Project 1.11.4

Benchmarking and Scaling-up Australia's Circular Economy Practices

PSG #2

Date: 17/08/2026

ACKNOWLEDGEMENTS

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Project 1.11.4 : Benchmarking and Scaling-up Australia's Circular Economy Practices

PROJECT'S AIM:

This project aims to **benchmark circular economy practices** in Australia, leveraging **a consistent framework** for a circular economy in the built environment. Specifically, it will analyse opportunities to **integrate circular economy principles and R-strategies** (e.g., reuse, refurbishment, recycling, etc.) into construction and infrastructure projects, thereby helping to **establish a circular economy ecosystem**. In addition, the project will **investigate key decision-making factors**—across social, economic, and environmental contexts—that **influence the scaling up of circular economy practices** in the built environment, to accelerate Australia's transition to a more sustainable future.

INDUSTRY OUTCOMES :

This project aims to deliver the following key industry outcomes:

1. **Actionable Policy Tools:** Ready-to-use model clauses, KPIs, and verification frameworks that enable industry and government agencies to embed CE principles in project planning and delivery.
2. **Material Reuse Systems:** Practical protocols that facilitate the reliable reuse of priority materials (e.g., bricks, timber, aggregates), creating trusted and scalable supply chains.
3. **Evidence Base for CE Value Proposition:** Demonstration of whole-life cost savings, carbon reductions, and social benefits from real-world pilots, providing the business case and replication guidance for scaling CE practices nationally.

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PROJECT'S OBJECTIVES:

Objectives of the project are to:

1. **Benchmarking Circular Economy Practices** by systematically assessing the current state of circular economy adoption, identifying gaps, enablers, and barriers across procurement, policy, material reuse, and life cycle practices.
2. **Integrate Circular Economy Principles** into Construction and Infrastructure Projects by developing and testing pathways for embedding CE principles and R-strategies (e.g., reuse, refurbishment, recycling) into procurement frameworks, material supply chains, and infrastructure delivery models.
3. **Evaluate Decision-Making Factors** for Scaling up CE by analysing socio-economic, environmental, and regulatory drivers that influence decision-making, and generate evidence on costs, carbon reduction, resilience, and social value to support widespread CE adoption.

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RESEARCH APPROACH AND METHODS:

	Benchmarking	Integration	Evaluation
	Research Questions	**Research Questions**	**Research Questions**
Questions	RQ1.1: What is the current state of the circular economy (CE) and key barriers and enablers in adoption across Australia's built environment sectors (construction and infrastructure)?	RQ2.1: How can CE principles and R-strategies (e.g., reuse, refurbishment, recycling) be effectively integrated into procurement frameworks and project delivery models?	RQ3.1: What socio-economic, environmental, and regulatory factors influence decision-making and investment in CE practices? RQ3.2: How do CE interventions affect project outcomes such as cost, carbon reduction, material efficiency, resilience, and social value?
	RQ1.2: How do current CE practices in Australia compare with international benchmarks and best practices?	RQ2.2: What pathways and tools can support the integration of CE principles across different phases of construction and infrastructure projects (design, delivery, operation, end-of-life)?	RQ3.3: What policy, business model, and governance mechanisms are needed to scale CE adoption nationally?
Methods	• Comprehensive literature review through SLR • Data mapping and gap analysis • Industry survey and interviews • Benchmarking framework	• Case study analysis • Co-design workshops • Pilot testing	• Focus group interviews • Decision-making analysis • Guideline development

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Case Studies

	Case Study 1 (WA)	Case Study 2 (NSW)	Case Study 3 (QLD)
Case Studies	Co-Creating Circular Design Standards for Pre-cast Systems: Aligning Stakeholder Priorities in the Construction Value Chain	Circular Economy Pathways for TfNSW: Optimising Material Reuse and Asset Lifecycle Value	Due to the Data Privacy Agreement, the project team will report the progress separately
Key Focus	The case study aims to develop a standardised design guideline that embeds core circularity principles, including design for disassembly and reuse, modularisation and material efficiency, low-carbon mix design, alternative materials, and long-term durability and adaptability.	The study aims to benchmark existing reuse, refurbishment, and recycling practices within the NSW rail network against national and international best practice and assess the potential for higher-order R-strategies (e.g., reuse, repurpose, remanufacture) to extend asset life and reduce waste.	Due to the Data Privacy Agreement, the project team will report the progress separately
Stakeholders	Precast designers, manufacturers, engineers, architects, builders, clients, regulators, and recyclers, etc.	NSW Transport, Sydney Rail, Ballast suppliers, Infrastructure NSW, Suppliers & Manufacturers, Asset Managers, Engineers, TfNSW, Standards bodies, Contractors, etc.	Due to the Data Privacy Agreement, the project team will report the progress separately

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Ethics Approval Secured
(Ready for data collection)

https://curtin.au1.qualtrics.com/jfe/form/SV_5uUvPK5YyIcb7ts

Australian Circular Economy Industry-Readiness Survey

Insert Survey QR Code and Link for Circulation

Project 1.11.4 : Case Study WA (Atlas Precast)

Atlas Pre-case Case Study in WA:

Co-Creating Circular Design Standards for Pre-cast Systems: Aligning Stakeholder Priorities in the Construction Value Chain

Overall Goal:

To develop a standardised, industry-aligned design framework that enhances the circularity of pre-cast concrete products by integrating multi-stakeholder priorities across the construction value chain. This framework aims to support Atlas Pre-cast in improving resource efficiency, reducing environmental impacts, and aligning with emerging circular economy principles, future regulatory expectations, and market demand for low-carbon, circular construction materials.



Case Study Approach:

Literature Review → **Multi-stakeholders Interview** → **Co-design workshop** → **Gap Analysis and Benchmarking**

Literature Review Preliminary Findings: #1

Circular Design Principles Are Well Established, but Implementation Remains Fragmented

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Where the Literature Agrees

Strong agreement on the circular design principles applicable to precast concrete systems:

- Design for Disassembly
- Design for Adaptability
- Modularity
- Standardisation
- Material Efficiency
- Design for Reuse
- Lifecycle Thinking
- Waste Prevention

No common implementation pathway was identified.

Where Approaches Diverge

Implementation approaches vary considerably — different studies combine:

- *BIM*
- *Material Passports*
- *Digital Twins*
- *LCA*
- *LCC*
- *MCDA*
- *Bespoke frameworks*

The literature has largely reached consensus on what circular design should achieve — but not how it should be consistently implemented across projects or organisations.

Literature Review Preliminary Findings: #2

Benchmarking Is Inconsistent Across the Literature

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Key Benchmarking Domains

Although benchmarking is widely used, studies benchmark different aspects of performance:

- **Resource Circularity:** material efficiency, waste reduction, recycled content, recovery potential
- **Circular Design:** adaptability, deconstructability
- **Environmental:** GWP, embodied energy, acidification, resource depletion
- **Economic & Delivery:** construction cost, whole-life cost, construction duration
- **Info & Decision Support:** traceability, composite sustainability, stakeholder-weighted assessment

But Measured Differently

Studies employ different measures — even when assessing similar concepts:

- Indicators
- Metrics
- Reporting units
- Functional units
- Lifecycle boundaries

Benchmarking is fragmented rather than standardised: two studies may benchmark the same concept while using completely different measurement approaches.

Literature Review Preliminary Findings: #3

The Indicator-Level Dataset Demonstrates a Lack of Harmonisation

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Inconsistencies Identified

Analysis of the indicator-level dataset revealed that many studies:

- Report multiple indicators together
- Use different reporting units
- Omit functional units
- Adopt different system boundaries

What Indicators Must Share

Indicators cannot be compared unless they first share:

- Common definitions
- Common metrics
- Common reporting units
- Common functional units
- Common lifecycle boundaries

E.g. "Material Efficiency" was used to describe material reduction, lightweighting, waste minimisation, and resource productivity, depending on the study

The main barrier to benchmarking is semantic inconsistency — rather than the absence of indicators

Literature Review Preliminary Findings: #4

The Literature Supports Development of a Standardised Benchmarking Framework

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The Building Blocks Exist

Collectively, the reviewed studies demonstrate that:

✓ Circular design principles exist

✓ Benchmarking indicators exist

✓ Assessment tools exist

✓ Digital technologies exist

What the Next Framework Needs

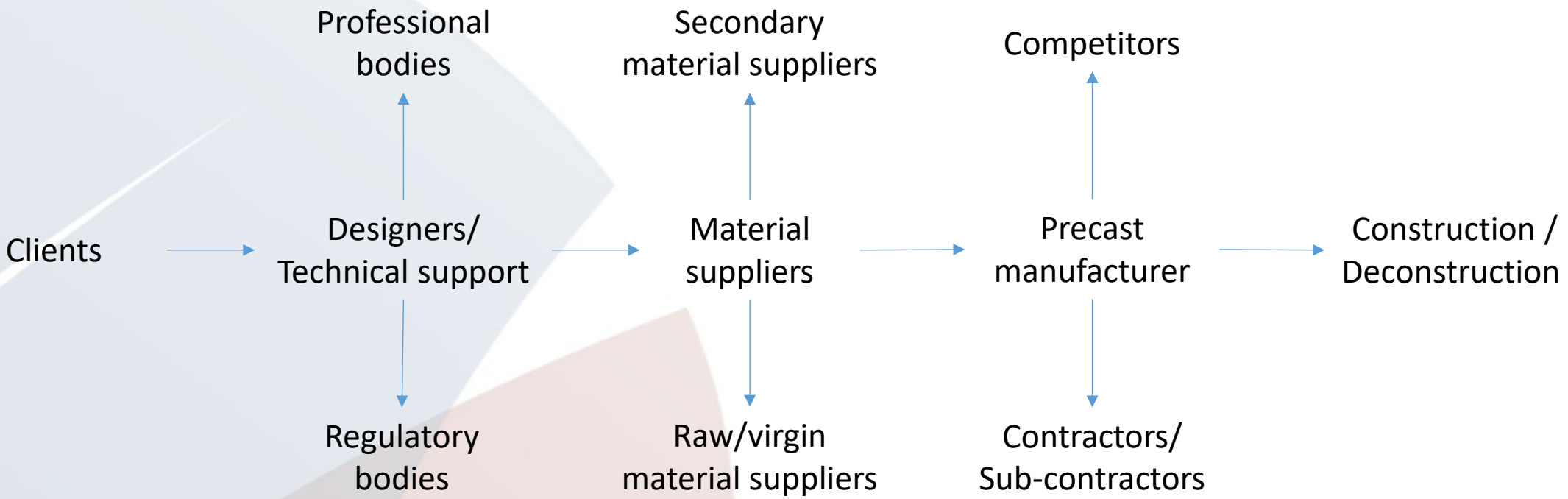
The next phase should develop and validate a framework that:

- Aligns stakeholder priorities
- Standardises indicator definitions
- Harmonises metrics and reporting
- Supports practical implementation within Australian precast concrete manufacturing

No study integrates all elements into one framework; few validate with industry stakeholders; and Australian evidence is particularly limited

The literature provides the building blocks for implementation — but not the implementation framework itself — using Atlas Precast as the industry case study

Preliminary Stakeholders Mapping



Project 1.11.4 : Case Study TfNSW (Railway)

Circular Economy Pathways for TfNSW:

Optimising Material Reuse and Asset Lifecycle Value

Overall Goal:

- *Benchmark current circular economy practices in NSW rail.*
- *Identify priority rail materials with the greatest circularity potential.*
- *Develop practical decision-support recommendations for TfNSW.*



Railways of NSW(Suburban): establishment and construction from first opening in 1855 to 1875.
(Source: https://www.transport.nsw.gov.au)

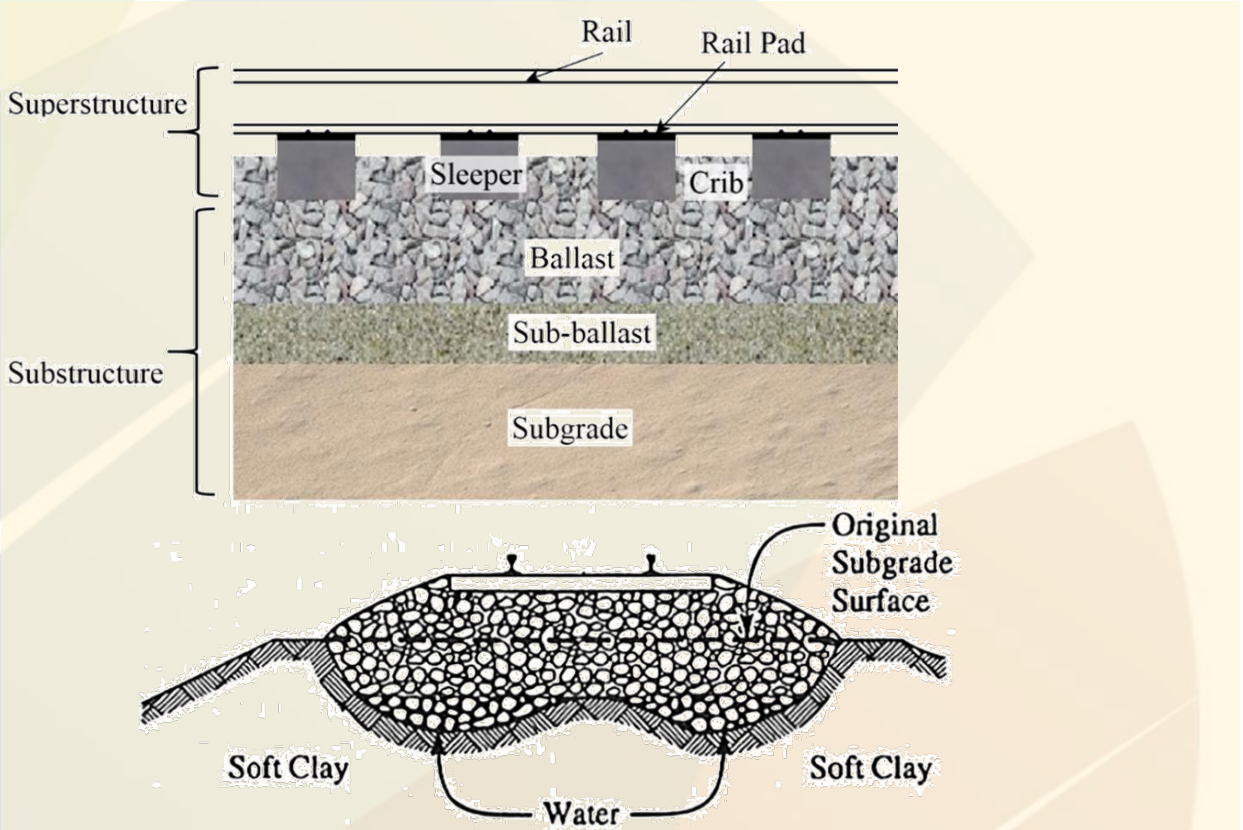
Case Study Approach:

Literature Review → **Candidate materials (Hotspot Prioritisation)** → **Stakeholders Interviews** → **Gap Analysis** → **Recommendation**

Case study of TfNSW:

Broad rail network across NSW

All Modes | Train | Metro | Bus | Light Rail | Ferry



Typical ballasted railway track. Cross and Longitudinal section-(Source: Sayeed, Md. Abu, 2016)



(Source: https://www.transport.nsw.gov.au/projects/current-projects/regional-rail)

Literature Review Preliminary Findings: #1

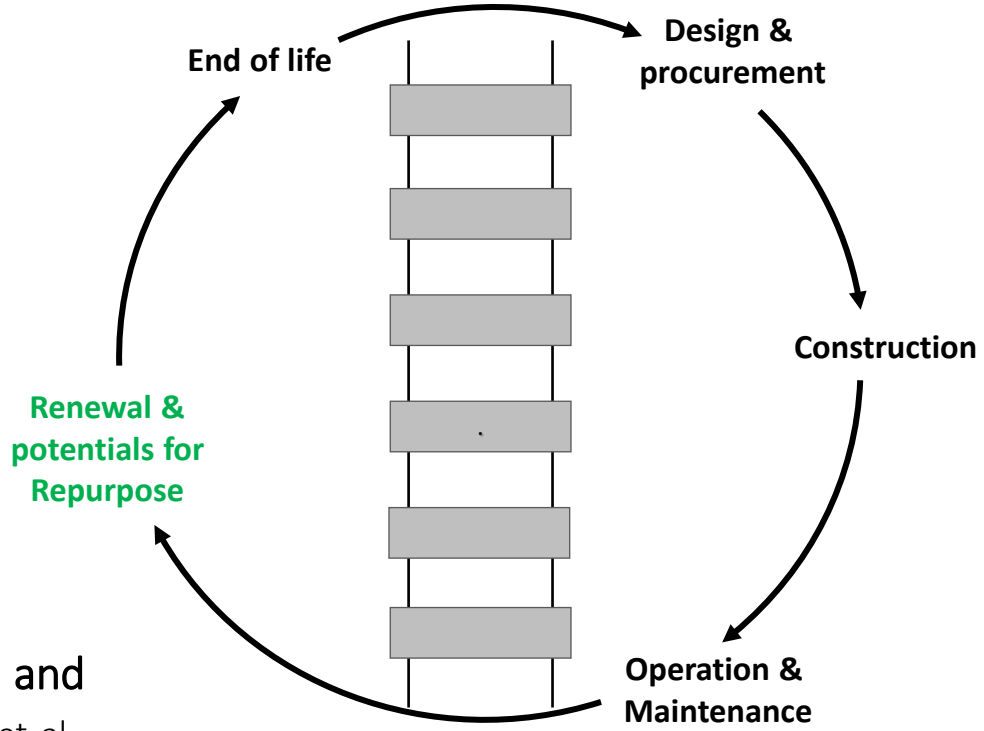
Highlighting literature findings:

Very limited CE research in Rail infrastructure in compared to building sector (Oleary et al., 2024)

- *decision-making*
- *asset management*
- *stakeholder collaboration*
- *lifecycle implementation*

Rail requires a system thinking approach (Waring and Liyanage,2026).

- *Maintenance, renewal & upgrades are key CE intervention points*



Successful CE implementation depends on technical, organisational and governance factors, not technical solutions alone (Oleary et al., 2024, Tan et al., 2026, ARS, 2026).

Literature Review Preliminary Findings: #2

Different Railway materials require different circular pathways

Candidate Materials and Asset Stream

High volume materials



Railway Ballast

- *Largest material volume*
- *High reuse, repurpose, recycle potential*



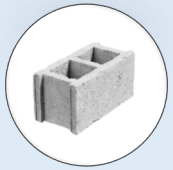
Rail sleepers
(Concrete, steel, Timber)

- *High material volume*
- *Reuse, repurposing, recycle potential*



Steel Rails & fasteners

- *High recycling value*
- *Downgrade reuse, Repurposing, recycle*



Concrete Elements

- *Large Material volume*
- *Reuse, repurposing, recycle potential*

Complex and high value asset



Copper cabling

- *High material value*
- *Recycle potential, Limited reuse*



ETCs & signalling

- *High asset value*
- *Reuse, refurbishment, recertification, spare-parts recovery, e-waste recycling*



Electrical & Mechanical

- *High asset value*
- *Repair, rebuilding, refurbishment, remanufacturing, spare-parts recycling*

No single circular strategy fits all railway assets. Different materials require different circular pathways.

Literature Review Preliminary Findings: #3

What are leading international rail organisation doing?

Targets & Governance	• *Measurable reuse & landfill diversion targets*
Circular procurement	• *CE criteria embedded in tenders*
Material Hubs	• *Recover, grade & redistribute assets*
Digital Exchanges	• *Digital material exchange, internal asset register*
Whole life carbon	• *Assess lifecycle carbon, not just waste*



Source: Network Rail (2025), The Greener Railway Strategy

International rail organisations are increasingly treating CE as a strategic asset-management issue rather than only a waste-management activity.

Existing Australian case studies: #4

ARTC Cabramatta Loop Project

- Crushed concrete spoil onsite and reused it as structural fill;
- Screened and reused ballast;
- Reused existing rail sleepers;
- Saved under $15 million;
- Avoided around 900 truck movements.

Metro Trains Melbourne Project

- Used asphalt with 30% recycled material and
- introduced condition-based wheel profiling that extended wheel life and saved approximately 530 tonnes of steel

PTA WA Byford Rail Extension Project

- Around 400 pre-used sleepers donated to heritage rail,
- some sleepers also reused within project operations.

Aurizon Material Flow Analysis

- Material-flow analysis supported reuse and recycling of ballast, sleepers and timber pallets;
- 87% of ballast was transferred to local landowners,
- 100% of concrete sleepers were crushed and reused.

PowerRail Australia

- Repair, rebuilding and refurbishment
- Extended asset life
- Diverted over 75 tonnes of material from landfill

Cross River Rail

- Used crushed recycled glass for pipe and cable embedment and bedding sand.
- Used recycled HDPE TufDuct cable troughs and composite fibre rail corridor components

Regional Rail Revival Program

- Used recycled plastic conduits,
- Reused more than 2.5 km of serviceable rail strings, used reclaimed asphalt pavement,
- Installed Duratrack composite sleepers made from 85% recycled plastic.

Sydney Road Asset Performance Contract

- Used crumb rubber asphalt on NSW State Road
- Incorporated reclaimed asphalt pavement in annual asphalt use.

CE practices is already happening in Australia

Industry report Findings: #5

Gaps and Inconsistency



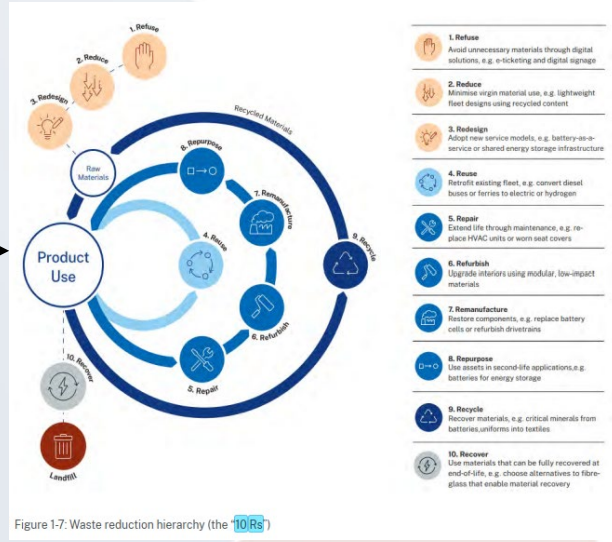


Figure 1-7: Waste reduction hierarchy (the "10 Rs")

1. Refuse
Avoid unnecessary materials through digital solutions, e.g. e-ticketing and digital signage

2. Reduce
Minimise virgin material use, e.g. lightweight fleet designs using recycled content

3. Redesign
Adopt new service models, e.g. battery-as-a-service or shared energy storage infrastructure

4. Reuse
Retrofit existing fleet, e.g. convert diesel buses or ferries to electric or hydrogen

5. Repair
Extend life through maintenance, e.g. re-place HVAC units or worn seat covers

6. Refurbish
Upgrade interiors using modular, low-impact materials

7. Remanufacture
Restore components, e.g. replace battery cells or refurbish drivetrains

8. Repurpose
Use assets in second-life applications,e.g. batteries for energy storage

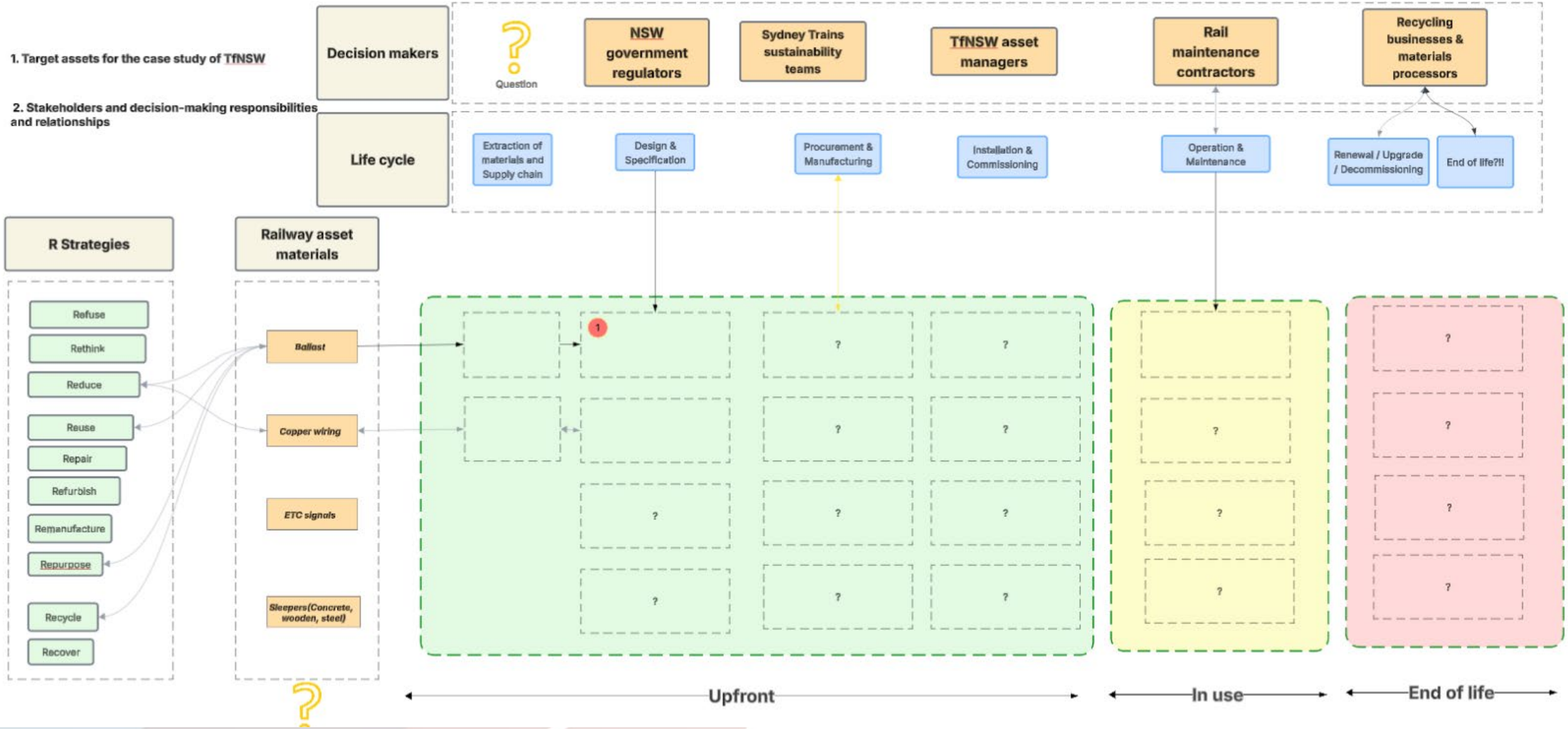
9. Recycle
Recover materials, e.g. critical minerals from batteries,uniforms into textiles

10. Recover
Use materials that can be fully recovered at end-of-life, e.g. choose alternatives to fibre-glass that enable material recovery

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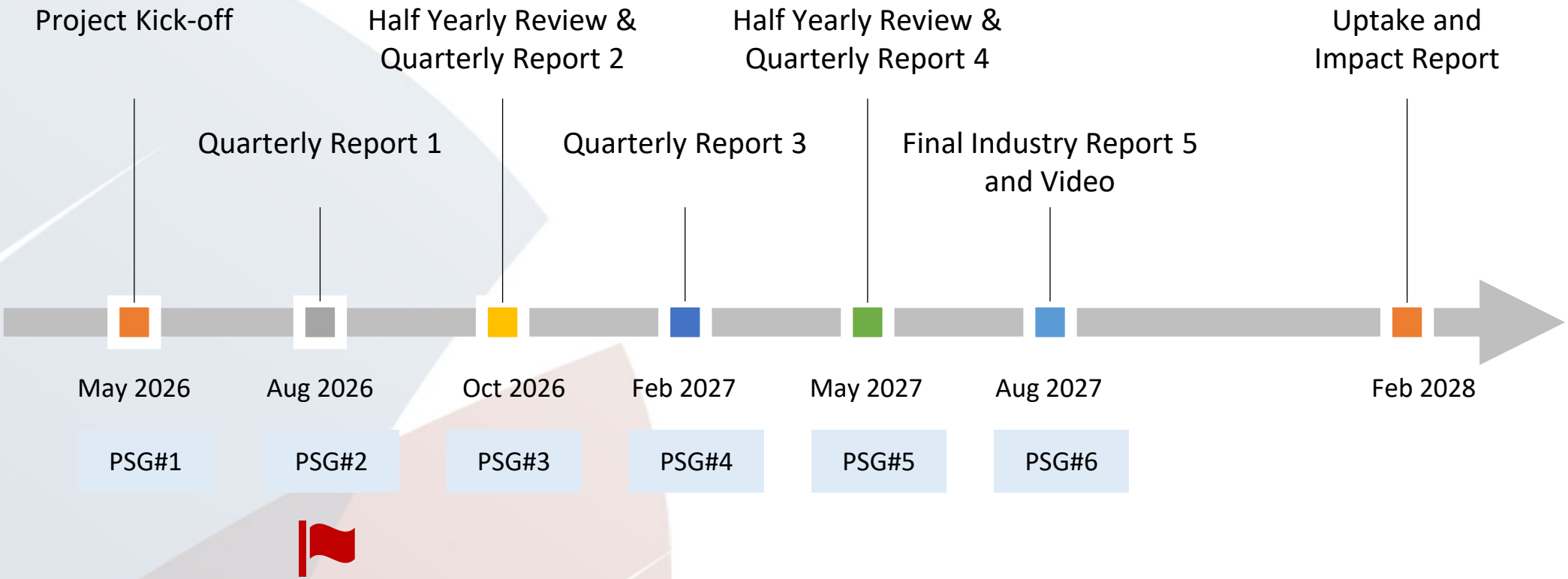
If circular strategies are not consistently defined, how can they be consistently applied in practice?

Preliminary Stakeholders Mapping



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Project Timeline (Attachment D)



P1.11.4: Project timeline and key deliverables