sieving, which consumes energy, but not as much as when processing crushed virgin aggregate.
– Material providers will often provide design recommendations or have them made available.

### Cons

– Without pre-treatment, using RCA at high percentage volumes involves adjustments to the concrete formulation to compensate for performance loss in workability, strength, or other durability parameters, increasing the costs to correct in some applications.
– There are currently no standards written for the use of recycled concrete aggregates.

### Supplier and product options

– Holcim – Aggneo recycled crushed concrete
– Sunshine Groupe – recycled crushed concrete and aggregates
– Repurpose It – recycles ballast and concrete, and supplies concrete aggregates
– Boral – recycled crushed concrete used in blocks, pipes and drainage materials

# Options table

- Recycled plastic
- Recycled or washed ballast
- Recycled concrete
- Supplementary cementing materials
- Recycled water
- Recycled rubber
- Recycled glass
- Recycled steel
- Sustainable options for lubricants

## Recycled concrete

### Product option details

– Holcim – Aggneo recycled crushed concrete

Aggneo recycled concrete aggregate from Holcim offers a high-performance aggregate for concrete construction. This product is primarily made from concrete collected in building demolitions diverting rubble from landfill and making it part of a circular economy for construction materials.

– Sunshine Groupe – recycled crushed concrete and aggregates

Sunshine Groupe offers waste management services for C&D waste types. They crush and recycle concrete, brick and rock for reuse in the construction sector. They have recycled over 2,500,000 tonnes of concrete, brick and rock for construction. They supply recycled crushed concrete, aggregates, cement stabilised blends, and bedding sands.

– Repurpose It – recycles ballast and concrete, and supplies concrete aggregates

Repurpose It offers a broad range of recycled concrete and aggregate products made from recovered concrete, ballast, and other C&D recoverable wastes. These products come in a range of sizes to suit multiple applications. Repurpose It will also work with industry groups to develop a recycled product tailored to their needs.

– Boral – recycled crushed concrete used in blocks, pipes and drainage materials

Boral manufactures recycled aggregates from processed sand, gravel, rock and demolition concrete deposits. Their aggregate products are suitable for concrete, asphalt and drainage systems. The aggregates produced using recycled concrete, bricks and masonry can come in sizes ranging from 7 to 20 mm. It is possible to procure fine aggregate products sized less than 5 mm.

### Resources


19. Holcim, Aggeno RCA, product website, https://bit.ly/3IU7fU2
20. Holcim, Aggeno RCA, product data-sheet, https://bit.ly/3s6cRE1
21. Sunshine Groupe, Crushed RCA, product website, https://bit.ly/34nDI6e
22. Repurpose It, Various grades of RCA, product website, https://bit.ly/3rjSFzj
23. Boral, RCA, product website, https://bit.ly/3uiXxX7
24. Boral, RCA, product data-sheet, https://bit.ly/3ojalZN


# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Supplementary cementing materials

### Summary

For all concrete applications, rail or other, it is possible to reduce the CO2 footprint by using waste materials, or low carbon-intensive alternatives, such as SCM in concrete. Two of these types of materials commonly used are slag and fly ash.

Slag is a by-product of smelting ores and used metals, and fly ash is a by-product of coal combustion in power stations. It is possible to completely replace the cement with these waste products in concrete applications; however, legislation does not always support such mixes.

Fly ash is widely available in Australia and used in blends with cement. Not all fly ash is the same; they are organised in classes, with the highest class providing the best performance. Most of the slag used in Australia is imported from Asia and then ground locally. These two SCMs are well known and standardised in Australia and are used in many construction applications.

### Contexts for its use in rail

SCM blend with cement for all concrete applications in rail, including concrete for sleepers, platforms, beams, drainage pipes and pits.

### Sustainability benefits of the option

Any substitutions and reductions in virgin cementing materials for concrete applications provide sustainability benefits. In addition, slag and fly ash pre-blended with cement are readily available in Australia and globally through well-established suppliers. The construction industry should continue to innovate with these recycled materials by increasing the percentage of substitution in cement using these products.

### Pros

– Slag and fly ash have specific standards in Australia and globally. There is a standard for concrete and rail applications specifying what can be blended and the percentage of substitution for recycled SCMs.

– It has been used in many applications globally, and there are many case studies available that demonstrate its efficiency and other benefits.

### Cons

– For some specific applications, there are strict limits to cement substitution. Some processes can also involve changes in processing concrete materials to meet performance requirements.

### Supplier and product options

– Independent Cement Ltd – slag and fly ash

– Cement Australia – slag and fly ash

– Boral – slag and fly ash

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Supplementary cementing materials

### Product option details

– Independent Cement Ltd – Slag and fly ash

Builders Ground Slag by Independent Cement is a first grade, high-performance product designed for building and heavy construction cement. When used as a filler, slag provides the benefits of sulphate resistance, higher strength, and greater permeability. Fly ash supplied by Independent Cement improves the workability and durability of concrete products.

– Cement Australia – Slag and fly ash

A range of industrial and environmental applications use Quicklime, supplied by Cement Australia. They provide granulated blast furnace slag (marketed as Ecocem). This slag enhances a range of performance characteristics, including reduced heat in mass concrete pours, reduced permeability, and improved durability in aggressive environments. Cement Australia also provides a fly ash product that improves the workability of concrete, reduces water demand, and lowers the heat generated from hydration. The fly ash improves long-term strength of concrete, reduces corrosion in reinforcing steel, and reduces the impact of chemicals with its reduced permeability.

– Boral – Slag and fly ash

Fly ash supplied by Boral offers a high quality and ecological concrete product designed for pavements, sub-bases and dams. The addition of their fly ash improves workability, pump ability and resistance to sulphate damage. The fly ash comes in fine or medium grades. Their slag product, marketed as Enviroment, is designed for heavy construction and high-rise concrete applications and complies with the AS 3582.2 standard for SCM.

All three suppliers can provide their products in bulk or smaller bags. Concrete product suppliers such as Holcim, Hanson, Boral and many other smaller suppliers will use these bulk SCMs in a blend with cement on their plant at different dosages, depending on the application. Many of these suppliers will have concrete mixes approved by different bodies for rail concrete applications, such as sleepers.

### Resources

25. Independent Cement, Ground Slag, product website, https://bit.ly/3ohMR7D
26. Independent Cement, fly ash, product website, https://bit.ly/3geAIvB
27. Cement Australia, SCMs & Quicklime, product website, https://bit.ly/3ANLT85
28. Cement Australia, Slag, product website, https://bit.ly/3s2L876
29. Cement Australia, Fly Ash, product website, https://bit.ly/32Ptfjt
30. Boral, Fly Ash and Slag, product website, https://bit.ly/3LeOnkP

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled water

### Summary

For rail applications, non-potable sources, such as rainwater, stormwater, reused water, and recycled water can substitute potable water. Substituting potable water with appropriate locally sourced non-potable water is an important part of infrastructure sustainability and is increasingly being adopted. The quality of the non-potable water supplied should match the quality required for the application.

### Contexts for its use in rail

Recycled or captured rainwater has several applications in the rail sector. Some of these include dust suppression and lubrication for ground operations, washing locomotives and wheels, used at stations for irrigation or site amenities (toilets/urinals), and construction of rail lines and access roads.

### Sustainability benefits of the option

Using recycled water in rail construction and operations significantly reduces environmental impact. Decreasing demand for freshwater supplies is the primary benefit, as well as eliminating the need to transport water long distances.

### Pros

– Resilience to disruptions of freshwater supply by establishing a decentralised source for water.

– Reduced costs of operations by eliminating the use of freshwater supplies.

– Low-cost investment for station or site amenity use.

### Cons

– Overuse of water when applying to land can cause excess groundwater recharge, waterlogging and secondary salinity.

– Larger tanks face issues if water is left stagnant for extended periods. Stagnant water may promote bacteria and algae growth.

– Inconsistent supply when tanks are in low rainfall environments.

### Supplier and product options

– Piped recycled water is available in some areas where there is nearby access to a purple pipe, and access has been granted by local water authorities.

– Poly Tanks – Polyethylene water storage tanks

### Product option details

– Poly Tanks – Polyethylene water storage tanks

The water tanks provided by Poly Tanks are made from UV stable polyethylene, suitable for outdoors, and can withstand most extreme weather. They come in sizes ranging in capacity from 1,000 to 5,000 L and cost AU$560–1,425 per tank. The tanks come in varieties suitable for above or below ground installation. The tanks are high strength, rigid, corrosion-resistant and built to last with a 10-year repair and replacement warranty. Every tank undergoes water fill testing and is Australian designed, owned, and manufactured.

### Resources

31. Poly Tanks, Water tank range, product website, https://bit.ly/3L4OHCe

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled rubber

### Summary

Recycled rubber in Australia is often derived from waste truck tyres but can also be from passenger car tyres, mining vehicle tyres, and conveyor belts. In 2018–19, estimates showed that 465,000 tonnes of Australian tyres were reaching their end of life, with an approximate domestic, high-value recycling rate of 14%. Recycled rubber has been employed as an energy-absorbing material to aid in the stability and longevity of track formations through mitigating ballast degradation.

### Contexts for its use in rail

Recycled rubber has several applications in the rail sector, including geogrids, retaining walls, crumbed rubber as an aggregate, and pads and mats between rail and sleeper, between sleepers and ballast, under ballast.

### Sustainability benefits of the option

Utilising recycled rubber reduces the amount of virgin material used in rail infrastructure construction while also diverting rubber waste, such as tyres, from landfill.

### Pros

– Recycled rubber has high dampening properties, reduces noise and vibrations, ballast degradation and impact or damage to track from heavy vehicles.

– Recycled rubber products such as geogrids and crumb rubber concrete can help to stabilise rail track substructures by distributing the forces from rolling stock to a larger surface area, helping to improve the life of ballast and reduce ongoing maintenance costs.

### Cons

– Re-manufacturing processes need appropriate additives to ensure a long lifespan for recycled rubber materials.

### Supplier and product options

– Geofabrics Australasia Pty Ltd – LamGrid Green geocomposite

– Pandrol – under sleeper pads and ballast mats

– Damtec – under ballast mats

– D&N Rubber Tyre Recycling – rubber crumb

– Ecoflex International – E-wall retaining wall

– Lomwest Enterprises Pty Ltd – C4M retaining wall

### Product option details

– Geofabrics Australasia Pty Ltd – LamGrid Green geocomposite

LamGrid Green geocomposite from Geofabrics combines Bidim Green non-woven geotextile made from recycled plastics and Tensar TriAx geogrid. These products are laminated together to form a high-performance geocomposite with stabilisation, separation and filtration functions. This product can be used in rail application areas with high water levels, soft subgrade soils, or when the granular fill is of poor quality. It can also be combined with aggregate fill to create a mechanically stabilised layer that is significantly stiffer than a conventional unbound aggregate layer, giving better performance and longer life.

– Pandrol – under sleeper pads and ballast mats

The under sleeper pads from Pandrol are resilient systems designed to reduce track maintenance, increase the quality of the track and provide vibration mitigation by fixing elastic elements to the bottom surface of the sleepers. The

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled rubber

pads improve track quality by reducing stresses on track components and substructure due to a better load distribution over the track. It reduces the life-cycle costs of track infrastructure by increasing the longevity of track components and reducing rail corrugation and ballast thickness. The pads can deliver vibration isolation up to 15 dB(v) and indirectly decrease noise by one dBA when compared to a new track.

Pandrol also supplies under ballast mats that can reduce track and ballast life-cycle costs. They require no maintenance and are compatible with many track design types. Depending on the location, the design parameters can be adjusted to achieve a vibration attenuation up to 25 dBv with a low resonance frequency. They can also be tuned to ensure attenuation across the most critical frequencies.

– Damtec – under ballast mats

The SBM-K under ballast mats from DAMTEC decouple and protect under rail systems. They reduce structure-borne noise and secondary airborne sound and vibration emissions. With ballasted track, the service life is extended by a lower and more uniform load. They also protect engineering structures and provide waterproofing.

– D&N Rubber Tyre Recycling – rubber crumb

The rubber crumb product from D&N Rubber is applied on road pavements, tile adhesives, synthetic turf underlays and rubber mats. D&N rubber work with organisations in manufacturing new types of products using their recycled crumb rubber.

– Ecoflex International – E-wall retaining wall

The E-Wall System by Ecoflex International can be used to construct both gravity and reinforced soil retaining walls. E-Wall delivers superior structural strength and dramatic cost savings in this application, particularly for high walls. The high strength of the E-Wall designs enables reduced material content for structural purposes. E-Walls provide a high-strength solution, drainage, flexible design and appearance, low cost and fast construction time.

– Lomwest Enterprises Pty Ltd – C4M retaining wall

Lomwest has developed a retaining wall system that is stronger and greener than current retaining systems. Combining the strength of high carbon steel with the anti-corrosive properties of rubber, Lomwest has produced a durable and high-quality retaining wall system that uses recycled rubber content.

**Resources**

32. Geofabrics, LamGrid Green Geocomposite, product website, https://bit.ly/3ASxbN5
33. Geofabrics, Bidim Green, product website, https://bit.ly/3GkjCXR
34. Geofabrics, Tensar TriAx geogrid, product website, https://bit.ly/3L6wHrw
35. Pandrol, Under sleeper pads, product website, https://bit.ly/3rjqNuW
36. Pandrol, Under ballast mat, product website, https://bit.ly/3gy5uzX
37. Damtec, SBM K under ballast mat, product website, https://bit.ly/3rjHt5F
38. D&N Rubber Tyre Recycling, Rubber crumb, product website, https://bit.ly/3ri3vWy
39. Ecoflex International, E-Wall, product website, https://bit.ly/3L3hozv
40. Lomwest Enterprises Pty Ltd, C4M Retaining wall, product website, https://bit.ly/3rmeuhO

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled glass

### Summary

Waste glass has a relatively high recycling rate compared to other waste materials, such as plastics. Not all glass waste types are recyclable, and in most countries, the rate of glass waste recycling can range from 10 to 60%. Colour sorting and separation, which is essential for glass recycling, can be challenging when working with small pieces or glass fines. Co-mingled recycling with glass also presents issues with contamination. Issues commonly arise when glass and organics like sugar and plastics are mixed. Because of contamination, significant portions of waste glass are stockpiled or landfilled. In 2016, Australia disposed of over 570,000 tonnes of glass to landfills. Recycled glass has many applications in rail but is most used as a coarse or fine aggregate or used to manufacture foams or fibres.

### Contexts for its use in rail

Recycled glass can be used as a substitute for virgin material aggregates in concrete for rail substructures. It can be used as an aggregate of up to 40% of the volume while maintaining optimal strength. Recycled glass fibres can reinforce some novel composite sleeper products. For example, recycled glass in foam aggregates can be applied as a track embankment fill, crushed recycled glass as a bedding sand replacement and an embedment material for piping and drainage.

### Sustainability benefits of the option

Using recycled glass as an alternative to virgin resources is the primary sustainability benefit, reducing the amount of natural resources extracted and energy used. Using this waste material reduces stockpiling and the amount of waste sent to landfill. Legislation bodies enforce strict guidelines that suppliers must follow to ensure the recycled material outputs are high quality and safe for application in construction, making this a more reliable sustainable material option. Recycled glass is tested and approved by many authorities globally in several rail applications.

### Pros

- Recycled glass fines and coarse aggregates have broadly available guidelines and approvals from several rail authorities in Australia.
- Certified products are readily available by a broad range of suppliers. There are examples of product applications in Australian rail networks.

### Cons

- For certain applications, foreign material or contaminant content can make the material not fit for use.
- Certain applications have specific requirements for particle size distribution, particle shape, cleaning requirements and must be acquired from specific sources of glass waste.
- Recycled glass presents potential health and safety issues due to the sharpness of glass fines, odours produced in processing and impacts on air quality.

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled glass

### Supplier and product options

– Expanded Glass Technologies – ECOLITE glass granules

– Alex Fraser – Recycled glass coarse and fine aggregate

– Trueco – Crushed glass aggregate

### Product option details

– Expanded Glass Technologies – ECOLITE glass granules

The ECOLITE glass granule product from Expanded Glass Technologies is a non-flammable, lightweight filler with excellent thermal and acoustic qualities. It is manufactured using recycled post-consumer glass and has applications for lightweight concrete, resin-based sleepers, and noise walls. The granule comes in seven sizes ranging from as fine as 0.1–0.3 mm to 4–8 mm.

– Alex Fraser – Coarse and fine recycled glass aggregate

Alex Fraser produces a range of recycled glass aggregates and sand for application in concrete, pavements, pipe bedding, walls, drainage, sleepers, and embankments. Their recycled glass products come in various classes and sizes to suit multiple applications and budgets.

– Trueco – Crushed glass aggregate

Trueco offers crushed glass aggregates sorted into four size categories and a wide range of colours. Their glass is offered under three types of treatment, including crushed glass unwashed, tumbled, and washed, and beach glass finish. They supply their products for commercial applications as a concrete aggregate.

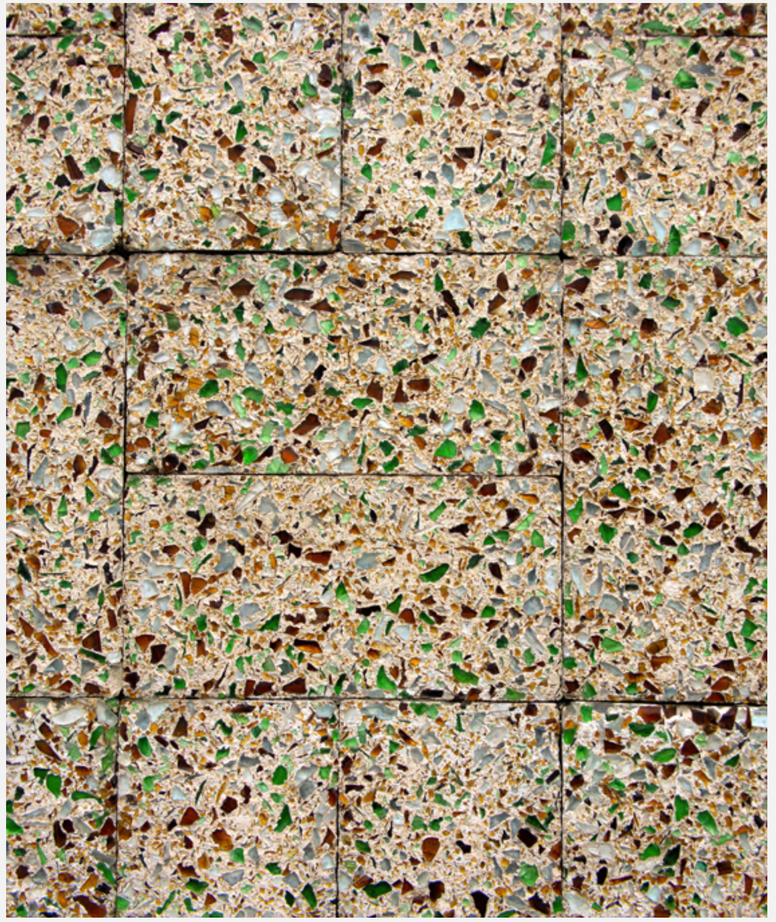
### Resources

41. Expanded Glass Technologies, ECOLITE, product website, https://bit.ly/3uj5j3f

42. Expanded Glass Technologies, ECOLITE, product brochure, https://bit.ly/3uzolmr

43. Alex Fraser, Recycled glass aggregate, product website, https://bit.ly/3B57GZb

44. Trueco, Crushed glass aggregate, product website, https://bit.ly/3geHamj



# Options table


- Recycled plastic
- Recycled or washed ballast
- Recycled concrete
- Supplementary cementing materials
- Recycled water
- Recycled rubber
- Recycled glass
- Recycled steel
- Sustainable options for lubricants


## Recycled steel

### Summary

The railway industry is one of the largest scrap metal producers in Australia. Removal and recycling of used rails and associated services present many safety challenges, particularly when working on ‘live’ tracks. There are also stringent environmental controls, especially where rail corridors pass through sensitive areas. Steel manufacturing is responsible for around 7% of global emissions. The Australian steel supply chain faces an expensive and technically challenging low carbon transition as currently the only readily available steel in Australia is emissions-intensive blast iron furnace steel.

### Contexts for its use in rail

Recycled steel has been used in Australia to produce steel wheels and axles. Recycling existing track from upgrade works can be used as sidings in stabling yards or for low-profile track.

### Sustainability benefits of the option

Recycling steel reduces the consumption of virgin materials, diverts scrap steel from landfill, and reduces air and water pollution by reducing the need for conventional waste disposal methods. It also reduces energy consumption and greenhouse gas emissions compared to virgin steel production.

### Pros

- Cost and energy requirements for re-manufacturing scrap steel into new steel products are significantly less than producing virgin steel.
- Scrap steel is regularly collected and recycled in Australia, providing a reliable supply chain.

### Cons

- Re-introduction of used steel assets to a rail network must be assessed on a case-by-case basis. This assessment should involve a technical review by a network engineering team, followed by engagement with other relevant stakeholders.
- Identified assets for reuse that do not meet the rail transport operators’ specified performance and technical requirements may need to apply for compliance approval.

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Recycled steel

### Supplier and product options

– Comsteel Manufacturing – recycled steel wheels and axles

– Infra Build – rail track and recycled steel products

### Product option details

– Comsteel Manufacturing – Recycled steel wheels and axles

Comsteel produces forged and rolled railway wheels for rolling stock utilising recycled scrap steel in the manufacturing process. Their wheels are specifically designed for high axle loads, have high hardness, and are wear resistant. Their wheels deliver improved performance in heavy haul, freight, passenger, and locomotive applications.

Comsteel also produces open die forged railway axles for rolling stock utilising recycled scrap steel in the manufacturing process. Comsteel produces a wide variety of axles with varying and complex shapes and a range of sizes from lightweight narrow gauge to broad gauge axles and large diameter axles for locomotive and heavy haul applications. Heat treatments and surface finishes are applied to improve axle load capacity and meet freight locomotive specifications.

– Infra Build – Rail track and recycled steel products

Infra Build is an integrated steel manufacturing and recycling business offering products for construction and transport. They produce their product, GREENSTEEL, using manufacturing processes that lower their carbon footprint. They operate two electric arc furnaces to re-manufacture scrap steel into new steel products. They produce a range of products, including steel mesh and reinforcing bars.

### Resources

45. Comsteel Manufacturing, Rail wheels, product website, https://bit.ly/3IZ95CW

46. Comsteel Manufacturing, Axles, product website, https://bit.ly/3rgguYF

47. Infra Build, manufactured steel, product website, https://bit.ly/3GmP9bs

48. Infra Build, manufactured steel, product brochures, https://bit.ly/34utdhC

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Sustainable options for lubricants

### Summary

Sustainable alternatives for track consumables, such as lubricants, have been explored in the rail industry. Industrial waste-based lubricant designs typically perform better than diesel oil-based products, with added benefits being lack of environmentally harmful compounds. Examples of bio-based rail lubricants can be found internationally, such as US-based products comprised of vegetable oils and lithium-based thickener. Other alternatives include using liquid nitrogen coolant in place of lubricants to prevent wear to locomotive wheels. Designs include compact units developed to expel liquid nitrogen to the contact surface of the wheel using a pipe system.

### Contexts for its use in rail

The primary use for lubricants in rail is at the interface between locomotive wheels and the rail. Lubrication improves the lifespan of both the wheels and rail assets and reduces the noise of vehicles in transit.

### Sustainability benefits of the option

Sustainable alternatives to traditional lubricants have the added benefits of being non-toxic for humans and animals and contain no volatile substances that can cause atmospheric pollution. Sustainable lubricant options can decompose into the environment without harming ecosystems. Additionally, options such as liquid nitrogen coolants remove the need for lubricants, reducing the potential impact they can have on air quality.

### Pros

– Low toxicity for environmental and air pollution.

– Lower health risks to people and animals.

– Reduced risk of waste particles having negative impacts on ecosystems.

– Reduced transfer to top rail and higher flash point.

### Cons

– There is low market maturity and awareness of sustainable alternatives to commonly used lubricant products in Australia.

# Options table

Recycled plastic
Recycled or washed ballast
Recycled concrete
Supplementary cementing materials
Recycled water
Recycled rubber
Recycled glass
Recycled steel
Sustainable options for lubricants

## Sustainable options for lubricants

### Supplier and product options

– AirLube – BIOCURVE lubricant

– Lubricon – KAJO-BIO rail grease

– Imtram Pty Ltd – Claretech Bioglide lubricant

– Rocol – BIO-SPL lubricant

### Product option details

– AirLube – BIOCURVE lubricant

The BIOCURVE lubricant from AirLube is a biodegradable rail curve grease comprised of vegetable oils and a lithium-based thickener. It is ideal for use on heavy haul and high traffic rail lines where ambient temperatures can range from –18 to 72 degrees Celsius. This lubricant is environmentally sensitive and causes no harm to ecosystems surrounding the track.

– Lubricon – KAJO-BIO rail grease

The KAJO-BIO rail grease from Lubricon is environmentally friendly, non-toxic, highly adhesive, and readily biodegradable. This bio grease is an alternative that can rival the performance of greases based on mineral oils in many cases. It is formulated for applications where protection of the environment is essential. Applications include construction equipment, mobile and stationary equipment, drill pipes, roller bearings, screw couplings, and wheel flanges for railway tracks. It is suitable for all-season lubrication of switch systems and easily applied with spraying devices.

– Imtram Pty Ltd – Claretech Bioglide lubricant

The Claretech Bioglide lubricant from Imtram offers long life for slide chairs of railway switches. It is biodegradable, environmentally safe, has strong water resistance, wide operating temperature and is easily applied using spray units, aerosol cans or a brush.

– Rocol – BIO-SPL lubricant

The BIO-SPL lubricant from Rocol is a specially formulated biodegradable oil for railway switch plates. Upon drying, a thin film provides excellent long-term lubrication. Testing shows that 90% of the oil breaks down within 21 days in the environment, indicating the oil is highly biodegradable. This lubricant is water-resistant, provides corrosion protection, and has a low viscosity for easy application with a spray can or brush.

### Resources

49. Air Lube, BIOCURVE lubricant, product website, https://bit.ly/3KZitbI

50. Lubricon, KAJO-BIO rail grease, product website, https://bit.ly/3saj6Xl

51. Imtram Pty Ltd, Claretech Bioglide lubricant, product website, https://bit.ly/3sd8ozp

52. Rocol, BIO-SPL lubricant, product website, https://bit.ly/3B5ddip

# Literature scan

Following the establishment of our research direction in the project inception meeting, the Arup and ARRB teams conducted a literature review with support from Arup's library. This section summarises the key findings from this review. Access a full copy of the literature review on the ACRI website.

The rail sector across Australasia is becoming more sustainable in its natural resource use and generation of greenhouse gas emissions through infrastructure construction and operations. One step towards reaching sustainable development in this sector is using recycled material options, which reduces material waste going to landfill, raw material use, and energy used in manufacturing and construction. Circular economy design principles were highlighted early in the review as priorities for the rail sector . These principles included:

– Design for reuse and recovery
– Design for waste efficient production
– Design for deconstruction and adaptability
– Design for offsite construction
– Design for material optimisation
– Design for reduced raw material use reconsider material needs.

The review covered a broad set of literature on four key areas:

– Recycled materials for rail infrastructure
– Sustainable material alternatives
– Reusing and recycling rail materials
– Decarbonisation of materials.

The selection of recycled materials explored in this review were based on laboratory research and field trials that have been undertaken within the rail industry to date across Australasia and globally. These materials include, but are not limited to:

– Recycled plastics
– Recycled glass
– Recycled rubber.

A selection of sustainable material alternatives was explored and identified as key materials relevant for freight rail, including:

– Dust-suppressant sprays for mineral freight
– Track consumables such as lubricants.

The rail infrastructure materials that could be reused or recycled were selected based on their widespread use and the current understanding of best practices for recycling at scale and applications of the recycled outputs. These materials included:

– Ballast
– Concrete
– Steel.

The decarbonisation of materials investigation targeted two materials that see extensive use in rail and have significant energy demands for manufacturing. These materials included:

– Steel
– Concrete.

These options, and others identified in later project stages, have been incorporated into this report's options table. The findings from this literature review informed the stakeholder engagement project that followed, including a survey and workshop gathering input from rail sector stakeholders. Survey respondents and workshop participants familiarised themselves with this review to inform their project contributions.

# Stakeholder survey

A survey was developed to gather insights into various aspects of recycled materials for rail and available options. This section summarises the key findings from the survey responses. These findings informed the project stages that followed, including the workshop and this report's options table.

A broad group of stakeholders took part in the survey, including rail system owners, operators, maintenance workers, construction/demolition workers, engineers/advisors, product providers, and material recyclers.

Two-thirds of participants were involved in material procurement for rail infrastructure. They were asked how much consideration they give to recycled material options in their procurement process. A majority give significant consideration (33%) or some consideration (44%) to recycled material options. Some give little consideration (22%), and none give no consideration. Participants gave further details on their procurement processes for recycled materials.

Highlights from their responses included:

– 'We are yet to formalise the process for using recycled materials, but those that pass trials can be considered for procurement on our network.'

– 'We have established sustainability performance criteria on tenders that supplier materials must meet.'

– 'We have internal sustainability guidelines as well as deliver our projects in line with specific ISCA ratings.'

## Recycled material options

Participants were asked which sustainable or recycled materials they had used or trialled to construct rail infrastructure. Figure 2 shows the number of participants that have used or trialled each option.

The option most widely used or trialled by participants was recycled plastics. For some participants, recycled plastic materials had already gone through internal approvals and were implemented on their network. Others were currently undergoing trials or had trials planned. Most participants used recycled plastics as a composite in sleepers, and some used recycled plastics for noise walls.

Recycled ballast and reuse of rail materials were the second most used or trialled options. Participants noted that ballast was regularly recycled after shoulder cleaning. Some participants had issues cost-effectively doing ballast cleaning and reuse, specifically with the transportation costs to recycling centres. A key challenge within the recycling industry is the geographical scarcity of recycling centres, both to receive materials to process and deliver recycled materials for use. Reused rail materials are often cascaded to sidings. For example, the inland rail project has repurposed over 200 km of rail for use on other networks. Reclaimed timber sleepers have been repurposed for construction,

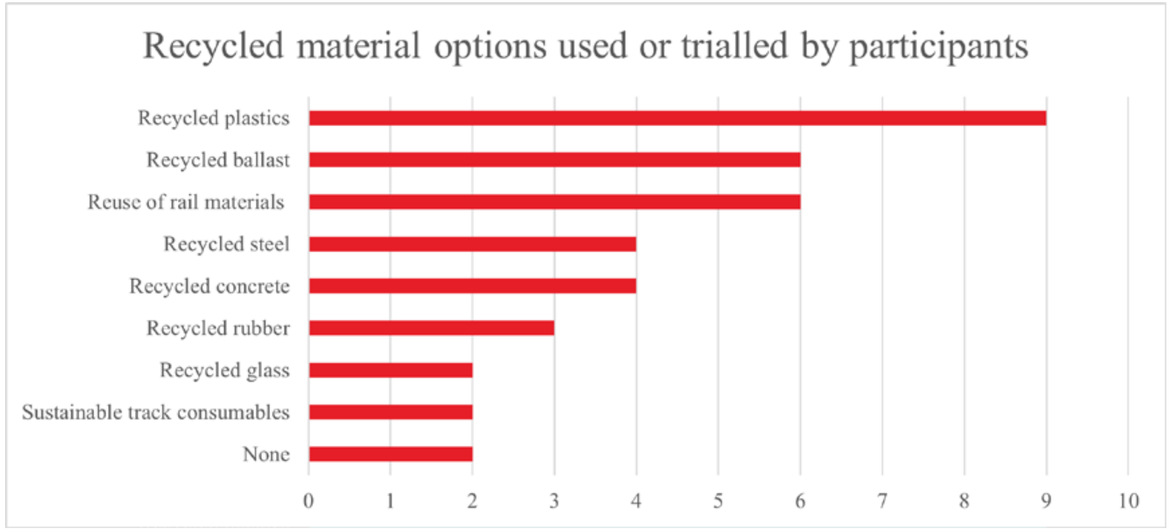



Figure 2 - Recycled material options used or trialled by participants

# Stakeholder survey

donated to communities, or mulched for re-vegetation of work zones.

The equal-third most used or trialled options were recycled steel and concrete. Participants noted that their railway wheels were manufactured using entirely recycled steel scrap from NSW for these options.

The remaining options used or trialled by participants were recycled rubber, followed by recycled glass and sustainable track consumables. Participants noted they were trialling recycled glass content in capping layers for these options. In addition, recycled rubber from tyres has been used to replace the injection of coke in the steel making processes.

## Recycled material suppliers

Participants were asked to provide details of the suppliers for these materials. Where provided, they are included in the options table. Participants were also asked follow-up questions including if there were any intellectual rights or restrictions that could limit others from using these materials, if any indicative costs could be provided, and if any documentation on the materials' sustainability benefits could be provided. Where appropriate, responses are in the options table.

## Challenges

Participants were asked if they have faced issues with recycled materials across different stages of implementation. Figure 3 shows the number of participants facing issues at each stage.

The most common stage where participants face issues is during trials. Participants noted they faced challenges with securing trial sites and getting buy-in and approvals to conduct material trials, including from operators and infrastructure owners. One participant experienced an issue with a crushed glass trial that caused odour issues for workers when installing. Trials of some plastic composite sleepers have failed when placed on a track. Participants noted plastic sleepers in high heat environments needs further testing. Differential heating on the top compared to the bottom of the sleeper was causing gauge widening. There also needs to be more tests on their ability to resist buckling forces.

The next most common issue faced by participants was during implementation and with gaining approvals or finance. Other issues included a limited appetite for infrastructure owners to implement alternative sleepers because of their operational financing models. In one participant's case, there were no established sustainability targets to drive change from what is always done. This same participant previously noted that their organisation gave little consideration of sustainable or recycled materials in their procurement processes. Another participant noted significant cost issues associated with ballast reuse, particularly for transportation to and from recycling centres. Regulatory issues have also limited some material recycling in NSW.

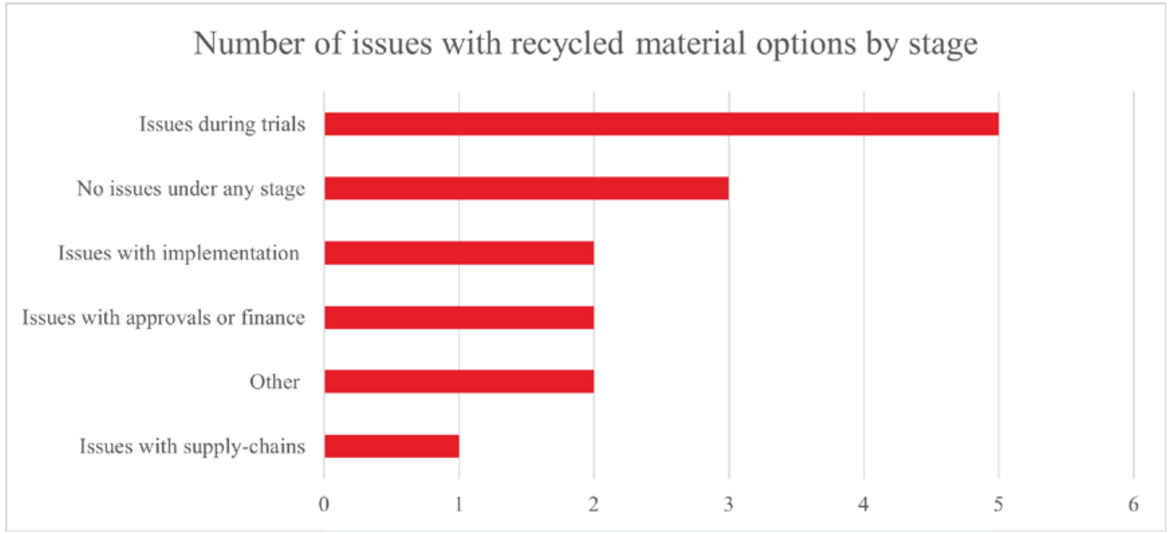



Figure 3 - Issues with recycled material options by stage

# Stakeholder survey

Other challenges participants faced include issues with supply chains, untested products, and levels of contamination in recycled material. Participants noted they had issues with quality control with recycled material stockpiles.

### Future trials and priority material options

Participants were asked if they had plans for future recycled material trial options. Seven participants had upcoming trials. These include:

- Several rail networks trailing recycled plastic and other recycled materials in sleepers
- Geosynthetics for formation stabilisation
- A capping material trial with approvals currently in progress. The material is a crushed rock (90%) and recycled glass sand (10%) blend
- Planning for a trial for increased use of fly ash, slag and geopolymers in concrete
- A trial exploring options for recycling material such as plastics in steelmaking process for rail.

Participants were asked to score a selection of sustainable and recycled material options based on how they perceived their impact on improving rail infrastructure sustainability. Participants scored options on a scale from 1 to 5. Figure 4 shows the average scores for each option.

The highest scoring option on average was recycled ballast. Participants noted heavy haul rail, such as that operating in the Pilbara, Western Australia, needs a high-quality track structure that minimises interruption to revenue-generating trains, i.e. keeping maintenance outages to a minimum. Products outside of track structure could be considered if they can withstand exposure to extreme weather and perform similarly to non-recycled products.

Reuse of rail materials closely followed this option. Participants noted reuse should be prioritised over recycling in line with the waste hierarchy. Reuse in cascading applications should be challenged and materials should be kept on main lines where possible.

Equally third, on average, were recycled plastics and recycled rubber. Participants noted these materials were a priority for reuse and recycling with the COAG waste ban, including plastics, rubber tyres and glass.

The fourth highest scored option was recycled concrete, recycled steel, recycled glass and sustainable track consumables. Other comments from participants noted old steel rails are often too low quality for reuse as rail lines are a better fit for steel furnace feedstock. Higher volume materials present the greatest opportunities for recycled materials, given the reliability of supply and higher potential to undertake regular testing to ensure confidence in a quality, consistent material stream.

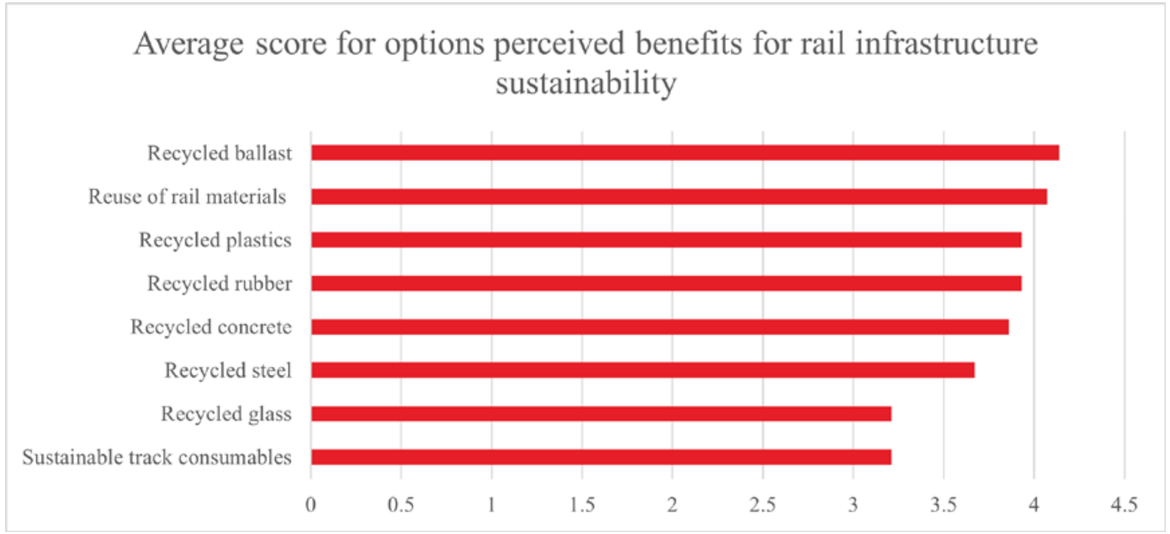



**Figure 4 - Average score for options' perceived benefits for rail infrastructure sustainability**

# Stakeholder survey

Participants were asked to select their top three recycled material options based on their interest in pursuing trials and/or their implementation in trail infrastructure construction. Figure 5 shows how many participants were interested in each option.

The top option was recycled plastics. Participants noted using recycled plastics as a composite material was an easy option for implementation because of its availability and success in past trials.

Equally second were recycled ballast, rubber, concrete and steel. For these options, participants noted there are opportunities to reuse the material on site after a cleaning process rather than recycling ballast. We can also investigate alternative materials for track formation, from capping layers to general fill.

The third highest scoring option was reuse of rail materials. Participants noted reuse should be prioritised over recycling where possible and there are opportunities for this with ballast and steel material.

Equally fourth were recycled glass and sustainable track consumables. Participants noted that the larger the volume of product used in rail, the greater the opportunity to use recycled materials. Benefits for high-volume materials extend through the supply chain, manufacturing, and installation.

Participants were asked to provide any additional comments regarding recycled materials for rail in Australasia. Highlights from the responses include:

– "As we move forward, we need to not only consider recycled materials, but consider the broader sustainability context and priorities of a circular economy, including principles and feedback loops."

– "There are still challenges to overcome with some recycled materials, such as plastics, withstanding high axle loads and high-temperature conditions. "

– "We need to identify and acknowledge where effective recycling and sustainable construction is happening within industry and share these successes broadly"

– "We are seeing less engagement from operators and infrastructure owners in wanting to adopt recycled materials in Australia. In Europe we are seeing stronger drives and incentives to adopt 'greener alternatives' and therefore we are seeing greater uptake of our composite sleepers in Europe"

– "Changes will need to be driven from a higher level (both in the organisations, at regulatory level and government) to adopt a long-term view and implement changes now"

– "There must be greater collaboration and support between R&D companies, rail companies and governments. There needs to be simpler regulations that will allow for more waste products to be recycled."

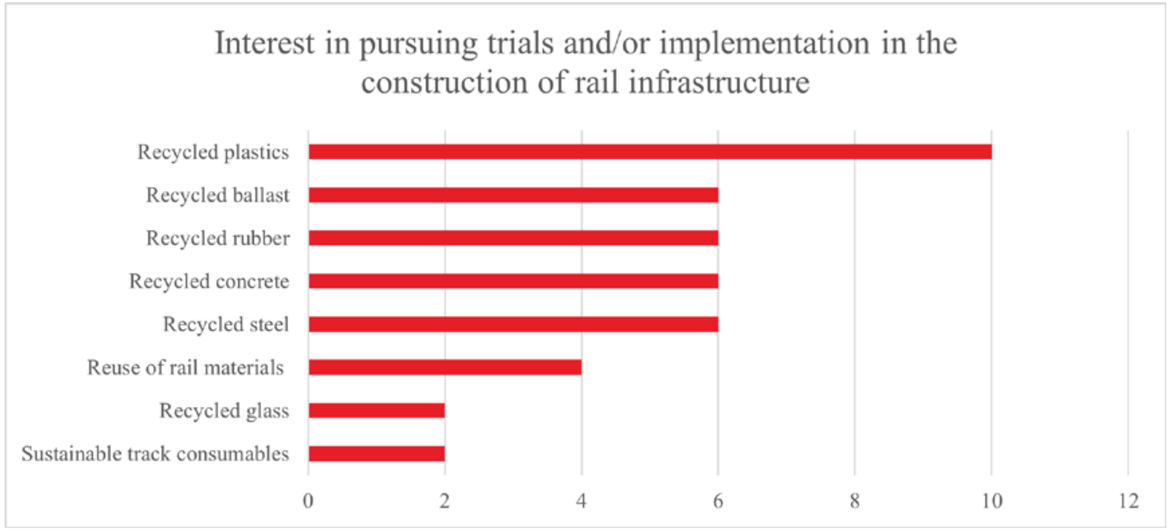



Figure 5 - Average score for options' perceived benefits for rail infrastructure sustainability

# Stakeholder workshop

An online workshop was held for the ACRI working group and rail industry stakeholders to discuss sustainable and recycled material options and challenges. ACRI, the Arup Foresight and Innovation team, and the ARRB research team facilitated the workshop. Rail and materials experts from Arup and ARRB were also in attendance to contribute to the discussion.

This section summarises the key findings from the workshop. A detailed report covering the full discussion outcomes from the workshop can be accessed on the ACRI website. The workshop involved 37 attendees from across the rail sector in Australasia and some attendees from other regions across the globe, such as Canada and the USA.

The workshop took the participants through five main activities to gain insights on sustainable and recycled material for rail. During the first activity, participants were asked 'How well adopted are recycled materials in the rail sector in Australasia currently?' A scale recorded responses with the options no adoption, low adoption, moderate adoption, significant adoption, and widespread adoption. Responses clustered around 'low adoption' with some close to 'moderate adoption'. We asked participants a follow-up question 'How much improvement in the adoption of recycled materials do you feel is needed for the rail sector in Australasia?'. Again, scale recorded responses with the options 'use less of these options, no improvement needed, a little improvement needed, moderate improvement needed, and significant improvement needed'. Responses mostly clustered between 'moderate improvement needed' and 'significant improvement needed', indicating that participants favoured giving these options greater consideration.

In the second activity, participants brainstormed their awareness of sustainable and recycled material options. Participants then voted on the top three options they thought had the greatest opportunities to provide sustainability benefits. The top five options that received the most votes included: use of recycled material composites in sleepers and transoms, recycled and cleaned ballast, recycled concrete, supplementary cementing materials for concrete, and recycled water.

The third activity had participants collectively discuss the top five options from activity two. It addressed the question 'What actions could be taken to make the most of each option's sustainability opportunities?' for each option. Highlights from these actions included:

– Considering re-recycling and keeping materials high in the value chain
– Research a composite sleeper material that is suitable for fast rail
– Develop a nationwide register of qualified suppliers
– Identify downstream uses for materials not necessarily in track formation
– Take measures to ensure minimal contaminants in materials that can be recycled.

In the fourth activity, participants brainstormed all the challenges faced with adopting sustainable and recycled materials they were aware of. Participants then voted on the top three challenges they thought were the most important for the rail sector to overcome and enable greater adoption of sustainable and recycled materials. The top four challenges that received the most votes included:

– Risk aversion
– Approvals and trials
– Understanding the whole-of-life benefits and impacts
– Differences in standards across jurisdictions and a lack of information about in-field performance.

The fifth activity had participants collectively discuss these top five challenges from activity four and address the question 'What actions could be taken to overcome these challenges or be a first step in reaching a solution?' for each challenge. Highlights from these actions included:

– Incentivise uptake with grants
– Ensure similar pricing for recycled material whole of life
– Allow for accelerated independent testing at local facilities
– Share results from trials and experience broadly
– Collect and share economic and durability data.

This workshop's recorded discussions and outcomes informed the development of the options table featured in this report.

# Conclusions

This research has been a collaboration between stakeholders across the rail sector to understand the current state of recycled material use, the challenges we face and the opportunities these materials unlock for improving the sustainability of the rail sector. This report's findings and options table aim to promote greater uptake of recycled materials in rail and drive an increase in research, trials, and implementation across rail networks in Australasia.

As the uptake of recycled materials increases, promoting increased competition and innovation between providers will be essential. This will enable the sector to strive towards greater sustainability outcomes and improved accessibility through reduced costs and broader material applications.

To support a growing recycled materials industry, efficient and local supply chains need to be established to ensure suitable supply for infrastructure needs and allow recyclable materials to be effectively captured and maintained at their greatest value in the circular economy waste hierarchy.

The challenges of risk aversion to adopting recycled materials will need addressing through industry collaboration. Sharing knowledge and experience from trials, simplifying processes for approvals, and establishing clear standards for recycled material use are ways the industry can respond and take steps towards greater sustainability outcomes.

# References


1. Integrated Recycling, Duratrack recycled plastic railway sleeper, Product website, https://bit.ly/3uhUrml
2. Sicut, recycled plastic and glass sleepers, product website, https://bit.ly/3sbhxIx
3. Sicut, recycled plastic and glass sleepers, product brochure, https://bit.ly/3L2nHn7
4. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, product website, https://bit.ly/3rl9s59
5. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, product standard, https://bit.ly/3GlGlCE
6. Delkor Rail & Sekisui Chemical, FFU synthetic sleeper, Product brochure, https://bit.ly/35JK6Wb
7. Axion, ECOTRAX composite sleeper, product website, https://bit.ly/342MIhv
8. Axion, ECOTRAX composite sleeper, product brochure, https://bit.ly/3HlRfdf
9. Replas, recycled plastic product range, product website, https://bit.ly/3rhUigW
10. Integrated Recycling, Envire recycled product range, product brochure, https://bit.ly/3GeNkgQ
11. Integrated Recycling, Envire recycled product range, product brochure, https://bit.ly/34va9jj
12. Lee Group, Recycled plastic noise wall, product website, https://bit.ly/3HkV8ih
13. Lee Group, Recycled plastic noise wall, product website, https://bit.ly/3GoxqR0
14. Geofabrics, Recycled drainage products, product website, https://bit.ly/3AY51jJ
15. RPM Pipes, Recycled drainage pipes, product website, https://bit.ly/34m6e8h
16. Allproof Industries, Recycled plastic drainage pits, product website, https://bit.ly/35vPHiz
17. Allproof Industries, Recycled plastic drainage pits, product brochure - https://bit.ly/3AHd6cw
18. Repurpose It, Reclaimed and recycled ballast, product website, https://bit.ly/34nBcwO
19. Holcim, Aggeno RCA, product website, https://bit.ly/3IU7fU2
20. Holcim, Aggeno RCA, product data-sheet, https://bit.ly/3s6cRE1
21. Sunshine Groupe, Crushed RCA, product website, https://bit.ly/34nDI6e
22. Repurpose It, Various grades of RCA, product website, https://bit.ly/3rjSFzj
23. Boral, RCA, product website, https://bit.ly/3uiXxX7
24. Boral, RCA, product data-sheet, https://bit.ly/3ojalZN
25. Independent Cement, Ground Slag, product website, https://bit.ly/3ohMR7D
26. Independent Cement, fly ash, product website, https://bit.ly/3geAIvB
27. Cement Australia, SCMs & Quicklime, product website, https://bit.ly/3ANLT85
28. Cement Australia, Slag, product website, https://bit.ly/3s2L876
29. Cement Australia, Fly Ash, product website, https://bit.ly/32Ptfjt
30. Boral, Fly Ash and Slag, product website, https://bit.ly/3LeOnkP
31. Poly Tanks, Water tank range, product website, https://bit.ly/3L4OHCe
32. Geofabrics, LamGrid Green Geocomposite, product website, https://bit.ly/3ASxbN5
33. Geofabrics, Bidim Green, product website, https://bit.ly/3GkjCXR
34. Geofabrics, Tensar TriAx geogrid, product website, https://bit.ly/3L6wHrw
35. Pandrol, Under-sleeper pads, product website, https://bit.ly/3rjqNuW
36. Pandrol, Under ballast mat, product website, https://bit.ly/3gy5uzX
37. Damtec, SBM K under ballast mat, product website, https://bit.ly/3rjHt5F
38. D&N Rubber Tyre Recycling, Rubber crumb, product website, https://bit.ly/3ri3vWy
39. Ecoflex International, E-Wall, product website, https://bit.ly/3L3hozv
40. Lomwest Enterprises Pty Ltd, C4M Retaining wall, product website, https://bit.ly/3rmeuhO
41. Expanded Glass Technologies, ECOLITE, product website, https://bit.ly/3uj5j3f
42. Expanded Glass Technologies, ECOLITE, product brochure, https://bit.ly/3uzolmr
43. Alex Fraser, Recycled glass aggregate, product website, https://bit.ly/3B57GZb
44. Trueco, Crushed glass aggregate, product website, https://bit.ly/3geHamj
45. Comsteel Manufacturing, Rail wheels, product website, https://bit.ly/3IZ95CW
46. Comsteel Manufacturing, Axles, product website, https://bit.ly/3rgguYF
47. Infra Build, manufactured steel, product website, https://bit.ly/3GmP9bs
48. Infra Build, manufactured steel, product brochures, https://bit.ly/34utdhC
49. Air Lube, BIOCURVE lubricant, product website, https://bit.ly/3KZitbI
50. Lubricon, KAJO-BIO rail grease, product website, https://bit.ly/3saj6Xl
51. Imtram Pty Ltd, Claretech Bioglide lubricant, product website, https://bit.ly/3sd8ozp
52. Rocol, BIO-SPL lubricant, product website, https://bit.ly/3B5ddip