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Abbreviations

4WD	Four-wheel drive
AAC	Ashburton Aboriginal Corporation
ABS	Australia Bureau of Statistics
ATRA	Australian Tyre Recyclers Association
CaLD	Culturally and Linguistically Diverse
CEFC	Clean Energy Finance Corporation
CME	Chamber of Minerals and Energy
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUSP	Curtin University Sustainability Policy Institute
CWTS	Controlled Waste Tracking System
DAWE	Department of Agriculture, Water and Environment
DIA	Department of Indigenous Affairs (WA)
DOC	Department of Communities (WA)
DOH	Department of Health (WA)
DPC	Department of Premier and Cabinet (WA)
DWER	Department of Water and Environmental Regulation (WA)
EMRC	Eastern Metropolitan Regional Council
EOLT	End-of-life tyre
EPA	Environment(al) Protection Authority
KDC	Kimberley Development Commission
KLC	Kimberley Land Council
LGA	Local Government Association
MRC	Mindarie Regional Council
NC	Not collected
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
OECD	Organisation for Economic Cooperation and Development
OTR	Off-the-road
PMC	Department of Prime Minister and Cabinet of Australia
POA	Price on asking
REMS	Remote and Essential Municipal Service

RET	Renewable Energy Target
RMF	Recycling Modernisation Fund
RRC	Rivers Regional Council
RV	Recreational vehicle
SUV	Sport utility vehicle
TDF	Tyre derived fuel
TPA	Tonnes per annum
TPSS	Tyre Product Stewardship Scheme
TSA	Tyre Stewardship Australia
VAGO	Victorian Auditor-General's Office
WA	Western Australia
WALGA	Western Australian Local Government Association
WARDT	Western Australian Regional Development Trust
WARR	Waste Avoidance and Resource Recovery Act
WMRC	Western Metropolitan Regional Council
WtE	Waste-to-Energy

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Executive summary

End-of-life tyre (EOLT) and conveyor belt management in Western Australia (WA) is a challenging and dynamic area of waste management, which disproportionately impacts regional centres, where waste generators have few incentives to manage these wastes for resource recovery. Improper management of EOLT and conveyor belts can have negative impacts on the associated environmentally and culturally sensitive regions in WA, and more work is required to develop new ways to extend the life of these materials, either through re-treading and repair, or recycling to recover materials that would otherwise be lost permanently from our economy. As more funding and investment opportunities arise in response to the drivers to meet resource recovery targets, new markets for the reuse of materials recovered from EOLT and conveyor belts need to be developed and enabled. This can be achieved through the development of appropriate policy and economic levers, evidence-based decision-making, and relevant industry and community engagement to realise the economic potential for the development of WA's EOLT and conveyor belt industry in regions where these wastes are predominantly generated.

This project was jointly funded by the Australian Government's National Environmental Science Program, WA Department of Water and Environmental Regulation (DWER), Waste Authority, Tyre Stewardship Australia (TSA); Commonwealth and Industrial Research Organisation (CSIRO) and Curtin University, and the project explored opportunities for increasing value recovery from EOLT and conveyor belts in WA. The approach included reviewing relevant regulatory and policy related to the management and disposal of EOLT, reviewing data on EOLT and conveyor belt arisings in WA on a regionally specific basis, and comparing the data with current and planned processing capacity. By generating an understanding of the arisings and fate of EOLT and conveyor belts, we identified gaps, barriers, and opportunities for developing market potential for recycled materials produced from EOLT and conveyor belts in WA.

We identified challenges to the management of EOLT that could be addressed through renewal of EOLT and conveyor belt management policy and regulation that would enable appropriate management and disposal of these materials across WA. A literature review showed that while technology is not a limiting factor for EOLT recycling or extension of life, the access to and implementation of technology at scale and in a manner suitable for regional WA is a challenge. A review of available arisings and regional economic and population data show that there are regionally specific opportunities for the development of EOLT re-treading and conveyor belt repair and recycling processes, especially in regional centres in the Goldfields Esperance, Gascoyne, and Pilbara regions, that would support resource recovery from mining and other predominant industries in those regions. However, the lack of data related to EOLT arisings, and the regulatory loopholes that allow on-site disposal by burial of these wastes are key barriers to understanding material flows and the development of regional EOLT and conveyor belt processing facilities.

A summary of the key findings on current barriers for value recovery are shown in Table 1 below.

Table 1. Summary of key findings on current barriers for value recovery from end-of-life tyres and conveyor belts in Western Australia.

Inconsistency of classification of end-of-life tyre (EOLT) arisings and related data This results in a lack of understanding about the types of EOLTs being generated, the fate of these arisings and the processing requirements (e.g., technology, capacity) for recycling at the end of life	**Conveyor belts are not currently classified as controlled wastes** Therefore, there is no existing mandate for the reporting of conveyor belt transports, and thus no data about conveyor belt arisings, which makes is impossible to determine the required processing capacity for the possible feedstock or develop markets for the end products.
No quality standards for imported tyres and conveyor belts in Australia As a result some tyres are not suitable for re-treading, and impact the efficiency of current recycling processes due to low quality tyres in feedstocks	**No mandatory product stewardship scheme for tyres and conveyor belts** As a result, some imported tyres and conveyor belts are not captured under the voluntary product stewardship scheme, reducing the funding available for value recovery.
Regional landfilling and on-site disposal by burial of EOLTs and conveyor belts is not restricted in WA This results in the permanent loss of materials from our economy and has unknown impacts on the Australia's unique biodiversity and the health of ecosystems, as well as co-located Indigenous communities.	**No incentives for returning EOLTs and conveyor belts for value recovery** This can lead to illegal dumping, or on-site disposal or management of these materials (e.g., EOLTs used on farm for silage).
No incentives for re-treading EOLTs in WA The market demand for re-treading has decreased because it is considered cheaper to purchase new tyres than extend the life of in-use tyres.	**The regulatory ecosystem of WA does not preference the use of products derived from EOLTs and conveyor belts for energy recovery** unless EOLTs and conveyor belt feedstocks are classified as residual waste.
Approval processes for the use of land for the development of recycling facilities can be slow This limits the recycling capacity for end-of-life tyre materials within a certain timeframe.	**Lack of EOLT and conveyor belt collection, processing, and recycling infrastructure for regional areas** This is where many OTR tyre and conveyor belt generators operate
Mismatch between product specifications and capabilities of recycling facilities planned and approved for of the generation of recovered rubber materials	**Need for greater efforts to engage Aboriginal Corporations for EOLT recycling initiatives in regional WA** where communities are impacted by improper disposal and handling of these materials and the impact on human and environmental health are largely unknown

Three key recommendations for improving the management, resource recovery and market pathways from EOLT and conveyor belts in WA are provided for consideration.

Key Recommendation 1

Consolidated and consistent, hierarchical waste categorisation codes for all EOLTs, waste conveyor belts and other rubber products in WA would support the preliminary assessment of material flows, and provide evidence to further investment into market pathways for EOLT and conveyor belt materials. These codes should be co-developed in consideration of other jurisdiction waste codes, with the view of creating a nationally consistent waste code for the management of EOLT and conveyor belts (and other wastes) in Australia.

Key Recommendation 2

Policies should support such a resource flow and connection across business and industry sectors and the tyre and conveyor belt supply chain. This would lead to the identification of new market pathways for recovered rubber materials and result in the maturation and growth of existing markets identified for EOLT and conveyor belt materials. Renewal of the policy and regulatory ecosystem related to the management of EOLT and conveyor belt wastes in WA could be undertaken to improve economies of scale, preferentially extend the life span of rubber products in our economy, and incentivise resource recovery to minimise waste generation and divert wastes from landfills and on-site disposal.

Key Recommendation 3

Further engagement and research to generate data should be undertaken to identify the impact of the disposal of EOLTs and conveyor belts on Country, and how future pathways should be designed to integrate EOLT recovery and management with Aboriginal economic empowerment. Indigenous communities can be disproportionately impacted by the improper management of EOLTs and conveyor belts. This is especially true in remote regions where the generation of EOLT arisings occurs and adequate waste disposal facilities are not available. To alleviate amenity issues of EOLTs in regional areas, TSA should consider collaborating with state-level agencies who can provide guidance on the complex nature of working with remote Aboriginal communities. This may further a more holistic understanding of the systemic issues in play related to EOLT waste, such as the prevalent issue of disused car bodies. To facilitate pathways of economic empowerment for remote communities, further engagement with Aboriginal Corporations is needed to determine what benefits are hoped to be gained from Indigenous-led business initiatives related to EOLT recovery and land remediation.

Generating consistent and consolidated data that delineates the types of EOLT and conveyor belt arisings is key to enabling the development of new recycling and resource recovery opportunities for EOLT and conveyor belts in WA. However, the recycling and resource recovery industry for EOLT and conveyor belts in WA cannot expand due to barriers related to the current regulatory ecosystem for these wastes, including permitting on-site and regional landfill disposal, the lack of hierarchical waste codes that can be consistently and non-subjectively applied to identify and semi-quantify waste arisings, and the lack of appropriate economic levers to drive investment and development of processing capacity. As Indigenous communities can be disproportionately impacted by the improper management of EOLT and conveyor belts, further engagement could be initiated to understand the impact of EOLT and conveyor belts disposal on Country and community. Moreover, opportunities should be identified for EOLT and conveyor belts management through Indigenous-led and co-designed initiatives.

1 Introduction

End-of-life Tyres (EOLT) was the third largest hazardous waste category by weight (6 %) in Australia in 2017-18 (excluding biosolids, due to their large tonnage, and the unresolved and variable nature of their hazard classification) (Latimer, 2019). In 2018-19, a total of 465 kt of tyres reached their end-of-life in Australia. Approximately 41 % (by weight) of tyres sold in 2018-19 were passenger tyres (which could include tyres from motorbike, car, and other passenger vehicles), 36 % truck tyres (which could include bus and various sized truck tyres) and 23 % off-the-road (OTR) tyres (i.e., tyres used by mining, heavy industry, and other unregistered applications).

Historically, EOLTs have been stockpiled, disposed on-site, or exported from Australia as a waste management solution. However, EOLTs were one of the four waste streams targeted by the Waste Export Ban under the *Recycling and Waste Reduction Act 2020*, and from 1 December 2021, tyre exports were restricted, with various conditions and exclusions related to the export of these products out of Australia.

Currently, all new tyres are imported to Australia (both as new products and as part of equipment) and there are no existing standards associated with the import of these tyres. EOLTs are regulated as controlled waste in all jurisdictions of Australia, but are still permitted for disposal in regional landfills and for on-site management at mine sites in WA. In comparison, there are some existing domestic conveyor belt manufacturing businesses in Australia (mostly in WA), though these materials are also imported as part of other equipment. Unlike tyres, there is no regulatory requirement to manage, track and appropriately dispose of end-of-life conveyor belt materials.

In 2018-2019, only 14 % of Australian EOLTs were recovered for domestic re-use, with 55 % recovered for export and 31 % not recovered at all. EOLTs not recovered were disposed on-site in pits or in landfills, stockpiled or illegally dumped in the environment. While 89 % of passenger and truck tyres were recovered, the recovery rate for OTR tyres was only 11 % (Randell et al., 2020). The remaining 89 % of OTR tyres currently managed (e.g. buried or stockpiled) on land represents a large loss of materials from the economy as well as a risk to communities and the environment.

Many regional locations in Australia struggle to adequately manage EOLTs in a manner that mitigates negative impacts on sensitive communities and environments, and their regional economies. A large user of OTR tyres is the mining industry, which has operations concentrated in regional and remote locations, often located near Indigenous communities, and both ecologically and culturally sensitive environments. These communities and environments are vulnerable to the potential hazards caused by EOLTs that are disposed of to landfill, stockpiled or dispersed across our environment.

Whole tyres pose a considerable fire hazard when stockpiled and if ignited, are difficult to extinguish (VAGO, 2019). When burned, tyres produce toxic smoke, and the runoff produced during firefighting activities can carry pollutants to surface water and groundwater (Genever et al., 2017). Stockpiled whole tyres can also attract pests, such as rats, and retain water which creates a habitat for mosquitos that can carry infectious disease (Bockstal et al., 2019). There is building evidence of the ecological hazards associated with the availability and release of chemicals from tyres, including heavy metals, polyaromatic hydrocarbons and N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPD-quinone) (Challis et al., 2021). However, the impact from EOLTs and associated chemicals on Australia's unique biodiversity and ecosystems still remains largely unknown.

There are many stakeholders that interact with EOLTs, including tyre retailers, collectors, recyclers, all levels of government, and other government agencies. However, current management frameworks often

lack regionally specific data related to the arisings and fate of EOLTs and coordinated programs to manage this resource in a proactive and effective manner. The knowledge gap and fragmented, ad hoc approach to the management of this critical waste stream results in poor management, particularly in regional areas and increased adverse impacts associated with handling, storage, and disposal of EOLTs. Some unique challenges with the management of EOLTs (and other wastes) in regional and remote areas also include:

- Lack of capacity or service providers and options for waste management and resource recovery due to a small market size;
- Long distances for collection routes adding significant logistics-related costs to waste management costs;
- Small and dispersed populations resulting in lower volumes of EOLT arisings, which are not enough to provide the critical mass of material supply, offset transport costs or underpin investment for processing equipment and associated business models;
- Limited regional market pathways for processed materials;
- Difficulties in regulating disposal in areas where unmanaged disposal is more accessible (i.e., more open space for dumping, unmanned and illegal landfills); and,
- Lack of available discretionary funds in smaller, revenue challenged councils and associated organisations to manage difficult waste streams or enable resource recovery, especially for councils managing vast and often remote areas within their jurisdiction.

In addition to EOLTs, conveyor belts are another notable waste stream produced by the mining industry. Waste conveyor belts have similar properties to waste tyres in terms of their rubber composition and means of on-site disposal. However, unlike waste tyres, there is limited information related to the generation and management of these wastes. In addition, regulations controlling the disposal and export of waste tyres, do not cover the disposal or export of waste conveyor belts, or other waste rubber products. As such, there is a further opportunity to investigate the potential for recycling and reuse of these materials in conjunction with waste tyres.

CSIRO produced a Circular Economy Roadmap in 2021 that identified key gaps in the management, reuse and recovery of plastic, glass, paper, and tyres (Schandl et al., 2021). It identified collection, remanufacturing and reuse, recycling, and use of recycled materials as key opportunities for the development of a circular economy for these materials. This project aimed to generate data and identify strategies to enable higher value recovery from EOLTs and conveyor belts in WA by redirecting waste to resource recovery, and addressing challenges related to logistics and cost, to guide investment and policy decisions. The specific project objectives were to:

- Generate/review data on EOLT and conveyor belt arisings in WA on a regionally specific basis;
- Map existing EOLT and conveyor belt collection, transport and recycling services, infrastructure and logistics in WA, and align with arisings;
- Explore the market potential for recycled materials produced from EOLTs and conveyor belts in WA;
- Identify environmental impacts from tyres and conveyor belts affecting Indigenous communities and opportunities for the economic development of Indigenous communities;
- Identify relevant regulatory and policy context; and
- Identify strategies to increase value recovery from EOLTs and conveyor belts in WA.

2 Methods

This report was generated to explore opportunities and challenges for value recovery from EOLTs and conveyor belts in WA, and the associated market development for products derived from EOLTs and conveyor belts. Methods including a systematic literature review and thematic analysis, gathering and analysis of available EOLT and conveyor belt arising data, and conducting semi-structured interviews with key government and industry stakeholders were applied to provide a snapshot of current arisings, reuse potential and market opportunities in WA related to EOLTs and conveyor belts.

2.1 Literature review and thematic analysis

Systematic literature reviews, often coupled with thematic analyses, are widely considered among the most rigorous approaches to the exploration of existing bodies of literature. Systematic literature reviews can deliver structured and reproducible reviews, while also limiting the influence of bias in the selection of included and excluded sources (Sovacool et al., 2018). A systematic literature review allows the researchers to collect many articles on a defined topic and zoom out on the gathered literature to find patterns and trends often hidden when sifting through individual articles (Littell et al., 2008; Snyder, 2019). This research method included four main steps. First, a Boolean research string was developed to gather literature related to EOLTs, conveyor belts and rubber materials and their reuse in various end-of-life pathways. The research string for this project was:

(tyres OR “conveyor belts” OR rubber) AND (“circular economy” OR reuse OR “material recovery” OR “resource recovery” OR recycl* OR “waste to energy”)

Second, this string was applied in Scopus, Web of Science, and ScienceDirect, searching for research articles in English and refining the results through the databases’ filtering system, limiting the research to studies which were achieved under the environmental science. Reports and grey literature from various sources were manually included to provide a broader context of tangible applications beyond the academic works. Third, duplicates of the results generated from each publication database were eliminated, and the remaining results were shortlisted by screening the titles and abstracts. From this screening, sources whose topics were not relevant to the research problem were excluded from the literature shortlist. That was the case of many sources which were investigating, for example, rubber recycling practices from components other than tyres or conveyor belts.

A thematic analysis was carried out on the shortlisted publications to identify and explore recurring themes and trends among the identified publications. Articles were grouped in the theme of recycling processes, in market opportunities, or policies. The themes and shortlisted articles were then used to inform the various sections of this report, to provide useful insights, and inspire the questions developed in the semi-structured interviews (see Section 2.3).

2.2 EOLT and conveyor belt arisings data gathering and analysis

Data related to EOLT transport were sourced from TSA and the WA DWER. Considering mining and energy resource industries are the major sectors contributing to the arisings of EOLTs and used conveyor belts in WA, during the initial phase of the project, the project team engaged with the Chamber of Minerals and Energy (CME) to collect data related to the tyre and conveyor belt procurement, generation of EOLTs and conveyor belts, and current practice of handling EOLTs and conveyor belts of their member companies in

WA. A questionnaire survey consisting of specifically formulated questions covering these aspects was formulated to assist with the data collection. The survey also intended to collect data on annual ore processing and commodity production quantities and to facilitate further engagements (e.g., interviews) with the participating companies.

2.3 Semi-structured interviews

Semi-structured interviews were undertaken with selected stakeholders to expand the current level of knowledge related to the generation, handling and management of EOLT and conveyor belt waste in WA, as well as the opportunities and capacity for processing and reuse, and opportunities and challenges for industries, communities, and regulators.

To better understand the ecosystem for EOLT and conveyor belt management and recycling in WA, the research team conducted semi-structured interviews with key stakeholders with roles and expertise in EOLT and used conveyor belt generators, rubber waste management or recycling providers, policy makers, and end users of products derived from EOLTs and used conveyor belts. Most stakeholders were from WA, but some stakeholders from other Australian states were also included to gain a broader view of relevant trends at a national level.

Framed by the systematic literature review and thematic analysis, a set of pre-defined questions were developed for semi-structured interviews to source useful qualitative insights from the interviewees, whilst also capturing information that might be missed in structured interviews (Kallio et al., 2016).

A total of 14 stakeholder interviews were conducted, each interview lasting between 40 and 70 minutes. The interviews were recorded and transcribed, and transcripts were used to identify and explore patterns, agreements, or tensions between the interviewees' recorded experiences. The de-identified insights from the interviews are presented in this report, throughout the relevant sections.

To support the semi-structured interview process, some stakeholders were also asked to provide quantitative data or other information via email, and email requests for information related to collection and management of EOLTs and conveyor belts were sent individually to all local government associations and regional councils in WA.

Ethics Approvals were obtained for this project from CSIRO (005/22) and Curtin University (HRE2022-0102) prior to conducting the interviews or asking for information from stakeholders.

3 Regulatory and policy settings affecting EOLT and conveyor belt management in Western Australia

EOLTs (and other rubber wastes) are globally recognised as priority waste streams requiring appropriate regulation to control the movement, handling, disposal, recycling, and reuse of materials and minimise the environmental or human health implications of improper management. Australia has a tiered waste management regulatory framework that is impacted by the requirement to meet international obligations related to the management of hazardous wastes, national waste and resource recovery policies, state-based regulations, and local and regional level waste management. Here, we discuss the policy environment at international, national, and state levels that relate to the management of EOLTs and, where available, conveyor belts in WA.

3.1 International regulation of EOLT and rubber wastes

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal regulates the movement of hazardous wastes across international boundaries (Basel Convention, 1992; Randell et al., 2020). Australia was a foundation signatory to the Basel Convention when it came into force in 1992 (Randell et al., 2020). Under this regulatory requirement, waste exporting countries are obliged to ensure that hazardous wastes are managed in an environmentally sound manner in the country of import. According to Article 1 of the Basel Convention (page 97), the following wastes that are subject to transboundary movement shall be "hazardous wastes" for the purposes of this Convention: (a) Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III; and (b) Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit. Although EOLTs are not listed in Annex I of the Basel Convention, they are listed in Annex IX (Secretariat of the Basel Convention, 2020), and contain approximately 1.5 % by weight of elements or compounds listed in Annex I of the Basel Convention (United Nations Environment Program, 2002). Moreover, EOLTs are regulated as hazardous or controlled waste in all jurisdictions in Australia. Therefore, consistent with Article 1(b), Australia reports waste tyre generation within Basel reporting as part of a subtotal of "additional waste categories" that are not included in Annex I (Randell et al., 2020). The Annex IX List B (page 140) states the following: "Wastes contained in the Annex (IX) will not be wastes covered by Article 1, paragraph 1(a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic." Moreover, "B3140 Waste pneumatic tyres, excluding those destined for Annex IVA operations" are listed in Annex IX List B. These statements exclude waste tyres from Basel transboundary movement requirements, including export permits, unless the waste tyres are being exported to be disposed (i.e., are not exported for recycling) (Randell et al., 2020).

As one of the signatory countries of the Basel Convention, Australia follows the Hazardous Waste (Regulation of Exports and Imports) Act 1989 to regulate transboundary movement – i.e., export, import and transit of hazardous wastes in Australia (Australian Government, 20179). Although the original Act of 1989 only controlled movements of wastes that lacked financial value and were destined for disposal operations such as incineration and landfill, the Act was amended in 1996 to include wastes that possess financial value and are destined for recycling and recovery operations (DAWE, 2021a). Under the amended

Hazardous Waste Act (1996), a permit is required for an operator or business before hazardous waste is exported from Australia or imported into Australia.

EOLTs (rubber wastes) are categorised as 'absolute non-hazardous' (ANH) under the European Union EWC-Stat Waste Categories (EUR_Lex, 2018). Despite this, the European Framework Directive 2008/98/EC mandates the handling of wastes to minimise negative effects on the environment and human health and to promote a circular economy based on the waste hierarchy framework. Though not considered hazardous waste, the management of EOLTs in the European Union is regulated through the landfill directive 1991/31/EC, which restricted the landfilling of whole EOLTs from July 2003, and shredded EOLTs from July 2006 (Valentini and Pegoretti, 2022). Additionally, there is increasing scientific evidence related to the environmental and human health impacts related to the release and management of chemicals of concern from in-use tyres and EOLTs that is likely to change the regulatory status of these wastes in the future (Challis et al., 2020).

3.2 Australian national regulations and policies for EOLT and rubber wastes

In addition to the Hazardous Waste Act, the *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998* (Controlled Waste NEPM) is also applicable for tyre waste as it is listed as controlled waste under Schedule A. The NEPM regulates the movement of controlled wastes between states and territories; however, the degree of tracking and reporting requirements in each state and territory differs (NEPC, 1998; Genever et al., 2017).

As part of the implementation of the Australian *Product Stewardship Act 2011*, Tyre Stewardship Australia (TSA) was launched in 2014. The national Tyre Product Stewardship Scheme (TPSS) is a voluntary scheme that aims to promote the development of viable markets for tyre-derived products and provide a pathway to reducing the environmental, health and safety impacts of EOLTs (DCCEEW, 2021a). Ten global tyre brands (Bridgestone, Continental, Goodyear/Dunlop, Hankook, Kumho Tyre, Michelin, Pirelli, Toyo Tires, Tyreconnect and Yokohama), three auto brands (Mercedes-Benz, Porsche, and Volkswagen) and seven OTR tyre importers (Ascenso, Bearcat, Bridgestone, Goodyear/Dunlop, Kal Tire, Michelin, Yokohama) support TSA in administering the scheme through the levy ($0.25 per equivalent passenger unit sold). TSA regularly releases '*Best Practice Guidelines*' for participants.

Most recently, Australia's *National Waste Policy* was enacted in 2018, which outlined an ambitious resource recovery target of 80 % by 2030. In 2019, the *National Waste Policy Action Plan* was released, setting out the targets and actions to implement the *National Waste Policy*. This Action Plan included the *Recycling and Waste Reduction (Export – Waste Tyres) Rules 2021*, which outline specific requirements and conditions for Australian businesses to export EOLTs out of the country.

Since 1 December 2021, the export of whole or baled tyres is not allowed (DCCEEW, 2021b), except for:

- tyres that have been processed into crumbs, buffings, granules or shreds;
- tyres that have been processed into fuel;
- tyres exported for re-treading; and,
- tyres that will be re-used on vehicles overseas.

Table 2 presents the key international and national regulatory and policy instruments for managing waste tyres and conveyor belts.

Table 2. International and national regulatory and policy instruments for managing waste tyres and conveyor belts.

Jurisdiction/Scope	Instruments	Brief description
International	The Basel Convention (1992)	The Control of Transboundary Movements of Hazardous Wastes and their Disposal
	Organisation for Economic Cooperation and Development (OECD) Decision C (2001)107	The Guidance Manual for the Control of Transboundary Movements of Recoverable Wastes for OECD countries. The guideline lists waste tyres under the "green control procedure"
National	Customs Act 1901	The Act requires that goods being exported from the country be reported (e.g., obtaining an Export Declaration Number) to the Department of Immigration and Border Protection.
	The Hazardous Waste Act 1989 (amended in 1996)	The regulation of exports and imports of hazardous waste in Australia
	National Environment Protection Measure (NEPM), Controlled Waste (1998)	Movement of Controlled Waste between States and Territories.
	Australia's Renewable Energy Target (RET)	Australia's Renewable Energy Target (RET) is federal legislation designed to achieve 33,000 GWh (or "at least" 20% of Australia's electricity) from renewable sources by 2020. The Clean Energy Finance Corporation (CEFC) has drafted a position paper on how and where energy recovery from EOLT may fit its investment portfolio.
	The National Tyre Product Stewardship Scheme	Tyre Stewardship Australia (TSA) was launched in 2014 to deliver the scheme which is a voluntary stewardship scheme. TSA regularly releases 'Best Practice Guidelines' which set out the requirements for participants of the Scheme.
	National Waste Policy (2018) and Action Plan (2019)	The National Action Plan set out the targets and actions to implement the 2018 National Waste Policy. These targets and actions will guide investment and national efforts to 2030 and beyond including banning the export of waste plastic, paper, glass and tyres, commencing in the second half of 2020.
	The Recycling and Waste Reduction Act 2020	The act implements an export ban on waste plastic, paper, glass, and tyres agreed upon by the Council of Australian Governments (COAG) in March 2020.
	Recycling and Waste Reduction (Export – Waste Tyres) Rules 2021	The Waste Tyres Rules (also known as the Tyre Waste Export Ban) set out the specific requirements and conditions (e.g., licence, specifications) that apply to the export of regulated waste tyres. Since 1 December 2021, an individual or business, is not allowed to export whole and baled tyres except for re-treading and reuse.

3.3 Western Australian regulations, policies and permitting

EOLT (waste code: T140) is regulated as hazardous or controlled waste in all jurisdictions of Australia, with Victoria being the most recent jurisdiction to update regulations related to waste tyres as reportable priority waste that must be stored safely (effective from 1 July 2021; Victoria EPA, 2021). Here, we discuss the specific regulatory environment as it pertains to the management of EOLTs (and conveyor belts, where applicable) in WA.

WA's current waste strategy, *Waste Avoidance and Resource Recovery Strategy 2030*, builds on the previous waste strategy, *Creating the Right Environment' to support the Waste Avoidance and Resource Recovery Act 2007* (WARR) (Waste Authority, 2019). The vision for the Strategy is for WA to become a sustainable, low waste circular economy in which human health and the environment are protected from the impact of waste. The strategy aims to reduce waste generation by 20 % per capita, and increase material recovery to 75 %, with only energy recovered from residual wastes by 2030. At the same time, the strategy aims to ensure that no more than 15 % of waste generated in the Perth and Peel region is landfilled, with all waste managed and/or disposed of to better practice facilities. The Strategy also notes

that local waste and resource recovery solutions are particularly important in WA where access to markets is limited, and transport costs and impacts are high. WA has an opportunity to benefit from greater local recycling activity. If local recycling options are not available, solutions within Australia are preferred.

Though being identified as a target waste for export bans by the Federal government, tyres are not directly regulated through the WARR by the WA State Government. As EOLTs are categorised as controlled waste, they are regulated under the Controlled Waste NEPM. The NEPM is overseen by State Government agencies such as the Department of Water and Environmental Regulation (DWER) and the Environmental Protection Authority of WA (WA EPA). However, the WA Government has specific regulatory requirements for EOLT management, as summarised in Table 3.

To help reduce illegal dumping of unwanted waste materials, including tyres, an amendment (Section 49A) to the *Environmental Protection Act 1986* was introduced. Subsection 49A(2) creates an offence for discharging or abandoning waste into water to which the public has access, and subsection 49A(3) creates an offence for discharging or abandoning waste into any place other than water to which the public has access. The maximum penalty for an offence against section 49A is $62,500 for an individual and $125,000 for a body corporate.

Table 3. Current policy and regulatory settings related to used tyre management in Western Australia. No reuse options are currently listed in the policy and regulatory instruments.

Activity	Description	Regulatory and policy instruments
Storage	Up to 500 tyres can be stored at a tyre fitting business or up to 100 tyres can be stored in any other place. Otherwise, the permitted quantity of used tyre storage will be the amount indicated on a licence of the prescribed premises Sites storing >100 tyres are subjected to licensing requirements.	Part 6 of the WA *Environment Protection Regulation 1987*
	Building Act 2011 & Building Regulations 2012 – empowering legislation of the National Construction Code (NCC-class 7 warehouse and class 8-processing/production building-floor greater than 500 sqm) where there are structures involved with the storage/processing facility (tyre storage and recycling facility).	*Building Act 2011* & *Building Regulations 2012*
Fire safety	Minimum fire safety recommendations for storage of rubber tyres (including shreds and crumbs), including those in open yards (external) or stored within buildings (internal).	*GN02, Bulk Storage of Rubber Tyres including shredded and crumbed tyres*, Department of Fire and Emergency Services WA, 2020
Transportation	Permitting and tracking is required when EOLT are transported from commercial premises. Controlled Waste Tracking Form required for all loads of bulk-controlled waste and packaged controlled waste equal to or greater than 200 kg (represented by 25 used passenger car tyres). Controlled waste carrier required for all controlled waste, regardless of quantities or packaging. Classified as controlled waste regardless of disposal, re-use, or re-treading options. Transport must be conducted by a licensed controlled waste carrier. Failure to ensure this occurs is an offence by the premises manager. Records of any controlled waste movement away from any premises must be retained for at least 3 years	*Environmental Protection (Controlled Waste) Regulations 2004*, Part 3
Tracking	Paper passed records must be kept for 3 years.	*Environmental Protection (Controlled Waste) Regulations 2004*, Part 3
Disposal	Disposal of EOLT is allowed in Tyre Landfill Exclusion Zone at approved sites that have written approval of the Chief Executive Officer. Disposal normally involves burial of batches of tyres at a landfill with minimum cover and separation distances between tyre batches to minimise fire risks. Beyond the Tyre Landfill Exclusion Zone tyres can be buried at a Class I, II and III landfills (defined in the LWCWD) where specified in waste acceptance conditions of respective licences. Disposal normally involves burial of batches of tyres at a landfill with minimum cover and separation distances between tyre batches to minimise fire risks.	Part 6 of the WA *Environmental Protection Regulations 1987.* *Landfill Waste Classification and Waste Definitions 1996* (as amended 2019)[LWCWD] The boundaries of the Tyre Landfill Exclusion Zone can be found in Schedule 5 of the *Environmental Protection Regulations 1987* *Waste Avoidance and Resource Recovery Strategy 2030*

Activity	Description	Regulatory and policy instruments
	1. Incineration – if emissions standards are met 2. Burial – Disposal of EOLT is restricted within the Tyre Landfill exclusion zone. Disposal of EOLT to landfill attracts inert landfill levy (currently $50/tonne). 3. Or any other method approved by Minister. Illegal disposal of unwanted waste materials	Part 6 of the WA *Environment Protection Regulation 1987* Section 49(A), *Environmental Protection Act 1986*
Energy Recovery	Guidance for potential proponents	*Waste Avoidance and Resource Recovery Strategy 2030* Waste to Energy Position Statement, Waste Authority 2020 Advice from the Environmental Protection Authority (EPA) and Waste Authority to the Minister for Environment on the Environmental and health performance of waste to energy technologies using thermal treatment (EPA Report 1468) under section 16e of the *Environmental Protection Act 1986*
Recycling	Formalises WA Waste Authority's views on recycling	*Waste Avoidance and Resource Recovery Strategy 2030*

3.4 WA Local Government Authorities (LGAs) and Regional Councils

3.4.1 Metropolitan and regional LGA

All practical facets of managing municipal solid waste from residential sources in WA are handled at the Local Government Authority (LGA) level. In some instances, LGA and other regional groups may operate waste facilities that can choose to accept wastes from other sources, including commercial and industrial (C&I) and construction and demolition (C&D) wastes.

There are 137 LGAs in WA, 44 of which fall in the Perth Metropolitan and Peel regions. Cross-boundary statutory bodies known as Regional Local Governments (more commonly known as Regional Councils) have been formed to oversee the management of waste and associated facilities for member councils within the Perth Metropolitan and Peel regions. This approach to inter-municipal cooperation has primarily emerged in the Perth region and most LGAs in the metropolitan region participate in these kinds of arrangements to some degree. That said, there are several Perth LGAs that are not members of a Regional Council. As a result, some waste management facilities in the metropolitan area are managed by individual LGAs, rather than a Regional Council. A summary of waste management facilities in the Perth Metropolitan and Peel area, and in Bunbury and Harvey that are managed by Regional Councils is shown in Table 4, including whether EOLTs are accepted and aggregated for collection by controlled waste carriers to tyre recyclers. It should be noted that conveyor belts do not appear as a waste category in scheduled fees for any Perth Metropolitan, Peel and Bunbury-Harvey Regional Councils or LGA-managed waste facilities, which is consistent with these wastes not being regulated or controlled wastes in WA.

Table 4. Waste management by Regional Council in WA

Regional Council	Member Councils	Waste facilities	Accepts tyres
Eastern Metropolitan Regional Council (EMRC)	Town of Bassendean, City of Bayswater, City of Kalamunda, Shire of Mundaring and City of Swan	Hazelmere Resource Recovery Park Red Hill Waste Management Facility	Yes – Car and four-wheel drive (4WD) only. Member Councils only.
Mindarie Regional Council (MRC)	Town of Cambridge, City of Joondalup, City of Perth, City of Stirling, Town of Victoria Park, City of Vincent, City of Wanneroo	Tamala Park Landfill and Transfer Station Neerabup Resource Recovery Facility	Yes – charged on a minimum per tonne arrangement to complement LGA specific arrangements for tyre collection.
Rivers Regional Council (RRC)	City of Armadale, City of Gosnells, City of Mandurah, Shire of Murray, Shire of	Nd	Nd

Regional Council	Member Councils	Waste facilities	Accepts tyres
	Serpentine-Jarrahdale, City of South Perth		
Resource Recovery Group (formerly Southern Metropolitan Regional Council)	City of Fremantle, Town of East Fremantle, City of Melville	Material Recovery Facility only, no waste management facility	No
Western Metropolitan Regional Council (WMRC)	Town of Claremont, Town of Cottesloe, Town of Mosman Park, Shire of Peppermint Grove, City of Subiaco, Town of Cambridge	West Metro ReCycling Centre	Yes – Passenger, Light Truck, Truck only. Member council and non-member council fees.
Bunbury-Harvey Regional Council	City of Bunbury, Shire of Harvey	Stanley Road Waste Management Facility	Yes – Passenger, Light Truck only.

Nd: not determined

There are several waste management facilities located in the Perth Metropolitan and Peel regions that are managed by individual LGAs. Some of these facilities accept EOLTs from residents and non-residents for disposal. A summary of these facilities is provided in Table 5. Outside of the Perth Metropolitan and Peel regions (and excluding the Bunbury-Harvey Regional Council), regional LGAs are responsible for waste management facilities located within their LGA area, and there is a total of 93 regional LGAs in WA. A summary of regional WA LGAs and their associated waste management facilities is shown in Table 6. Where conveyor belts are accepted, these have also been indicated.

Table 5. Metropolitan LGA tyre collections

Region	Waste facilities	Managing LGA	LGAs serviced	Accepts tyres
Perth	Walliston Transfer Station	City of Kalamunda	City of Kalamunda	Yes – Passenger[a], Light Truck[b], Truck from domestic and commercial residents
	Coppin Road Recycling Centre Mathieson Road Recycling Centre	Shire of Mundaring	Shire of Mundaring	Yes – Passenger and Light Truck only.
	Bullsbrook Recycling Centre Malaga Recycling Centre	City of Swan	City of Swan	Yes – Passenger and 4WD only
	Balcatta Recycling Centre	City of Stirling	City of Stirling City of Perth Town of Cambridge City of Vincent City of Wanneroo	Yes – Passenger and 4WD only
	City of South Perth Recycling Centre	City of South Perth	City of South Perth City of Perth Town of Victoria Park	Yes – Passenger and Light Truck only
	Armadale Landfill and Recycling Centre	City of Armadale	City of Armadale City of Gosnells	Yes – Passenger, Light Truck and Truck
	City of Canning Waste Transfer Station	City of Canning	City of Canning City of Gosnells City of Melville City of Belmont	Yes – comprehensive fee schedule for EOLT
	Fremantle Recycling Centre	City of Fremantle	City of Fremantle Town of East Fremantle City of Melville	Yes – Passenger and Truck
	Henderson Waste Recovery Park	City of Cockburn	City of Cockburn City of Melville	Yes – Passenger and 4WD only
	Miller Road Landfill and Recycling Facility	City of Rockingham	City of Rockingham City of Kwinana	Yes – online fee schedules different from data collected from LGA
Peel	Boddington Refuse Site	Shire of Boddington	Shire of Boddington	No
	Mandurah Waste Management Centre	City of Mandurah	City of Mandurah	Yes – Passenger and Truck
	Corio Road Waste Transfer Station Dwellingup Waste Transfer Station	Shire of Murray	Shire of Murray	Yes – comprehensive fee schedule

[a] Some LGAs accept passenger tyres that also includeHi SUV and 4WD tyres, but in most instances, this is not specifically described.
[b] Some LGAs accept bus tyres in Light Truck and Truck categories, but in most instances, this is not specifically described.

Table 6. Regional LGA tyre collections

Region	LGA	Waste facilities	Accepts tyres
Kimberley	Shire of Derby-West Kimberley	Derby Landfill Fitzroy Crossing Landfill	Yes – outside Shire disposals cost more.
	Shire of Halls Creek	Halls Creek Rubbish Tip	Yes
	Shire of Wyndham-East Kimberley	Kununurra Landfill Site Wyndham Landfill Site	Yes
	Shire of Broome	Broome Waste Management Facility	Yes
Pilbara	City of Karratha	Karratha 7 Mile Waste Facility and Transfer Station Roebourne/Wickham Waste Transfer Station	Yes – tyres over 2 m not accepted
	Shire of East Pilbara	Newman Waste Management Facility Nullagine Refuse Site Marble Bar Refuse Site	Yes
	Shire of Ashburton	Tom Price Waste Disposal Site Paraburdoo Waste Disposal Site Onslow Waste Disposal Site	Yes – Passenger and Light Truck only
	Town of Port Hedland	South Hedland Landfill	Yes
Gascoyne	Shire of Carnarvon	Browns Range Waste Management Facility	Yes
	Shire of Upper Gascoyne	Unknown	Unknown
	Shire of Shark Bay	Shark Bay Refuse Site	Yes
	Shire of Exmouth	Quaking Scarp Landfill	Yes
Mid-West	Shire of Carnamah	Carnamah Rubbish Tip	Yes
	Shire of Chapman Valley	Nabawa Refuse Site	No
	Shire of Coorow	Unknown	Unknown
	Shire of Cue	Unknown	Unknown
	City of Greater-Geraldton	Meru Waste Disposal Facility Mullewa Transfer Station	Yes
	Shire of Irwin	Irwin Waste Transfer Station and Recycling Centre	Yes
	Shire of Meekatharra	Unknown	Unknown
	Shire of Mingenew	Mingenew Waste Transfer Station	Unknown
	Shire of Morawa	Morawa Waste Transfer Station	Yes
	Shire of Mount Magnet	Mount Magnet Landfill	Unknown
	Shire of Murchison	Unknown	Unknown
	Shire of Northampton	Northampton Rubbish Tip Kalbarri Rubbish Tip	Yes
	Shire of Perenjori	Perenjori Refuse Site Latham Refuse Site	Unknown
	Shire of Sandstone	Unknown	Unknown
	Shire of Three Springs	Three Springs Refuse Site	Unknown
	Shire of Wiluna	Unknown	Unknown
	Shire of Yalgoo	Unknown	Unknown
Wheatbelt	Shire of Beverley	Beverley Landfill Site	Unknown
	Shire of Brookton	Brookton Refuse Site	Unknown
	Shire of Bruce Rock	Bruce Rock Tip	Unknown
	Shire of Chittering	Muchea Landfill Site Bindoon Landfill Site	No
	Shire of Corrigin	Corrigin Waste Transfer Station Participates in a cross-LGA waste disposal site located in Bendering (shared between Shires of Corrigin, Kondinin, Kulin, Narembeen)	Unknown
	Shire of Cuballing	Cuballing Waste Transfer Station Popanyinning Waste Transfer Station	Yes – Car, Truck, Tractor
	Shire of Cunderdin	Cunderdin and Meckering Waste Transfer Stations	Unknown
	Shire of Dalwallinu	Dalwallinu Rubbish Tip	Unknown
	Shire of Dandaragan	Badgingarra Transfer Station Cervantes Transfer Station and Recycling Centre Dandaragan Landfill Site and Recycling Depot Jurien Bay Landfill and Recycling Centre	Yes – fee schedule is very comprehensive.
	Shire of Dowerin	Amery Refuse Site	No
	Shire of Dumbleyung	Dumbleyung Kukerin	No
	Shire of Gingin	Gingin Landfill Lancelin Landfill Seabird Landfill	Yes – car, light truck, truck and small tractor
	Shire of Goomalling	Goomalling Refuse Site	Yes
	Shire of Kellerberrin	Kellerberrin Waste Transfer Station	No

Region	LGA	Waste facilities	Accepts tyres
	Shire of Kondinin	Kondinin and Hyden Waste Transfer Stations Regional waste disposal site at Bendering (shared between Shires of Corrigin, Kondinin, Kulin, Narembeen	Unknown
	Shire of Koorda	None	N/A
	Shire of Kulin	Kulin Waste Transfer Station Regional waste disposal site at Bendering (shared between Shires of Corrigin, Kondinin, Kulin, Narembeen	No
	Shire of Lake Grace	Lake Grace Tip Lake King and Varley Tip Newdegate Tip	Yes – no details available.
	Shire of Merredin	Merredin Landfill and Resource Recovery Site	No
	Shire of Moora	Moora Refuse Site	No
	Shire of Mt Marshall	Unknown	Unknown
	Shire of Mukinbudin	Unknown	Unknown
	Shire of Narembeen	Narembeen Waste Transfer Station Regional waste disposal site at Bendering (shared between Shires of Corrigin, Kondinin, Kulin, Narembeen	Unknown
	Shire of Narrogin	Narrogin Waste Management Facility and Transfer Station	Yes – passenger, light truck and truck
	Shire of Northam	Old Quarry Road Waste Management Facility Inkpen Road Waste Management Facility	Yes
	Shire of Nungarin	Unknown	Unknown
	Shire of Pingelly	Pingelly Waste Management Facility	Yes
	Shire of Quairading	Quairading Waste Management Facility	Yes – small, medium, large
	Shire of Tammin	Tammin Refuse Site	Unknown
	Shire of Toodyay	Toodyay Waste Transfer Station	Yes – small, medium, large
	Shire of Trayning	Unknown	Unknown
	Shire of Victoria Plains	Bolgart Landfill Calingiri Landfill Mogumber Landfill	No
	Shire of Wagin	Wagin Refuse Site	Unknown
	Shire of Wandering	Wandering Transfer Station	Yes
	Shire of West Arthur	Darkan Refuse Site Duranillan Refuse Site	Unknown
	Shire of Westonia	Rural Landfill Site	Unknown
	Shire of Wickepin	Harrismith, Tincurrin and Yearling Waste Transfer Stations	Unknown
	Shire of Williams	Williams Transfer Station	Yes
	Shire of Wongan Ballidu	Wongan-Ballidu Waste Management Facility	Yes – small or large
	Shire of Wyalkatchem	Unknown	Unknown
	Shire of Yilgarn	Southern Cross Landfill Facility	Yes – small, medium, large, tractor
South West	City of Bunbury	Stanley Road Waste Management Facility managed through regional council	
	Shire of Harvey	Stanley Road Waste Management Facility managed through regional council Richardson Road Refuse Site	Yes
	Shire of Augusta-Margaret River	Davis Road Waste Management Facility	Yes – only residents
	Shire of Boyup Brook	Boyup Brook-Arthur River Road Transfer Station and Recycling Facility	Unknown
	Shire of Bridgetown-Greenbushes	Bridgetown Waste Management Facility Greenbushes Transfer Station	Yes
	Shire of Capel	Capel Waste Transfer Station	Yes – car or truck
	Shire of Collie	Collie Waste Transfer Station	Yes
	Shire of Dardanup	Dardanup Waste Transfer Station	Yes
	Shire of Donnybrook-Balingup	Donnybrook Waste Management Facility Balingup Waste Transfer Station	Yes
	Shire of Manjimup	Manjimup Refuse and Recycling Centre Pemberton Transfer Station Northcliffe Transfer Station Walpole Transfer Station	Yes – most comprehensive fee schedule of regional LGA
	Shire of Nannup	Nannup Waste Management Facility	Yes
Great Southern	City of Albany	Hanrahan Road Waste Facility, Corner of Hanrahan and Cuming Road, Mt Melville (scheduled closure 2026) Bakers Junction Waste Facility (secondary)	Yes – car, trucks, tractors
	Shire of Denmark	Denmark Waste Management Facility Peaceful Bay Waste Management Facility	Yes
	Shire of Jerramungup	Jerramungup Waste Transfer Station	Yes

Region	LGA	Waste facilities	Accepts tyres
		Bremer Bay Waste Transfer Station	
	Shire of Plantagenet	O'Neill Road Waste Management Facility Kendenup Transfer Station Kamballup Landfill Site Porongurup Transfer Station Rocky Gully Transfer Station	Yes
	Shire of Broomehill-Tambellup	Tieline Road Waste Transfer Station Hankinson Road Waste Transfer Station	Unknown
	Shire of Cranbrook	Cranbrook Waste Facility Frankland River Waste Facility	Yes
	Shire of Gnowangerup	Gnowangerup Borden Ongerup	No
	Shire of Katanning	Katanning Refuse Site	Yes
	Shire of Kent	Pingrup Refuse Site Nyabing Refuse Site	Unknown
	Shire of Kojonup	Kojonup Refuse Site	Unknown
	Shire of Woodanilling	Woodanilling Refuse and Recycling Site	Yes – tyre
Goldfields-Esperance	Shire of Coolgardie	Kambalda Waste Facility Coolgardie Waste Facility	Yes – fees for > and < 20" tyres
	Shire of Dundas	Norseman Refuse Disposal Site Eucla Refuse Disposal Site	Yes
	Shire of Esperance	Wylie Bay Refuse Site	Yes
	City of Kalgoorlie-Boulder	Yarri Road Refuse Site	Yes – fees are discretionary for tyres and conveyor belts (POA)
	Shire of Laverton	Unknown	Unknown
	Shire of Leonora	Unknown	Unknown
	Shire of Menzies	Unknown	Unknown
	Shire of Ngaanyatjarraku	Unknown	Unknown
	Shire of Ravensthorpe	Ravensthorpe Waste Transfer Station Hopetoun Waste Transfer Station	Yes

3.4.2 Waste categories and scheduled fees

In a review of scheduled fees for waste at LGA- and Regional Council-operated waste management facilities in WA that was undertaken in March 2022, a total of 54 different categories of EOLT and rubber products were noted (Table 7). There was little consistency between the categorisation of tyre types included in categories. For example, four-wheel drive (4WD) tyres were included in the description of scheduled fees for Passenger tyres for some LGA or Regional Councils, and in light truck tyres for other LGA or Regional Councils. Similarly, the categorisation of medium, large, and extra-large EOLT also appeared to be arbitrary in most scheduled waste fees. Some LGA scheduled fees were very specific, listing up to 12 tyre types, while others were less specific and often just listed small, medium, and large tyres as their waste categories, often without further clarification on what these sizes meant in terms of tyre type and size.

In addition to the broad and inconsistent application of waste categories, additional fees and surcharges have been applied at the discretion of the LGA or Regional Council. These fees and surcharges have been associated with the acceptance of tyres that are on rim, received from residents or member councils, received from commercial entities, contaminated with dirt or other materials, or have otherwise non-rateable properties. The application of these additional fees and surcharges has also been variable, ranging from 50 % to 350 % on top of the scheduled fees for these properties.

All LGAs in WA have scheduled fees for passenger and light truck (including 4WD and sport utility vehicle (SUV)) tyres; however, the inclusion of tyre types in each of these categories varied across all LGAs. In addition, the scheduled fees were also notably variable. Scheduled fees ranged (as of March 2022) from $3.69 to $20 and $5.7 to $25 per tyre for passenger and light truck tyres, in the Perth and Peel metropolitan area, respectively. In regional WA, the scheduled fees for passenger and light truck tyres ranged from $3 to $25 and $7 to $29.7 per tyre, respectively.

There has been little to no acceptance of large EOLTs within the Perth Metropolitan and Peel regions, except for LGAs located within the Peel region. As such, it is unlikely that data collected from these regions related to EOLTs would include any movement or disposal of OTR tyres.

Generally, there was a concurrent increase in the scheduled fees observed for EOLT disposal with the increasing size of tyres. However, as with the smaller tyre types, the scheduled fees were variable across LGAs, as were the categories of waste tyres. For the Earthmoving category, there were 17 different descriptors of EOLTs, dictated by machinery type and size included in this category, which resulted in the scheduled fees ranging from $50 to $210, depending on the size and whether it was accepted on rim and with contamination.

Most regional LGAs have accepted truck tyres (including truck, heavy truck, large, bobcat). LGAs with pastoral industries located within their region have also accepted earthmoving tyres (e.g., tractor tyres), though the categorisation of the tyres accepted in this size range has been dependent on inclusion and descriptors in the scheduled fees. In some instances, LGAs have listed price on asking (POA) for these larger and speciality tyres.

Only two regional LGAs had schedule fees for OTR tyres from mining vehicles, and these were categorised as Haulpak or similar. These were LGAs with mining tenements located within their shire, and the disposal fee was $420 at one shire, and $1,140 at the other shire. No other LGAs within WA accepted mining OTR tyres at LGA-managed waste management facilities. Despite this, the scheduled fee for disposal of these tyres differed by a factor of greater than 2.5 between the scheduled fees of the two LGAs.

Similarly, only 5 LGAs in regional WA specified other rubber products in their scheduled fees. The categories included shredded tyres and commercial rubber products (including or excluding conveyor belts). The scheduled fees for these materials have typically been given as a minimum charge per tonne, and the fee ranges from $29.7/tonne for shredded tyres to $880/tonne for commercial rubber products (including conveyor belts). The LGAs that have listed conveyor belts specifically within their scheduled fees have been in regions of WA where mining has been a dominant industry. No LGA- or Regional Council-managed facilities in the Perth and Peel region have listed conveyor belts or other rubber products in their scheduled fees.

Table 7. Summary of waste categories and scheduled fees related to EOLTs and other rubber products (including conveyor belts) in WA. NC = not collected.

Waste Category	Examples of inclusions	Additional Subcategories	Gate Fees per tyre[f]					
			Perth and Peel LGAs		Metropolitan Regional Councils[a]		Regional LGAs	
			Min	Max	Min	Max	Min	Max
Passenger	Motorcycle Car Domestic tyres Passenger (<18") Small Tyres Light Vehicle[e] Tyre (<20") Hot Rod	Resident/non-resident Member/non-member Commercial/non-commercial On rim Off rim Contaminated	3.69	20.00	5.70	15.00	3.00	25.00
Light truck	SUV 4WD[b] Light truck Small truck Truck Passenger (>18") Bobcat Hot Rod Medium Tyre (>20")	Resident/non-resident Member/non-member Commercial/non-commercial On rim Off rim Contaminated	7.37	25.00	5.70	15.00	7.00	29.70
Truck[c]	Truck Heavy truck Large Bobcat	Resident/non-resident Commercial/non-commercial On rim Off rim Contaminated	19.20	61.11	18.00	30.00	7.00	59.60
Super Single Truck		On rim Off rim	24.49	97.30	NC	NC	23.00	113.00
Forklift	Forklight (Pneumatic) Forklift (Solid) Forklift (<60 cm) Forklift (>60 cm)	Contaminated	16.32	66.00	NC	NC	5.00[g]	
Earthmoving	Machine Large machinery Heavy machinery Earthmover small (0-1 m) Earthmover large (1-1.5 m) Earthmover large (1.5-2 m) Grader Loader Earthmoving/large machinery Farm machinery Extra Large Small tractor Tractor (<1 m) Tractor (>1 m) Tractor large (0-1 m) Tractor small (1-2 m) Large plant	On rim Off rim Contaminated	50.00	210.00	NC	NC	20.00	221.00
Other OTR	Haulpak/dump truck Haulpak or similar	On rim Off rim Contaminated	NC	NC	NC	NC	420.00	1140.00

Other tyres and rubber materials	Mixed tyres Assorted tyres Rubber products (conveyor belts etc) Commercial rubber products (including conveyor belts) Commercial rubber products (excluding conveyor belts) Shredded tyres Commercial tyres (minimum charge, regardless of type)	Resident/non-resident Commercial/non-commercial On rim Off rim Contaminated Shredded Non-rateable properties All other tyres	NC	NC	NC	NC	29.70/T	880.00/T
Other fees	Entrance Fees Disposal Fees Additional surcharge on scheduled fee	Usually applied to enter facility, or for processing tyres that are contaminated or on rim. Can be applied as a set fee), or as a percentage of scheduled fee.	50.00	130.00	26.70		50 %	350 %

[a] Some metropolitan regional councils only collect tyres per tonne (e.g., minimum 380.00 per tonne)
[b] 4WDs were also sometimes grouped as Passenger tyres at some LGAs but were mostly categorised in the Light Truck category.
[c] Not collected by all LGA, particularly within Perth and Peel Region.
[d] Only one LGA collected machinery/tractor tyres in the Perth and Peel Region.
[e] Light Vehicles was often used by Regional LGAs to categorise small tyres belonging to both the passenger and light truck categories.
[f] Unit is per tyre unless otherwise indicated in the table.
[g] Only one Regional LGA had a specified scheduled fee for Forklift tyres, otherwise it was POA, or included in Passenger Tyres.

3.5 Findings from stakeholder interviews

The recent changes in the national and state government regulatory requirements set specific performance targets. For example, the *National Waste Policy Action Plan* 2019 that outlines a target of 80 % for resource recovery by 2030 across all waste streams. However, the national resource recovery targets may not consider specific waste streams such as EOLTs and conveyor belts. The *Waste Export Ban* for whole and baled tyres has already impacted Australian tyre waste recycling practices as the processing of tyres is required before exporting to overseas countries unless tyres are exported for exempted purposes (reuse or re-treading). The following sections discuss insights from stakeholder interviews.

3.5.1 Inconsistent categorisation and reporting of wastes make it difficult to track and quantify arisings and identify market potential

The high number of waste categories applied to EOLTs makes tracking the collection and disposal and identifying opportunities for reuse markets of EOLTs difficult, regardless of the source of the wastes. In addition, conveyor belts (consisting of rubber combined with one or more layers of, plastic, fabric, and metal) are used primarily in the mining and resources industry, including quarries and in ports that require mass material movements, but are not subject to the same regulatory requirements as EOLTs.

The inconsistency in the waste categorisation makes it challenging to ensure sustainable management of end-of-life waste. For example, unlike EOLTs, conveyor belts are not considered and categorised as a ‘controlled waste’ despite their similar (rubber) constituents. Therefore, the manufacturers, users and recyclers of conveyor belts are not required to report on the generation, collection, transportation, recycling, and disposal of conveyor belts. As a result, very limited information is available on the generation and management of the end-of-life conveyor belts. Conveyor belts may have different requirements for management based on the differential composition of the materials when compared to EOLTs. However, it is unknown whether there are similar risks to stockpiling and storage of conveyor belts related to fire safety, or to potential ecological receptors, as have been identified for EOLTs.

Implementing a standard waste categorisation for end-of-life rubber products that also includes conveyor belts, natural and synthetic rubber products, or other articles and products that have rubber components would enable data collection and accurate material flow analysis to be completed for waste rubber arisings in WA. Of course, this is true across a range of waste categories not only those with rubber constituents.

3.5.2 Landfilling and on-site disposal of EOLTs and other wastes hamper recycling and resource recovery

Interviewed stakeholders noted that WA's landfill and burial licenses are problematic for the management of EOLTs, conveyor belts and other wastes, especially in the regions outside of the Perth Metropolitan Tyre Landfill Exclusion Zone. In the regional areas of WA, it is still common practice to dispose of EOLT and conveyor belts in landfills (either managed, unregulated/illegal or inground for mining operations) as it is more cost effective than actively recovering value from these waste streams. According to one stakeholder, with supply chain problems during COVID, it would be cheaper in Sydney to shred tyres locally and then send them to landfill, which is allowable given landfilling is only banned for whole tyres.

According to some stakeholders, regulatory changes need to be imposed to stop on-site waste burial and markets would follow the burial ban. Allowing mining companies to bury waste at mine sites appears to be a major hindrance to the recovery and recycling of OTR tyres and conveyor belts in remote and regional areas of WA. One stakeholder indicated that if the regulatory requirements related to the on-site disposal of mining OTR tyres changed, the company would respond quickly and manage the additional costs attributed to the management of these wastes to remain compliant with state regulations. In some countries, such as Chile, there is rapid evolution of legislation to stop the burial of EOLTs to facilitate recycling. The legislation in Chile requires 100% recovery of mining tyres by 2026, and the implementation of the legislation has been instrumental in enabling Kal Tire company to invest in, develop and build a new pyrolysis facility for mining tyres (Randell and Baker, 2020). However, in some cases, the legislation has not been supported with commercialised solutions, which has resulted in stockpiling. Therefore, it is crucial to consider the balance between legislation and the availability of commercialised solutions.

It was noted by one stakeholder that some mining companies in WA voluntarily remove OTR tyres from their mine sites, which was likely in response to Caring for Country responsibilities agreed with First Nation traditional landowners. Overall, it was suggested by stakeholders (including those from mining companies) that mining companies should play a greater role in better managing OTR tyres and conveyor belts as part of their corporate social and environmental responsibility.

High transport costs have sometimes been used as an argument for not mandating the recovery of EOLTs and conveyor belts from mine sites. However, reverse logistics could enable the transportation of EOLTs and conveyor belts back to recycling centres with the same trucks or trains that take new tyres or conveyor belts to the mine sites. According to some stakeholders, mining companies bury tyres because it is cheaper than paying for waste contractors to pick and collect the waste and transporting them off-site. However, if the EOLTs were attributed a higher resource value (e.g., $1,000), there would be more of an economic drive for solutions to deal with them in other ways. Therefore, in addition to on-site disposal ban for EOLTs, an advanced recycling fee implemented nationally or other incentive to promote recycling of EOLTs (including OTR ones) could be an option.

Illegal dumping arose as a common concern among the participants of this study. Arguably, illegal, or informal dumping is a limited phenomenon, which is mainly limited to passenger tyres. Despite its almost negligible scale, the common concern is that if end users were required to undertake more sustainable practices for their end-of-life rubber products, the amount of illegally disposed of materials would most likely increase. In contrast, if tyre and conveyer belt suppliers were required to undertake more sustainable

practices for end-of-life rubber products, the amount of illegally disposed materials would most likely decrease. In many circumstances, patrolling could be a solution to informal dumping. However, due to the vast extent of WA and the minimal market density, patrolling would be largely infeasible. To mitigate the issue of illegal dumping, a strategy would be the adoption of upfront recycling fees at the point of purchase (implemented nationally) and a refund when the consumers return the tyres for recycling or to a licenced operator.

3.5.3 Current regulatory ecosystem is a barrier to resource recovery from EOLTs and conveyor belts

As noted by several stakeholders, the Western Australian Waste Avoidance and Resource Recovery Strategy 2030 gives preference to waste avoidance, reuse, reprocessing and recycling over the use of EOLTs and rubber products as Tyre Derived Fuel (TDF) to generate energy (Figure 1). However, the current practice is to shred tyres in WA and export the shredded material as TDF. TDF has a high caloric value and can replace fossil fuels in high-temperature or thermal processing, for example in cement kilns. In New Zealand, Golden Bay Cement uses up to 50% of New Zealand's EOLTs in cement production (Fletcher Building, 2022). Some stakeholders suggested that TDF should be also considered for domestic use. Other stakeholders interviewed as part of this project indicated that most cement manufacturers in Australia already use some other alternative fuel to offset the energy consumption of their processes, but to date, no TDF is used in cement kilns in Australia (Randell and Baker, 2020).

One stakeholder identified that a key barrier to resource recovery has been the lengthy process of obtaining permission or approval to use land for setting up new recycling facilities in WA. Therefore, shortening the processing times of approvals and permits could help to accelerate the growth of the capacity to reuse tyres and conveyor belts in WA.

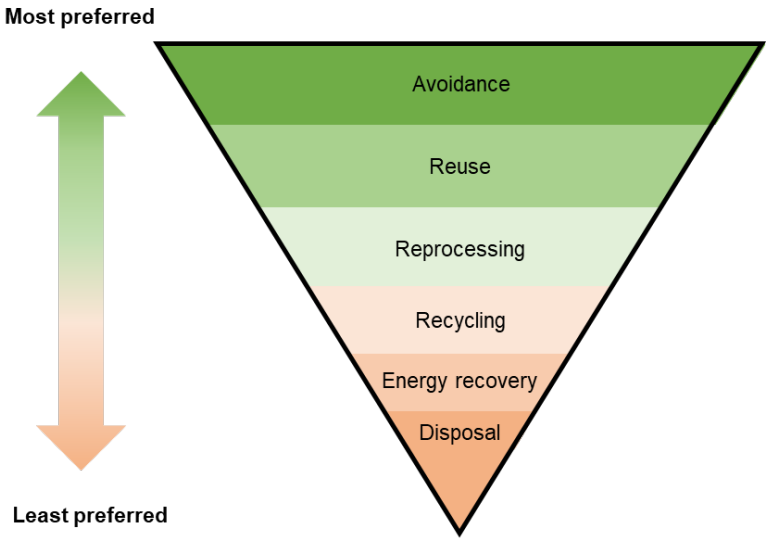

Figure 1. Waste hierarchy (Adapted from the Western Australian Waste Avoidance and Resource Recovery Strategy 2030).

Historically, lack of policy and regulatory enforcement, regulatory loopholes, and unscrutinised grant schemes have allowed informal operators (referred to as "cowboys" by multiple stakeholders) to stockpile millions of tyres across Australia. For example, according to one of the interviewed stakeholders, four to five years ago an operator in Tasmania had collected tyre disposal fees and stockpiled 2 million tyres on farmlands, as further recycling or reprocessing of the collected tyres were not compulsory and stockpiling tyres on farmlands was not illegal. However, given the legacy tyre stockpiles are a major problem and can

cause severe environmental and fire hazards, clear and enforceable regulatory policies with appropriate penalties have been considered by stakeholders as mechanisms to help restrict unlawful practices. One stakeholder suggested that having caps on the number of stockpiled tyres (e.g., at 5,000) would force collectors to find markets for collected tyres.

An amendment of Subsection 49A(2) to the *Environmental Protection Act 1986* made in 2010 mandates an offence for discharging or abandoning waste into the water to which the public has access, and Subsection 49A(3) mandates an offence (the maximum penalty is $62,500 for an individual and $125,000 for a body corporate) for discharging or abandoning waste.

Anecdotally, regional stakeholders indicated that illegal dumping occurred across their LGAs, and these incidents were sporadic and usually contained 1-2 tyres of various types and sizes, but there was no formal way of monitoring the amount or type of wastes that were dumped. It was suspected that the Tyre Landfill Exclusion Zone proximity to the built-up areas was a key driver for the illegal dumping of EOLT. In addition, this exclusion zone has likely resulted in the diversion of some EOLT waste streams from Perth Metropolitan and Peel regions to regional WA where these wastes are not excluded from landfill disposal.

3.5.4 Promoting EOLT recycling and reuse through product stewardship

Many interviewed stakeholders (including those in tyre manufacturing and distribution, recycling, and recycled product end-users) have supported introducing stricter and mandatory financial incentive mechanisms to promote the recycling and recovery of value from EOLTs. The mechanisms suggested by stakeholders included an upfront tyre recycling and disposal levy and a carbon tax paid for by consumers to create a local market and attract appropriate investment for the tyre recycling industry.

In 2014, TSA announced the TPSS with the aim to promote and increase environmentally sustainable collection and recycling processes and to explore new uses for recycled EOLT. Currently, the industry-led voluntary scheme is funded by voluntary levy-paying members (10 tyre importers, 7 OTR importers, and 3 vehicle importers) and the scheme has approximately 1,700 participating organisations. Stakeholders agreed that the TPSS is an important tool for EOLT product stewardship in Australia but indicated that the current voluntary scheme could be reformed to a co-regulatory or a mandatory product stewardship scheme to capture all tyres, conveyor belts and other rubber products (including those imported as part of vehicles or other equipment and machinery) from all importing countries, and to better cater for the desired resource recovery outcomes for EOLTs. One tyre distributer indicated that the extension of the TPSS into a mandatory extended product stewardship scheme would be key for certain investments into the recycling of and resource recovery from EOLTs and rubber products. Another stakeholder also noted that the TSA Board comprises of mostly representatives from tyre manufacturers and retailers, but not recyclers, and better representation of the supply chain may help to identify key barriers and opportunities for the recycling industry and markets for products derived from EOLTs and other rubber materials.

One stakeholder also recommended an upfront recycling fee or disposal fee (e.g., 20 cents/kg) that importers would need to pay based on weight of tyres imported into Australia or paid for by consumers when they procure new tyres and conveyor belts. They suggested that the fee could go into a centralised fund and be used for the collection and recycling of the equivalent tyres when they come to the end of their lives. It was also suggested that upfront fees could be reimbursed to consumers when they return the used products for recycling, with the reimbursement provided as a discount on new tyres (as an example).

A stakeholder also noted that it is problematic when all financial reimbursement occurs at the waste collection stage rather than at the recycling stage. For example, tyre recyclers that transport and shred tyres may only make 5-10 cents per tyre of the $2 collection reimbursement. In comparison if they buried the tyres, waste managers would collect the full reimbursement, which makes the playing field uneven if

licensed operators are allowed to bury their tyres. According to another stakeholder, New Zealand is considering mandating tyre disposal levies, which would fund a mandatory product stewardship scheme (Tyrewise) in which the scheme manager would distribute the levied funds among licensed collectors.

3.5.5 Supporting tyre re-treading through standards and incentives

According to some stakeholders involved in tyre manufacturing and distribution, good quality, more expensive tyres provide more durability, more mileage and can be re-treaded. These attributes are linked to greater safety and performance and can extend the life span of tyres in use. In comparison, lower quality and often cheaper tyres have greater environmental impact related to the atmospheric release of rubber micro- and nanoparticles and contaminants of concern, have low repurposing or reuse potential and according to stakeholders in the recycling sector, have a detrimental impact on process efficiency when recycling EOLTs. Traditionally though, consumers have opted for lower-quality, cheaper tyres, a behaviour which has led to increased landfill disposal and resulted in the permanent loss of materials from our economy.

Improved and consistent standards for the quality of tyres imported into Australia, harmonised import codes that account for tyres and rubber products imported as part of other equipment and a mandatory tyre and conveyor belt product stewardship scheme might be considered to improve the flow of tyre and rubber materials in our economy. In addition, these would also improve the market for second life of tyres by increasing repair and reuse, and result in the diversion of EOLTs from landfill and development of the EOLT and rubber product recycling markets in WA. A concurrent campaign to educate consumers and shift behaviour towards repair and reuse was also noted as an important aspect for promoting the extension of the life of tyres.

Multiple stakeholders agreed that the government should enact legislation that all truck tyres (and other tyres associated with aviation, transport, and mining) to be re-treaded at least once within their life and, if not then the users should pay a higher disposal fee as a disincentive to early disposal by not extending the life of tyres. Also, introducing a financial incentive for re-treading was seen by stakeholders as a mechanism to extend the life span of old tyres. This may be a matter for the Australian Federal Government but would require collaboration with all levels of government to ensure success. It would be important to ensure that the re-treaded tyres comply with safety standards to ensure that no additional risk to use safety will result from retreated tyres. Similarly, repaired conveyor belts should meet safety standards. Practical implementation of re-treading programs in Australia could be developed with learnings from similar programs already in action in other countries, such as Chile, which have been established through the introduction of the Chilean Waste Tyre Laws. These laws have established goals for the collection and recovery of tyre waste (and similar arisings) and mandate reuse, recycling and recovery over disposal (Scott, 2020).

3.6 Key Regulatory and Policy Recommendations

Based on the review of regulatory and policy instruments and related stakeholder interviews, the following recommendations are made to improve value recovery from EOLTs and conveyor belts in WA, and more broadly, the whole of Australia:

- **Consider imposing restrictions on the disposal of EOLTs, conveyor belts and rubber products in landfills and on-site (including mine-site tyre burials) in WA.**
- Given the increasing use in mining, pastoral, and other primary industries, **consider classifying conveyor belts as 'controlled waste' in line with EOLTs**, and associated export bans that may flow

from such a classification, including the export of whole or part-processed conveyor belt materials. Consideration to the ecological and safety risks of conveyor belts and their components as has been completed for EOLTs would assist with making decisions around the inclusion of these materials into a regulatory ecosystem.

- **Consider consolidated and consistent, hierarchical waste categorisation codes for all EOLTs, waste conveyor belts and other rubber products in WA.** These codes should be co-developed in consideration of other jurisdiction waste codes, with the view of creating a nationally consistent waste code for Australia.
- **Consider mandatory reporting requirements for the generation, transport, and processing of all EOLTs (including OTR tyres) and conveyor belts and other rubber products**, using WA's Controlled Waste Tracking System (CWTS) (if deemed the appropriate system).
- **Consider a review of WA's CWTS to assess its adequacy to track and trace the movement and fate of hazardous wastes in WA**. If inadequate, develop a new tool (or integrate with the existing digital tool such as Environment Online) for this purpose, in conjunction with hazardous waste tracking tools being developed across other Australian jurisdictions.
- **Consider establishment of a mandatory or a co-regulatory product stewardship scheme to capture all tyre and conveyor belt imports** (including tyres imported on vehicles, equipment, and machinery), with appropriate upfront levy to ensure resource recovery from EOLTs and conveyor belts.
- **Consider incentives for re-treading tyres and repairing conveyor belts, and for EOLT and conveyor belt recycling.** Disincentives for disposal to encourage the extension of the material life and resource recovery, and to discourage landfilling or illegal dumping could also be considered.
- **Consider quality standards for imported tyres to ensure tyres can be re-treaded and recycling of EOLTs and conveyor belts is not compromised by poor quality feedstocks.** Review and harmonise import standards to account for imported tyres and conveyor belts, and if included as part of machinery or equipment assess import standard needs.
- **Consider reviewing policy so that products derived from EOLTs, and conveyor belts can be used for beneficial purposes in WA**, including for TDF, with due assessment of the safety of reuse products for human health and the environment.
- **Review approval and licencing processes for EOLT and conveyor belt processing facilities in WA** and identify and address potential hindrances or delays to those processes.

4 EOLT and conveyor belt arisings in WA

This study aimed to generate and review data for EOLT and conveyor belt arisings in WA to compare the data with existing and planned processing capacity. The project team concedes that the sources of data (including assumptions and estimates where applied), and subsequent analysis are only likely to provide an approximate indication of EOLT arisings and outputs in WA, as there is no systematic, "best-practice' framework in place to collect data related to EOLT in WA, or in Australia. Moreover, as conveyor belts and other rubber products are not regulated as controlled waste in WA, no data could be obtained related to the arisings or disposal of these products. This report provides a preliminary indication of where opportunities and challenges exist and will also form the basis for future research and development to further enable the markets for products derived from EOLTs and conveyor belts in WA. The general findings related to EOLT and conveyor belt arisings in WA are outlined here.

4.1 Data sources, limitations and assumptions

Regional EOLT arisings were estimated through analysis of data sources obtained from DWER and TSA. Where data gaps were identified, the findings were supported by qualitative themes obtained from semi-structured interviews and ad-hoc data obtained from various stakeholders.

In March 2022, CME helped to contact a total of approximately 250 people (including contacts in different divisions of the same companies) from approximately 46 companies to survey information on tyre and conveyor belt procurement, generation of EOLTs and conveyor belts, and current practice of handling EOLTs and conveyor belts in WA. However, the response rate from companies to the survey was low, with only three (3) responses formally recorded (6.5 % response rate for companies and 1.2% for contacted individuals).

Given the low industry response rate, data on the transportation of EOLTs were instead used as a proxy to estimate EOLT arisings in WA. The data related to EOLT transport was sourced from DWER and TSA. Regional EOLT arisings were estimated through analysis of data sources obtained from DWER and TSA. Where data gaps were identified, the findings were supported by qualitative themes obtained from semi-structured interviews and ad-hoc data obtained from various stakeholders. The EOLT transport data did not include OTR tyres, and organisations that did respond to our survey were not able to provide data on OTR arisings at their mine sites, and hence, OTR tyre arisings that are reported are based on previously published estimates.

As the reporting of the transportation or management of used conveyor belts is not mandatory in WA, no data on used conveyor belt arisings were available from the stakeholders engaged for the project.

4.1.1 Controlled Waste Tracking Data

The data obtained from DWER was extracted from the Controlled Waste Tracking System (CWTS). Under the Environmental Protection (Controlled Waste) Regulations 2004, the tracking of controlled waste only needs to occur where:

- It is as a result of a commercial or industrial process, and
- Where it will be transported on a public road, and

- In the instance of tyres, if the amount transported is over 200 kg.

When considering data from the CWTS, it was noted that the data was likely to be incomplete. For example, there have likely been arisings not classified as controlled waste and hence, there would be no requirement for tracking, and instances where EOLT may have been transported and disposed of within the same site and therefore would not have been recorded. In addition, some of the entries from the CWTS may have been duplicated, capturing arisings in multiple movements related to individual and agglomerated consignments of controlled waste, and this could have skewed the analysis, especially in regional WA. Lastly, the data extracted from the CWTS did not delineate between EOLT categories, but rather represented the total collected arisings for EOLTs under the waste code T140. The following assumptions should be noted related to the presentation of regional arisings of EOLT in WA:

1. Data was reviewed in its entirety to remove obvious duplicate information. However, double tracking of controlled waste may still be present, as in some cases, it was impossible to identify where movements had been agglomerated.
2. In some instances, the unit of measure recorded for controlled waste was reported as a mass in kilograms (kg), and in others it was reported as a volume in cubic metres (m^3). Without a clear understanding of what categories of EOLTs were transported, it was not possible to calculate the conversion from volume to mass. In these instances, a correction factor of 1000 was applied (i.e., 1000 kg in m^3). However, it is likely that these occurrences of inconsistent units of measure can both over- and under-estimate arisings for regions and sectors, due to variable tyre densities and packing densities of piles of tyres.
3. Origin and fate tags were subjectively applied to each tracking movement to determine where arisings originated, and where EOLTs were finally disposed/recycled. The tags were provided based on general internet searches of entity names and information garnered from DWER licence information. Identifying information related to the origin and fate of EOLTs in WA has not been presented in this report.
4. The data obtained from the CWTS is unlikely to capture movements of OTR tyres outside of the Perth Metropolitan region due to the allowance of on-site disposal.

There was no data related to end-of-life conveyor belt arisings in any region of WA, as it is not subject to controlled waste regulations and there is no mandatory requirement to report movement of these materials.

4.1.2 TSA participant data

The data provided by the TSA comprised of voluntary reporting of EOLTs from participants of the voluntary TPSS managed by the TSA. The data set provided some categorisation of EOLTs based on vehicle of origin but did not provide any data related to arisings of OTR tyres or conveyor belts, and mostly covered arisings generated by tyre retailers near the Perth Metropolitan and other regional centres. As it is not mandatory to report data to the TSA, it is likely that the TSA data set does not cover all arisings of EOLTs in WA. The data provided by TSA is also an aggregate of the region and as a result, no single entity, individual or organisation can be identified from the data set provided for this study.

4.2 Estimated EOLT arisings from CWTS movements

4.2.1 EOLT arisings in WA

In 2021, the estimated total arisings of EOLTs in WA (extracted from the CWTS data) was approximately 42,499 tonnes (Figure 2). The transported EOLT arisings extracted from the CWTS was slightly higher than the 40,798 tonnes reported for the sum of passenger and truck tyres in WA by Randell et al. (2020) for year 2018-19 (total EOLT arisings: 61,343 tonnes, with an estimated 20,635 tonnes attributed to OTR tyres). Combined, Perth Metropolitan and Peel regions generated 26,132 tonnes (61.5 % of total arisings) and the other regions of WA contributed 16,367 tonnes (38.5 % of total arisings). The remaining EOLT arisings in 2021 (38.5 %) were reported from all other regions in WA combined. The Pilbara (11.1 %) and South West (9.8 %) regions contributed to the highest EOLT arisings outsides of the Perth Metropolitan and Peel regions (Figure 3, Table 8).

Perth Metropolitan and Peel regions had the highest total arisings (61.5 %), which was consistent with population density within these regions (333 people/km^2). Generally, higher population densities contributed to higher volumes of wastes, including EOLTs generated in these regions. The South West region of WA was the second most densely populated region of WA (50.4 people/km^2), which correlated with the high arisings in this region (Table 8). A similar trend was observed in the Goldfields Esperance region, where the population density was slightly lower when compared to the South West (42.6 people/km^2), and the associated EOLT arisings represented approximately 6 % of the total arisings in WA as reported by the CWTS.

In contrast, the Pilbara region is one of the least densely populated regions of the state (0.67 people/km^2), with the population mostly located in regional centres such as Port Hedland. However, reported EOLT arisings were like those of the highly populated South West region (9.8 %). Noting the assumptions related to the recording and tracking of data generated for controlled waste, it is likely that the higher arisings in the Pilbara region could have been attributed to arisings generated from predominant regional industries concentrated in this region, including mining (Figure 4), resources, and agriculture (Table 8). Similarly, other regions where mining, agriculture and resources are the predominant industries, including Goldfields Esperance and Mid West, may also have proportionally higher arisings of EOLTs due to the generation of EOLTs from commercial and industrial sources.

Analysis of the EOLT arisings in regional WA showed a generally increasing trend in EOLT arisings across all three years in all regions, apart from the Wheatbelt region (Figure 5). This increasing trend is likely to continue in regions with increasing population growth forecasted to 2036 (Table 8), which include Kimberly, Pilbara, Gascoyne, and areas of the Mid West (particularly City of Greater Geraldton). It is not clear what a decreasing population trend for the Goldfields Esperance region will mean for EOLT arisings, given that the predominant industry in this region is mining. As OTR mining tyres are unlikely to be captured in the CWTS, the trend related to OTR mining tyres cannot be determined.

Regions where already high EOLT arisings have been recorded, in combination with high forecasted population growth and complementary predominant industries that favour the generation of EOLTs, OTR tyres and other rubber products (including conveyor belts), could be potential locations for processing hubs for resource recovery and reuse of these materials.

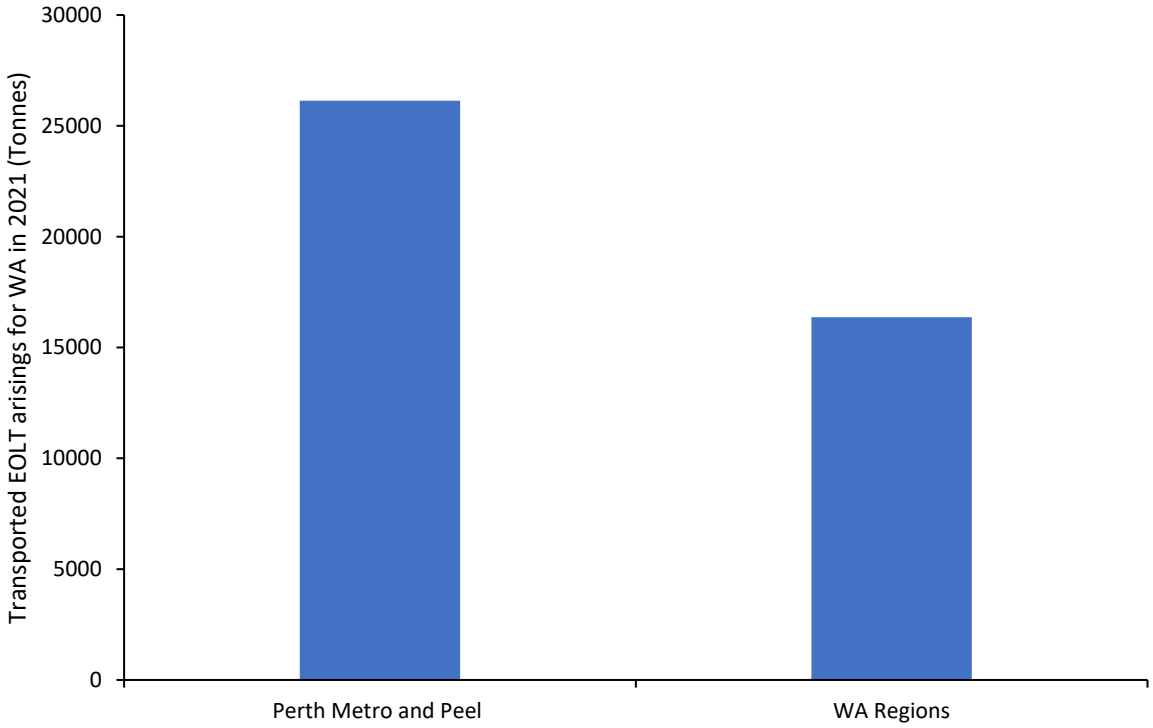

Figure 2. Transported EOLT arisings in Perth Metro and Peel regions and the rest of regional WA in 2021, extracted from Controlled Waste Data Tracking (source: DWER). Note that the data is unlikely to include OTR tyres which are often disposed on-site.

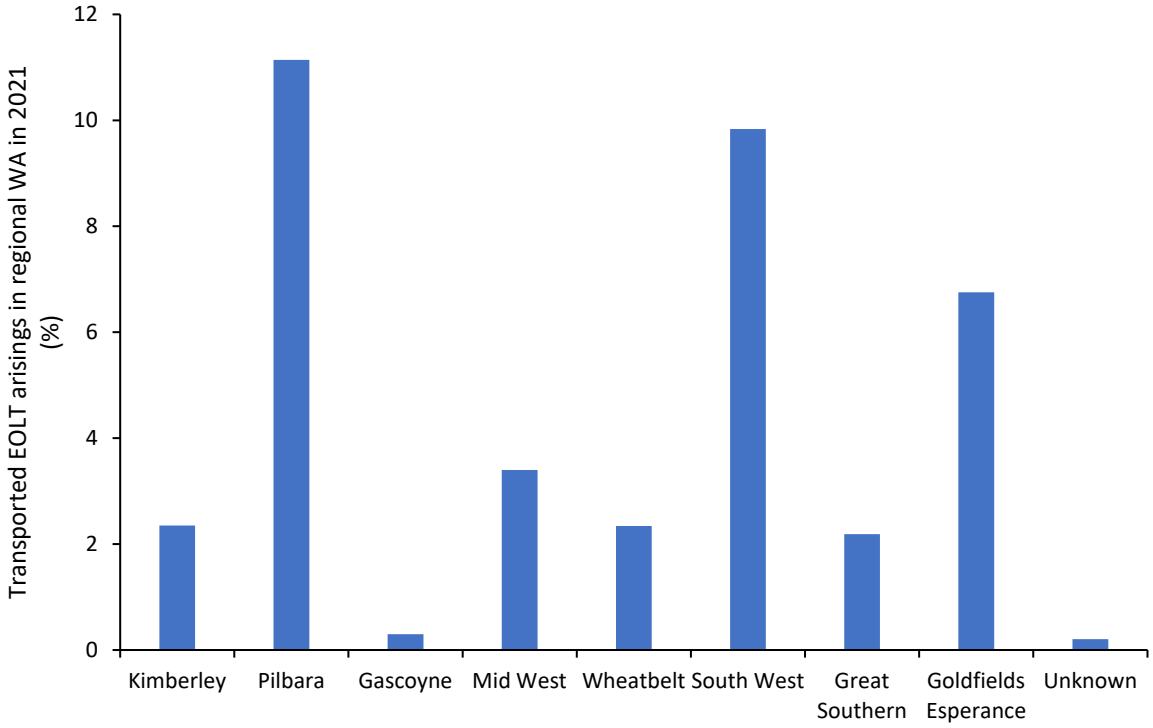

Figure 3. Percentage of transported EOLT arisings attributed to regional WA in 2021, extracted from Controlled Waste Tracking Data (source: DWER). Note that the data is unlikely to include OTR tyres which are often disposed on-site.

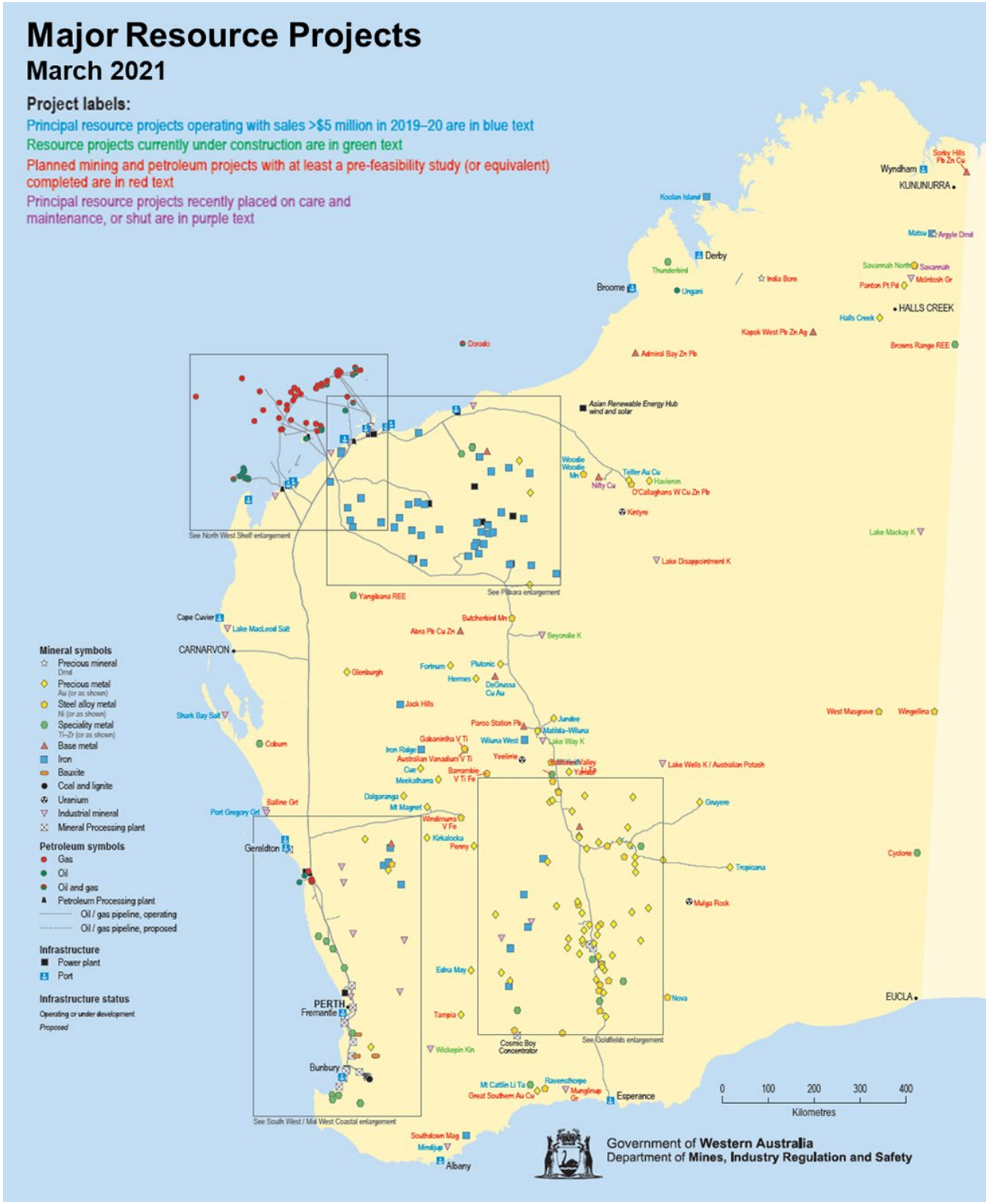

Figure 4. Major resource projects in WA as of March 2021, which show the concentration of mineral resources activity in the Pilbara, Gascoyne, Mid West and Goldfields Esperance regions (reproduced with permissions from Department of Mines, Industry Regulation and Safety).

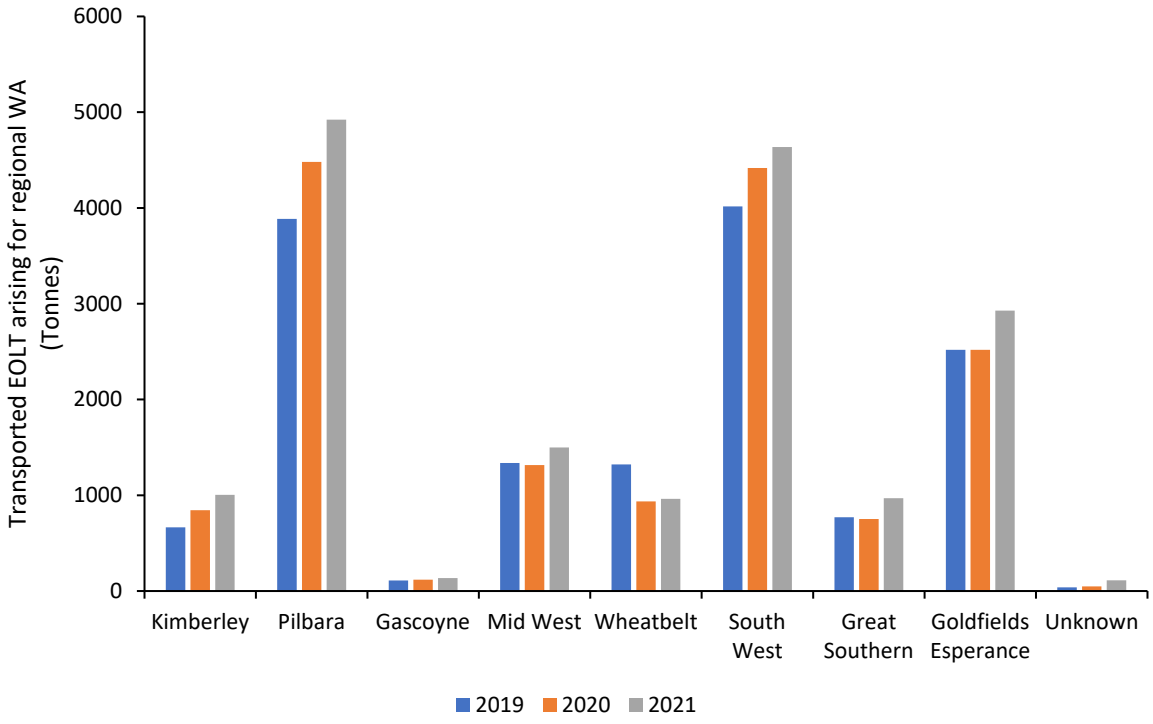

Figure 5. Transported EOLT arisings for 2019, 2020 and 2021 in regional WA. The data excludes extraordinary data recorded for Kimberley region in 2019 (9,870 tonnes in Shire of Wyndham-East Kimberley), as similarly high data was not reported in subsequent years. Note that the data is unlikely to include OTR tyres which are often disposed on-site.

Table 8. Summary of land size, predominant industries, population density, transported EOLT arisings (Figure 5) recorded by the CWTS and predicted population growth to 2036 for regional WA (excluding Perth Metropolitan and Peel regions).

Region	LGAs	Land size (km^2)	Predominant regional industries[a]	Population density 2021 (people/km^2)[b]			EOLT arisings (tonnes)[c]			Predicted population growth to 2036 (people/km^2)[b]		
				Average	High (LGA)	Low (LGA)	2019	2020	2021	Average	High (LGA)	Low (LGA)
Kimberley	4	413,976	Health care & social assistance (15.9 %), Education & training (13.4 %), Accommodation & food services (9.5 %)	0.12	0.31 (Shire of Broome)	0.023 (Shire of Halls Creek)	665[d]	844	1,004	49.9	108 (Shire of Broome)	9.47 (Shire of Halls Creek)
Pilbara	4	504,687	**Mining (45.7 %), Construction (17.6 %), Transport, postal & warehousing (4.9 %)**	0.67	1.35 (Town of Port Hedland)	0.028 (Shire of East Pilbara)	3,885	4,480	4,922	55.8	125 (Shire of Karratha)	6.73 (Shire of East Pilbara)
Gascoyne	4	125,192	Accommodation & food services (11.5 %), **Mining (11.5 %), Agriculture, forestry & fishing (11.1 %)**	0.15	0.42 (Shire of Exmouth)	0.006 (Shire of Upper Gascoyne)	110	118	135	18.0	36.7 (Shire of Exmouth)	-4.73 (Shire of Carnarvon)
Mid West	17	480,682	**Mining (11.4 %),** Health care & social assistance (11.1 %), Education and training (9.8 %)	0.38	3.06 (City of Greater Geraldton)	0.003 (Shire of Sandstone)	1,336	1,315	1,499	-2.93	80.9 (City of Greater Geraldton)	-21.9 (Shire of North
Wheatbelt	42	156,720	**Agriculture, forestry & fishing (30.3 %),** Health care & social assistance (8.8 %), Education & training (8.6 %)	0.85	7.76 (Shire of Northam)	0.052 (Shire of Mt Marshall)	1,321	936	962	-2.75	48.0 (Shire of Chittering)	-23.7 (Shire of York)
South West	12	23,950	Retail trade (12.1 %), Heath care & social assistance (12.1 %), Construction (10.6 %)	50.4	486 (City of Bunbury)	0.452 (Shire of Nannup)	4,015	4,417	4,636	212	1,177 (City of Busselton)	-31.4 (Shire of Manjimup)
Great Southern	11	61,252	**Agriculture, forestry & fishing (16.4 %),** Health care & social assistance (12.3. %), Retail trade (11.0 %)	13.9	129 (City of Albany)	0.098 (Shire of Kent)	770	751	961	30.6	357 (City of Albany)	-29.3 (Shire of Katanning)
Goldfields Esperance	9	677,103	**Mining (34.4 %),** Health care & social assistance (7 %), Retail trade (6.6 %)	42.6	383 (City of Kalgoorlie Boulder)	0.004 (Shire of Menzies)	2,518	2,518	2,928	2.76	110 Shire of Kalgoorlie Bounder)	-41.1 (Shire of Coolgardie)

[a] Predominant regional industries in regions of WA identified by Economy Profiles for regions on REMPLAN (REMPLAN, 2022). (Industries where EOLT and conveyor belt arisings are likely to occur are in **bold**)

[b] Extracted from Western Australia Tomorrow population forecasts, Population Report No. 11.

[c] Estimated from CWTS data provided by DWER.

[d] Excludes extraordinary data recorded for Kimberley region in 2019 (9,870 tonnes in Shire of Wyndham-East Kimberley). This data was excluded from the analysis as it did not recur in future years.

4.2.2 Sector-based EOLT arisings in WA

Analysis of CWTS data indicated that the majority of transported EOLTs reported in 2021 were arisings generated from tyre retailers and distributors, or mechanical service providers (either whole car or tyre servicing). EOLT arisings attributed to “Tyre & Auto” represented 66 % of total arisings recorded in 2021 (28,234 tonnes), with the majority of these likely being attributed to passenger, light vehicle, or truck tyres, though no categorisation of EOLT arisings is provided in the CWTS (Figure 6). Transported EOLT arisings were second highest in the category of “Mining”, which included specific OTR mining distributers and mining companies that could be identified from the CWTS. “Transport” (9.0 %) and “Waste” (4.3 %) represented the next highest generating sectors for EOLTs reported by CWTS data. “Transport” includes companies involved in haulage and freight, while “Waste” captures data relating to the movement of EOLTs from a collector to a nominated fate (Recycler, Landfill or Other Processor).

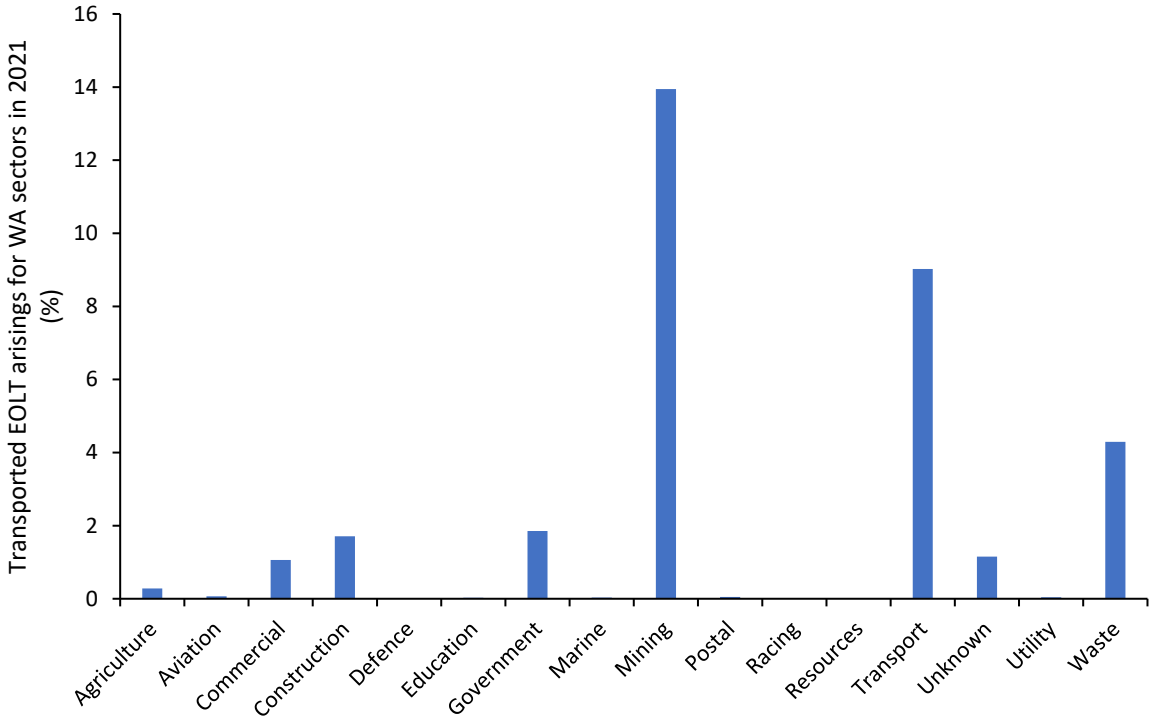

Figure 6. Percentage of transported EOLT arisings in WA for 2021 attributed to various sectors, extracted from Controlled Waste Tracking Data (source: DWER). This figure excludes the category “Tyre & Auto”, which represents approximately 66 % of total EOLT arisings tracked by the CWTS. Note that the data is unlikely to include OTR tyres which are often disposed on-site.

Most of the transported mining EOLT arisings were reported in the Perth Metropolitan and Peel regions (69.5 %). Other transported arisings occurred throughout regional WA (Figure 7), with Goldfields Esperance (9.6 %), Mid West (5.2 %), Great Southern (4.9 %), Wheatbelt (4.4 %), Pilbara (2.3 %) and the South West (2.0 %) regions all having reported transports related to the mining sector. No mining EOLT arisings were recorded for the Kimberley region, and minor arisings were reported for the Gascoyne, which agrees with population density and waste generation from small, dispersed communities, but is at odds with the predominant industries identified for those regions. Given the concentration of mining and resource operations, and agriculture industries scattered throughout these regions, it is unlikely that the CWTS has captured any data related to OTR tyre arisings, and if it is captured, it cannot be separated from the whole data contained therein. This agrees with previous reports that (96 %) of mining OTR tyres are being buried

on-site due to the lack of recycling channels to recover tyre-derived products and fuels from OTR tyres (Kariyarra-Tyrecycle, 2022).

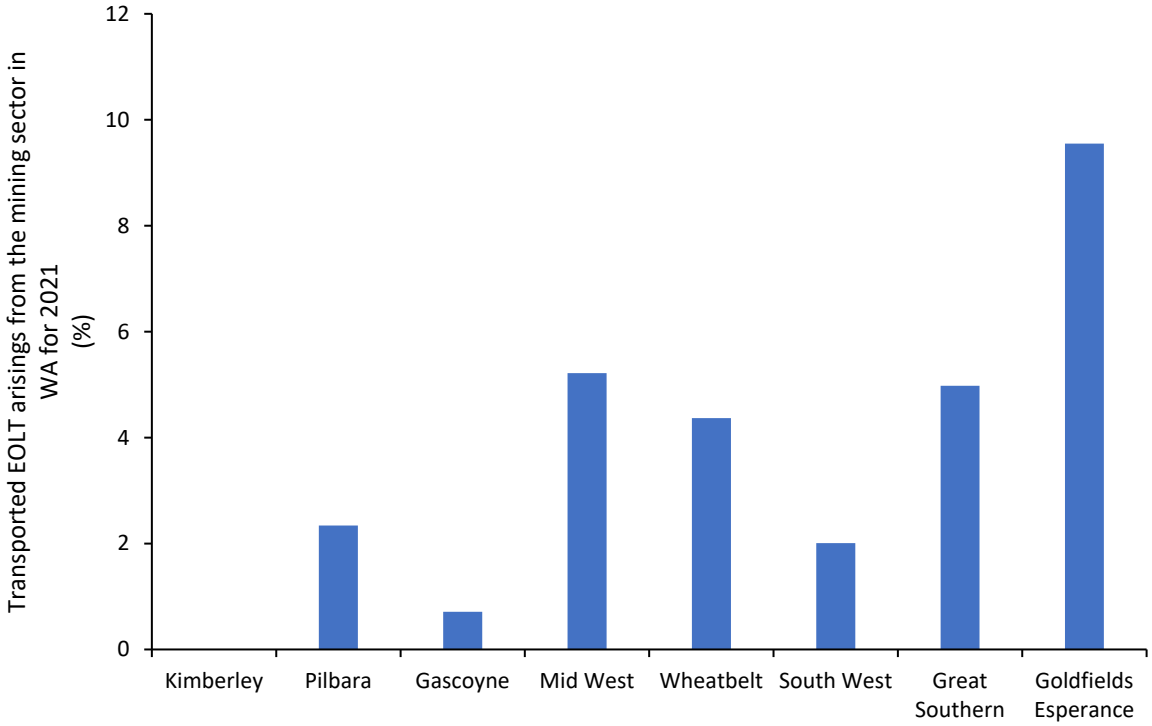

Figure 7. Transported EOLT arisings (%) attributed to the mining sector for regions of WA for 2021 (excluding the Perth Metropolitan and Peel regions), extracted from Controlled Waste Tracking Data (source: DWER).

4.2.3 Fate of EOLTs in WA in 2021

A review of the fate of transported EOLT arisings extracted from the CWTS data indicated that 70 % of transported EOLT arisings reported for WA ended at a recycling facility for processing (Figure 8). The percentage of recycled EOLT arisings generated from the CWTS data generally agreed with Randell et al. (2020) who estimated that 67 % of EOLT arisings in WA for 2018-19 were recycled. Of these, 63 % were recovered for export and only 4 % for domestic use (Randell et al., 2020). Approximately 27 % of transported EOLT arisings recorded by the CTWS data for WA in 2021 were still sent to regional waste management facilities, where it is assumed that they have been landfilled (outside of the Tyre Landfill Exclusion Zone). Some EOLT arisings (3.32 %) could not be attributed a fate due to incomplete or inconsistent information. A small amount (0.02 %) of transported EOLT arisings were sent to other waste processors where the management of those arisings was not apparent.

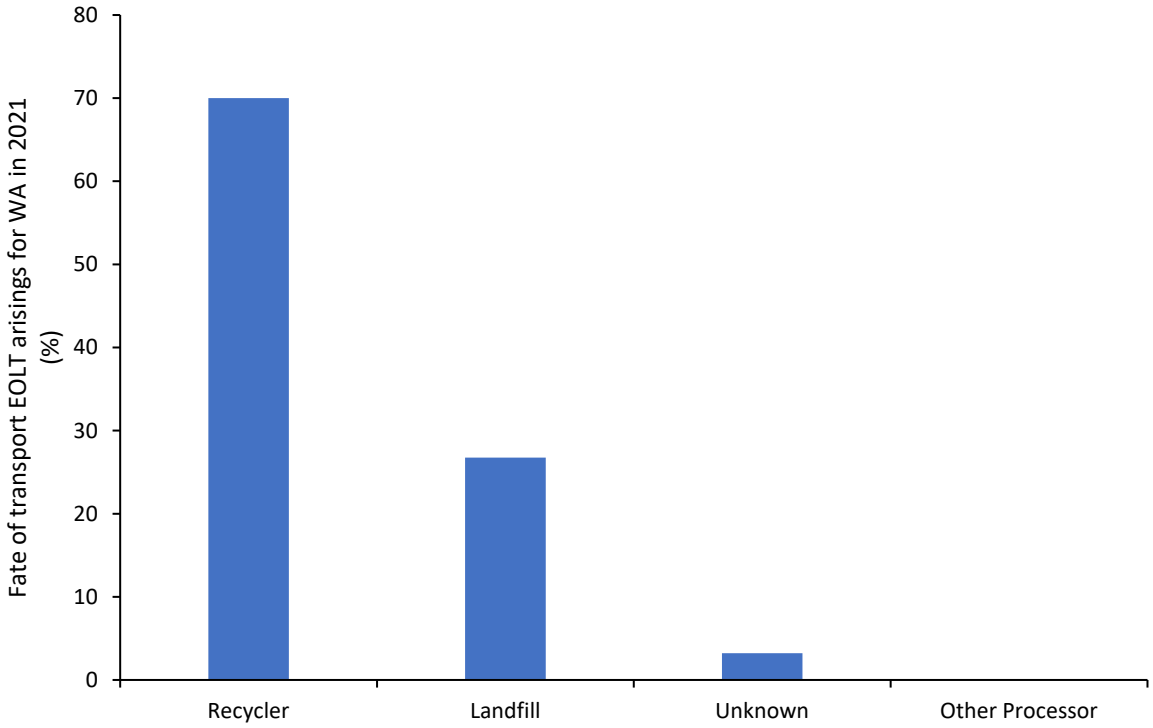

Figure 8. Fate of transported EOLT arisings in 2021 for WA, extracted from Controlled Waste Tracking System Data (source: DWER). Note that the data is unlikely to include OTR tyres which are often disposed on-site. The value for Other Processor was 0.02 %.

4.3 Estimated EOLT arisings from TSA data

Data supplied by TSA included voluntary reporting of EOLT movements from/to TSA member entities in 2021, in the form of inputs or outputs reported by retailers, recyclers or collectors of EOLTs. The categories did not include OTR tyres, which were not captured in the data set. The extracted data set included 2,997 reports of EOLT arising from 200 participating entities. The TSA members in WA reported 9,800 tonnes of total EOLT arisings, which represented 23 % of total transported arisings in WA, as reported by the CWTS data. However, the dataset did not include movements to or from the largest EOLT recycler in WA, and so was incomplete for the purposes of this study, though the delineation of EOLT arisings in the TSA data does allow better resolution of the types of EOLT being reported by participating WA entities.

4.4 Findings from stakeholder interviews

4.4.1 Stakeholder insights on EOLT arisings

Feedback from metropolitan-based waste management providers and stakeholders indicated that no tyres were reported to be disposed to landfill within the Perth Metropolitan region, which was in accordance with the Tyre Waste Disposal Exclusion Zone. All tyres collected at Metropolitan waste management facilities have been stockpiled in accordance with landfill licence arrangements, collected by a controlled waste contractor and transferred to a waste processing service provider. The CWTS data indicated that all EOLT arisings that were landfilled were done so in regional waste management facilities, which has been permitted under the WA regulations that cover the management of EOLTs.

Feedback from regional LGA stakeholders indicated that in larger regional centres, such as Bunbury, Busselton-Dunsborough, Esperance, and Albany (in the South West), tyres were collected and stockpiled as per licencing arrangements for their respective waste management facilities. These tyres were then regularly collected by a waste management contractor with a controlled waste movement licence and transported to Perth for waste processing. In these regional centres, it was predominantly waste passenger tyres that were collected, but shires did report that a small number of larger tyres were collected intermittently. This anecdotal information suggests that no or limited movements of OTR or large earthmoving tyres would have been captured by the CWTS. However, one of the interviewed stakeholders had estimated the annual OTR tyre arisings in the Pilbara alone to be approximately 30,000 tonnes.

Anecdotally, the volume of tyre wastes collected in regional agricultural areas was reported as “low” or none, likely due to low population densities, untraceable disposal, and on-farm management and reuse (e.g., for silage, bunding, boundaries). Regional LGAs with mining tenements did not receive OTR tyres, so it is likely that these tyres have been managed by on-site disposal (by burial) as permitted under a mine site's licence conditions, regulated under the WA Environmental Protection Act 1986 and its regulations. Several regional shires reported that residents were not taking waste tyres to the local waste management facility, with most reporting anecdotally that waste passenger tyres were taken back to the local distributer during servicing, and other tyres, including earthmoving tyres were stockpiled and reused or buried on farms.

Few LGAs reported illegal dumping, with limited data recorded. One shire reported less than 4 tonnes of tyres illegally dumped in 2021, and this was in combination with other illegally dumped waste. Another shire reported that there were more than 20 reports of illegal dumping in 2021, “many” of which have a “tyre or two” among them, but no formal metric for illegal tyre dumping could be derived from engagement with LGAs.

4.4.2 Stakeholder insights on used conveyor belts arisings in WA

Although no quantitative data on used conveyor belts arisings was available, interviewed stakeholders indicated that conveyor belts are used at all mine sites in WA, as well as other industries, such as quarries and port facilities that require mass material movement, with the resources sector being the primary user. Iron ore mines represent the major conveyor belt consumers in WA, although also underground gold mines use conveyor belts. Arisings of imported conveyor belts could also be estimated at time of import; however, these materials are usually not accounted for during import as they are considered a component of equipment. Additionally, there is no data available regarding the domestic manufacture or sale of conveyor belts, in line with the current regulatory environment related to these materials in both WA and Australia.

Conveyor belt arisings in mining could be estimated based on the consumption and production capacity of mine sites. However, the production capacity of both mines and the conveyor belts, as well as the maintenance and replacement of conveyor belts, are all considered by the interviewed stakeholders as commercial-in-confidence information, because of the competitive environment and few players in the industry. The type and composition of conveyor belts used on-site depends on the type of mine and commodity that is being mined and may have varying impacts on resource recovery. For example, conveyor belts with fire retardants are required for underground mines, and this may impact downstream recovery and recycling processes due to the presence of fire retardant chemicals of concern. Steel cord conveyor belts are mainly used with high weight high volume and hard rock materials such as iron ore, whereas poly- or ply-woven conveyor belts are used for less abrasive materials such as coal. This difference in the composition may require some additional source separation at the recycling stages, which would need to be accounted for in feasibility assessments for recycling these materials.

The life span of conveyor belts was reported to depend on the application, usage and volumes and types of materials the conveyor belts are used for moving. Belts often last for 11-12 months, some less or more. The causes of reported conveyor belt failures include (1) product failure (rare); (2) damage (e.g., by large rocks); (3) worn out or fatigue of the casing (in this case, generally a longer section of the belt would need to be replaced). Many mines have the equipment to measure belt thickness and damage of conveyor belts in real-time to enable predictive maintenance or replacement of the belts, and hence, the projected lifespan of the conveyor belts does not necessarily reflect when they get changed out and disposed. They might get changed out during shutdowns if the forecast indicates that it is too risky to wait longer in case a failure happens during a time that will interrupt operations. For example, the operation of conveyor belts is critical during the loading of ships in ports. Therefore, some of the remaining lifespan of a belt may be sacrificed, but the degree of the sacrifice depends on the location and the criticality of the belt. Conveyor belts are generally repaired on-site as it is not practical to send long conveyor belts for repair. The damaged conveyor belt can be repaired by doing what is known as “splicing”, which joins the steel cords within the belt together. This involves matching up steel cords, cables joining, heating, and curing of rubber.

According to one stakeholder, when conveyor belts reach their end of life, most mine sites stockpile them on-site. There is reluctance to bury the entire steel wheel that holds the conveyor belt, and typically there is a lot of land area around mine sites for stockpiling. Unlike EOLTs, there are no restrictions to stockpiling these materials. One stakeholder estimated that up to 25 % of used conveyor belts would be disposed on-site immediately once they reach EOL, with the fate of any stockpiled material uncertain.

4.5 Recommendations for understanding EOLT and conveyor belt arisings in WA

Based on the review of the EOLTs and conveyor belts, the following recommendations are made:

- **Consider harmonisation of the categorisation of EOLT types and conveyor belts across** WA and throughout Australia, to ensure consistency and accuracy of the arisings data.
- **Consider restricting regional landfilling and on-site disposal by burial of EOLTs, conveyor belts and other rubber materials** to improve landfill diversion and recycling of these materials (currently, 70 % of transported EOLT arisings are recycled).
- **Consider the inclusion of conveyor belts and other rubber materials as controlled waste** allowing transports to be tracked according to controlled waste regulations.
- **Explore industry arisings data-capture and value recovery benefits from banning on-site disposal (including burial) of EOLTs (including OTR tyres) and conveyor belts.**
- **Establish appropriate and harmonised reporting of all transport of EOLTs and end-of-life conveyor belts** (units of measurement, categorisation of waste types) for WA.
- **Establish appropriate reporting of end-of-life OTR tyre and conveyor belt arisings.**
- **Review how to track and report illegal dumping** occurrences to understand the impact and leakage of materials via this disposal method.

5 EOLT and conveyor belt processing capacity in WA

This section provides an assessment of the current and planned processing capacity of EOLTs and conveyor belts, as well as a preliminary estimation for the quantities of tyre and conveyor belt-derived products in WA. Where data is lacking, estimates of processing capacity and product types and quantities have been derived from funding and applications for licences, as well as anecdotal information from interviewed stakeholders.

5.1 Processing options EOLTs and conveyor belts

The three circular economy principles include: regenerate nature, avoid waste, and circulate products and materials for longer (Ellen Macarthur Foundation, 2023). The planting of rubber trees for sustainable rubber production in agroforestry systems (rather than in monocultures) – in combination with fruit and trees, useful shrubs, medicines, and herbs for the production of bio-based rubber could be one way of regenerating nature, as rubber agroforestry has been reported to increase ecosystem services and biodiversity, while sequestering carbon and diversifying farmers' incomes (Hua et al., 2021). Currently there is no new tyre production in Australia, but re-treading industry and conveyor belt manufacturing could potentially increase the use of bio-based rubber. Regeneration of nature could also include the targeted recovery of EOLTs and conveyor belts from landfills and mine sites and restoration of contaminated sites.

According to the waste hierarchy (Figure 9), the most preferable waste management option is to avoid the generation of tyre and conveyor belt waste completely. However, as tyres and conveyor belts are critical components required for mining, modern manufacturing and everyday life, avoidance for EOLTs and conveyor belt waste is not feasible. Waste minimisation as a component of Avoidance is the next best strategy, and this can be achieved by extending the primary life of products. Improving the durability and quality of tyres and conveyor belts would be critical to ensuring maximum life spans are achieved for these materials.

The third circular economy principle on circulating products and materials for longer in the economy can be supported through tyre re-treating and conveyor belt repair, and reprocessing, recycling and energy recovery from EOLT and conveyor belt materials. The most preferable option of these is to repair products for reuse. Remanufacturing rebuilds the product to specifications using a combination of used, repaired and new parts. Damaged or worn-out components that affect the performance of the product should be repaired or replaced. In the case of tyres, the tread is typically worn extensively, while the belt, side walls, casings and beads retain their usability longer. Therefore, the remanufacturing of tyres typically includes re-treading of EOLTs by replacing the outer tread. Re-treading is only possible for tyres with thick side walls (Curry et al., 2011). On average, a re-treaded tyre is 40 % less expensive, saves 70 % of raw materials and decreases CO_2 emissions by 60 kg per re-treaded tyre as compared to new tyres (Michelin, 2015). In addition to re-treading, re-grooving can also extend the lifespan of tyres. For conveyor belts, repair is often undertaken to maximise the production capacity prior to the end-of-life. The repair can reduce the material and energy costs as compared to new products, and result in a temporary diversion of materials from end-of-life disposal.

When tyres and conveyor belts have reached their end-of-life and can no longer be repaired, reprocessing can enable the recovery of materials from the wastes, thereby reducing the need for virgin materials to manufacture new materials. Mechanical processing uses shredders, screens, and granulators to reduce the particle size, separate materials and manufacture various products without notably changing the chemical composition of the materials. Initial size reduction is typically performed at ambient temperature, whereas

low-temperature processing can enable the separation of metals and textiles and the production of finer particles (Shulman, 2019). The main products from mechanical processing of EOLTs and conveyor belts are shred (50-150 mm), rubber granules (2-15 mm), buffings (<2 mm), crumb rubber (<1 mm), steel, nylon, and textiles (polyester fabrics) (Genever et al., 2017).

Chemical processing changes the chemical composition of EOLTs and conveyor belts. Pyrolysis and gasification are thermochemical processes that use high temperatures to thermally decompose materials and extract resources (Roy, 1990; Genever et al., 2017). Pyrolysis is conducted at 400-1,200 °C in the absence of any reactive gases such as oxygen or air and generates syngas, oil, and carbon black or char. Gasification is conducted at 700-1,400 °C at low oxygen concentrations and generates syngas, ash/char, and oil (ARUP and Rawtec, 2018; Xu et al., 2021). In both approaches, steel and textiles are usually removed as part of size reduction pre-treatment (e.g., shredding) (ARUP and Rawtec, 2018). If steel is not extracted before the pyrolysis, the expected resultant material percentages are 37 % pyrolysis oil, 34 % char, 16 % pyrolysis gas, and 13 % steel (Tsai, 2017). Based on the waste hierarchy, combustion for energy is the least preferred resource recovery option for tyres and conveyor belts. Shredded tyres and conveyor belts can be used as alternative energy sources to replace fossil fuels such as gas, coal, and oil in industrial applications such as cement kilns and electricity and heat generation (Kelman, 2017).

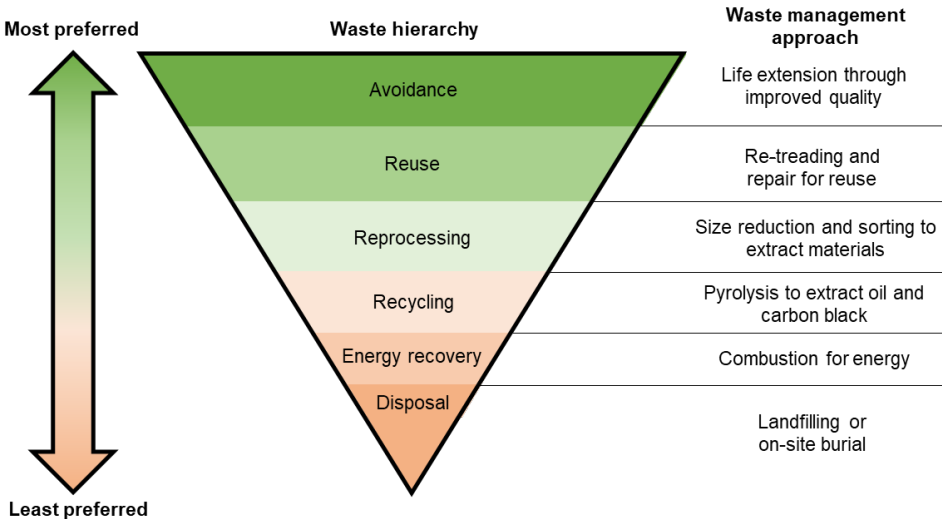

Figure 9. Waste management approaches for EOLT and conveyor belts based on waste hierarchy.

5.2 Processing capacity in WA

Currently, new tyres are not manufactured in Australia. In comparison, conveyor belts are manufactured in Australia, and WA has one of the world's largest conveyor belt manufacturing facilities that produce steel cord conveyor belts. Manufacturing facilities in Victoria and NSW produce poly-woven or ply conveyor belts. Interviewed stakeholders have reported efforts by conveyor belt manufacturers to maximise the performance of conveyor belt products to reduce consumption and waste generation.

WA has processing capability for tyre re-treading, re-grooving, shredding, crumbing and the separation of steel and fabric (Genever et al., 2017; Randell et al., 2020). Tyres have also been baled and used for civil engineering applications. Some capability also exists for pyrolysis, although, according to some stakeholders, this technology has not been implemented at scale in WA.

Snapshots of the geographic locations of identified supply chain and recovery channels of tyres and conveyor belts for the whole of WA and the Perth metropolitan area are shown in Figures 3A and 3B, respectively. Tyre retailing, repair and re-treading services are available in the South West and along the

north coast of WA. The servicing of truck and passenger tyres is typically conducted by tyre dealerships. According to the interviewed stakeholders, re-treading is only currently undertaken for truck and bus tyres. Shredding capability is so far concentrated in the Perth Metropolitan region. According to interviewed stakeholders from the recycling industry, the total tyre shredding capacity in WA in 2021 was estimated to be 36,500 tonnes per annum. In addition, the crumbing and pyrolysis capacities in WA were estimated to be 2,000 tonnes per annum and 10,400 tonnes per annum, respectively. The shred and crumb were predominantly produced using passenger, light truck and truck tyres, with approximately 2,250 OTR tyres recycled in 2021.

Figure 10. Snapshot overview of identified supply chain and recovery channels for EOLTs and conveyor belts for A) WA state-wide and B) Perth Metropolitan and Peel regions. Data for these figures was extracted from publicly available information (i.e., Google search, Yellow and White Pages, membership lists of industry associations).

Fate of WA EOLTs in 2018-19 was as shown in Figure 11 and Table 9, originally reported by Randell et al. (2020). In 2018-19, overall, only 4.4 % of EOLTs were recovered for domestic use while 62.5 % were recovered for export. The remaining 33.1 % were lost to on-site disposal, landfilling, dispersed dumping, and stockpiling, which agrees generally with the movement of EOLTs extracted from the CWTS data supplied by DWER (see Section 4). Export was the dominant fate for passenger (96.3 %) and truck (78.9 %) tyres whereas the majority (79.1 %) of OTR tyres were disposed on-site. EOLTs were used for crumb, granules, buffings, pyrolysis, or exported as an energy source for kilns, boilers, or furnaces (Randall et al., 2020).

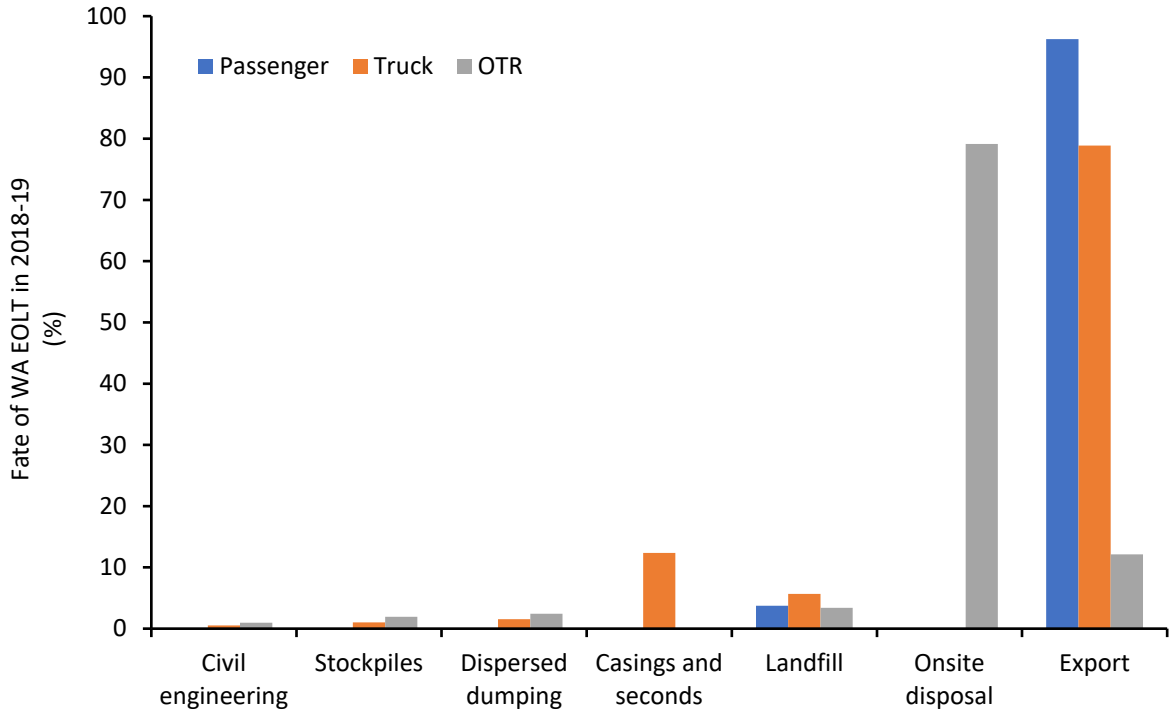

Figure 11. Fate of WA EOLTs in 2018-19. The fate to crumb granules, buffings, pyrolysis, and use as energy source for kilns, boilers and furnaces was 0 tonnes (Redrawn with data from Randell et al., 2020).

Table 9. Fate of WA EOLTs in 2018-19. The fate to crumb granules, buffings, pyrolysis, and use as energy source for kilns, boilers and furnaces was 0 tonnes (0 %) (Data from Randell et al., 2020).

Fate	Volume							
	Passenger		Truck		OTR		Total	
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes	%
Civil engineering	0	0.0	100	0.5	200	1.0	300	0.5
Stockpiles	0	0.0	200	1.0	400	1.9	600	1.0
Dispersed dumping	0	0.0	300	1.5	500	2.4	800	1.3
Casings and seconds	0	0.0	2,400	12.4	0	0.0	2,400	3.9
Landfill	800	3.7	1,100	5.7	700	3.4	2,600	4.2
On-site disposal	0	0.0	0	0.0	16,300	79.1	16,300	26.5
Export	20,600	96.3	15,300	78.9	2,500	12.1	38,400	62.5
Total	21,400		19,400		20,600		61,400	

The Australian and WA Governments have partnered to transform WA's recycling industry through the Australian Government's Recycling Modernisation Fund (RMF). A total of $28M has been awarded subject to contracts to seven infrastructure projects for plastics and tyre waste recycling. Four of the seven infrastructure projects aim at increasing the recycling capacity of tyres in WA (Table 10). The RMF has been instrumental in enabling the building of the new processing capability in WA. Another key driver for developing and increasing EOLT processing capacity has been the intent of the WA Government to use locally produced crumb rubber in WA, and the increasing trend in EOLT arisings in WA. After the construction of the planned recycling facilities funded under the RMF, the total capacity for tyre shredding, crumbing and pyrolysis in WA has been estimated to be approximately 102,000 tonnes, 24,000 tonnes and 15,000 tonnes per year, respectively.

Table 10. Recipients of Recycling Modernisation Fund (RMF) funding for building tyre recycling capability in WA (WA Government, 2022).

Recipient	RMF Funding ($)	Purpose of funding
Tyrecycle Pty Ltd	5,191,383	Invest in equipment at a site in the Perth metropolitan area to produce up to 42,000 tonnes of export-approved tyre shred and 3,000 tonnes of tyre crumb annually.
Complete Tyre Solutions	3,500,000	Build a tyre recycling plant to process waste tyres into crumb rubber to Main Roads WA specifications to be used in the WA asphalt and spray seal industry. The annual processing capacity of the proposed project is over 9,000 tonnes.
4M Waste Pty Ltd	2,966,505	Expansion of operations at a new site in the Perth metropolitan area to allow recycling of up to 12,000 tonnes of EOLTs annually as a crumb rubber product to be used in road construction.
Elan Energy Matrix Pty Ltd	357,867	Purchase a high-capacity shredder as part of process of turning tyres into products such as oil, carbon char and milled steel using thermal processing technology. The Welshpool facility proposes to increase recycled waste tyres by 40 per cent, raising the existing recycling capacity from 5,000 to a total of 7,000 waste tyres per day.

Under the RMF, a new mechanical processing facility is planned for development in Rockingham that will have the capability to produce both rubber shreds and crumbs. Another new facility was planned for Port Hedland to enable the processing of OTR tyres collected in the region, rather than relying on Perth-based processing options for these tyres. The facility was planned to be a 50 % Indigenous-controlled joint venture and to have a total tyre-processing capacity of 25,000 tonnes per year. However, according to DWER, the project is not proceeding.

An EOLT processing facility was previously planned to be established in Port Hedland to make the tyre processing more accessible to OTR tyres. However, the application to the RMF was withdrawn as the Karriyarra-Tyrecycle Pty Ltd partnership was dissolved, and therefore the project is not proceeding. The average distance between mines and EOLT processing facilities has been an average of 832 km (minimum 101 km and maximum 1,713 km) (Randell and Baker, 2020). The proportion of WA mines that are less than 500 km from tyre processing facilities is 13 %, with mines between 500 km and 1,000 km from tyre processing facilities making up 62 %, and those greater than 1,000 km away from processing facilities making up the remaining 24 % (Randell and Baker, 2020). For comparison, the corresponding values for all Australian mines have been 57 %, 30 % and 13 %, respectively, which indicates that the tyranny of distance is a greater waste management challenge for WA mines than elsewhere in Australia, but comparable to regional and remote mines in Queensland and Northern Territory. Moreover, only a few of the existing tyre processors are able to process OTR mining tyres, and most require further investment to be able to process large OTRs.

There are few on-site repairers for OTR tyres, but a few repair facilities are located close to mining sites, notably in regional centres close to concentrated mining activities (e.g., Kalgoorlie and Port Headland) (Personal communication from stakeholder interviews, 2022; Bridgestone, 2022). Moreover, according to interviewed stakeholders, some repairs are conducted in Perth, a service which requires that the OTR tyres are transported on trucks. Prior to transport for offsite repair, the tyres are assessed to determine whether they are repairable. Typically, the transport is organised by the mining company as they normally have better rates with logistics providers. As new mining tyres can cost up to $40,000-$50,000 per tyre, the extension of the tyre lifespan through repair is financially attractive, where sufficient tread remains.

Mine tyre lifespan can also be extended by using chains around worn tyres, though mining OTRs have so far not been re-treaded in Australia. Previous attempts for re-treading have failed due to the wear of casings, and lack of capacity and demand to make domestic re-treading an economically attractive option in Australia. Interestingly, Kal Tire has reported the re-treading of over 1,000 OTR tyres annually in Canada, Chile, UK, Mexico, and West Africa (Kal Tire, 2022; Randell and Baker, 2020).

Currently, there are no dedicated recycling facilities for conveyor belts in WA. Stakeholders indicated that existing EOLT processing facilities are not designed for processing end-of-life conveyor belts because technically, this is problematic due to (1) size of used conveyor belts being too large to be handled by existing equipment; (2) composition of conveyor belts being too complex (e.g., embedded with fibre and steel cords that would cause damage to equipment). However, the same infrastructure that is used for tyre shredding and crumbing, could potentially also be used for processing conveyor belts after initial size reduction. Anecdotally, some companies are investigating the opportunities of setting up conveyor belt recycling plants in WA and shredding conveyor belts to extract steel and produce rubber crumbs. Based on stakeholder interviews, some companies receive old scrap conveyor belts from their clients for free, returning the belts to Perth. Some end-of-life conveyor belts are used to make top liners and used on agricultural floors to protect the hooves of animals. Lightweight ply or poly woven conveyor belts are to some extent repurposed for agricultural uses, e.g., in the horse industry in Hunter Valley in NSW. Heavier steel cord conveyor belts are not commonly reused this way.

5.3 Challenges and opportunities identified by stakeholders

The establishment of new processing facilities requires considerable capital investment. For example, a tyre re-treading facility would cost $1.5-2M and a rubber plant for manufacturing the rubber base (pre-cured thread and bonding material) may cost $80-100M. Currently, at least for some re-treading companies, pre-cured tread and bonding material are manufactured in Queensland. According to interviewed stakeholders, the establishment of OTR re-treading capacity would require $50-100M capital investment, and the generation of data for OTR arisings that would require re-treading. Additionally, the running of the facilities would incur notable annual costs to ensure safe, reliable, and good-quality products.

The length of process (up to eight months) for obtaining permits and approvals for the use of land in WA for recycling and waste treatment has been reported by some stakeholders as a hindrance to the set-up of new recycling facilities in WA. Moreover, interviewed stakeholders (WA-based recyclers) commented that no business can survive without incomes while waiting for the government decision on their licence applications

Another challenge is a potential mismatch between the products to be generated from some EOLT recycling facilities and the specifications of products required by reuse markets. One stakeholder noted that RMF supported a multi-million project which aimed at making 2 to 4 mm rubber granules from EOLTs for road production. However, as the industry can only accept 0.7 mm rubber crumb products for any road applications, and the use of recovered rubber in asphalt is seen by stakeholders as a major reuse pathway in WA, there was a lack of market and technical understanding in the application and funding approval processes.

As one of the challenges for conveyor belt recycling, stakeholders listed the inability to conveniently recycle conveyor belts (e.g., due to distance or pre-processing required), and the lack of available and suitable technology to efficiently recycle these materials. Stakeholders suggested that mining companies may initially pay to transport conveyor belts to Perth, but after a while they would expect recycling facilities to be set up in regional areas closer to mine sites to meet the demand for management of materials in the regions where generation was occurring. It was suggested that if there was an economic instrument, such

as a deposit refund system, that would enable the companies to get some money back for used conveyor belts, it would likely lead to increased recycling of the used conveyor belts.

5.4 Recommendations

Based on the review of the EOLT and end-of-life conveyor belt processing capacity in WA, the following recommendations are made:

- **Consider the restriction of landfilling and on-site disposal of all EOLTs and conveyor belts** to ensure that current and planned recycling facilities have sufficient feedstock volumes to make their operation economically viable.
- **Consider prioritising future funding for the development of recycling facility capacity in regional areas**, close to mine sites and populated centres where EOLT (including OTR tyre) and conveyor belt arisings are occurring, and future growth is identified.
- **Consider the introduction of quality standards for imported new tyres** on to ensure good quality stock for reuse and recycling purposes.
- **Consider the introduction of policies that promote sustainable and circular procurement**.
- **Promote re-treading as a favourable option for extending the life of all EOLT.** This could include the development of education campaigns and the introduction of incentives to promote re-treading, or investment in the re-treading and second-life tyre industry.
- **Seek the development of technologies and investment in facilities for used conveyor belt recycling** to improve the recovery of resources from these materials.
- **Seek to tie market technical demands and product specifications to the application and approval of funding for new recycling facilities.**
- **Consider reviewing permitting and approvals processes for the use of land for recycling and waste management** to streamline and enable the development of new and additional capacity for EOLT and conveyor belt management. This may relate to other land-use planning processes that fall out of Part V (EP Act) licensing processes and frameworks and would require collaboration across departments and government levels to review.

To catalyse the described opportunities, however, businesses along the material supply chain should be encouraged to align and collaborate closely, providing a consolidated platform where materials and resources are shared across industries. To achieve such a platform, a consortium of businesses could be established, ensuring a connection between the tyre and conveyor belt producers, users, recyclers, resource extractors, road builders, and civil work operators. Policies should support such a resource flow across business and industry sectors, shifting stakeholders' perceptions. Eligible users, businesses, recyclers, should all be aligned in considering that sustainable end-of-life operations for rubber products are needed and welcomed.

6 Market potential for products derived from EOLTs and conveyor belts in WA

EOLTs and conveyor belts generated in WA have been to a large extent treated as waste, and as a result, value recovery, especially for domestic use has until now been relatively low and markets of sustainable end-of-life options are extremely underdeveloped. However, with the export ban for whole and baled tyres, an increased community voice urging better stewardship, and an increasing understanding of the benefits of recovered materials, the markets have started to change. In this section market opportunities and challenges for products derived from EOLTs and conveyor belts are discussed using the waste hierarchy framework (Figure 9), which considers waste avoidance as the most effective measure towards environmental benefits, followed by reuse, recycling, resource extraction, energy extraction, and finally disposal (Winternitz et al., 2019; Zaman, 2016). Disposal is not investigated as a market opportunity as it is considered the last resort and the one that, as arose from the expert interviews, is often the *status quo*. Recommendations are provided to overcome the identified challenges.

6.1 Evaluation of market potential based on waste hierarchy

6.1.1 Waste avoidance through life extension and quality improvement

Circular economy principles and the waste hierarchy framework suggest that waste avoidance is the most efficient way to mitigate the environmental and social impacts of societal operations (Allwood, 2014; Stahel, 2016). However, in the tyre and conveyor belt market, waste avoidance is inherently complex due to the nature of these goods: both products are necessary to move and carry loads, and neither of them can be discounted or avoided. Even though product use cannot be avoided, waste avoidance (and minimisation) can still be sought through the extension of serviceable life, which in turn, is achieved with better quality entry products that can be re-treaded or re-used for a secondary purpose (Wang et al., 2018).

As highlighted by one of our interviewed stakeholders, improved quality tyres are usually sold at higher price ranges, which might result in lower sales for the higher-quality and longer-lasting products, even though the purchaser would experience economic savings due to better performance, in the longer term. Although this paradigm applies more commonly to EOLTs arising due to domestic, commercial, and light industrial use, the same can be said for OTR mining and other heavy industry tyres. Waste avoidance through life extension is certainly a feasible strategy for the tyre market in WA, and it could be promoted and fostered more substantially with product quality standards and extended producer responsibility schemes. If the tyre manufacturers were responsible for decommissioning of tyres, they would ensure a higher quality of the final product to deal with less waste in the short run. This strategy is already adopted in some product sectors in Australia (albeit limited and with prominent examples in the fashion, resources, and electronic sectors), but its introduction to tyres may have adverse ramifications, including further increasing the price of already expensive, good-quality tyres.

When considering the conveyor belt market sector, the quality and durability of conveyor belts are critically understood by all stakeholders, from producers to final users, and consequently, conveyor belts currently in use tend to reach their optimal lifespan and material use. This leaves a small margin for the improvement of life span, and recovery of materials is really the only option for the management of these wastes.

6.1.2 Re-treading and reuse options

In WA, the tyre re-treading market remains primarily limited to truck and bus tyres. According to one interviewed stakeholder, a total of more than 30,000 truck and bus tyres were re-treaded per year in WA, with transport and logistics companies being some of the main market clients, and some of the re-treaded tyres exported to New Zealand. The main driver for large truck companies to adopt re-treaded tyres is the cheaper cost, but the environmental advantage should not be overlooked. Often, tyre trucks last only for half a year, which means that substantial amounts of waste can be avoided with re-treaded tyres. Some stakeholders reported that previously, there was a much larger network of re-treading service centres through WA, and that currently, the market demand for re-treaded tyres is smaller than elsewhere in Australia. It was noted, however, that increasing the re-treading network to previous levels would benefit WA both economically and environmentally. Re-treading has struggled in WA due to misguided cultural attitudes that do not reflect market realities. Moreover, the lack of incentives for the use of re-treaded tyres has also slowed down the uptake of re-treads in WA. Additionally, the demand for re-treaded passenger tyres has been low because of the import of cheap low-quality tyres that are not suitable for re-treading.

Although OTR tyre repair is underway, OTR tyres are currently not re-treaded due to lack of capacity and demand. During the supply shortage, major mining companies were briefly interested in OTR re-treading, but the enthusiasm and associated short-term cost benefits were lost as soon as the supply issues were resolved. There is also some scepticism within WA mining companies as to whether re-treads would be reliable in harsh conditions (e.g., hot climates). According to some stakeholders, re-treaded truck tyres are used for long distances e.g., between Brisbane and Darwin and Brisbane and Melbourne, and the cultural attitude was more supportive of re-treaded tyres.

Despite the small number of local companies that conduct re-treading and conveyor belt repairs, there is an opportunity for the integration of recovered materials into tyre re-treading and conveyor belt repairs. In this context, according to stakeholder interviews, carbon-rich char is already used in about 30 % of non-Australian new rubber. Further, up to 46 % of recovered materials are already used in hydrogen-powered race cars.

For conveyor belts, repairing is the norm. Conveyor belts are essential components in the industry sectors where they are utilised. If a conveyor belt breaks, there is a significant cost to production due to downtime and process interruption. For that reason, the belts are closely observed and monitored. Their health is measured in relation to the thickness of their rubber layer, and when the thickness in the central section of the belt reaches a critical point (variable with the belt type and size), sections are substituted, extending the overall lifespan of the belt. The repair of the conveyor belts is often conducted on-site.

6.1.3 Recycling of rubber and other materials

The recycling of rubber and other materials from EOLTs and conveyor belts is facilitated by mechanical processing through shredding and crumbing for size reduction and magnetic separation of rubber crumbs and steel wire. Currently, local recycling companies export tyre shreds and sell the extracted steel to recycling facilities. On the other hand, imported rubber crumb has been used in civil applications for road constructions as rubberised binder, in retaining walls due to their high permeability, and for geopolymer mortar (Chegenizadeh et al., 2018; Wongsa et al., 2018). Rubber crumb is especially useful when mixed with concrete increasing its strength, improving drainage and insulation, and resulting in a lighter mix. Using rubber crumbs in road applications is a safe way to decrease the use of virgin aggregate materials and helps to save up to 9.3 kg CO_2 equivalent per tonne of road base (Imteaz, 2018). Other applications include rubber lined pipes for the mining industry, soft bricks for playgrounds, and recycled rubber mats

used in the fitness sector. Additionally, although in limited amounts, rubber crumbs are already used in the re-treading industry, in which up to 13 % of rubber materials are coming from the recycling stream. The lack of standards and specifications for the recycled components has slowed down the uptake of the recycled materials as the consistency and material properties vary depending on the composition of the recycled materials.

The consumption of crumb rubber in WA increased from 800-1000 tonnes in 2018, to nearly 2,000 tonnes in 2020 (Sustainability Matters, 2020). Road applications by Main Roads WA and LGAs were identified by stakeholders as a key end use of the crumb rubber. Main Roads WA creates specifications for desired products that asphalt producers then produce asphalt using crumb rubber procured from tyre recyclers. Based on stakeholder interviews, using crumb rubber for asphalt production offers a notable engineering benefit as it increases the life of the asphalt by 30 % with only a marginal increase in capital cost. However, crumb rubber modified bitumen mix has a limited application life span and hence, can only be transported for 1,000 km from the production location. This constraint would need to be considered when planning for the locations of asphalt production and end-use, and limitations may apply for use in regional and remote locations of WA where large stretches of roads are required to be constructed, replaced, or repaired.

The intent of the WA Government to use locally produced crumb rubber in WA has motivated the development of tyre crumbing capability in WA to supply domestic rubber crumb to the local WA markets. According to a report published by Main Roads WA, crumb rubber has predominantly been imported from overseas (Indonesia) and Victoria, but the supply of crumb rubber has been increasing through WA-based tyre recyclers (Main Roads, 2021). During 2019/20, approximately 1,900 tonnes of crumb scrap rubber was used by Main Roads WA across the state-controlled road network. This amount is equivalent to 380,000 passenger car tyres and has fulfilled the goal by Main Roads WA to double the usage of crumb rubber from 600 tonnes to 1,200 tonnes by 2021 (Main Roads, 2021).

6.1.4 Resource extraction

In WA, resource extraction from EOLTs through pyrolysis has so far been explored at a relatively small scale, and therefore the markets for the pyrolysis products are immature. The oil and syngas from pyrolysis can be used as fuels and carbon black as feedstock for new tyres (Xu et al., 2020), though there are some technical challenges with replacing pure carbon black (<0.5 % ash content) with recovered carbon black from recycled tyres (up to 15 % ash content). Sale of the extracted resources (e.g., oils) can be challenging due to the small scale of production, and buyers' preference to buy cheap virgin resources, which are certified and of consistent quality. However, according to interviewed stakeholders, some global tyre and conveyor belts producers have already adopted materials extracted via pyrolysis, indicating that there is an underdeveloped market for these recovered materials in Australian that has significant potential for further development. Australian recyclers could potentially form joint ventures with European businesses to extract materials such as carbon-rich char and enable the integration of these materials to create new rubber. Similarly, green diesel and gas could be extracted and reused as fuel in several industrial processes.

6.1.5 Waste-to-energy and manufacturing approaches

Waste-to-energy (WtE) is widely considered the least favourable preference in the waste hierarchy framework, excluding disposal to landfill. However, WtE is still effective in eliminating waste and, at the same time, it allows the recovery of part of embodied rubber-waste energy. Export markets currently exist for TDF (shred), whereas TDF is not yet utilised domestically as energy in WA, or elsewhere in Australia. For example, Australian cement kilns use other wastes as alternative energy sources. Moreover, the upcoming WtE plant in Kwinana is not planned to use rubber as a feedstock (Mellentine and Kreuder, 2018). Other

applications for WA-produced TDF could be as fuel for green steel production, paper and pulp mills and industrial boilers in both domestic and international settings. Like tyres, shredded conveyor belts could also be used as a source of energy. In WA, end-of-life conveyor belts are yet to be considered as feedstock for WtE or TDF.

6.2 Market limitations in Western Australia

The limitations of the market opportunities explored in Section 6.1 above can be summarised as limitations related to the maturity and acceptance of the products, regulatory constraints, the tyranny of distance, economies of scale, economic returns, education, and disconnections in the supply chains. This section outlines these limitations in the WA context. It is important to discuss these features and characteristics of the WA market of circular economy tyres and conveyor belts because they are intertwined and create additional complexity beyond technical and socio-economic difficulties.

6.2.1 Maturity of market

As stated in Levitt's prominent work (1965), a mature market follows the stages of market growth and can be defined as the product's stage when "*Demand levels off and grows, for the most part, only at the replacement and new family-formation rate*". In the case of the second life of tyres and conveyor belts, that might mean a stage in which large companies take an interest in products that derive from second-life rubber. The markets of second-life tyres and conveyor belts in WA do not seem to fit this definition. The main reason for such immaturity is the lack of a need for second-life solutions. That is partially due to new and affordable products coming from cheaper market sources. Even though the quality of these products might be inferior to the quality of more established brands, they are largely preferred due to their more appealing price tag. Concepts such as economies of scale and the tyranny of distance as well as regulatory constraints are strongly linked to the immaturity of the market and are explored in the following sub-sections.

Improving economies of scale and addressing regional barriers to recycling

The WA market of tyres is dual-faceted. Tyres for passenger vehicles are largely used in Perth or in the major cities (which are mostly located in the Perth and Peel region and in the relatively small South West region). For this reason, most passenger EOLTs are in these relatively local areas. Conversely, large tyres, more typically OTR products, are used within vast and sparsely populated regions. Consequently, these OTR tyres when used in remote locations and reach their end-of-life, are often buried on-site. Conveyor belts are also typically used in remote regions and to a large extent buried on-site once they reach their end-of-life, which is not environmentally attractive and does not abide by the desire to achieve reuse. Buried tyres and conveyor belts will eventually re-emerge with seasonal floods and droughts, and in the meantime, they can leach harmful substances (Challis et al., 2021). Due to the long distances between WA mine sites and densely populated areas, gathering and transporting these materials has been suggested to be complex and not economically feasible. Problematically, as highlighted in our stakeholder interviews, tyre recycling facilities are – literally and figuratively – few and far between. These facilities are needed to bridge the supply-chain disconnect towards closed-loop supply chains. However, reverse logistics and other strategies might evolve that could be explored for overcoming distance challenges.

Regulatory Constraints

In WA, it is allowable to bury OTR tyres on a mine site, even though this practice is widely considered environmentally and socially marginal, if not harmful. Undertaking more sustainable end-of-life practices is not mandated and there are no economic instruments in place to improve the economics of recovery. In

our interviews, stakeholders suggested that a mandate to regulate the on-site disposal of OTR tyres would cost more and impact profit margins. But, if faced a policy change, it is likely that these additional waste management costs could be absorbed as an operational cost and would have a positive impact more broadly on corporate environmental and sustainability reporting. To enable a positive shift for managing OTR tyres in an alternative manner, decentralised and communal processing for rubber products at convenient locations that many companies could access would assist in the collection and management of these wastes. Increasing collection then subsequently incentivises new markets, pushing for market growth and eventually maturity.

6.2.2 Disconnection between stakeholders across the supply chain

A common reason for concern and tension shared across the expert interviewees is the disconnection between stakeholders involved in the supply chain of the second life of tyres and conveyor belts. The stakeholders appear disconnected, once again and perhaps unsurprisingly related to the vastness of the WA geography. However, in this context, justifying the disconnect between involved stakeholders seems reductive – as a matter of fact, more significant issues hinder a closed-loop supply chain of tyres or conveyor belts. In simple terms, too many elements of this chain are entirely missing (e.g., large-scale recyclers, efficient means of transport), while incentives to *do the right thing* (as sensitively put by many of our interviewees) are not in place. A closed-loop supply chain is the backbone of a circular economy of industrial rubber components. Several somewhat disconnected supply chain elements need to be addressed in WA. There is much to address, but it should be recognised that improvements and desire to do better across the supply chain over even the last 5 years have been substantial.

6.3 Recommendations to incentivise market of second-life tyres and conveyor belts

When shifting to sustainable operations, each country has regional and unique socio-political-geographical challenges. When providing recommendations to incentivise the sustainable uptake of EOLTs and conveyor belts, it is important to underline that the technology to support these operations is usually available, but the identification of available technology, and the development, investment and scale up of specific technology with an Australian context remains a challenge.

Taking technology out of the equation allows policymakers, scholars, and practitioners to focus on the remaining gaps to bridge. Specifically, as highlighted in sections 6.1 and 6.2 above, despite the opportunities to increase the market of second-life tyres and conveyor belts in WA, many challenges stand in the way. The following recommendations can be made to incentivise the market of second-life tyres and conveyor belts.

- **Consider implementing extended responsibility or product stewardship at national level to foster circular economy solutions for tyres and conveyor belts.** Extended responsibility has been successfully used in many industry sectors. In the context of rubber waste, such a measure would spread the cost of sustainable end-of-life solutions across producers, users, and disposers. As a result, extended responsibility would most likely increase the product sale cost, which would reflect on the sales, but would also result in the protection of the environment and the creation of new markets.
- **Review the option to restrict disposal of EOLTs and conveyor belts and products derived from these to landfills and by on-site burial.** On the consumers' end, especially concerning OTR tyres, regulations do not address the burying of tyres on-site nor the legacy of already buried tyres. We

note that if EOLTs were to be considered as decommissioned products at mine sites, they would need to be dealt with in an environmentally friendly way, as part of the environmental protection strategy stated in the Australian Government's Mine Closure Handbook (Australian Government, 2016).

- **Identify and establish market potential for use of WA-produced rubber products for waste-to-energy and waste-to-manufacturing processes, both in Australia and internationally**. TDF could become the alternate fuel for hard to abate industries such as cement and green steel production, paper and pulp production and any other high temperature manufacturing process.
- **Consider grant and funding opportunities that prioritise new and at-scale recycling facilities in appropriate regional locations.** Some shredding pyrolysis, facilities already exist in WA. However, as the interviewed experts highlighted, such facilities are – literally and figuratively – few and far between. Large-scale grant and funding opportunities, alongside the recommendations above would help the establishment of new companies, eventually bridging the supply-chain disconnect towards closed-loop supply chains.
- **Consider incentives for re-treading facilities for OTR tyres to be located near mine sites to increase the uptake of re-treaded OTR tyres.**
- **Develop quality standards that could be applied to new products to improve the quality and composition of tyres and conveyor belts that are imported into Australia.** The aim would be to improve the durability, safety and overall life span of these materials when used for their primary function. The introduction of quality standards would also improve end-of-life management of these wastes by ensuring quality feedstocks and the production of safe secondary materials for reuse purposes. Such standards should have a view to chemicals embedded in the materials and their risk profile upon use and reuse.
- **Consider a review into whole-of government procurement policies that might support the use of re-treaded tyres wherever possible, and disincentivise the purchase of new tyres and support the uptake of products derived from EOLT and conveyor belts.** Subsidy policies might not only allow for the use of re-treads but might also actively encourage it. Similarly, procurement policies should be created that.
- **More research on sustainable EOLT and conveyor belt management and resource recovery are needed**, with a specific focus on the latter, as studies on conveyor belts were almost entirely missing to add into the systematic review undertaken in this study.

Working through these recommendations would foster the creation of new markets, which in turn would improve market maturity and result in a better economy of scale in the long run.

7 Impacts and opportunities for Western Australia's remote First Nations communities

WA's vast landscape is home to approximately 25 distinct bioregions to which First Nations peoples hold a deep and enduring connection. Approximately 200 discrete Aboriginal communities and townships exist in WA today, with most located in the Kimberley, Pilbara, and Goldfields-Esperance regions.

The contemporary locations of these communities reflect a legacy of settler activities such as Christian missions, as well as earlier State and Federal Government protectorate policies. Despite a turbulent and traumatic history, Aboriginal communities have demonstrated resilience, autonomy, and an enduring connection to their traditional lands. Aboriginal Australia is frequently lauded for being the world's oldest continuing culture, having lived as stewards of Country for at least 65,000 years (National Museum of Australia, 2022). It is widely accepted that the Australian Aboriginal peoples' ongoing connection to their traditional lands almost certainly predates the human settlement of Europe and the Americas.

Within Aboriginal communities, the challenges of providing remote municipal services mean there is a significant gap between resource recovery opportunities available in these contexts compared to the State's urbanised areas. Interpersonal governance issues within communities themselves can also create further challenges in facilitating ideal behaviours of responsible EOLT management. Outside of community contexts, the rise of WA's mining boom has led to high impact environmental activity taking place on the traditional lands held sacred to each bioregion's traditional custodian groups. At present, the generation of commercial EOLT and conveyor belt resources is yet to be realised as an ongoing economic opportunity by remote Aboriginal communities despite some effort having taken place toward establishing joint venture collaboration.

This section of the report represents the first phase of inquiry into the current environmental concerns and potential economic opportunities for remote Aboriginal communities concerning EOLT and conveyor belts. In this section, a clearer understanding of the nature of remote settlements, an examination of the relevant policy context and a review of the literature was explored. To conclude, three Aboriginal enterprise snapshots are offered to showcase efforts undertaken thus far to generate jobs and training opportunities out of the peripheral by-products of local mining operations.

7.1 Remote communities, municipal services and EOLTs

Approximately 20 % of the Aboriginal population in WA (~ 15,000 people) live in remote communities or Aboriginal townships such as Derby, Meekatharra, and Wiluna. The Kimberley region features the highest number of such communities, with other communities and townships dispersed throughout the Pilbara, Mid-West, Gascoyne, and Goldfields Esperance regions (Figure 12).

In virtually all circumstances, these communities and towns are classed as *Very Remote* according to the Australia Bureau of Statistics' Accessibility Remoteness Index Structure (ABS, 2022). Broome and Kununurra are the only settlements with more than 25 % Aboriginal-identifying populations classified as *Remote* rather than *Very Remote*.

Figure 12. Locations of Western Australia's Aboriginal communities. Reproduced with permission from WA Department of Premier and Cabinet (2019).

For residents in remote communities, options for the recovery and/or sanitary disposal of cumbersome waste streams are vastly different to those available in metropolitan areas and regional hubs. With tyres being a consumer good that is essentially designed to facilitate travel, it is not surprising that unwanted EOLTs persistently find their way to being a nuisance in remote locations. Over the years, WA has implemented specialised programs to support the delivery of municipal waste management services in remote communities, with variable success.

While approximately 20 Aboriginal communities self-manage municipal waste services with direct grant funding from the Department of Communities (WA), most communities receive municipal services via a collective contract arrangement program known as the Remote and Essential Municipal Service (REMS) program. REMS is also managed by the Department of Communities.

REMS emerged in its current form in 2015 and provided that municipal services to remote Aboriginal communities would no longer receive federal funding (Heiss, 2016). Notably, the largest concentration of Aboriginal communities affected by this policy change were within WA. State governments were offered one-time funding deals at the time, giving them money to support communities for 1-2 years, and then absorb the costs themselves henceforth. In 2015, the WA Government received a $90 million payment of this nature to assume responsibility and future costings for the program which resulted in the establishment of the REMS program.

Following this devolution of servicing provision from Commonwealth to State jurisdiction, the delivery of municipal waste services in remote communities is now solely a state government policy matter, rather than a joint Commonwealth and State responsibility. This change in jurisdictional responsibility might be perceived by some as an opportunity to streamline engagement and advocacy on EOLT services. However, it is important to recognise that each Aboriginal community has its own distinct relational dynamic and cultural protocols. Accordingly, engagement in the enhancement of municipal services needs to be undertaken in a way that recognises the multiple levels of governance in play. Alongside working with the Department of Communities and REMS service providers, successfully working with the individual community boards is said to be a key avenue to achieve 'buy-in' from the community to enhance EOLT outcomes, to ensure any changes to infrastructure or recovery options are properly embraced by Aboriginal community members.

Currently, REMS services are delivered in the three Western Australian regional designations with the highest number of Aboriginal communities – the Kimberley, Pilbara and the Ngaanyatjaraka region located within Goldfields-Esperance. The current service providers are three Aboriginal corporations linked to one of each area's Traditional Owner groups as shown in Table 11.

Table 11. Providers of the Remote and Essential Municipal Service delivered in the three Western Australian regional designations with the highest number of Aboriginal communities – the Kimberley, Pilbara and the Ngaanyatjaraka region.

WA regional designation	Aboriginal Corporation parent organisation	Business entity providing municipal waste services	Approximate number of communities serviced
The Kimberley	Marra Worra Worra Aboriginal Corporation	Kimberley Regional Service Providers	101
Pilbara	Pilbara Meta Maya Aboriginal Corporation	Pilbara Meta Maya Group of Companies	26
Goldfields-Esperance	Ngaanyatjarra Council Aboriginal Corporation	Shire of Ngaanyatjarraku	14

A review of the grey literature (i.e., government agency research and reports) was conducted to better understand EOLT management as a municipal waste service in Aboriginal communities. It was found that no research has yet taken place specifically about tyre impacts.

Across 2015 and 2021, an investigation and a follow-up investigation were conducted by the Office of the Auditor General titled *Delivering Essential Services to Remote Aboriginal Communities*. This has been the most significant major public inquiry to have so far explored essential services in WA's remote Aboriginal communities. Unfortunately, the scope of this inquiry did not include waste management services as the remit was to focus on how well the State was "delivering power, water and wastewater repair and maintenance services to selected remote Aboriginal communities" (Office of the Auditor General of Western Australia, 2015).

In 2020, the WA Auditor General's office undertook another audit titled *Waste Management – Service Delivery* which amounted to a state-wide investigation of service provisions. While this 2020 inquiry would perhaps have been an optimal opportunity to yield waste management insights on the experience of remote Aboriginal communities, these communities were unfortunately not included in the scope of this review.

Concerning the environmental impacts within communities from EOLT generation, no specific research has been undertaken to specifically identify the degree to which EOLTs are contributing to fire hazard, amenity degradation and pest issues – issues encountered elsewhere due to suboptimal EOLT management practices (Torretta et al., 2015). Anecdotal feedback regarding facilities for tyre disposal in Aboriginal communities indicates significant variations. Some communities have disposal areas with distinct areas for recoverable or hazardous materials (such as tyres, green waste, and car batteries) whereas other facilities are simply a "hole in the ground" landfill without liners or leachate management.

International research has demonstrated that some tyre-derived contaminants, such as N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone (6PPD-Q) induce hepatoxicity in mice (Fang et al., 2023) and acute mortality in salmon (Tian et al., 2021). In addition, EOL tyres and conveyor belts can also contain other chemicals of concern, such as heavy metals, bisphenol A (BPA) and flame retardants such as polybrominated diphenyl esters (PBDE), all of which have notable impacts on human and environmental health (Rahman et al., 2001; Capolupo et al., 2020). Recent research has shown that freshwater and marine leachates produced from crumb rubber have been reported to decrease algal growth and impact embryonic development of mussels (Capolupo et al., 2020). Organic compounds that were detected at notable concentrations in the marine leachates included acetophenone, benzothiazole, n-cyclohexylformamide, phthalide and BPA, whereas Mn, Co, Cu, Zn, Sr, Sb and Pb were elevated in freshwater and/or marine leachates (Capolupe et al., 2020. BPA and phthalates are potential endocrine disrupting chemicals as they are able to impart hormone regulation in wildlife and humans (United Nations Environment Program, 2017; European Chemical Agency, 2018). Another study reported crumb rubber to cause mild to severe developmental malformations, reduced growth, and specifically impaired the development of the brain and cardiovascular system in chicken embryos. The observed systematic effects on chicken embryos were suspected to be due to a complex mixture of toxic chemicals leaching from crumb rubber, such as metals (e.g., Al, As, Cd, Cr, Cu, Pb, Zn) and amines (e.g., benzothiazole) (Xu et al., 2019). Cu, Cr, Zn and Pb were also detected in the albumin, yolk, liver, heart and brain of exposed embryos at higher concentrations than controls in most cases (Xu et al., 2019). There has been some relevant Australian data generated regarding the release of microplastics and other contaminants from tyre wear particles in Australia (Mitchell, 2022). However, studies focussed on the impacts of contaminants from buried EOL tyres and reuse of recovered rubber materials on Australia's unique ecosystems and communities have thus far been limited, and is the focus of current research in the NESP Hazardous Wastes, Substances and Pollutants impact area (Sustainable Communities and Waste Hub, 2022).

Some insights can be inferred from a 2008 survey titled *Environmental health needs of Aboriginal communities in Western Australia*, conducted by the then Department of Indigenous Affairs and Department of Health (DIA and DOH, 2008). As can be seen in Figure 13, the findings of the report showed that 61 % of the Aboriginal communities had access to a managed rubbish disposal facility at the time of the research (DIA and DOH, 2008). An appropriate facility was deemed to be either a town waste disposal area, another community's waste disposal area, or the community had their own waste disposal area, which was either a dug pit or trench that was both suitably sited and fenced.

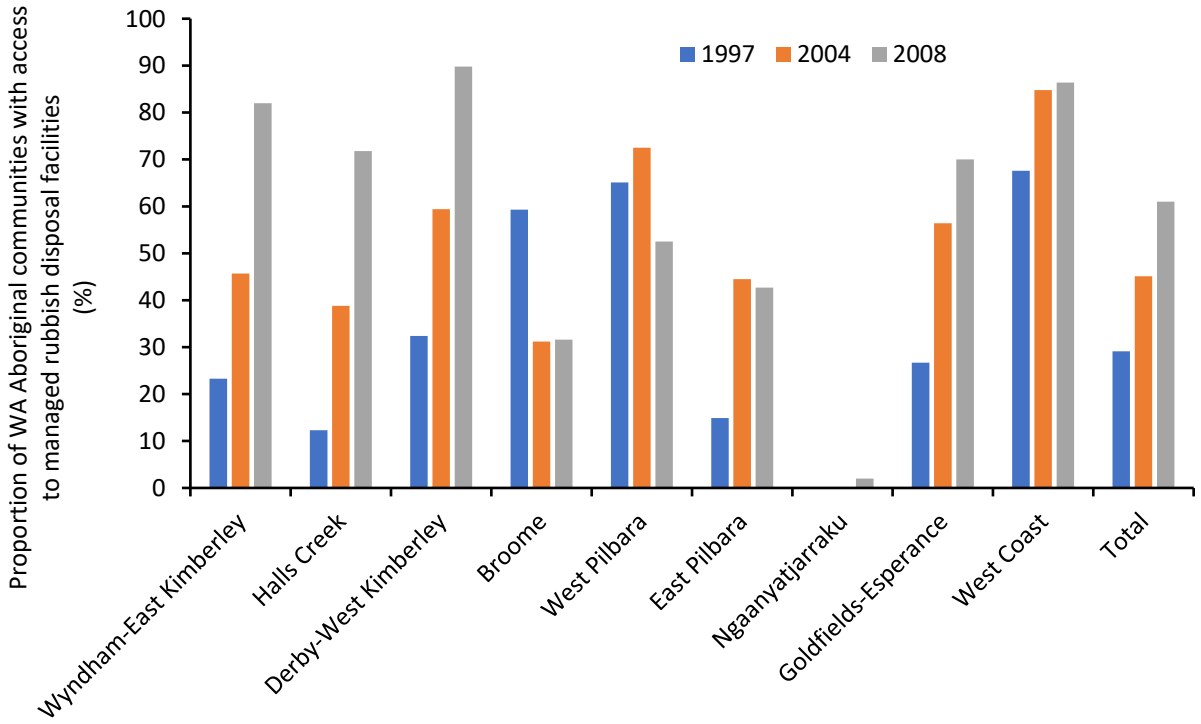

Figure 13. Progressive developments in the proportion of WA Aboriginal communities with access to managed rubbish disposal facilities (Reused with permission from DIA and DOH, 2008).

As this study involved surveys undertaken periodically in 1997, 2004 and 2008, it is worth noting the improvements that took place across the study period. The total proportion of community members with access to a managed waste disposal facility doubled from 29.1 % in 1997 to 61.0 % in 2008 (DIA and DOH, 2008). In the absence of more recent survey data, it can be inferred that a trajectory of progress has likely continued since 2008 – but it is unclear by how much, or what specific arrangements for EOLTs may have emerged in each community. Further, it is also possible that the earlier rates of improvement have slowed in recent years as the earlier years' developments may have represented the 'low hanging fruit' in infrastructure and social improvements for these Aboriginal communities.

This 2008 report also offers insight into the potential environmental impact of EOLTs on remote Aboriginal settlements in terms of waste disposal area capacities. Capacity refers to the estimated time which each community has available before it is expected their waste disposal area will be full. Approximately one-third (36 %, 60 communities) reported that they were operating with less than 12 months of landfill capacity. EOLTs, which are large and hardy and known for taking up space in landfills while also causing pest and fire hazard issues (Torretta et al., 2015), are likely exacerbating landfill capacity issues in Aboriginal communities across all regions of the State. The Department of Communities has guidelines for Regional Service Providers to "extend the life of landfills" by creating tyre stacking areas that are a minimum of 5 metres away from the fence line and other waste types (DOC, 2017).

The environmental impacts of EOLTs in Aboriginal communities are interlinked with the broader problem of end-of-life car bodies – a known amenity issue in many Aboriginal communities. The 2008 report included a finding that car bodies were an issue in most communities, with some communities reporting more than 200 car bodies each. Government departments have undertaken efforts to reduce this problem by arranging free collection of car bodies from communities. Unfortunately, such efforts have not been accepted by all community members.

Stockpiling or amenity issues that result from improper disposal of EOLTs in remote and regional WA could be addressed through the pooling of resources and centralised management of infrastructure designed to be shared between geographically dispersed communities. For example, it may be possible that an investment in mobile tyre-shredding equipment could be shared between purchased and utilised across multiple remote communities to alleviate EOLT amenity issues. As the REMS program (and municipal service grants) exist within a centralised program structure hosted by the Department of Communities, it could be possible to pair an extended producer responsibility network for EOLTs to the REMS program to achieve economies of scale across multiple geographically dispersed communities that experiencing similar stockpiling or amenity issues from EOLTs.

A notable example of where an Aboriginal community drastically improved its EOLT management are the achievements of Gumatj Corporation Ltd in Arnhem Land, Northern Territory. When Gumatj took over the management of Nhulunbuy's waste disposal facility, there was a significant issue of tyre stockpiling. With funding from the Federal Government, Northern Territory Government and Rio Tinto Alcan (the local mining operator), they purchased a tyre shredder and eliminated their 8000-tyre stockpile over a three-year period (NEPC 2013).

Ultimately, further dialogue is encouraged between peak tyre bodies and industry, and the WA Department of Communities on what types of collaboration and support would most likely achieve both value-for-money and address amenity issues in Aboriginal communities related to EOLT in these contexts.

7.2 Indigenous cultural considerations concerning tyre burial practices in regional Western Australia

In considering how contemporary commercial EOLT practices impact Aboriginal peoples, the interconnected nature of Aboriginal land custodianship principles, spiritual wellbeing and intergenerational responsibility needs to be considered.

As noted earlier, many OTR tyres and conveyor belts are buried in remote and regional areas at their end of use. Such a practice is not illegal. Rather, the practice is typically included in the on-site landfill licencing for those mine sites.

Notably, stakeholder engagement revealed the original intent of first allowing tyre burial was rooted in optimism some decades ago that expected future generations would one day wish to dig up these tyres and find a beneficial use for them. This optimism has proven to be heavily misguided. Indeed, while enthusiasm for a circular economy is currently higher than ever in the 21st century, there is now further clarity that buried and contaminated mining tyres will never emerge as an *economically attractive* feedstock. With about 140,000 tonnes of OTR tyres sold each year in Australia and 85 % of end-of-life units buried on-site or landfilled (TSA, 2021) – it is increasingly clear that tyre and conveyor belt burial offers little resource recovery potential, is highly polluting and effectively deflects responsibility for dealing with this waste onto future generations and impacts Traditional Custodians.

One industry stakeholder described the current practice of burying tyres as extremely problematic for First Nations people. It was suggested that as Australian Aboriginal culture has been oriented around land

stewardship and caring for country for 65,000 years, it was striking to consider that the recent few decades of mining may result in contaminated and dislodged land, and other ongoing issues for future Traditional custodians. Following the finalisation of the South West Settlement in 2022, approximately 82 % of WA's area is covered by registered determinations of native title (DPC, 2021; PMC, 2022). Native title requires Aboriginal peoples to prove they have had a continuous and unbroken connection to their Country since colonisation, which in WA began in 1829 (KLC, 2022).

To fully contextualise how Aboriginal peoples are impacted by the intergenerational impacts of tyre burial, it is necessary to first grasp the concept of 'Country' from an Aboriginal worldview. Linguistically, 'Country' is not only a common noun but also a proper noun in Aboriginal English (Rose, 1996). As per the work of Dr Deborah Bird Rose (acclaimed ecological ethnographer and researcher of Australia's First Nations groups), Aboriginal people "talk about Country in the same way that they would talk about a person: they speak to Country, sing to Country, visit Country, worry about Country, feel sorry for Country, and long for Country" (Rose, 1996).

Rose's observations on the concept of *Country* are reflected in the commentary of WA's First Nations leaders and scholars throughout the State, such as Nyikina Warrwa Traditional Custodian Dr Anne Poelina (The Kimberley); Palyku novelist and law professor Ambelin Kwaymullina (Pilbara) and Nyoongar elder and story-teller Uncle Noel Nannup (South West and metropolitan regions).

An earlier study on Aboriginal perspectives on custodianship by the Department of Planning (2004) captured insights from Traditional Owners in the Kimberley region and provided the following quote: "*Because these non-Aboriginal people don't see us on the Country, they think nobody owns it but it is our Country, passed down to us from our old people and we have the responsibility to care for it for future generations*".

It is the enduring epistemological outlook of Country within traditional Aboriginal worldview that highlights how WA's current tyre burial practices are so strikingly at odds with intergenerational responsibility and 'Caring for Country'. With 82 % of the state now recognised as *Country* with enduring and unbroken cultural significance (as per Native Title settlements), moving away from burial of EOLTs and conveyor belts on Country represents a cultural and moral imperative.

7.3 Economic and social prospects: policy context and cases of symbiotic projects between Aboriginal Corporations and mining activity

Accelerating the shift to more sustainable OTR tyre and conveyor belt management in WA not only relieves future Traditional Custodians of dealing with environmental impacts, but also offers economic opportunities in remote areas, where gaining meaningful employment in line with cultural values has been scarce. The proximity of WA's resource-driven economic regions and Aboriginal community locations is shown in Figure 14. A map depicting WA's current and planned mining projects was also provided earlier in the report in Figure 4. These figures indicate how mining projects are frequently located in proximity to potential Aboriginal workforces. As the brown shaded areas in Figure 14 indicate resource-driven economic regions as per the future land use pressures identified in WA's State Planning Strategy 2050, we can also see how mining activity is likely to continue expanding into lands with a high occupancy of Aboriginal people.

The decentralised nature and remoteness of the state's mining projects mean that it would almost certainly be unviable to install technologies at each site to fully process EOLTs and conveyor belts through e.g., pyrolysis or crumbing. However, it may be viable to undertake size reduction through shredding in decentralised locations. Size reduction, while requiring specialised equipment, supports the transport of processed OTR tyre materials to other facilities, where further processing can take place.

To initiate OTR tyre recycling in WA in a way that supports Aboriginal jobs and skills development, the expertise of established operators would be essential to support viable partnerships and businesses. The abundance of OTR tyres requiring management in WA means that joint ventures between recyclers and Aboriginal community groups, private companies with affirmative action policies, and a broader ecosystem of logistics businesses, could participate in a state-wide tyre recovery effort that offers an increase in proximate opportunities for remote-based Aboriginal people. The next sub-section explores the current policy context and builds the case for how Aboriginal economic empowerment can be supported through EOLT resource recovery.

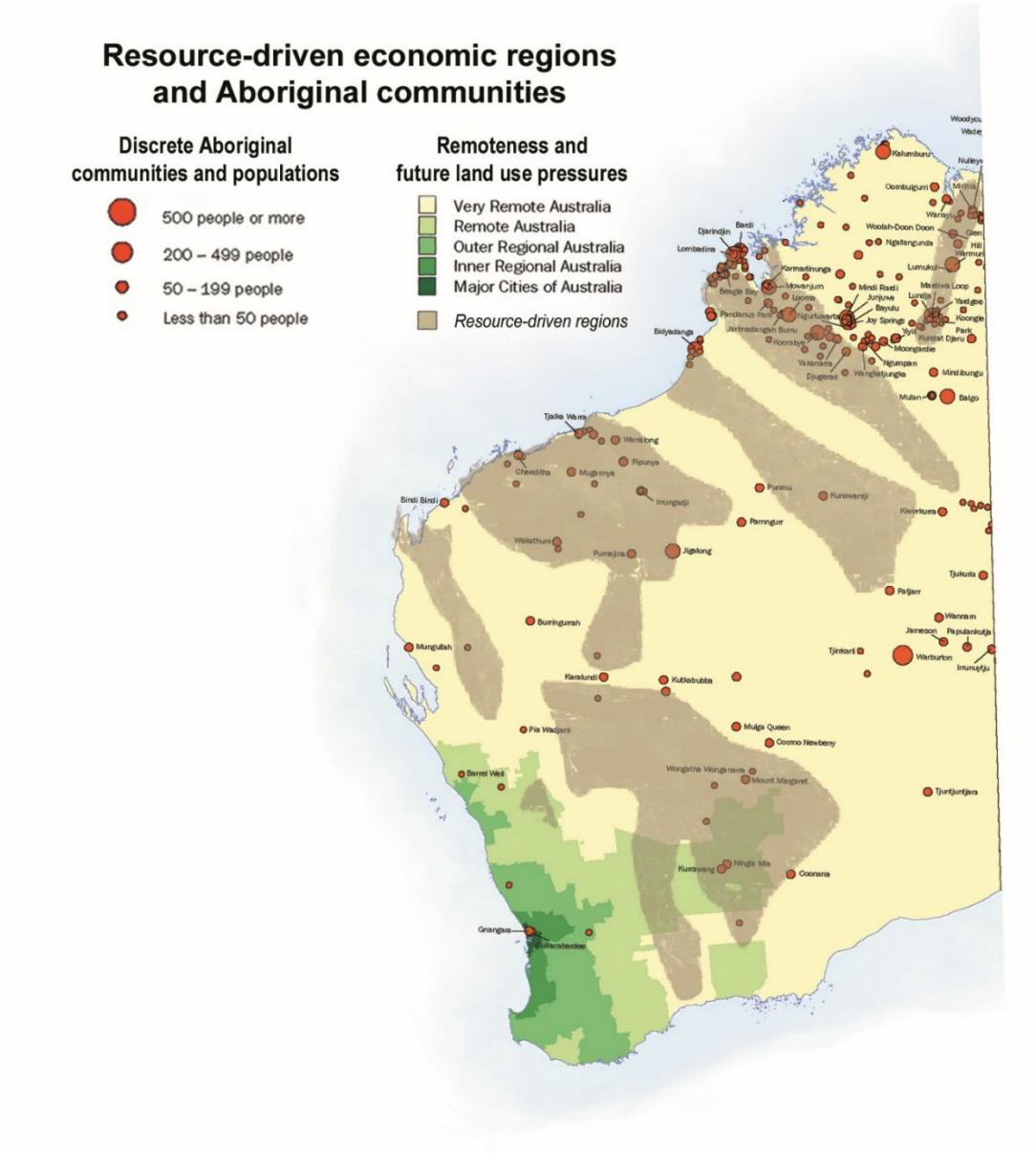

Figure 14. Resource-driven regions of WA in proximity to remote Aboriginal community locations (WA State Planning Strategy 2050). Brown shaded areas indicate resource-driven economic regions as per the future land use pressures identified in WA's *State Planning Strategy 2050* and shows how mining activity is likely to continue

expanding into lands with a high occupancy of Aboriginal people. Modified with permission from Australian Bureau of Statistics (2005).

7.3.1 Current policy context and social drivers

WA's key Indigenous affairs policy framework, procurement policy and regional development policy frameworks all potentially align with expanding EOLT recovery in collaboration with Aboriginal communities. The *Aboriginal Empowerment Strategy 2021-2029* (Figure 15) sets out where the WA Government should apply its efforts and resources to empower Aboriginal people, families, and communities to "live good lives and choose their own futures from a secure foundation" (DPC, 2021).

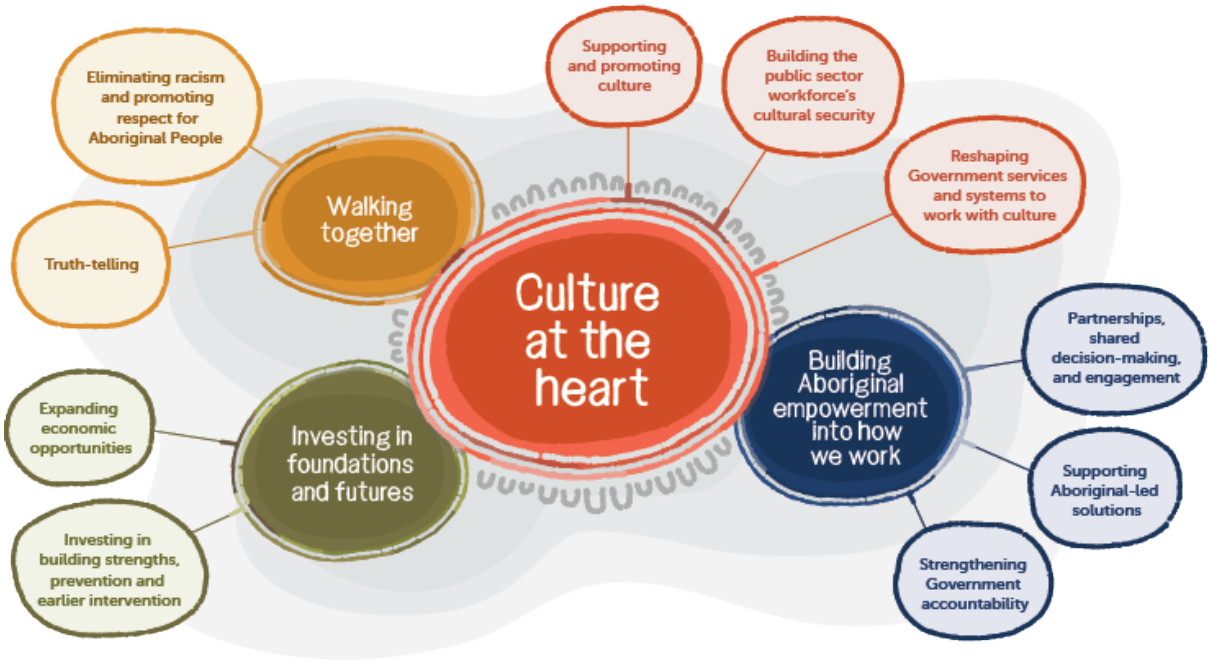

Figure 15. Visual depiction of the key elements of the Aboriginal Empowerment Strategy 2021-2029. (Reused with permission from DPC, 2021).

Developed in partnership with the Aboriginal Advisory Council of WA, the Strategy recognises that traditional Aboriginal cultural values should be woven into future pathways of economic activity and governance. Future businesses in tyre processing and reuse should be developed that operate under the joint venture model and are supporting the key goals, as defined by the WA Aboriginal community, including Self-determination; Taking back care, control, and responsibility; Walking in two worlds; A culturally rich way of life; The opportunity to be guardians of their futures; and, Safe families, clever families, working families, healthy families.

The resource recovery industry is recognised for generating an estimated 9.2 jobs per 10,000 tonnes of material recycled, compared to 2.8 jobs for the equivalent mass to be landfilled (DAWE, 2009). In the context of OTR tyre recycling in regions, the generation of jobs in reuse and recycling is notably higher when compared to burial with an ecosystem of jobs needed across administration, logistics and management and recycling of wastes.

The resource recovery sector is also acknowledged for catering to a broad range of skill levels. At one end, the sector is built on a foundation of entry-level and accessible roles, often involving manual handling. Alongside these roles are other occupations that offer internal development opportunities and highly transferrable skills such as machine operation and maintenance; occupational safety; sales and business

relationship management; and logistics. In the context of catering to the diverse spectrum of First Nations persons' levels of experiences, the resource recovery sector appears well-positioned.

As WA's economic and social development is typically approached through the state's 9 commissioned regions, it is notable that the expansion of Aboriginal employment through improved tyre management also aligns with the WA Regional Development Trust's five Strategic Themes (Table 12) (WARDT, 2020). The purpose of the themes is to help the nine regional development commissions understand what to focus on in terms of "impactful projects". While the expansion of tyre recovery in Australia can be seen to support all five themes, projects that engage and nurture an Aboriginal workforce are directly supporting *Theme 4: Normalise Aboriginal economic development.*

Table 12. Regional Strategic Themes for Western Australia (WARDT 2020).

Regional Development Strategic Themes for Western Australia	
Theme 1:	Grow* existing, and find and develop new, non-renewable-resource and related industries
Theme 2:	Grow* existing, and find and develop new, alternative industries
Theme 3:	Normalise regional living standards
Theme 4:	Normalise Aboriginal economic development a) Full involvement of employable and entrepreneurial people into existing workplaces b) Modify workplaces to give full involvement to not-currently-employable people
Theme 5:	Organisational excellence

**Grow in this context means: Extend temporally, Expand spatially, Go downstream and/or Leverage economically.*

Businesses considering a joint venture model will also be bolstered by the WA Government's *Aboriginal Procurement Policy*. The policy applies to all state agencies when purchasing goods, services and works, including the construction of roadways (a promising market for tyre-derived aggregate in asphalt).

In 2022-2023, all agencies have a target of 3.5 % for Aboriginal procurement, rising to 4 % the following financial year. Additionally, contractors operating in regions with a higher Aboriginal population (such as the Pilbara and Kimberley) have higher targets than metropolitan areas for their Aboriginal workforces.

Aboriginal businesses and joint ventures looking to enter the tyre recovery market are very well-placed to receive favourable "social benefits assessments" in value-for-money determinations, by virtue of the environmental benefits yielded by their operations and their clear alignment with caring for country values.

A generation of Aboriginal leaders have sought to raise awareness that dependence on passive welfare, an issue that is notably higher in regional Australia, is destructive to Aboriginal persons' dignity (KPMG 2016). While the drivers and consequences of disadvantages in remote Aboriginal communities are complex and interrelated, the lack of a mainstream economic base is consistently attributed as a key challenge (KPMG, 2016).

Addressing this issue means continuing the work of growing skills attainment, employment opportunities and entrepreneurial activity among Aboriginal people. Aboriginal-owned businesses are 100 times more likely to hire Aboriginal people (Supply Nation, 2018). Elders report that Aboriginal communities are hungry for success stories and role models for their young people, and it is critical that stories of success and journeys of growth are seen and celebrated in these communities (KDC, 2019). Conversely, commercial partners can benefit from an Aboriginal workforce in that these workers are highly stable residents of the region (a known challenge for businesses based in remote contexts) and multicultural workplaces benefit from a diversity in perspectives, knowledge, and cultural richness (Stevens et al., 2008).

7.3.2 Enterprise snapshots and social outcomes

Should WA look toward a future which seeks to integrate EOLT recycling with remote Aboriginal economic empowerment, previous Aboriginal business models can provide inspiration on pathways forward. The following enterprise snapshots showcase three business models oriented around how Aboriginal Corporations have sought to stimulate resource recovery employment from each community's links to mining activities.

Enterprise snapshot: Gumatj timber sawmill

One instance of where a reciprocal relationship has emerged between a Traditional Owner group and the local mining industry is the Gumatj Corporation's timber sawmill and workshop. Gumatj Corporation, which represents the Gumatj people of the North-East Northern Territory, established the business as an opportunity to recover tree timber that would otherwise go to waste or be burned during the tree-felling phases of local mining activities in their region.

This enterprise involves Yolngu Gumatj men identifying trees suitable for recovery and then milling them into hard heavy logs. The logs are later transported to their workshop for dressing, treatment and carpentry works. The timber is ultimately built into roof trusses, decking, screens, homewares, and artisan furniture. Rather than sourcing timber from trees solely felled for the purpose of timber production, businesses who purchase this timber are creating value out of a material that would have otherwise gone to waste.

With the tyranny of distance posing an issue for remote communities such as Gumatj, the ready availability of high-quality timber supports the construction of local housing and business premises. Gumatj Corporation is also able to create a local timber supply chain for other Aboriginal communities in Arnhem Land such as Elcho Island, Ramingining and Gunyangara.

The products from the sawmill and workshop have found especially lucrative markets outside of Arnhem Land. For example, the heat mitigation project in Darwin's CBD was built with Gumatj timber latticework and vertical supports. Other construction projects such as the Darwin Botanic Visitors' Centre and Nhulunbuy Aged Care Facility are also made of Gumatj recovered timber.

Other Indigenous businesses can use the timber to nurture a local ecosystem of Aboriginal businesses supporting each other. For example, Manapan is an Indigenous-owned furniture maker on Millingimbi Island in Arnhem Land which integrates Gumatj timber into its artisan pieces while also providing a furniture making training academy and work experience programs for local youth.

Gumatj Corporation is notable for being a success story in transforming a waste by-product from mine development (tree-felling) into a resource with a network of local economic and social benefits. Gumatj Corporation has also achieved acclaim for several other business ventures it has also embarked on, including Gumatj Waste Management Pty Ltd which operates the local landfill in Nhulunbuy.

After winning the contract for the management of the waste site in 2007, Gumatj is acknowledged for improving the functionality of the site dramatically (NEPC 2013). This includes resolving previous drainage issues, isolating the site's hazardous waste such as batteries and dealing with a stockpile of 8000 tyres through the purchase and installation of an on-site shredder. Gumatj won the 2010 Northern Territory Tidy Towns Award for best refuse site (NEPC, 2013).

Figure 16. Yolngu men workers of Gumatj timber sawmill (Photo used with permission from Gumatj Corporation).

Figure 17. Gumatj timber sawmill (Photo used with permission from Gumatj Corporation and Australian Broadcasting Corporation).

Enterprise snapshot: AshOil

Over the last 15 years, an Aboriginal Corporation based in Tom Price, WA has grown an enterprise which turns Pilbara mining camps' waste cooking oil into a sought-after biofuel product. AshOil is a subsidiary business of Ashburton Aboriginal Corporation that produces up to 10,000 litres of eco-conscious fuel each week.

The biodiesel produced by the organisation is sold under contract to Rio Tinto Iron Ore for use in their drill and blast operations. With the cost of fuel being extremely high in the Pilbara, AshOil's biofuel not only supports circular economy outcomes in the region, but it is also an economically sound product. The other by-products generated during the production process (such as crude glycerol) are also salvaged for use in industrial, agricultural, and chemical applications (AAC, 2022).

Like Gumatj Corporation's timber skills training centre, AshOil uses its production facilities to provide important training and employment opportunities to the Pilbara's Aboriginal population, including work experience programs for Tom Price High School students in the past. With many mining companies in the Pilbara actively seeking to increase the number of Indigenous employees in their workforce, AshOil's training programs have long been viewed as an effective launchpad for Aboriginal workers to enter the sector (Probono, 2013).

Enterprise snapshot: Tyrecycle proposed joint venture in the Pilbara

Currently, the vast majority (96 %) of OTR tyres are being buried on-site due to the lack of recycling channels to recover tyre-derived products and fuels from OTR tyres (Kariyarra-Tyrecycle, 2022). Among the challenges that have hindered tyre recyclers from moving into the OTR sector are the difficulties associated with specialised approach needed to deconstruct and process rubber from OTR tyres, due to their scale and durability, and the high cost to transport OTR tyres.

Efforts have been undertaken to establish a joint venture between a major Australian recycler and a local Traditional Owner group to recycle OTR tyres in WA. The model, which would have established a joint venture between Tyrecycle and the Kariyarra Aboriginal Corporation of the Pilbara region, represented a pragmatic and market-conscious effort to reduce the practice of tyre burial. Unfortunately, due to inter-organisational challenges that emerged, the joint venture has since been scrapped, and Tyrecycle plans to progress the facility without the Aboriginal partner.

As Australia's largest recycler of waste tyres, Tyrecycle proposed and secured funding for a business model which would provide a means for the Pilbara's mining tyres to be received at a facility in Port Hedland, sheared for size reduction, aggregated, and then shipped to the organisation's network of conversion partners to turn the tyres into crumb rubber (Figure 18).

Among the key goals of the Kariyarra-Tyrecycle arrangement was to establish an avenue for stable jobs and training opportunities for local Kariyarra men and women, such as training in the operation of bobcats, forklifts, and excavators. The environmental and social virtues of the planned project led to support from both the State and Federal Governments.

Although no longer progressing (due to issues unrelated to the viability of the business model), the model taken by Kariyarra-Tyrecycle during the development of this project provides some insight into how WA's problem with OTR mining tyres can be resolved through establishing viable ongoing channels for recovery with willing partners.

Figure 18. Tyrecycle OTR tyre recovery process model (Reused with permission from Tyrecycle).

7.4 Recommendations

Based on the review of the environmental, social, and economic landscape concerning EOLTs and remote Aboriginal communities in WA, the following recommendations are made:

- **Generate current data on the environmental impacts of EOLTs on remote Aboriginal communities.** The review of the grey literature revealed that the Auditor-General Office's inquiries into remote municipal services undertaken in 2015 and 2021, and into state-wide waste management practices undertaken in 2020, did not include any assessment of waste management services in remote communities. As there continues to be a lack of knowledge related to remote the experiences of Aboriginal communities with EOLTs, it is difficult to make an informed choice on which pathways should be taken to improve EOLT recovery, management, and engagement strategies for these communities. Data of this nature would facilitate better resource allocation decisions and allow appropriate government departments and industry associations to consider which communities should be selected for trials on future EOLT infrastructure and community engagement program activities.
- **Explore project collaboration opportunities between TSA and state-level agencies.** As the remote municipal servicing arrangements for remote Aboriginal communities in WA (i.e., REMS and municipal grants) are now hosted solely at the state level (rather than the previous mix of state and federal), there is an opportunity to explore joint EOLT management and recycling projects between

EOLT industry associations and WA state agencies. Associations wishing to engage with remote Aboriginal communities to support environmental and social outcomes concerning EOLTs, state agencies would be able to provide important guidance on the broader systemic considerations in play. For example, suboptimal tyre disposal in remote Aboriginal communities should be seen as interconnected with broader community waste management issues, such as the prevalent issue of disused car bodies. State agencies may be able to support industry associations in understanding how to approach these issues, and what community governance arrangements and differences exist between communities. Throughout WA, there appears to be significant variation between communities' disposal facilities and available recovery channels. The REMS program in WA (hosted through the Department of Communities) represents an avenue for a tyre producer responsibility group (i.e., TSA) to channel funding or program support to strategically curb the impacts of EOLTs within Aboriginal communities. While economies of scale across multiple communities is possible, the complexity of working with Aboriginal communities means it will be important to take the time to understand the nuances of each community, to ensure any such initiatives are integrated as community behaviours and norms.

- **Undertake engagement with Aboriginal Corporations throughout WA to gain a clearer understanding of how to design robust and adaptable joint ventures related to EOLT and conveyor belt recovery.** The proximity of remote Aboriginal communities to industrial EOLT generation, a supportive policy landscape and an eagerness by tyre producers to support social outcomes are all facilitators of a future economic landscape that integrates EOLT recovery with Aboriginal economic empowerment. As Indigenous communities can be disproportionately impacted by the improper management of EOLTs and conveyor belts in regions where waste disposal facilities are not available and industry waste generators are located, a socio-environmental imperative also exists for further engagement to identify the impact of EOLTs and conveyor belts on Country, and what opportunities for their management through Indigenous-led initiatives should aim to achieve.

8 Conclusions and recommendations

EOLT and conveyor belt management in WA is a challenging and dynamic area of waste management, which disproportionately impacts regional centres, where the generators of EOLT and conveyor belts are not required to appropriately manage such wastes. On-site disposal or improper management of EOLTs and conveyor belts can have negative impacts on the associated environmentally and culturally vulnerable regions in our state, and more work is required to develop new ways to extend the life of these materials, either through re-treading and repair, or recycling to recover materials that would otherwise be lost permanently from our economy.

As more funding and investment opportunities arise in response to the drivers for resource recovery, new markets for reuse of materials recovered from EOLTs and conveyor belts are likely to emerge and need to be developed and enabled. This can be achieved through the development of appropriate policy and economic levers, evidence-based decision making, novel approaches to reuse, and relevant industry and community engagement to realise the economic potential for the development of WA's EOLT and conveyor belt industry in regions where these wastes are predominantly generated.

In this study, the literature review showed that while technology is not a primary limiting factor for EOLT recycling or extension of life, the access to and implementation of technology at scale and in a manner suitable for regional WA is a challenge. The review of data available on arisings and regional population showed that there are regionally specific opportunities for the development of EOLT re-treading and conveyor belt recycling processes, especially in regional centres in the Goldfields, Esperance, Gascoyne, and Pilbara regions that would support resource recovery from mining, resource, and other operators in those regions. However, the lack of enabling policy and regulation and consistent data related to EOLT arisings were identified by stakeholders as key barriers to the development of regional investment and processing facilities.

Based on the literature review and stakeholder engagement completed in this study, there are **several key barriers** that were identified as hindering the value recovery from EOLTs and conveyor belts in WA.

- **Regional landfilling and on-site disposal by burial of EOLTs and conveyor belts is not restricted in WA**, which results in the permanent loss of materials from our economy and has unknown impacts on the Australia's unique biodiversity and the health of ecosystems, as well as co-located Indigenous communities where unquantified EOLT and conveyor belt wastes are arising and being disposed to land.
- There is **inconsistency of classification of EOLT arisings and related data** (i.e., units of measurement) in WA (and indeed, Australia), which results in a lack of understanding about the types of EOLTs being generated, the fate of these arisings and the processing requirements (e.g., technology, capacity) for recycling at the end of life. **Understanding flows of materials is imperative to making evidence-based decisions that support economic development and investment.**
- **Conveyor belts are not currently classified as controlled wastes, and as such, there is no existing mandate for the reporting of conveyor belt transports.** This is also true for other rubber materials outside of the T140 EOLT classification. As there is no data about conveyor belt arisings, it is impossible to determine the required processing capacity for the possible feedstock or develop markets for the end products.
- **There is no mandatory product stewardship scheme for tyres and conveyor belts.** As a result, some imported tyres and conveyor belts are not captured under the voluntary product stewardship scheme, reducing the funding available for value recovery.

- **There are no quality standards for imported tyres or conveyor belts in Australia**, resulting in some tyres not being suitable for re-treading, and impacting the efficiency of current recycling processes due to low quality tyres in their feedstocks. In addition, harmonised import codes do not account for all tyres and conveyor belts imported into Australia as part of other equipment.
- **There are currently no incentives for returning EOLTs and conveyor belts for value recovery**, which can lead to illegal dumping, or on-site disposal or management of these materials (e.g., EOLTs used on farm for silage).
- **There are currently no incentives for re-treading of EOLTs in WA.** Historically, re-treading was a bigger industry in WA, but the market demand for re-treading has decreased because it is considered cheaper to purchase new tyres than extend the life of in-use tyres.
- **The regulatory ecosystem of WA does not preference the use of products derived from EOLTs and conveyor belts for energy recovery** unless EOLTs and conveyor belt feedstock classified as residual waste.
- **Approval processes for the use of land (particularly in the regional and remote locations) for the development of recycling facilities can be slow**, which limits the recycling capacity for EOLT materials within a certain timeframe (achieving the regional and national waste management targets).
- **There is a lack of EOLT and conveyor belt collection, processing, and recycling infrastructure for regional areas** where EOLT and conveyor belt generators operate.
- **There is a mismatch between product specification requirements and the capabilities of recycling facilities** planned and approved for of the generation of recovered rubber materials.
- **There is a need for greater efforts to engage Aboriginal Corporations for EOLT recycling initiatives in regional WA**, where communities are impacted by improper disposal and handling of these materials and the impact on human and environmental health are largely unknown.

Considering the identified barriers from the literature and stakeholder engagement, **three key recommendations** are made to increase the value recovery from EOLTs and conveyor belts in WA:

Key Recommendation 1

Consolidated and consistent, hierarchical waste categorisation codes for all EOLTs, waste conveyor belts and other rubber products in WA would support the preliminary assessment of material flows and provide evidence to further investment into market pathways for EOLT and conveyor belt materials. These codes should be co-developed in consideration of other jurisdiction waste codes, with the view of creating a nationally consistent waste code for the management of EOLT and conveyor belts (and other wastes) in Australia.

Key Recommendation 2

Policies should support such a resource flow and connection across business and industry sectors and the tyre and conveyor belt supply chain. This would lead to the identification of new market pathways for recovered rubber materials and result in the maturation and growth of existing markets identified for EOLT and conveyor belt materials. Renewal of the policy and regulatory ecosystem related to the management of EOLT and conveyor belt wastes in WA could be undertaken to improve economies of scale, incentivise resource recovery, preferentially extend the life span of rubber products in our economy and minimise and divert waste from landfill. New and revised policy could include:

- Consider ceasing the allowance of the disposal of EOLTs, conveyor belts and rubber products in all landfills (including regional landfills) and on-site in WA;
- Investigate the implications for classifying conveyor belts as controlled waste and the subsequent requirement to report the transport of conveyor belts;
- Consider implementing a mandatory levied product stewardship scheme on all tyre and conveyor belt imports (including tyres imported on vehicles), with funds used to encourage resource recovery from EOLTs and conveyor belts;
- Investigate the introduction upfront recycling fees incorporated to the price of new tyres and conveyor belts and refund could be considered to promote the return of these products to recycling.
- Consider the introduction of incentives for re-treading tyres and repairing conveyor belts, and returning EOLTs and conveyor belts for resource recovery could also improve barriers related to the economies of scale in regional WA;
- Develop quality standards for imported tyres, which may ensure that imported goods are of suitable quality for re-treading and recycling;
- Enable the use of all products derived from EOLTs and conveyor belts for beneficial purposes in WA;
- Consider the product specification requirements in the application and approval of funding for new recycling facilities; and,
- Consider preferencing the development of recycling capacity in regional areas as a priority, especially for OTR tyres and conveyor belts generated in regions where arisings are likely to be high but are currently unquantified.

Key Recommendation 3

Further engagement and research to generate data should be undertaken to identify the impact of the disposal of EOLTs and conveyor belts on Country, and how future pathways should be designed to integrate EOLT recovery and management with Aboriginal economic empowerment. Indigenous communities can be disproportionately impacted by the improper management of EOLTs and conveyor belts. This is especially true in remote regions where the generation of EOLT arisings occurs and adequate waste disposal facilities are not available. To alleviate amenity issues of EOLTs in regional areas, TSA should consider collaborating with state-level agencies who can provide guidance on the complex nature of working with remote Aboriginal communities. This may further a more holistic understanding of the systemic issues in play related to EOLT waste, such as the prevalent issue of disused car bodies. To facilitate pathways of economic empowerment for remote communities, further engagement with Aboriginal Corporations is needed to determine what benefits are hoped to be gained from Indigenous-led business initiatives related to EOLT recovery and land remediation.

Generating consistent and consolidated data that delineates the types of EOLT and conveyor belt arisings is key to enabling the development of new recycling and resource recovery opportunities for EOLTs and conveyor belts in WA. However, the recycling and resource recovery industry for EOLTs and conveyor belts in WA cannot expand due to barriers related to the current regulatory ecosystem for these wastes, including permitting on-site and regional landfill disposal, the lack of hierarchical waste codes that can be consistently and non-subjectively applied to identify and semi-quantify waste arisings, and the lack of appropriate economic levers to drive investment and development of processing capacity. As Indigenous communities can be disproportionately impacted by the improper management of EOLTs and conveyor belts, further engagement could be conducted to understand the impact of EOLTs and conveyor belts

disposal on Country and community. Moreover, opportunities should be identified for EOLT and conveyor belts management through Indigenous-led and co-designed initiatives.

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Appendix 1: List of engaged organisations

Australian Flexible Pavement Association (AfPA)

Australian Tyre Recyclers Association (ATRA)

Bandag Bridgestone

Chamber of Minerals and Energy (CME)

Continental (Conveying Solutions)

Data WA

DWER (Controlled Waste tracking, secondary reuse of recovered materials)

Elan Energy Matrix Pty Ltd

Fremantle Ports Authority

Great Southern Development Commission

Better Wear Solutions

Infrastructure WA

Kimberley Development Commission

Kimberly Ports Authority

Main Roads WA

Michelin Australia Pty Ltd

4M Waste Pty Ltd

Newcrest Mining Ltd

Pearl Global

Southern Ports Authority

Tyre Stewardship Australia

Tyrecycle

Unnamed conveyor belt engineering consultancy

Unnamed framer from the Great Southern Region

Western Australian Local Government Association (WALGA)

Wheatbelt Development Commission

Organisations contacted with no response:

Austroads

CD Dodd Scrap Metal Recyclers

Department of Transport

Development WA

Gascoyne Development Commission

Goldfields Esperance Development Commission

Forrestfield Recyclers

Landgate

Lomwest Enterprises Pty Ltd

Mid West Development Commission

Mid West Ports Authority

One Rail Australia

Peel Development Commission

Pilbara Development Commission

Pilbara Ports Authority

Primary Industries and Regional Development

PROK Conveyors

Public Transport Authority

Rural Business Development Corporation

South West Development Commission

Tytec Recycling Australia

WA Belting

WA Farmers

Western Australian Farmers Federation (WAFarmers)

Western Australian Planning Commission

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