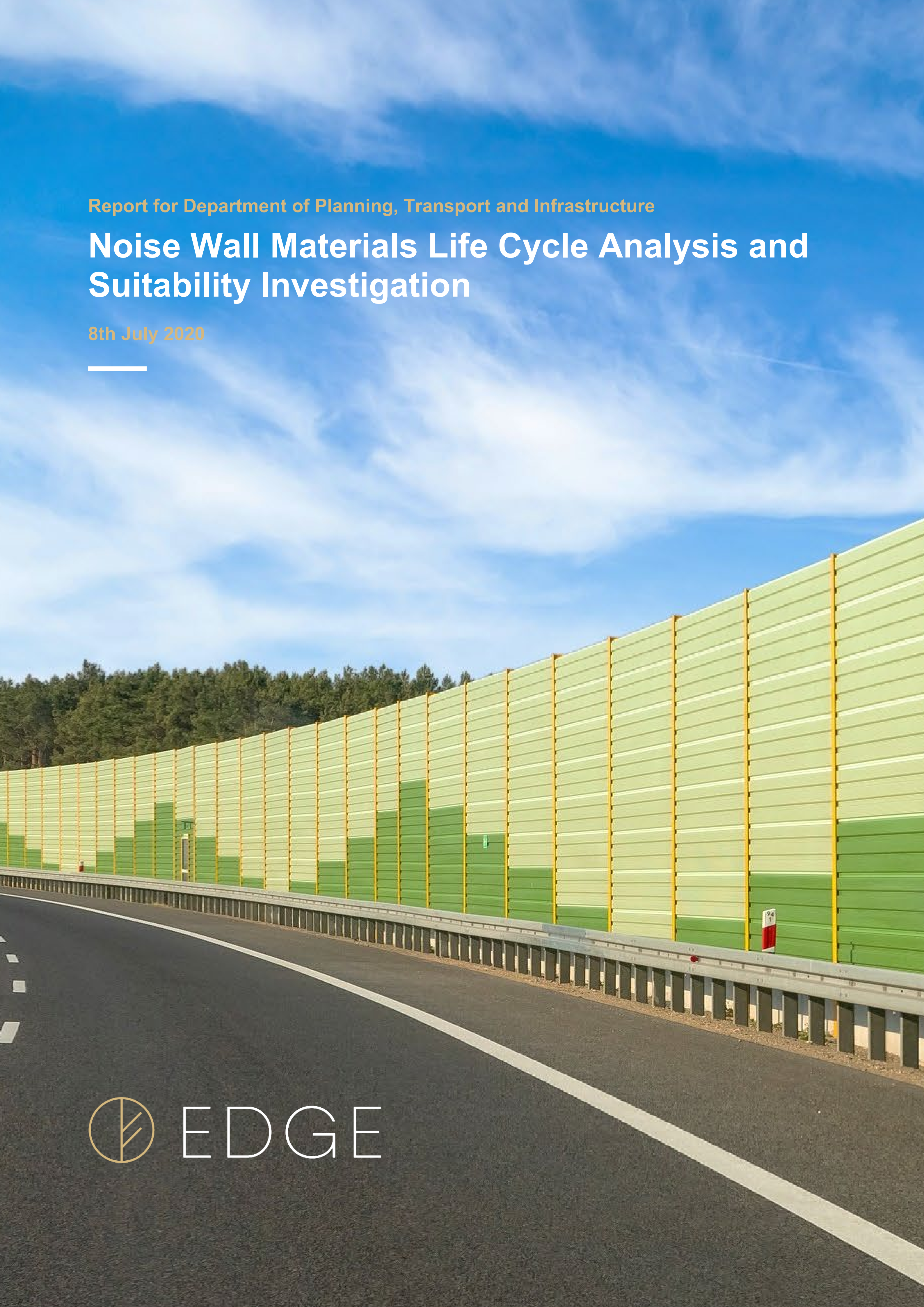
Report for Department of Planning, Transport and Infrastructure

Noise Wall Materials Life Cycle Analysis and Suitability Investigation

8th July 2020



EDGE

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1 Introduction

Infrastructure plays a critical role in our daily lives and is fundamental to achieving a sustainable future. However, without significantly overhauling the way we design, use and reuse our infrastructure it will continue to account for a significant amount of Australia's carbon emissions.

South Australia was the first Australian state to legislate emissions reduction targets. The current **Directions for a Climate Smart South Australia** sets out emissions reduction priorities. The South Australian Government has committed to net zero emissions by 2050 and has an interim goal to reduce emissions by more than 50% by 2030.

The South Australian (SA) Government's **Directions for a Climate Smart South Australia** sets out emissions reduction and climate change adaptation outcomes that will guide all SA Government agencies, under five policy directions:

1. Unlock innovation and economic opportunity
2. Reduce net emissions
3. Build resilience and adapt
4. Provide accessible information
5. Government leading by example

It is vital to understand the possible mitigation potential in the infrastructure sector, and the role the Department of Planning, Transport and Infrastructure (DPTI) has in driving the reduction in emissions. DPTI has diverse responsibilities for transport systems and services, infrastructure planning and provision, and strategic land use within South Australia.

DPTI ensures that South Australia's needs for the movement of people and freight, and the delivery of services across the transport and infrastructure sectors, and balances economic, environmental and social needs.

The selection of sustainable materials in infrastructure projects can also support the South Australia government's current and future strategies, policies and guidance such as:

- Draft South Australia's Waste Strategy 2020-2026
- DPTI Sustainability Manual (May 2020)

DPTI has previously commissioned work to investigate greenhouse gas reduction opportunities in the infrastructure sector. The study included an assessment of the emissions reduction achieved through sustainability initiatives implemented on a range of project types, both in Australia and overseas.

Of the 34 emission reduction initiatives investigated, expanded polystyrene (EPS) noise walls were identified as having the potential to deliver an estimated reduction of 299 tCO_2-e/km (71%) when compared with precast concrete. EPS noise walls were highlighted as providing a negative cost of abatement of as much as $1,406 $/tCO_2$-e.

However, emissions reduction benefits must be considered alongside other project requirements and Government objectives, including:

- compliance with technical specifications
- constructability,
- urban design,
- ease of maintenance,
- circular economy, including opportunities to use recycled content as well as materials' recyclability or disposal at end-of-life,
- climate resilience including thermal properties,
- material lifecycle impacts, and
- whole of life costs.

1.1 Objectives

The objective of this project is to assess a range of noise wall materials that can deliver lower greenhouse gas emissions and cost savings in infrastructure project delivery, while maintaining functionality. The material options and assessment criteria are listed in Table 1

Table 1 – Summary of study parameters

Material options	Assessment criteria
• Concrete • Lightweight concrete • Expanded polystyrene (EPS) • Recycled polyethylene terephthalate (PET) • Recycled wood and plastic composite (WPC)	• Carbon life cycle assessment • Whole of life costing • Compliance with DPTI specifications • Recycled content and end of life disposal • Noise reduction potential • Impact on urban heat island effect (thermal mass) • Local supply • Time of construction • Maintenance requirements • Durability • Aesthetics and inclusion of urban design elements • Available dimensional and curve radii

The materials selected for the study include commonly used materials such as precast concrete, newer products such as expanded polystyrene (EPS) and lightweight concrete, and innovative materials including recycled polyethylene terephthalate (PET) and recycled wood and plastic composite (WPC).

Following research, stakeholder engagement and analysis, the study will provide a summary of the benefits and limitations of the material types and recommendations for their application.

The findings of the study will:

1. Provide data to infrastructure projects, enabling the selection of the most appropriate and sustainable material for noise wall applications
2. Identify new materials that have the potential to reduce carbon impacts or support a circular economy, while being cost effective and suitable for noise wall applications

1.2 Material options investigated

Precast concrete is the mostly commonly used noise wall material, but its high emissions footprint has prompted investigation into other materials/products' emissions intensity, life-cycle cost and suitability for noise wall applications.

This study has investigated five different noise wall material and product types, as follows:

- Concrete
- Lightweight concrete
- Expanded polystyrene (EPS)
- Recycled polyethylene terephthalate (PET)
- Recycled wood and plastic composite (WPC).

1.2.1 Concrete

Concrete is the primary and most frequently used type of noise walls in South Australia. The wall systems are constructed from steel-caged reinforced concrete. They are manufactured off-site in a controlled environment and then transported to the site for installation, with specialist advice and heavy machinery. Concrete has great inherent flexibility, and is, therefore, very suitable for noise walls. The walls have a reflective property and superior noise reduction potential. Texture, pattern, colour, and paint can be customised to assist with the urban design objectives. At the end of life, concrete can be crushed and reused for another purpose.

The disadvantage of standard concrete is its weight, which makes it more challenging to fix, particularly in retrofit situations and on existing structures. Further, if a patterned panel is damaged some years after initial construction, it may be difficult to replace it.

Examples of concrete noise walls: Gallipoli underpass, SA; Torrens to Torrens, SA; Shell Cove development, NSW; Melbourne City Link project, VIC; Seven Avenue Bridge, WA.

1.2.2 Lightweight concrete

Autoclaved aerated lightweight concrete panels have been used extensively throughout Australia. The wall panels consist of autoclaved aerated concrete and steel reinforcing mesh.

The material offers reduced mass and improved thermal performance in comparison to other building products of similar function (i.e. brick or concrete). The installation process does not require heavy machinery. The panels have high noise reduction potential. While autoclaved aerated concrete can be coloured with integral dyes, it is not possible to obtain consistent colours. Any colour required will need to be painted onto the surface. Panels are fire-resistant, which can be useful in bushfire-prone areas.

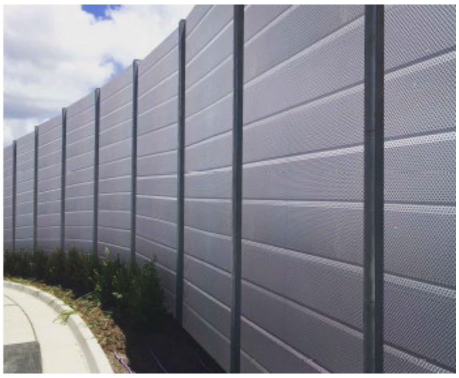
Examples of lightweight concrete noise walls: WestConnex Motorway, NSW; Southern Sydney Freight Rail, NSW

1.2.3 Expanded polystyrene (EPS)

EPS is currently used for noise walls across New South Wales., Queensland and Western Australia The wall panels are constructed from a combination of fibre-reinforced cementitious sheets surrounding an EPS core, to which a high-impact reinforcing layer and adhesive are added. The fibre cement outer skins are fire-resistant and non-combustible. They have a smooth finish and can accommodate urban design elements. The lightweight nature of the product enhances safety on-site and allows for rapid construction times, without the need for cranes and heavy digging equipment. The panels have high acoustic performance. When separated from the outer skin, EPS panel cores can be fully recyclable.

Examples of the EPS noise walls: Captain Cook Drive, Caringbah; Alfords Point Road; Central Station, Sydney NSW; Bruce Highway, Cooroy QLD; Roe Highway, WA

1.2.4 Recycled polyethylene terephthalate (PET)



The panels are constructed from a high-density PET core and a pre-coloured, perforated aluminium outer skin. Sound waves penetrate the perforated face of the panel and are absorbed within the core material, resulting in high sound-insulation performance. The products are effective for noise intensive environments, such as noise and rail corridors, as well as businesses that make extensive use of loading docks, heavy machinery, or large-scale generators.

Examples of PET noise walls: Goodman Fielder Bakery, VIC; Coles Ashmore, QLD

1.2.5 Recycled wood and plastic composite (WPC)

Wood plastic composite products are generally produced by thoroughly mixing ground wood particles and heated thermoplastic resin. The product of interest in this project is produced from recycled waste wood and plastic. It has the potential to reduce pressure on natural resources (as virgin materials) and landfills (as end of product life). WPC materials can be separated and reused in the construction of other products. Current product ranges include bollards, decking, fencing, fitness trails, and furniture, as well as products suitable for traffic control, parks, gardens, and the utility industry. Currently, there is no noise wall produced from this material. The acoustic performance of the panels has not been investigated.

Advanced Plastic Recycling (APR) currently produces recycled timber and HDPE products sourced from kerbside waste. One product example is railway sleepers for Queensland Rail.

Replas currently produces recycled soft plastic products sourced from supermarket collection points. However, to date, neither has constructed noise walls.

1.3 Assessment criteria

As part of this study, a wide range of noise wall attributes have been assessed. This will allow the selection of materials while considering environmental impact, cost, and performance.

1.3.1 Carbon Life Cycle Assessment

Life Cycle Assessment (LCA) is a methodology used to estimate the overall environmental impact of materials or products during their lifetime. LCA is the only method that assesses the environmental impacts of a product over its entire life cycle taking into consideration:

- Extraction and treatment of raw materials
- Product manufacturing
- Transport and distribution
- Construction processes
- Use-phase or operation (maintenance and replacements are accounted for in the material calculator)
- End of life (not included in the material calculator).

For this project, the carbon LCA of various noise wall constructions and materials has been considered, in order to determine how they can be utilised to reduce an infrastructure project's overall carbon impact.

1.3.2 Recycled content

The South Australian government is seeking to encourage the reduction of waste and opportunities to promote a circular economy. Noise wall materials that contain recycled content reduce waste to landfill, avoid the use of virgin materials and may have a lower carbon impact.

1.3.3 Whole of life costing

Whole-life cost analysis is often used for option evaluation when procuring new assets and for decision-making to minimise whole-life costs throughout the life of an asset. In the case of a noise wall, all material types considered in this study have a design life of over 50 years, so maintenance costs are minimal. The cost of materials purchase is the most significant factor.

1.3.4 Noise reduction potential

Cities have always been noisy places and traffic has always been a source of noise. However, with growing levels of traffic, expanding economies, higher population density, and higher expectations of quality of life, noise has become an important issue in the development and operation of road and rail networks. Consequently, noise walls have become a necessary and highly visible component of most modern road networks.

The primary function of a noise wall is to reduce the noise experienced due to a road or rail project. Noise walls act as a barrier, absorbing and reflecting sounds. Several factors influence the effectiveness of a noise wall, including its height, location, continuity of construction, and the performance of the materials. The effectiveness of a wall's sound insulation is rated by its Weighted Sound Reduction Index (Rw), which is determined by laboratory testing.

To meet DPTI PC – ENV4 Noise Assessment Treatment Design and Implementation: Noise Barrier Minimum Design Requirements, a noise wall must meet the requirements in the following clause:

"Barrier panels shall be constructed with a material to achieve a Weighted Sound Reduction Index Rw, when determined in accordance with AS/NZS ISO 717.1, of not less than 26 for normal use and an Rw of not less than 31 where noise reductions of more than 10 dB(A) are required."

Concrete, lightweight concrete, EPS and PET noise walls have undergone laboratory testing to determine Rw and meet the acoustic performance requirements of the DPTI Master Specification.

For WPC noise walls to meet acoustic performance requirements, testing will be required. However, it is expected that a compliant product will be able to be produced by determining the thickness of the wall to achieve the required Rw value.

1.3.5 Urban Heat Island Effect

Urban structure, hard surfaces, and shortage of vegetation cause an artificial temperature increase in cities, known as the urban heat island (UHI) effect. A study of UHI in Adelaide[1] indicated that the most intense urban-rural temperature differences occurred around midnight. However, in the afternoon, there was more temperature variation in the urban area. In the late afternoon, the near-surface urban heat fluctuated by 2°C within three kilometres and by 1.2°C in just one kilometre.

Urban infrastructure elements, such as noise walls, can contribute to UHI in two ways: by reflecting heat into an area and by retaining heat. For this study, the thermal mass of each material option will be considered as an indicator of how it will retain heat. Although this is not a detailed assessment of the element's contribution, it will allow a comparison of the performance between material types.

1.3.6 Local supply availability

Products that are designed and manufactured in South Australia will not only reduce transportation costs and carbon impacts, but will also support local business, and create demand for locally recycled products and source materials.

1.3.7 Time of construction

The construction time of noise walls varies depending on materials and product types, quantity, and dimensions of the product. One significant factor in the speed of construction is weight. Without the use of cranes and heavy digging equipment, the manufacture and installation of lightweight panels can be expedited, making it a cost-effective solution. The reduced weight of parts and the composite construction methodology also minimise the risk of material damage during installation.

1.3.8 Maintenance requirements

Occasional maintenance of noise walls will be required, for instance, to repair or replace damaged panel sections, remove graffiti, and wash or paint sections of the wall. It is essential to design a wall that minimises the need for ongoing maintenance, thus reducing costs.

Designs must allow for safe and convenient access for maintenance personnel and plant. Similarly, where the landscape is a component of the design, access to all planted areas must be provided, without the need to close lanes if this is at all possible. Maintenance requirements must be considered in consultation with the road design engineer during the concept design stage.

1.3.9 Graffiti removal

A long stretch of wall with a high degree of public exposure makes it difficult to deter graffiti. Graffiti can be reduced through the application of anti-graffiti treatments and ongoing maintenance, but this can be a costly approach. Therefore, it is essential to consider how the material reacts to graffiti and how easily it can be repaired when comparing the cost-effectiveness of various options.

A rough-textured finish can be used to deter graffiti artists. Smooth surfaces are more attractive targets for tagging but are easier to clean or repaint than textured finishes. In general, walls should be painted to reduce maintenance and to enable graffiti to be painted over.

1.3.10 Durability

Durability and impact resistance are key attributes to enable the wall to withstand collision and vandalism. The product should not rust, rot, warp, or burn. A wall that is expected to last for 25 years or

[1] Patterns of Urban Heat Island Effect in Adelaide: A Mobile Traverse Experiment Ehsan Sharifi & Ali Soltani

more without reconstruction will need highly durable materials, especially in areas with aggressive climate conditions. Most noise wall panels are designed with a minimum lifespan of 50 years.

1.3.11 Wall appearance and aesthetics

Flexibility to paint (either plain or textured), render, and add architecturally designed elements is an important attribute to consider. The panel should appear natural and in harmony with the surrounding landscape. Most importantly, the colour and patterns should not overly distract passing motorists, particularly on high-speed roads. In some locations, noise walls may have two faces with different visual requirements.

Planting may be considered alongside a noise wall, especially along a public open space edge. The design will depend on location and climatic conditions. Where it is cost-effective to do so, it can be advantageous to communities to increase the green space and reduce UHI.

1.3.12 Dimensions and curve radii

The choice of noise wall material is often influenced by constraints on height and width. Standard thickness, width, and height of panels vary across product types.

The possible curve radius of a noise wall is dependent on either its ability to be formed in a curve, or on the minimum length of an individual unit. All noise wall materials investigated were found to be customisable and present no limits to curve radii in infrastructure applications.

1.3.13 Compliance with DPTI specifications

The DPTI specifications applicable to noise walls include:

- PC – ENV4 Noise Assessment Treatment Design and Implementation: Noise Barrier Minimum Design Requirements
- Master Specification Design of Structures: 14 Noise Barriers

The key requirements include acoustic performance, maintainability (including protection from vandalism), wind loading, and impact resistance. These requirements have been included in the list of noise wall attributes that are under investigation in this study.

2 Methodology

Assessment and comparison of selected materials was based on desktop research, stakeholder interviews, lifecycle assessment and whole of life costing.

2.1 Desktop research

Following an inception meeting with DPTI, the first stage of this project involved gathering the data necessary to carry out the comparative analyses and to prepare a comparative appraisal between the five material options. The desktop research undertaken comprised research, use of publicly available information and research papers, and supplemented by Edge's own experience in infrastructure and construction projects.

2.2 Stakeholder interviews

In addition to the information gained through desktop research, stakeholder interviews were held with the companies and individuals listed in Table 2. These interviews enhanced understanding of the construction and installation of noise walls, and any obstacles in the use of new products in the South Australia market.

Table 2 – List of interviewees

Organisation	Interviewee
Fulton Hogan	Mike Freeman, Engineer (Metropolitan Roads Program Alliance)
Sonus	Mathew Ward, Acoustic Engineer
Modular Walls	Colin Brown, Senior Commercial Manager Nick Holden, Owners and Managing Director
Regency to Pym (R2P) Alliance	Deanna Melino, Senior Project Engineer Luka Andric, Structural Engineer
Advanced Plastic Recycling	Ryan Lokan, CEO
Replas	Robbie Westley, SA State Manager
Woodtex	Yanick Pierce, Managing Director

Although the interviews were conducted in an open-ended style, the following issues/topics were used to structure the conversation:

- Typical applications of the product
- Product benefits
- Limitations of the product
- End of life considerations
- Typical product life
- Maintenance requirements
- Local availability
- Graffiti resistance or cleaning
- Installation.

2.3 Life cycle assessment

The life cycle carbon impacts of noise walls of different design and construction parameters have been assessed using the ISv2.0 Materials Calculator and data from SimaPro, a widely used life cycle assessment inventory.

Life cycle assessment (LCA) is a methodology used to estimate the overall environmental impact of materials or products during their lifetime. LCA is the only method that assesses the environmental impacts of a product or an activity (a system of products) over its entire life cycle, taking into consideration:

- Extraction and treatment of raw materials
- Product manufacture
- Transport and distribution
- Construction processes
- Use-phase or operation (maintenance and replacements are accounted for in the material calculator)
- End of life (not included in the material calculator).

LCA is used to measure the environmental impacts across a product's life cycle and to help to avoid burden shifting between life cycle stages and/or types of environmental impacts, i.e. minimising the impacts at one stage of the life cycle, or in a geographic region, or in an impact category, while helping to avoid increases elsewhere. For example, reducing the volume and impact of the initial construction materials, but with higher operational and maintenance impacts. The main goal of LCA is to lessen the environmental impacts of products and services by guiding the decision-making process.

For each stage of the life cycle, the agreed methodology for the carbon impact assessment is based on a subset of the Building Product Life Cycle Inventory (BP LCI) impact assessment method.

2.4 Costing

Edge assessed the whole of life cycle cost of five noise-reduction wall options: concrete; lightweight concrete; EPS; PET and WPC. The modelling included the costs of supplying and maintaining noise-reduction walls of different designs over the operational life span of 50 years.

The capital expenditure requirements were determined as being the cost of supplying all constituent materials to the site, using Adelaide Metro as the default site location. This location was chosen to provide an 'average' travel distance.

As all constituent materials were determined to have an operational life span of 50 years or more, there was no material replacement and, therefore, no operational expenditure required. Therefore, the overall cost was calculated as the upfront capital expenditure for each option assessed.

For comparability, the cost of each option was assessed on a linear metre basis. Where the materials supplied were not available on a per linear metre basis, the longest panel size was adjusted to determine a cost per linear metre estimate.

The cost of wall installation was not included in the analysis as it is highly dependent on a specific site Manufacturers of noise wall systems using alternative materials typically estimate that the cost of installation of their product is lower than that of traditional materials. This is due to the increased speed of handling lighter noise wall panels. However, infrastructure contractors have suggested that prices for the installation of familiar and widely available materials (i.e. concrete) can be more competitive. It is suggested that price of installation should considered for specific projects.

2.5 Suitability analysis

In the suitability analysis, the results of all previous assessments – including carbon footprint, costing, and the physical attributes of each noise wall material – are summarised. The summary will be provided in the form of a colour-coded table so that easy comparison can be made between the various options.

A table will be produced for 1.6m, 2.5m, and 3.6m high noise walls. These heights have been selected to provide information for a range of noise wall applications and to align with common module sizes for the pre-formed noise wall products.

3 Results

3.1 Noise wall attributes

Desktop research and stakeholder interviews were used to develop a summary of the characteristics of the five noise wall types. The results of this research are summarised in the following sections.

3.1.1 Concrete noise walls

Table 3 – Desktop research: Concrete noise walls

Criteria	Discussion
Noise reduction potential	• No sound passing through
Thermal mass	• High
Local supply availability	• Yes; many local suppliers
Time of construction	• 100 days for 1,200m noise wall • Slower installation due to heavier elements, compared with other noise wall materials
Recycled content	• Typical mix may include 30% cement replacement • 5%
End of life recyclability	• Concrete can be crushed and used as aggregate
Maintenance requirements	• Minimal
Graffiti removal	• Difficult to remove graffiti • Touch-up paint is more cost-effective than cleaning
Durability	• Durable; not easy to replace when damaged • Estimated product lifetime: 50 or 100 years
Inclusion of urban design elements	• Custom texture, pattern, colour, and exterior grade paint
Dimensions	• 100 – 200mm thickness 2,400mm length • Up to 8m height
Impact resistance	• Very high

3.1.2 Lightweight concrete noise walls

Table 4 – Desktop research: Lightweight concrete noise walls

Criteria	Discussion
Noise reduction potential	• Rw 35dB - 40dB
Thermal mass	• Moderate
Local supply availability	• Yes
Time of construction	• Faster construction and installation due to being of lighter weight than precast concrete
Recycled content	• 0%

End of life recyclability	• Concrete can be crushed and used as aggregate
Maintenance requirements	• Minimal
Graffiti removal	• Anti-graffiti coating can be applied
Durability	• Durable; easy to replace when damaged • Resists high wind loads, vandalism, fire, and termites • Estimated product lifetime: 50 years
Inclusion of urban design elements	• Custom routed to a design
Dimensions	• 100 – 200mm thickness • Up to 6,000mm length • Up to 8m height
Impact resistance	• Very high

3.1.3 Expanded polystyrene (EPS) noise walls

Table 5 – Desktop research: Expanded polystyrene noise walls

Criteria	Discussion
Noise reduction potential	• Rw 28 – 34 dB
Thermal mass	• Low
Local supply availability	• No; available in NSW
Time of construction	• Quick and easy
Recycled content	• Recycled content in aluminium facing • 2%
End of life recyclability	• In theory, the product can be recycled but this has not been tested by the manufacturer
Maintenance requirements	• Maintenance-free
Graffiti removal	• Anti-graffiti coating can be applied
Durability	• Durable; easy to replace when damaged • High-impact resistance
Inclusion of urban design elements	• Custom texture, pattern, colour and accept all exterior grade paints
Dimensions	• 75 – 150mm thickness • Up to 4,200mm length • Up to 12m height
Impact resistance	• Moderate

3.1.4 Recycled polyethylene terephthalate (PET) noise walls

Table 6 – Desktop research: Recycled polyethylene terephthalate noise walls

Criteria	Discussion
Noise reduction potential	• Rw 29 – 45db • Absorptive • NRC rating of up to 0.9
Thermal mass	• Low
Local supply availability	• No; available in NSW and VIC
Time of construction	• Fast
Recycled content	• Aluminium facing and PET insulation • 85%
End of life recyclability	• In theory, the product can be recycled but this has not been tested by the manufacturer
Maintenance requirements	• Maintenance-free
Graffiti removal	• Anti-graffiti coating can be applied
Durability	• Durable • Estimated product lifetime unknown
Inclusion of urban design elements	• Pre-coloured, perforated aluminium outer skin
Dimensions	• 75mm – 100mm thickness • 2400 – 4,000mm length • Up to 6m height
Impact resistance	• Moderate

3.1.5 Recycled wood and plastic composite (WPC) noise walls

Table 7 – Desktop research: Recycled wood and plastic composite noise walls

Criteria	Discussion
Noise reduction potential	• No laboratory testing has been carried out to date • A similar project provides 22 Rw at 55mm thick[2], so it is expected that 31 Rw can be achieved at greater thickness
Thermal mass	• Low
Local supply availability	• Material: Yes • Noise wall product: No
Time of construction	• Fast construction
Recycled content	• Wood and plastic input materials are post-consumer recycled material • 93%

[2] https://www.permatimber.com.au/gallery/products/fencing-screening/perma-fence/

End of life recyclability	• Yes, the product can be shredded and reformed into new products
Maintenance requirements	• Maintenance-free; only repainting required
Graffiti removal	• Graffiti does not bind easily to the resin surface • Easy to clean with high-pressure water spray
Durability	• Not been tested for noise wall panels
Inclusion of urban design elements	• Custom texture, colour, design, and dimension
Dimensions	• Custom dimension available
Impact resistance	• Moderate

3.2 Life cycle assessment (LCA)

The life cycle carbon impacts of noise walls of different design and construction parameters have been assessed using the ISv2.0 Materials Calculator and data from SimaPro.

3.2.1 Base case

To be able to calculate a reduction in life cycle carbon, a suitable base case must be selected. For this study in both the LCA and costing, precast concrete was assumed to be the base case as it is the most frequently used material for noise walls in South Australia. It is also the most carbon-intensive of all the material options, even with the 25% supplementary cementitious material that was assumed for material specification.

3.2.2 Material data

GHG emission factors for the materials investigated for this project have been obtained from the following sources:

- Concrete from ISv2.0 Materials Calculator
- Precast concrete from ISv2.0 Materials Calculator
- Lightweight precast concrete from Hebel Power Panel 100mm EPD
- Expanded polystyrene wall with FC outer skin
- Recycled PET (with perforated aluminium facing) and WPC from SimaPro v9.0.0.35.

3.2.3 Travel distances

Several of the materials investigated in this study are not manufactured in South Australia. Table 8 represents assumed travel distances from where the material is currently manufactured to Adelaide.

Table 8 – Noise wall panel assumed travel distances

Material	Location	Travel distance (km)
Concrete	South Australia	100*
Lightweight concrete	South Australia	100
EPS	New South Wales	1,300
PET	Victoria	750
WPC	South Australia	100

*100km was included as a default travel distance when materials are available locally, as included in the IS v2.0 Materials Calculator.

3.2.4 Panel support system

Several assumptions were required to carry out the life cycle assessment and cost modelling. The assumptions made provide a generic evaluation of the noise wall options, ensuring that all aspects of noise wall construction were considered, including framing, transport, and foundations.

- Wall heights: 1.6m, 2.6m, and 3.6m. (These heights were selected to align with common module sizes of the pre-formed noise wall products)
- Wind loading: 41m/s.
- Framing: Assumed to be steel framing.
- Spacing of supports: 3m centres.

As the purpose of this study is to provide a comparison between differing noise wall systems, the support system included is a conservative, generic approach and is the same between noise wall options. If a more accurate analysis is required, with consideration of more refined versions of the support system of the noise walls, detailed structural calculations will be necessary.

Table 9 – Life cycle assessment results (per linear meter of wall installed)

Reference	Noise wall option	Height (m)	GHG emissions (tCO2-e)	GHG emissions reduction vs base case (tCO2-e)	% GHG emissions reduction
C1.6	Precast concrete	1.6	0.36		
C2.6	Precast concrete	2.6	0.56		
C3.6	Precast concrete	3.6	0.81		
LC1.6	Lightweight precast concrete	1.6	0.29	0.05	16%
LC2.6	Lightweight precast concrete	2.6	0.44	0.08	15%
LC3.6	Lightweight precast concrete	3.6	0.65	0.10	13%
EP1.6	Expanded polystyrene wall with FC outer skin	1.6	0.25	0.09	27%
EP2.6	Expanded polystyrene wall with FC outer skin	2.6	0.31	0.21	40%
EP3.6	Expanded polystyrene wall with FC outer skin	3.6	0.57	0.19	25%
PET1.6	Recycled PET with perforated aluminium facing	1.6	0.18	0.16	46%
PET2.6	Recycled PET with perforated aluminium facing	2.6	0.26	0.26	50%
PET3.6	Recycled PET with perforated aluminium facing	3.6	0.46	0.29	39%
WPC1.6	Recycled wood and plastic composite	1.6	0.21	0.13	39%
WPC2.6	Recycled wood and plastic composite	2.6	0.30	0.23	43%
WPC3.6	Recycled wood and plastic composite	3.6	0.51	0.25	33%

3.3 Costing

The overall cost of supplying and maintaining the noise-reduction wall options was calculated on a **per linear metre basis**. As no operational expenditure or capital replacement is required in the 50-year life span of the noise-reduction wall options, the cost per linear metre was calculated as the initial capital cost of each option.

Table 10 – Life cycle costing results (per linear meter of wall installed)

Reference	Noise wall option	Height (m)	Cost	Cost compared to base case	% cost increase/reduction
C1.6	Precast concrete	1.6	$846.87	-	-
C2.6	Precast concrete	2.6	$1,025.96	-	-
C3.6	Precast concrete	3.6	$1,270.98	-	-
LC1.6	Lightweight precast concrete	1.6	$660.26	-$186.61	-22%
LC2.6	Lightweight precast concrete	2.6	$931.15	-$94.80	-9%
LC3.6	Lightweight precast concrete	3.6	$1,229.57	-$41.40	-3%
EP1.6	Expanded polystyrene wall with FC outer skin	1.6	$560.04	-$286.83	-34%
EP2.6	Expanded polystyrene wall with FC outer skin	2.6	$639.09	-$386.87	-38%
EP3.6	Expanded polystyrene wall with FC outer skin	3.6	$958.58	-$312.40	-25%
PET1.6	Recycled PET with perforated aluminium facing	1.6	$955.79	$108.92	13%
PET2.6	Recycled PET with perforated aluminium facing	2.6	$1,403.84	$377.89	37%
PET3.6	Recycled PET with perforated aluminium facing	3.6	$1,752.38	$481.40	38%
WPC1.6	Recycled wood and plastic composite	1.6	$1,539.79	$692.92	82%
WPC2.6	Recycled wood and plastic composite	2.6	$2,261.18	$1,235.23	120%
WPC3.6	Recycled wood and plastic composite	3.6	$2,985.91	$1,714.93	135%

At a high level, the lightweight concrete and expanded polystyrene products were less expensive than the reference case of concrete, irrespective of wall height.

It should be noted that the PET and WPT options are a newly developed product, and prices may decrease as the product becomes more widely used and produced in larger volumes. It is recommended to reassess the costs in a couple of years to account for any changes in the market.

3.4 Suitability analysis

To perform the suitability analysis, the results of this study have been combined into a single table for each wall height option. This will allow the comparison of materials for a noise wall application.

3.4.1 1.6m wall

Table 11 provides an overview of the suitability analysis for a 1.6m high noise wall. All the materials investigated provide a carbon reduction when compared with the base case of precast concrete. PET and WPC provide a greater carbon saving than lightweight concrete and EPS but cost more to install.

Table 11 – Suitability analysis of 1.6m noise wall material options (per linear meter)

1.6m Wall	Concrete	Lightweight concrete	EPS	PET	WPC
Carbon Impact (tCO2-e)	0.36	0.29	0.25	0.18	0.21
Carbon reduction (%)	0%	16%	27%	46%	39%
Whole of life costing ($)	$847	$660	$560	$956	$1,540
Cost difference (%)	-	-22%	-34%	13%	82%
Cost of abatement ($/kg)		-$3.41	-$3.15	$0.69	$5.24
Best acoustic Performance (Rw)	34dB	40dB	34dB	45dB	TBC
Thermal mass	High	High	Moderate	Moderate	Moderate
Local supply availability	Yes	Yes	No	No	Yes
Time of construction	Slow	Moderate	Quick	Quick	Quick
Maintenance requirements	None	None	None	None	None
Graffiti removal	Yes	Yes	Yes	Yes	TBC
Durability	High	High	Medium	Medium	Medium
Inclusion of urban design elements	Yes	Yes	No	No	Yes
Compliant with DPTI specifications	None	None	None	None	TBC
Recycled content	5%	0%	5%	85%	93%
End of life recyclability	Can be crushed for aggregate	Crushed for aggregate	TBC by manufacturer	TBC by manufacturer	Yes – new product can be formed

3.4.2 2.6m wall

The results for the 2.6m wall are similar to those for the 1.6m wall, as shown in **Error! Reference source not found.**. In fact, the carbon saving and cost-saving attributes of EPS increased at the higher wall height.

Table 12 – Suitability analysis of 2.6m noise wall material options (per linear meter)

2.6m Wall	Concrete	Lightweight concrete	EPS	PET	WPC
Carbon Impact (tCO2-e)	0.56	0.44	0.31	0.26	0.30
Carbon reduction (%)	0%	15%	40%	50%	43%
Whole of life costing ($)	$1,026	$ 931	$639	$1,404	$2,261
Cost difference (%)	-	-9%	-38%	37%	120%
Cost of abatement ($/kg)		-$1.18	-$1.85	$1.45	$5.47

Best acoustic Performance (Rw)	34dB	40dB	34dB	45dB	TBC
Thermal mass	High	High	Moderate	Moderate	Moderate
Local supply availability	Yes	Yes	No	No	Yes
Time of construction	Slow	Moderate	Quick	Quick	Quick
Maintenance requirements	None	None	None	None	None
Graffiti removal	Yes	Yes	Yes	Yes	TBC
Durability	High	High	Medium	Medium	Medium
Inclusion of urban design elements	Yes	Yes	No	No	Yes
Compliant with DPTI specifications	None	None	None	None	TBC
Recycled content	5%	0%	5%	85%	93%
End of life recyclability	Can be crushed for aggregate	Crushed for aggregate	TBC by manufacturer	TBC by manufacturer	Yes – new product can be formed

3.4.3 3.6m wall

The results of the 3.6m analysis (Table 13) begin to show reduced carbon reduction through alternative panel material selection, as the carbon impacts of the framing and foundations become more significant.

Table 13 – Suitability analysis of 3.6m noise wall material options (per linear meter)

3.6m Wall	Concrete	Lightweight concrete	EPS	PET	WPC
Carbon Impact (tCO2-e)	0.81	0.65	0.57	0.46	0.51
Carbon reduction (%)	0%	13%	25%	39%	33%
Whole of life costing ($)	$1,271	$1,230	$959	$1,752	$2,986
Cost difference (%)	-	-3%	-25%	38%	135%
Cost of abatement ($/kg)		-$0.41	-$1.68	$1.64	$6.88
Best acoustic Performance (Rw)	34dB	40dB	34dB	45dB	TBC
Thermal mass	High	High	Moderate	Moderate	Moderate
Local supply availability	Yes	Yes	No	No	Yes
Time of construction	Slow	Moderate	Quick	Quick	Quick
Maintenance requirements	None	None	None	None	None
Graffiti removal	Yes	Yes	Yes	Yes	TBC
Durability	High	High	Medium	Medium	Medium
Inclusion of urban design elements	Yes	Yes	No	No	Yes
Compliant with DPTI specifications	None	None	None	None	TBC
Recycled content	5%	0%	5%	85%	93%
End of life recyclability	Can be crushed for aggregate	Crushed for aggregate	TBC by manufacturer	TBC by manufacturer	Yes – new product can be formed

4 Research and development funding in South Australia

DPTI has expressed an interest in supporting local businesses in developing noise wall products that reduce carbon and provide a market for recycled materials.

There is a high level of confidence that a compliant WPC product can be delivered which meets DPTI's requirements, but further testing will be required, specifically.

- Rw (Weighted noise resistance)
- Impact testing

To support further research, there are several funding opportunities that local suppliers may wish to consider, as discussed in the sections below.

4.1.1 Circular Economy Market Development Grants – Green Industries SA

The grant program will assist South Australian companies, local authorities, organisations, and research institutes to further their market development efforts associated with recycled materials and recycled-content products within the current challenging environment, and to transition to a more circular economy business model.

Eligibility: Local councils, industry associations, not-for-profit organisations, research institutes, and businesses that produce, manufacture, sell or promote South Australian recycled materials and/or recycled-content products.

Value: Up to $100,000 per applicant.

Further information: https://www.greenindustries.sa.gov.au/market-development-grants

4.1.2 Valuing Business Waste Grants – Green Industries SA

The grant program will support South Australian businesses to identify better ways to manage waste and transition to a circular economy. Projects should focus on identifying ways to recover materials for beneficial or higher-value reuse and increase the amount of waste diverted from landfills, prioritising waste avoidance, reduction, reuse, and recycling.

Eligibility: Businesses, not-for-profit organisations, tertiary education centres, and government organisations.

Value: Up to $15,000 per applicant.

Further information: https://www.greenindustries.sa.gov.au/business-waste

4.1.3 Planning and Development Fund – DPTI

The grant program supports a range of local government projects, including the revitalisation of reserves, redevelopment of main street and town centre precincts, and development of safe shared-use trails for local communities.

Further information: https://www.dpti.sa.gov.au/updates/news_item?a=568405

6 Conclusions and next steps

The results of the sustainability analysis show that all five of the materials that have been investigated are suitable for noise wall applications, including acoustic performance. All established products comply with the DPTI requirements and can be adapted for specific locations and dimensions. The key differences between the material types that need to be considered when selecting the most suitable for a location and application are:

- Cost
- Carbon reduction
- Average cost of carbon abatement
- Recycled content
- Impact resistance.

Table 14 provides a summary of the key differences, averaged across the three different wall heights that were investigated in this study.

Table 14 – Summary of key noise wall material features

	Average cost difference	Average carbon reduction	Average cost of abatement ($/kg CO_2)	Typical % recycled content	Impact resistance	Comments
Precast concrete	-	-	-	5%	High	• Very high impact resistance • Can be used as a barrier
Lightweight concrete	-11%	15%	-$2.29	0%	High	• High impact resistance • Reduced carbon and cost
EPS	-32%	31%	-$2.22	5%	Moderate	• Carbon and cost savings
PET	29%	45%	$1.26	80%	Moderate	• Highest carbon reduction
WPC	112%	38%	$5.86	93%	Moderate	• High carbon reduction • New material, under development

6.1.1 Precast concrete

Precast concrete noise walls are a well-known product, offering excellent noise reduction performance and can be customised for a project. If a noise wall is required to also act as a physical barrier, precast concrete may be the most suitable option.

However, it has the highest carbon impact of all the materials investigated and can be slower and more labour-intensive to construct.

6.1.2 Lightweight concrete

Lightweight concrete noise walls offer most of the benefits of precast concrete, but in addition provide a carbon and cost saving when compared with traditional precast concrete.

This study suggests that lightweight concrete should be considered as a lower carbon and lower cost option when a noise wall is also required to act as a physical barrier, with a reduced impact resistance of standard concrete.

6.1.3 Expanded polystyrene (EPS)

The EPS system offers the greatest reduction in cost and a significant reduction in carbon. This product will be suitable for applications where the noise wall is not required to be a barrier.

This product is not yet available in South Australia. However, there are significant carbon savings even when the impact of transportation is taken into account.

It should be noted that the relative reduction in carbon estimated in this report is less than that reported in the recent Review of Emissions Reduction Opportunities[3] developed for the DPTI. This is due to taking into consideration the supporting structure and foundations required for noise wall construction, and the carbon emissions associated with transportation from NSW.

6.1.4 Recycled polyethylene terephthalate (PET)

PET is a new noise wall product that is currently available in New South Wales and Victoria. As it is manufactured from recycled waste product, the embodied carbon is extremely low. Given time, it is likely that the price of this product will reduce. This material represents a good option for achieving both circular economy and carbon reduction objectives.

6.1.5 Recycled wood and plastic composite (WPC)

WPC is a material that is produced in South Australia, by recycling local waste materials. As yet, the acoustic performance (Rw) of the material has not been tested, but it is expected that a noise wall that is compliant with the DPTI requirements can be made.

It offers significant carbon savings and circular economy benefits, but as a new product it also currently has the highest cost of all the noise wall materials studied. With further product development and testing, it may be possible to reduce the cost of this locally produced product, making it a viable, low-carbon noise wall material.

6.2 Recommendations for reducing carbon through noise wall material selection

This study has demonstrated that there are several alternative noise wall materials that can reduce embodied carbon and utilise recycled materials, while meeting DPTI's functionality requirements.

The recommendations of this report are discussed in the following sections.

6.2.1 Raise awareness of alternatives to concrete for noise wall construction

This study has found that there are several alternatives to precast concrete for noise wall construction that have sustainability and cost benefits, but to date the have not been widely used. It is recommended that infrastructure project teams within South Australia are made aware of the sustainability, buildability, and cost benefits of alternative noise wall materials. This can be achieved by publishing this report, and the factsheet for infrastructure projects, included in Appendix A.

6.2.2 Include noise wall material options assessment in project requirements

It is recommended that DPTI to consider requiring projects to undertake a simple high-level options assessment when deciding on material choice for a noise wall. This could be incorporated into the requirements of the DPTI Sustainability Manual, and PC-ST1 Sustainability in Design Master specification (Section 7, Estimate of Impacts and Section 2, Identification of Sustainability Initiatives)

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[3] https://www.dpti.sa.gov.au/ INF065_FinalReport_rev2.pdf

The assessment should consider the key criteria identified in this study, namely:

- Carbon impact
- Cost to install
- Noise performance
- Recycled content
- Maintenance

6.2.3 Further research into WPC suitability

WPC shows potential to be used for noise wall applications. It is recommended that further research into the suitability and noise performance of a locally produced WPC product is undertaken. This material offers significant carbon savings and can be a way of promoting a circular economy in South Australia. However, there is crucial product data, such acoustic performance, that must be produced before WPC can be widely used as a compliant noise wall product.

State government support by be available to develop this data, and examples of funding that may be applicable are included in Section 4 of this report.

Another opportunity for demonstrating the benefits of a WPC noise wall is to identify a site where the new material could be trialled. Although there would be an upfront cost, this would allow DPTI, a WPC manufacturer and a construction partner to test the manufacture, installation, and performance of a WPC noise wall.

Appendix A: Factsheet

Noise wall construction
Sustainable alternatives to precast concrete

Introduction

DPTI is committed to sustainability in the infrastructure sector. In alignment with the DPTI Sustainability Manual, infrastructure projects are encouraged to reduce their carbon emissions, while balancing economic, environmental and social needs.

The selection sustainable materials for key infrastructure elements can create a significant reduction on the carbon footprint of a project. Noise walls have been identified providing a major opportunity for carbon mitigation, without additional cost, or sacrificing on functionality.

Noise wall material options

DPTI have commissioned a study that compares the impact and feasibility of five noise wall material options. While precast concrete is the most commonly specified noise wall material in South Australia, other materials can provide carbon and cost savings.

- Precast concrete
- Lightweight concrete
- Expanded polystyrene (EPS)
- Recycled polyethylene terephthalate (PET)
- Recycled wood and plastic composite (WPC)

Key considerations in selecting noise wall material

- acoustic performance
- cost
- ease of installation and maintenance
- carbon footprint
- recycled content and end of life disposal

Lightweight concrete and EPS were found to offer reduced cost and carbon impact when compared with precast concrete. Lightweight concrete may be the most suitable option when a high impact resistance of structural strength is required.

PET and WPC provide significant carbon savings and have high recycled content, contributing to the SA Government's circular economy agenda. However as new materials the cost is currently higher than more widely used materials.

Summary of alternative noise wall material benefits and features

	Average cost difference	Average carbon reduction	Average cost of abatement ($/kg CO2)	Typical % recycled content	Impact resistance
Precast concrete	-	-	-	5%	High
Lightweight concrete	-11%	15%	-$2.29	0%	High
EPS	-32%	31%	-$2.22	5%	Moderate
PET	29%	45%	$1.26	80%	Moderate
WPC	112%	38%	$5.86	93%	Moderate

More information

- DPTI Sustainability Manual
- Noise Wall Material Lifecycle Analysis and Suitability Investigation Report

Appendix B Noise Wall materials and LCA results

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
C1.5	Precast concrete wall	Precast concrete (25% SCM)	32 MPa Reinforced precast concrete	7% reo.by mass	50	1.80	0.15	99.67	2.40	64.58	18.4	Rigid Truck	1.40
C1.5	Precast concrete wall	Steel framing 180UB18	Steel Welded Beams & Columns- Australian		100	0.18	0.09	79.73	0.02	1.44	4.1	Rigid Truck	0.00
C1.5	Precast concrete wall	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.90
C2.5	Precast concrete wall	Precast concrete (25% SCM)	32 MPa Reinforced precast concrete	7% reo.by mass	50	2.70	0.15	99.67	2.40	96.88	27.6	Rigid Truck	2.10
C2.5	Precast concrete wall	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	116.28	0.02	2.09	6.0	Rigid Truck	0.00
C2.5	Precast concrete wall	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.80	0.60	100.00	2.40	115.20	18.5	Concrete Agitator Truck	1.50
C3.5	Precast concrete wall	Precast concrete (25% SCM)	32 MPa Reinforced precast concrete	7% reo.by mass	50	3.60	0.15	99.67	2.40	129.17	36.8	Rigid Truck	2.80
C3.5	Precast concrete wall	Steel framing 200UB18.2	Steel Universal Beams & Columns		100	0.20	0.10	152.82	0.02	2.78	7.9	Rigid Truck	0.10

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO_2 eq)[1]	Transport mode	Transport impact (t CO_2 eq)[2]
C3.5	Precast concrete wall	Footing	32 MPa Reinforced concrete	7% reo.by mass	50	1.00	0.80	100.00	2.40	192.00	30.9	Concrete Agitator Truck	2.50
LC1.5	Lightweight Concrete wall	Hebel PowerPanel 100mm	Autoclaved Aerated Concrete Panel		50	1.80	0.10	99.67	1.84	33.01	11.3	Rigid Truck	0.7
LC1.5	Lightweight Concrete wall	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	79.73	0.02	1.44	4.1	Rigid Truck	0
LC1.5	Lightweight Concrete wall	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.9
LC2.5	Lightweight Concrete wall	Lightweight Concrete	Autoclaved Aerated Concrete Panel		50	2.70	0.10	99.67	1.84	49.51	17.0	Rigid Truck	1.1
LC2.5	Lightweight Concrete wall	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	116.28	0.02	2.09	6.0	Rigid Truck	0
LC2.5	Lightweight Concrete wall	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.80	0.60	100.00	2.40	115.20	18.5	Concrete Agitator Truck	1.5
LC3.5	Lightweight Concrete wall	Lightweight Concrete	Autoclaved Aerated Concrete Panel		50	3.60	0.10	99.67	1.84	66.02	22.6	Rigid Truck	1.4
LC3.5	Lightweight Concrete wall	Steel framing 200UB18.2	Steel Universal Beams & Columns		100	0.20	0.10	152.82	0.02	2.78	7.9	Rigid Truck	0.1
LC3.5	Lightweight Concrete wall	Footing	32 MPa Reinforced concrete	7% reo.by mass	50	1.00	0.80	100.00	2.40	192.00	30.9	Concrete Agitator Truck	2.5

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
EP1.5	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall core		50	1.80	0.09	99.67	0.01	1.97	7.0	Rigid Truck	0.1
EP1.5	Expanded polystyrene wall with FC outer skin	Fibre Cement	Fibre Cement			1.80	0.00	99.67	1.10	0.89	1.1		
EP1.5	Expanded polystyrene wall with FC outer skin	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	69.77	0.02	1.26	3.6	Rigid Truck	0
EP1.5	Expanded polystyrene wall with FC outer skin	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.9
EP2.5	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall core		50	2.70	0.09	99.67	0.01	2.96	10.5	Rigid Truck	0.1
EP2.5	Expanded polystyrene wall with FC outer skin	Fibre Cement	Fibre Cement			2.70	0.00	99.67	1.10	1.33	1.7		
EP2.5	Expanded polystyrene wall with FC outer skin	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	102.99	0.02	1.85	5.3	Rigid Truck	0

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
EP2.5	Expanded polystyrene wall with FC outer skin	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.9
EP3.5	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall with FC outer skin	Expanded polystyrene wall core		50	3.60	0.09	99.67	0.01	3.95	14.0	Rigid Truck	0.1
EP3.5	Expanded polystyrene wall with FC outer skin	Fibre Cement	Fibre Cement			3.60	0.01	99.67	1.10	1.97	2.4		
EP3.5	Expanded polystyrene wall with FC outer skin	Steel framing 200UB18.2	Steel Universal Beams & Columns		100	0.20	0.10	149.50	0.02	2.72	5.4	Rigid Truck	0.1
EP3.5	Expanded polystyrene wall with FC outer skin	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	1.00	0.80	100.00	2.40	192.00	30.9	Concrete Agitator Truck	2.5
PET1.5	Recycled PET with perforated aluminium facing	Recycled PET	Recycled PET (with perforated aluminium facing)		50	1.80	0.10	99.67	0.01	2.20	1.8	Rigid Truck	0
PET1.5	Recycled PET with perforated aluminium facing	Aluminium facing	Aluminium		50	1.80	0.00	99.67	0.00	0.00	<0.0		
PET1.5	Recycled PET with	Steel framing 180UB18	Steel Universal		100	0.18	0.09	69.77	0.02	1.26	3.6	Rigid Truck	0

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
	perforated aluminium facing		Beams & Columns										
PET1.5	Recycled PET with perforated aluminium facing	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.9
PET2.5	Recycled PET with perforated aluminium facing	Recycled PET	Recycled PET (with perforated aluminium facing)		50	2.70	0.10	99.67	0.01	3.67	3.0	Rigid Truck	0.1
PET2.5	Recycled PET with perforated aluminium facing	Aluminium facing	Aluminium		50	2.70	0.00	99.67	0.00	0.00	<0.0		
PET2.5	Recycled PET with perforated aluminium facing	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	109.63	0.02	1.97	2.4	Rigid Truck	0
PET2.5	Recycled PET with perforated aluminium facing	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.80	0.60	100.00	2.40	115.20	18.5	Concrete Agitator Truck	1.5
PET3.5	Recycled PET with perforated aluminium facing	Recycled PET	Recycled PET (with perforated aluminium facing)		50	3.60	0.10	99.67	0.01	5.14	4.2	Rigid Truck	0.1
PET3.5	Recycled PET with perforated	Aluminium facing	Aluminium		50	3.60	0.00	99.67	0.00	0.00	<0.0		

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
	aluminium facing												
PET3.5	Recycled PET with perforated aluminium facing	Steel framing 200UB18.2	Steel Universal Beams & Columns		100	0.20	0.10	149.50	0.02	2.69	7.7	Rigid Truck	0.1
PET3.5	Recycled PET with perforated aluminium facing	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	1.00	0.80	100.00	2.40	192.00	30.9	Concrete Agitator Truck	2.5
WP1.5	Recycled wood and plastic composite	Recycled wood and plastic composite	Recycled wood and plastic composite (WPC)		100	1.80	0.10	99.67	0.68	12.24	4.5	Rigid Truck	0.3
WP1.5	Recycled wood and plastic composite	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	69.77	0.02	1.26	3.6	Rigid Truck	0
WP1.5	Recycled wood and plastic composite	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.60	0.50	100.00	2.40	72.00	11.6	Concrete Agitator Truck	0.9
WP2.5	Recycled wood and plastic composite	Recycled wood and plastic composite	Recycled wood and plastic composite (WPC)		100	2.70	0.10	99.67	0.68	18.37	6.7	Rigid Truck	0.4
WP2.5	Recycled wood and plastic composite	Steel framing 180UB18	Steel Universal Beams & Columns		100	0.18	0.09	109.63	0.02	1.97	2.4	Rigid Truck	0
WP2.5	Recycled wood and	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	0.80	0.60	100.00	2.40	115.20	18.5	Concrete Agitator Truck	1.5

Reference	Element	Material	Standard Material	Notes	design life (years)	Height (m)	Width (m)	Length (m)	Density/ Factor	Quantity per 100m (Tonnes)	GHG emissions per 100m of noise wall (t CO2 eq)[1]	Transport mode	Transport impact (t CO2 eq)[2]
	plastic composite												
WP3.5	Recycled wood and plastic composite	Recycled wood and plastic composite	Recycled wood and plastic composite (WPC)		100	3.60	0.10	99.67	0.68	24.49	9.0	Rigid Truck	0.5
WP3.5	Recycled wood and plastic composite	Steel framing 200UB18.2	Steel Universal Beams & Columns		100	0.20	0.10	149.50	0.02	2.69	7.7	Rigid Truck	0.1
WP3.5	Recycled wood and plastic composite	Foundations	32 MPa Reinforced concrete	7% reo.by mass	50	1.00	0.80	100.00	2.40	192.00	30.9	Concrete Agitator Truck	2.5

[1]Source: GHG emissions for precast concrete, steel frames and footings from IS V2.0 Materials Calculator, for Lightweight precast concrete from Hebel Power Panel 100mm EPD, for Expanded polystyrene wall with FC outer skin, Recycled PET (with perforated aluminium facing) and Recycled wood and plastic composite from SimaPro v 9.0.0.35.

[2]Source: IS V2.0 Materials Calculato