APPENDIX 11
ATTACHMENT 1

Hyder

MINDARIE REGIONAL COUNCIL
INFRASTRUCTURE OPTIONS ASSESSMENT

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MINDARIE REGIONAL COUNCIL

WASTE PROCESSING INFRASTRUCTURE OPTIONS ASSESSMENT

Waste processing infrastructure options assessment

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ACRONYMS

Acronym	Meaning
BAU	Business as usual
BOO(T)	Build, own, operate (transfer)
C&D	Construction and demolition
C&I	Commercial and industrial
CPI	Consumer price index
D&C	Design and Construct (D&C)
DCMO	Design, construct, maintain and operate (DCMO)
EfW	Energy from waste
EOI	Expression of interest
FOGO	Food and garden organics
GO	Garden organics
Hhld	Household
MBT	Mechanical biological treatment
MCA	Multi-criteria analysis
MRF	Materials Recovery Facility
MSW	Municipal solid waste
MRC	Mindarie Regional Council
RDF	Refuse derived fuel
RRF	Resource recovery facility
TP	Tamala Park

EXECUTIVE SUMMARY

Hyder has been engaged to provide an assessment of the most appropriate regional waste infrastructure approach for the members of the Mindarie Regional Council, in order to achieve the state government set waste diversion targets of 65% of municipal solid waste diverted from landfill by 2020. In order to fully assess the ideal approach for the members of the MRC, Hyder developed and modelled a number of infrastructure scenarios which are outlined in the table below:

Table 1 General waste scenarios

Scenario	Description
Business as usual (BAU)	Existing arrangements regarding Neerabup Resource Recovery Facility (RRF) and landfill continue, with Stirling & Cambridge's garden organics (GO) sent to a separate compost facility, and residual waste from any processing is sent to landfill
Scenario 1 2 bin system, second MBT	Collection systems as in BAU, all general waste goes to mechanical biological treatment (MBT) – either Neerabup RRF or a second MBT, only residuals from the MBT's go to landfill
Scenario 2 2 bin, EfW	Collection systems as in BAU, existing flows of general waste to Neerabup RRF continue and remainder goes to an energy from waste (EfW) facility (including bulk waste, MBT and MRF residuals)
Scenario 3 - 3 bin – residual to Neerabup, GO separately	All councils implement a greenwaste bin, with collected material open-windrow composted. All general waste would be processed via Neerabup RRF. Remaining material would go to landfill.
Scenario 4 3 bin – residual to LF	All councils have a third bin, Stirling for greenwaste only, all other councils collect all organics (including garden, food, nappies, contaminated paper etc) in the third bin for processing at Neerabup RRF and residuals go to landfill.
Scenario 5 3 bin residuals to EfW	All councils have a third bin, Stirling greenwaste only, all other councils collect all organics (including garden, food, nappies, contaminated paper, etc) in the third bin to be processed at Neerabup RRF with all residuals to energy from waste (including bulk waste and MRF residuals)

The modelling is dependent on a range of assumptions including costs and performance data on council collection systems; population projections for each council; waste generation projections; types of waste processing facilities and diversion performance; facility locations; assumed typical gate fees for various types of processing facilities; costs of new equipment and services; as well as price inflation and landfill levy increases. Hyder has used actual data where it was available from member councils, supplemented by typical industry data. Where such assumptions have been made, they are outlined in the report. The modelling scenarios and assumptions were discussed and reviewed at the MRC Strategic Working Group meetings.

Evaluation process

To determine preferred scenarios, a multi-criteria assessment (MCA) was undertaken using environmental impacts, cost, social impacts and risks as the key criteria. Each member council was asked to separately nominate their preferred weightings for the criteria. The average of the weightings was applied to rank the scenarios. The cost impact (measured as cost per household), and environmental impact (primarily based on diversion performance) were the most heavily weighted criteria.

The multi-criteria assessment showed that the business as usual case was the least desirable, even though it has the lowest cost per household. The poor environmental performance (diversion) proved to be a key differentiator and as such the BAU Scenario was not considered for further modelling. The scenario of 2 bins with a second mechanical biological treatment facility (Scenario 1) was considered by members to be politically unsuitable and was therefore also discounted from further consideration.

Whilst the 3-bin option (Scenario 3), with all organics collected separately and residuals to landfill also scored poorly due to its low diversion performance, it had a low implementation cost given the limited requirement for infrastructure spending. Only two of the scenarios, being Scenario 2 and 5, are likely to deliver the diversion targets by 2022 and these options scored highly in the MCA. Both scenarios include the development of EfW infrastructure to recover energy from the residual waste stream. With increased recovery of recyclables or bulk waste scenarios 3 and 4 would come close to 60% diversion, but would be unlikely to reach the 65% state government diversion target. Therefore three scenarios – Scenario 2, 3 and 5 - were included for further modelling in the Stage 2 multi-criterial analysis.

Stage 2 of the modelling aimed to determine the most suitable sites based on transport implications for the region. The transport options were overlayed against the original modelling to provide an additional level of assessment of the preferred scenarios for the region. The main differences in the Stage 2 analysis were the modified cost impacts (per household, due to differences in the transport costs for key facilities), while the social impact and risk ratings were also adjusted based on issues related to the specific sites. Social considerations included likelihood of residential encroachment on the site and resident concerns about odour, traffic congestion, noise and perceptions of EfW technologies. Risk considerations included issues such as whether the proposed site is already a waste facility, the approval and development status for facilities and particular sites, and reliable access to markets (e.g. power).

Preferred scenarios

The modelling has identified scenario 2C (2 bin, energy from waste) as the preferred scenario based on the agreed criteria, however it was closely followed by 5C (3 bin, energy from waste). In either case, significant new EfW capacity is required, although the EfW capacity requirement is slightly higher under a 2-bin model. The analysis did not consider the impact of potential future state government policy, which currently favours but does not mandate three bin collection systems. Implementing a third bin requires additional community engagement and a slightly higher cost, however it is better aligned with the waste hierarchy and state government policy. In developing and procuring new waste infrastructure, the members of the MRC should consider the potential for 3 bin systems to be mandated in the future, such as through the current review of the Waste and Resource Recovery Act. If a three bin system was agreed to, a policy could be established for high density areas such as City of Perth and large parts of the Town of Victoria Park and City of Vincent to opt-in to a third bin service as appropriate.

As a result of the modelling, the preferred scenario resulted in the following (see Table 2) recommended facilities and preferred locations.

Final locations, ownership arrangements, operating models and procurement methods will need to be evaluated on a case-by-case for each infrastructure project. This provides an opportunity for the MRC or its member councils to deliver the land, infrastructure and processing services where it is most beneficial to do so, or to outsource to the market where it is most efficient to do so.

Table 2 Recommended infrastructure and preferred locations

Processing facility	Capacity required	Preferred location
Landfill	74,000 tpa (existing)	Tamala Park
Mechanical biological treatment	100,000 tpa (existing)	Neerabup
Materials recovery facility	100,000 tpa	Neerabup
Transfer station	300,000 tpa	Balcatta
Green waste processing facility (open windrow)	35,000 tpa	Neerabup
Bulk waste sorting shed	40,000 tpa	Balcatta
Waste to energy facility	250,000 tpa	TBC – market to determine

The state government has implemented a policy that is broadly supportive of EfW in the context of the waste hierarchy. Therefore additional waste diversion opportunities have been considered to determine the feasibility of maximising recovery prior to EfW treatment.

Currently each council offers a scheduled bulk waste collection from the vergeside. Some councils are considering an on-call service, either with or without provision of a skip bin. If an on-call bulk waste service is introduced it can be expected to significantly reduce the amount of bulk waste collected (based on performance of similar systems). In addition the waste could continue to be landfilled, or be subjected to enhanced recovery by either kerbside separation or processing in a sorting shed. The additional contribution to the overall diversion rate is likely to vary from 0.8% - 3.4% depending on the option selected.

The majority of member councils could improve their recycling recovery through improved education and bin monitoring. It is estimated that improvements in kerbside recycling could increase recovery by 1-3% for the region. However this additional recovery requires intensive effort and additional cost to engage further with the community.

Recommendations

As a result of the modelling it is recommended that the MRC and its member councils:

1 Agree on a broad waste infrastructure direction as outlined in the infrastructure plan, and seek endorsement of the plan from their respective councils.

2 Agree to commence discussions regarding the preliminary work required to develop the appropriate business plans and procurement options for each infrastructure project.

3 Agree to the actions outlined in this plan when infrastructure solutions are being considered by the MRC or its member councils, which includes bringing any proposed infrastructure solutions which may impact on the region to the attention of both the MRC and the Strategic Working Group.

4 Agree to support the MRC pursuing regular kerbside waste audits to inform the regional waste strategy and monitor progress on system changes.

1 INTRODUCTION

In 2010, the Mindarie Regional Council (MRC) commissioned an extensive study into waste processing options for the region, including a multi-criteria analysis of a range of scenarios. The study was undertaken soon after the commissioning of the Neerabup Resource Recovery Facility (RRF). Since the previous study was undertaken, a number of significant state government policy changes have occurred including:

- Significant increases to the landfill levy commencing 2015,
- Proposed local government amalgamations,
- The Better Bin Program – encouraging collection of organics in a third bin,
- The waste to energy policy, supporting appropriate use of energy recovery technologies; and
- Review of Waste Avoidance and Resource Recovery Act 2007.

Each of these issues has a significant impact on the MRC and its member councils, and opens up a number of opportunities that were not available or considered viable, when the original study was conducted.

Hyder has been engaged by the MRC to update the original modelling, and factor in some alternative scenarios in consultation with the MRC's members, to provide an assessment of the most appropriate waste infrastructure approach for the region.

The aims of the study were to:

- Identify scenarios that will assist the region in reaching the state government set waste diversion targets of 65% of municipal solid waste diverted from landfill by 2020,
- Determine high level cost implications,
- Identify necessary infrastructure and capacity required to process agreed waste streams,
- Outline possible ownership and operating options for each facility,
- Identify optimal locations for infrastructure, including transport modelling,
- Propose a practical and staged timeframe for infrastructure implementation and
- Provide detail on existing EfW providers in the WA market – including optimal size and acceptable material for each processing technology.

Key opportunities for the MRC's region include:

- Drop off centres for hazardous and other problem wastes,
- A MRF for the region,
- A green waste processing facility,
- A bulk waste sorting and reuse shed and
- An EfW facility, or other mixed waste processing facility for the region.

The WA Waste Authority State Waste & Recycling Infrastructure Project identified a number of potential waste infrastructure sites. Some of those are within the MRC's region and have been considered in the current infrastructure assessment.

Each major waste stream and its potential collection and processing options have been considered separately. The diversion potential and total estimated cost implications take into account all waste streams combined.

2 EXISTING WASTE SERVICES

This section outlines the existing collection systems within the member councils. These have been used in the business as usual (BAU) baseline modelling. For City of Stirling the modelling assumptions relate to the system that has already been committed to, and will be implemented from 1 July 2015.

The majority of member councils offer a two bin collection system, 240L general waste weekly and 240L recycling fortnightly, as shown in Table 2-3. Town of Cambridge and City of Stirling provide a three bin collection system, including a garden organics collection fortnightly. Some councils are starting to offer a wider range of bin sizes on an optional basis such as a 360L bin for recyclables.

Table 2-3 Summary of kerbside collection services

Waste stream	General waste		Recycling		Garden organics	
Council	**Bin size**	**Frequency**	**Bin size**	**Frequency**	**Bin size**	**Frequency**
Cambridge	120L / 240L	Weekly	240L / 360L	Fortnightly	240L	Fortnightly
Joondalup	240L	Weekly	240L	Fortnightly		
Perth	240L	Weekly	240L	Fortnightly		
Stirling*	140L	Weekly	240L	Fortnightly	240L	Fortnightly
Victoria Park	240L	Weekly	240L	Fortnightly		
Vincent	240L	Weekly	240L/360L	Fortnightly		
Wanneroo	240L	Weekly	240L	Fortnightly		

*Note City of Stirling's 3 bin system commences 1 July 2015

The majority of member councils provide scheduled vergeside waste collections for general bulk waste and greenwaste. Table 2-4 shows the current service frequency. One to two general bulk waste collection services are offered each year, and one to four greenwaste services. In addition Wanneroo, Joondalup and Stirling offer greenwaste disposal vouchers to residents. Stirling also offer their residents tip vouchers for one tonne per year of general waste and one tonne per year of inert waste for disposal.

Table 2-4 **Vergeside waste service summary**

Council	Vergeside bulk waste frequency	Vergeside greenwaste frequency	Tip vouchers	
			Greenwaste No	General waste No
Cambridge	Two per year	Two per year (collected at the same time as bulk waste)	None	None
Joondalup	Once every 9 months	Once every 9 months (collected at the same time as bulk waste)	4	None
Perth	One per year	One per year (collected at the same time as bulk waste)	None	None
Stirling	Oncall (skip)*	Once every 9 months **	4	4
Victoria Park	Two per year	Four per year	None	None
Vincent	One per year	Two per year	None	None
Wanneroo	One per year	Two per year	4	None

*Currently once per year. The oncall skip bin service will commence July 2015.

**Currently once per year. The 9-month cycle will commence July 2015.

Some councils in Perth are moving towards a skip bin bulk waste service. City of Stirling will be implementing the service from 1 July 2015. Bulk waste collection options and implications are discussed further in section 5.1.

Most member councils are recovering white goods, e-waste and mattresses from their bulk waste using separate contractors to their regular waste bulk waste collection contractor. A summary of materials recovered is outlined in Table 2-5.

Table 2-5 **Verge collections – collection contractors and recovered materials**

Council	Contractor/s	Items recovered through junk collection
Cambridge	Alvito (T/A Incredible Bulk) Spyder Waste	white goods, car batteries mattresses
Joondalup	Spyder Waste	white goods, mattresses
Perth	Inhouse	e-waste, white goods
Stirling	Inhouse	e-waste, metals, inc. white goods, mattresses
Victoria Park	All Earth Services Spyder	white goods, e-waste mattresses
Vincent	Steann Spyder	metals, inc. white goods, e-waste Mattresses
Wanneroo	Inhouse	White goods

Cities of Wanneroo, Perth and Stirling all undertake in-house waste collection services. All other councils contract their services out to third parties. A summary of collection contractors is provided in Table 2-6.

Table 2-6 Service provider – collection

Council	General waste	Recycling	Garden organics	Bulk verge	Bulk Greenwaste
Cambridge	Perth Waste	Perth Waste	Perth Waste	Incredible Bulk	Incredible Bulk
Joondalup	Cleanaway	Cleanaway	N/A	Wanneroo (inhouse)	Wanneroo (inhouse)
Perth	Inhouse	Inhouse	N/A	Inhouse	Inhouse
Stirling*	Inhouse	TBC	TBC	Inhouse	Inhouse
Victoria Park	Cleanaway	Cleanaway	N/A	All Earth Waste Services	All Earth Waste Services
Vincent	Perth Waste	Perth Waste	N/A	Steann	Steann
Wanneroo	Inhouse	Inhouse	N/A	Inhouse	Inhouse

* Contract to commence from 1 July 2015

Under the MRC's constitution all member councils are required to send their general waste which is not recycled to a MRC facility for disposal or processing. The MRC's Neerabup RRF facility provides 100,000 tpa processing capacity for MSW through a mechanical biological treatment (MBT) facility. City of Stirling has also committed to send at least 14,000 tpa of MSW to the Anaeco MBT facility, which is currently in commissioning and expected to commence operations in 2015. The remainder of the material is sent to Tamala Park for disposal to landfill. For source separated material (including dry recyclables and organics) the member councils arrange their own processing contractor. Table 2-7 outlines the processing contractors for each of the member councils. Some councils are unable to send their material to the Neerabup RRF facility as the receival floor is not compatible with rear-loader vehicles.

Table 2-7 Service provider – processing

Council	General waste	Recycling	Garden organics	Bulk verge	Bulk Greenwaste
Cambridge	MRC- TP/ RRF	Perth Waste	Perth Waste	MRC –TP	Brockway
Joondalup	MRC – TP/ RRF	Cleanaway	N/A	MRC –TP	WRC
Perth	MRC – TP	Cleanaway	N/A	MRC - TP	Brockway
Stirling	MRC –TP / Aneaco	TBC	TBC	Balcatta	Balcatta
Victoria Park	MRC –TP/ RRF	Cleanaway	N/A	MRC – TP	Maddington
Vincent	MRC –TP / RRF	Perth Waste	N/A	MRC – TP	Brockway
Wanneroo	MRC – TP/ RRF	Cleanaway	N/A	MRC –TP	WRC

MRC –TP (Tamala Park); RRF (Neerabup Resource Recovery Facility); WRC (Wangara Recycling Centre)

3 WASTE CHARACTERISTICS

The data in this section has been used for the baseline BAU modelling. It is based on actual data submitted to the MRC for the 2013/14 financial year.

The region generates approximately 320,000 tpa of municipal solid waste, excluding self-haul and commercial waste taken to Tamala Park. Approximately 28% is diverted from landfill City of Stirling has already committed to a 3-bin waste collection system, which Hyder estimates will bring their diversion performance up to around 48% and boost the regional diversion performance to around 41% in 2015. As waste volumes grow and with the processing capacity of the Neerabup RRF fixed at 100,000tpa, regional diversion is forecast to gradually decline (to 35% in 2022) unless additional processing capacity is developed.

A breakdown of the kerbside collected material diverted, disposed to landfill and the diversion rate for each council is provided in Table 3-8. The diversion rates are lower than some councils actual diversion rates as self-haul material and some other recycling – such as greenwaste, construction and demolition waste and council operations waste are excluded from the baseline kerbside modelling. Individual council diversion rates vary significantly, which is heavily influenced by the amount of general waste currently diverted via the Neerabup RRF facility. The modelling shows that to reach the state waste diversion targets of 65% by 2020 significantly more recycling will need to be undertaken by the region.

Table 3-8 Total tonnages MRC, 2013/14

Council Name	Total Diverted (t)	Total Disposed (t)	Total Generated (t)	Diversion Rate (t)
Cambridge	7,154	7,869	15,023	48%
Joondalup	34,843	51,757	86,660	40%
Perth	1,187	14,067	15,254	8%
Stirling	513	79,976	80,459	1%
Victoria Park	6,570	11,845	18,415	36%
Vincent	7,137	11,117	18,254	39%
Wanneroo	36,387	49,884	86,272	42%
Region	**93,792**	**226,484**	**320,276**	**29%**

The tonnage diversion is broken down further by waste collection stream in the following tables. The kerbside collection streams are shown in Table 3-9.

Table 3-9 Kerbside collection - tonnes, 2013-14

Council	Residual Waste		Recyclables		Garden Organics	
	Recovered (t)	Disposed (t)	Recovered (t)	Disposed (t)	Recovered (t)	Disposed (t)
Cambridge	1,124	6,067	3,170	464	1,797	0
Joondalup	19,933	32,552	10,289	5,479	N/A	N/A
Perth	-	13,893	1,098	99	N/A	N/A
Stirling	-	72,206	-	-	N/A	N/A
Victoria Park	2,922	8,929	2,685	801	N/A	N/A

Council	Residual Waste		Recyclables		Garden Organics	
Vincent	3,763	9,124	2,865	479	N/A	N/A
Wanneroo	22,573	30,572	10,616	3,996	N/A	N/A
Region	**50,316**	**173,343**	**30,724**	**11,317**	**1,797**	**0**

Data from each council's bulk verge collection system is provided in Table 3-10. The quantity of bulk waste disposed by each council varies significantly, ranging from 74 tpa in City of Perth to 11,894tpa from City of Joondalup. This is likely to be a function of many factors including the population serviced by each council, the demographics of that population, and the type of service offered.

Table 3-10 Verge collections and other council waste - tonnes, 2013-14

Council	Residual Waste				GO	
	Recovered[1] (t)	Clean-up Disposed (t)	Council Waste Disposed[2] (t)	Total Disposed (t)	Recovered (t)	Disposed (t)
Cambridge	17	1,252	86	1,338	1,043	-
Joondalup	178	11,894	1,832	13,726	4,403	-
Perth	1	71	3	74	88	1
Stirling	513	7,265	475	7,470	-	-
Victoria Park	25	1,960	-	1,960	931	155
Vincent	20	1,514	-	1,514	488	-
Wanneroo	192	6,474	8,323	14,797	2,964	519
Region	**946**	**30,430**	**10,720**	**41,149**	**9,917**	**675**

[1] Material recovered from the bulk waste, including material salvaged at the tip face

[2] Includes litter bins, depots, parks etc.

4 MODELLING: GENERAL WASTE SCENARIOS

General waste is the largest component of the kerbside waste stream. To reach the 2020 diversion targets, significant additional material will need to be recovered from this stream. On that basis Hyder focused the initial modelling on collection and treatment options for the general waste stream.

The 2010 modelling study also focussed on infrastructure options for general waste. The data from the original scenarios has been updated to give a revised BAU model and 2-bin scenarios. Three bin scenarios have also been evaluated.

The modelling evaluates the regional waste system as an annual time series, but analysis of the outcomes is focussed on the year 2022, which is representative of regional performance after implementation of the new waste infrastructure in each scenario. The business as usual scenario assumes a 2-bin system for all councils except for Cambridge and Stirling, which are modelled as having a third bin for garden organics. Recycling arrangements stay the same under each scenario (performance based on 2013/14 data), with the assumption that all councils will continue to offer a commingled recycling collection fortnightly.

Table 4-11 outlines the scenarios considered in the initial options modelling. In any modelling involving this number of member councils there are a range of options and assumptions inherently involved, which are outlined in section 4.1.

Table 4-11 General waste modelling scenarios

Scenario	Description
Business as usual	Existing arrangements regarding Neerabup RRF and landfill continue, with Stirling & Cambridge's garden organics (GO) sent to a separate compost facility, and residual waste from any processing is sent to landfill
Scenario 1 2 bin system, second MBT	Collection systems as in BAU, all general waste goes to MBT – either Neerabup RRF or a second MBT, only residuals from the MBT's go to landfill
Scenario 2 2 bin, EfW	Collection systems as in BAU, existing flows of general waste to Neerabup RRF continue and remainder goes to an EfW facility (including bulk waste, MBT and MRF residuals)
Scenario 3 - 3 bin – residual to Neerabup, GO separately	All councils implement a greenwaste bin, with collected material open-windrow composted. All general waste would be processed via Neerabup RRF. Remaining material would go to landfill.
Scenario 4 3 bin – residual to LF	All councils have a third bin, Stirling for greenwaste only, all other councils collect all organics (including garden, food, nappies, contaminated paper etc) in the third bin for processing at Neerabup RRF and residuals go to landfill.
Scenario 5 3 bin residuals to EfW	All councils have a third bin, Stirling greenwaste only, all other councils collect all organics (including garden, food, nappies, contaminated paper, etc) in the third bin to be processed at Neerabup RRF with all residuals to energy from waste (including bulk waste and MRF residuals)

4.1 MODELLING ASSUMPTIONS

The modelling is dependent on a range of assumptions including:

- Performance data on council collection systems (e.g. capture rates, contamination rates, participation rates)
- Projected population data for each Council
- Projected waste generation
- Waste composition
- Processing locations and types of facilities
- Assumed typical gate fees for various types of processing facilities
- Facility diversion rates
- Costs of equipment and services
- CPI and landfill levy increases

Hyder has used actual data where it was available. Where actual data was not available Hyder has used industry accepted figures based on similar systems locally and interstate. It is important to note that some modelling parameters can vary across a wide range and the values adopted by Hyder are considered to be typical. The key assumptions used are outlined in **Appendix A.**

The projected diversion rates and estimated capacities of processing facilities are heavily dependent on the assumed waste composition. No recent waste audits have been undertaken by the MRC. Some composition data was provided by the Town of Victoria Park and compared with average waste data from other metropolitan councils in WA. The major components of the average residual waste composition are shown in table below, which is based on averaged data from waste audits undertaken by similar Perth metropolitan councils between 2010-2015 (for 2-bin collection systems).

Table 4-12 General waste composition assumptions

Material category	Assumed proportion (% weight)
Potential food organics	22.0%
Potential garden organics	26.7%
Recyclable paper	4.5%
Recyclable glass	4.5%
Recyclable plastic	2.0%
Recyclable metals	2.5%
Other organics (nappies, contam paper etc)	13.2%
Non-recyclable	24.6%

4.2 MODELLING OUTCOMES – STAGE 1

This section provides a summary and discussion of the modelling outcomes for the first stage of scenario modelling, focussing on the estimated performance in 2022.

Figure 4-1 indicates that only two of the scenarios are likely to deliver the diversion targets by 2022, which are the two processing scenarios (2 & 5) that involve EfW. The contribution towards the target from each waste stream is also provided with the recyclables being constant across each scenario, but the amount of organics and kerbside residuals varying significantly. Note: kerbside waste processed through the Neerabup RRF facility is considered to be residuals processing, except in scenarios 4 and 5, where the third bin results in a clean organics stream which is processed through the RRF, and is therefore modelled as organics processing.

Figure 4-1 Total regional diversion under each scenario

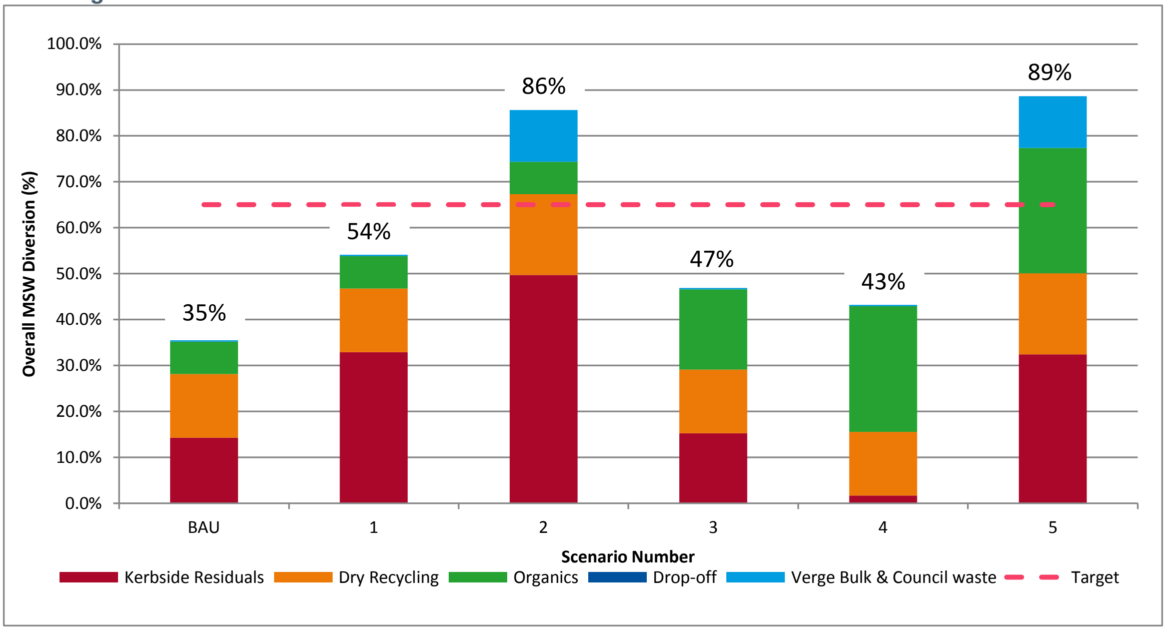


Figure 4-2 considers the cost of each scenario in 2022 on the basis of average cost per household, total cost per tonne collected and total cost per tonne diverted. These financial considerations have been overlayed with the diversion rate to determine value for money.

The average cost per household in 2022 ranges from $444 - $526 with business as usual being the cheapest option. However BAU produces the worst diversion performance and therefore has the highest cost per tonne diverted from landfill ($955/tonne). The energy from waste scenarios are the most expensive at $520/hhld (scenario 2) and $526/hhld (scenario 5) but with the lowest cost per tonne diverted ($463/tonne and $454/tonne respectively).

For reference, the average cost per household for business as usual in 2015 is estimated to be $342.

Figure 4-2 Regional unit cost vs diversion performance 2022

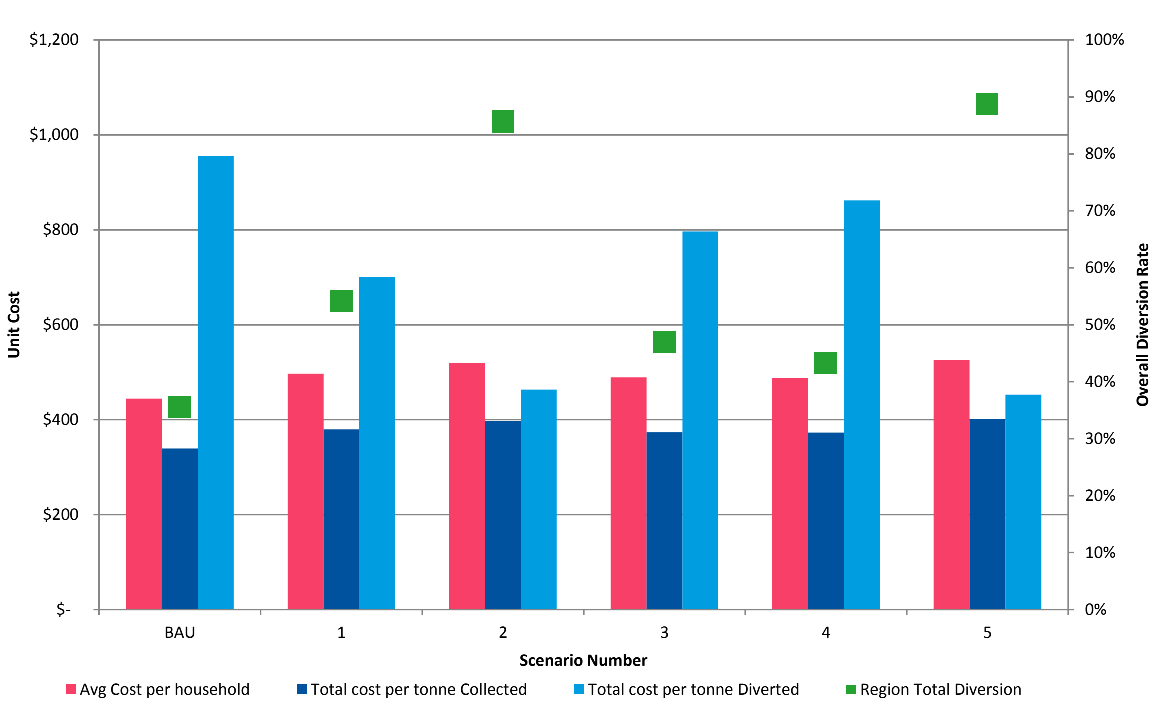


Figure 4-3 shows the total expected annual cost for the region using 2022 as an example. The total cost ranges between $140-165 million per year depending on the scenario. If a three bin system was to be implemented it is assumed the equipment cost would be incurred as a capital cost over one year, through either grant or reserve funding, therefore the equipment cost in this instance relates to bin maintenance/replacement costs only.

Figure 4-3 Total region major costs under each model scenario

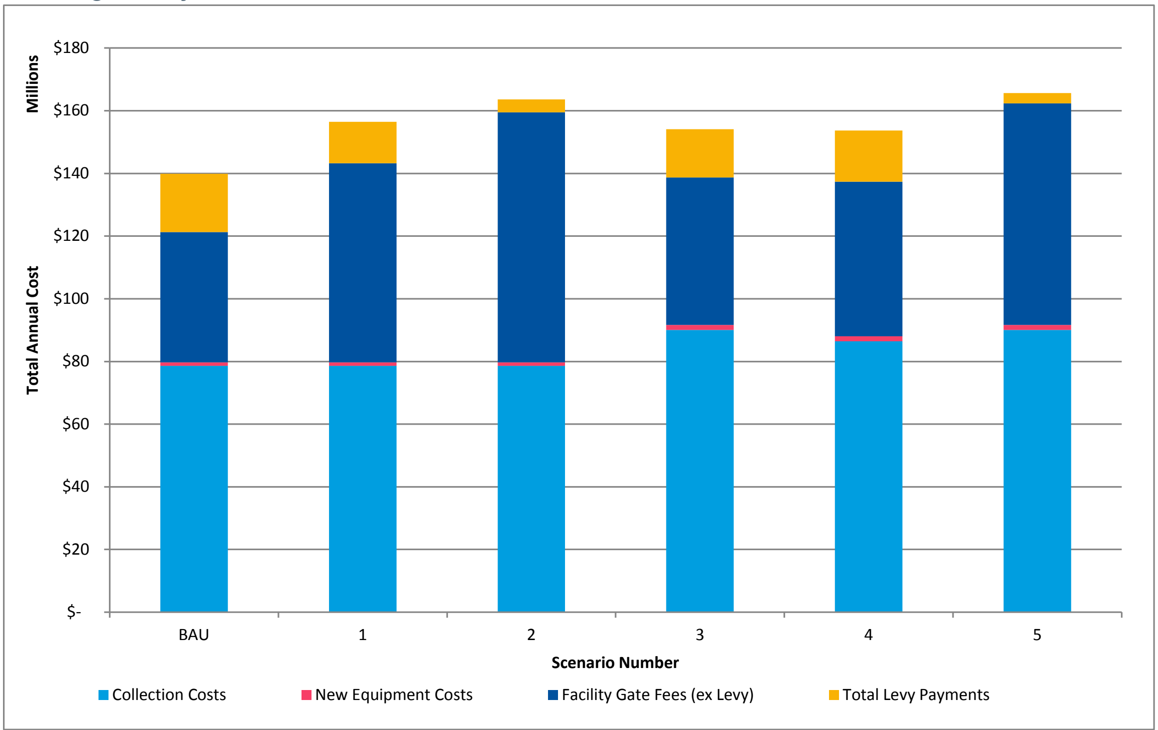
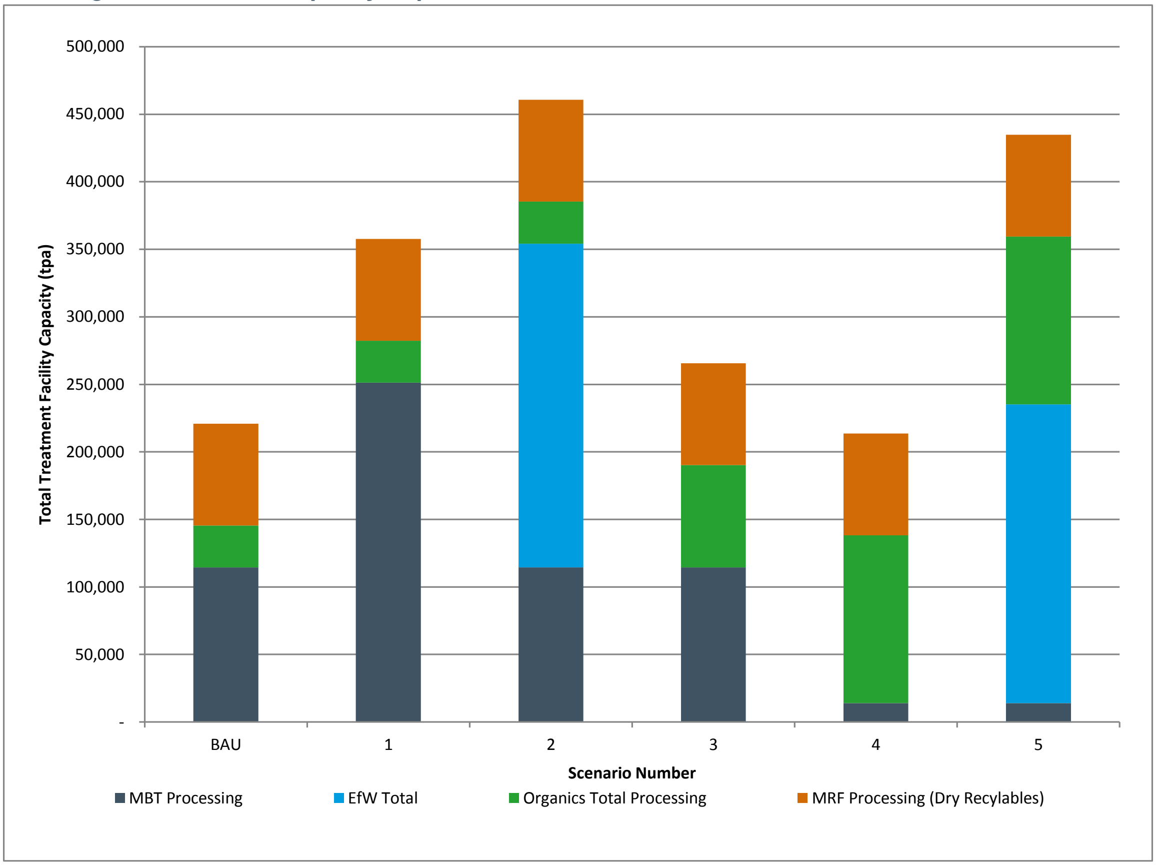


Figure 4-4 provides the total processing capacity required under each scenario. Business as usual and scenario 4 have the lowest processing infrastructure requirement (approximately 200,000tpa) including the existing capacity at the Neerabup RRF. Scenarios 2 and 5 have the highest infrastructure requirements (around 450,000tpa), which is partly due to the double handling of some waste streams such as EfW treatment of MBT, MRF and bulk waste residuals.

Figure 4-4 Total regional treatment capacity required under each scenario



4.3 MULTI-CRITERIA ASSESSMENT – STAGE 1

To determine preferred scenarios a multi-criteria assessment was undertaken, using the above modelling results as a key input. Hyder used the same multi-criteria assessment format and high level criteria as agreed in the original 2010 study. The main criteria (tier 1) and sub-criteria (tier 2) are shown in Table 4-14.

Table 4-13 Criteria used in the multi-criteria assessment

Tier 1 Criteria	Tier 2 criteria
Environmental	Waste diverted (tonnes) Resources recovered (tonnes) Net energy balance (GJ consumed / exported)
Financial	Financial impact ($ per household)
Social	Odour, visual amenity and emissions perception Community acceptance of bin system
Risk level	Highlighting project risk related to the likely timeframe of planning, approvals and finance.

Each member council was asked to separately nominate their preferred weightings for the Tier 1 criteria based on the importance and value placed on each factor by that council, as shown in Table 4-14. All Councils nominated to assign the majority of the weighting to environmental and financial criteria – however there is quite a range on the emphasis councils put on each criteria. For the assessment, Hyder adopted a straight mean of the weightings provided.

Table 4-14 Individual council nominated multi-criteria assessment weightings

Criteria	Council 1	Council 2	Council 3	Council 4	Council 5	Council 6	Council 7	Average
Environmental	30%	40%	20%	30%	60%	36%	30%	**35%**
Financial	35%	40%	40%	40%	20%	33%	30%	**34%**
Social	10%	10%	20%	20%	10%	13%	30%	**16%**
Risk	25%	10%	20%	10%	10%	18%	10%	**15%**
Total	100%	100%	100%	100%	100%	100%	100%	**100%**

The environmental and social criteria were further broken into sub-criteria, with weightings assigned by Hyder as outlined in Table 4-15.

Table 4-15 Sub criteria assessment weightings

Criteria	Subcriteria	Sub-weighting
Environmental	Waste diverted	80%
	Resources recovered	10%
	Net energy balance	10%
Social	Facility siting & technology - odour, visual amenity, and emissions perception	50%
	Collection system impacts	50%

The consolidated weightings were then applied to each scenario to provide a short list of preferred scenarios for further discussion. **Appendix B** contains a detailed breakdown of the quantitative data that was used in assessing the multi-criteria assessment. Table 4-16 provides the outcomes of the multi-criteria assessment. This ranks the scenarios from one to six based on the weighted scores. This shows that the BAU case is the least desirable, even though it has the lowest cost per household. The poor environmental performance (primarily diversion) proved to be a key differentiator. Scenario 4 also scored poorly due its low diversion performance. The EfW scenarios (2 and 5) both scored highly on the multi-criteria rankings, mostly due to the high diversion rates.

Table 4-16 Multi-criteria assessment outcomes - Stage 1

Rank	Scenario	Description	Weighted Score	Cost/hhld/ year 2022	Diversion rate
1	2	As per BAU, some general waste to Neerabup, remaining MSW+bulk+MRF residuals to EfW	86%	$520	86%
2	5	All councils with 3-bins (except Perth), Stirling GO only, others for all organics, MSW+bulk+MRF residuals to EfW	85%	$525	89%
3	1	As per BAU, but all general waste to MBT and residues to landfill	81%	$497	54%
4	3	All councils with 3-bin GO (except Perth), general waste to Neerabup or landfill	80%	$489	47%
5	BAU	BAU based on current practice, with Stirling and Cambridge on 3-bin GO, and existing RRF	78%	$444	35%
6	4	All council with 3-bins, Stirling GO only, others for all organics, residuals to landfill	76%	$486	43%

These options were presented to the MRC Strategic Working Group. Significant discussion revolved around which should be the third option to be modelled in further detail, with scenario 2 and 5 clearly viable options, but with little to differentiate between scenarios 1 and 3. It was determined that introduction of a second MBT would not be politically desirable and that a lower infrastructure option would be preferable to model. Therefore Hyder further assessed scenarios 2, 3 and 5 in the detailed transport modelling to determine optimal locations for key infrastructure. The detailed outcomes of the MCA are provided in **Appendix B**.

4.4 TRANSPORT MODELLING ASSUMPTIONS

The base modelling was overlayed with three location options for major infrastructure in each of the three preferred scenarios from Stage 1, based on a range of transport modelling assumptions. The transport modelling assumptions were discussed and refined in consultation with the Strategic Working Group.

There are a number of existing waste facilities, or proposed waste precincts, that are under consideration in this study as outlined in Table 4-17. Some other sites were considered, but where they were a similar distance for transport purposes (ie Canning/ Bibra Lake, Kwinana/ Rockingham or Balcatta/ Osborne Park) only one of the locations was included in the study. The areas included in the transport modelling are outlined on the map in **Appendix C.**

Table 4-17 Potential processing locations

	Drop-off Centres	Transfer Stations	Bulk Waste Shed	MRF	GO processing	MBT	EfW
Neerabup	✓	✓	✓	✓	✓	✓	✓
Tamala Park	✓	✓	✓	✓	✓	✗	✗
Wangara	✓	✓	✓	✗	✓	✗	✗
Red Hill	✓	✓	✓	✓	✓	✓	✓
Balcatta	✓	✓	✓	✓	✗	✗	✗
Bayswater	✓	✓	✓	✓	✗	✗	✗
Hazelmere	✓	✓	✓	✗	✓	✗	✗
Canning	✗	✗	✗	✓	✓	✓	✗
Kwinana	✗	✗	✗	✓	✗	✗	✓

Distances from the centroid of each council area to the existing waste facilities, or proposed precincts were calculated and applied to the relevant scenarios.

To estimate the potential additional transport costs, Hyder devised two different transport cost rates:

- a short haul rate ($ per tonne, per kilometre) for additional transport of waste directly in the collection vehicle, beyond the BAU distance assumed to be already covered in the modelled collection costs (ie, bin lift rates); and
- A long haul rate, which combines a set base fee ($/tonne) to cover the transfer, bulking and loading activities, plus a variable rate to cover the transport element ($ per tonne per km).

The rates were based on cost data provided by some member councils and Hyder's knowledge of waste industry transport costs. The transport assumptions are set out in **Appendix A.**

Where material is taken to a transfer station and then bulked and hauled to a second location, the short haul rate was applied to the transfer station location, and an additional long-haul cost was estimated for the distance from the transfer station to the final destination.

The bulk waste shed, MRF and greenwaste processing baseline assumptions were determined by a separate analysis of each identifying the most beneficial location for all councils on a regional basis. In each case, the preferred locations for these operations were chosen based on currently available land parcels so as to minimise the overall regional transport costs. Where member councils choose to put infrastructure projects out to tender, other locations may well become available. For bulk waste it was assumed one facility would be appropriate for the region. Balcatta was the most beneficial for the entire region, closely followed by Wangara.

The MRF modelling assumes that councils used their existing MRFs, except for Joondalup, Stirling and Wanneroo that are considering a joint MRF procurement for a new facility. Balcatta was identified as the most beneficial from a transport cost perspective, followed by Neerabup. Green waste processing could be conducted over two sites. Of the sites considered appropriate for greenwaste the baseline site was determined based on which of Hazelmere or Neerabup was closest to the centroid of each member council. However Tamala Park presents a viable bulk waste and greenwaste processing alternative.

Based on this analysis, the baseline transport assumptions which were common to each scenario are outlined in Table 4-18.

Table 4-18 Baseline transport assumptions

Council	Landfill	Bulk Waste Shed	MRF	Green Waste Processing	MBT
Joondalup	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup
Perth			Bayswater	Neerabup	
Stirling			Balcatta	Neerabup	
Vincent			Bibra Lake	Hazelmere	
Wanneroo			Balcatta	Neerabup	
Cambridge			Bibra Lake	Hazelmere	
Victoria Park			Bayswater	Hazelmere	

4.5 TRANSPORT MODELLING RESULTS

The initial modelling results presented earlier in the report assume that the transport cost to the business as usual facilities is already included in the current bin lift rates. The transport modelling takes into account the potential transport savings or additional cost against BAU depending on the waste facility locations proposed in each scenario. It should be noted that actual transport costs are likely to vary from those assumed in the modelling and between member councils. The purpose of this transport modelling is to differentiate between facility location options on cost basis (where possible), rather than to provide an estimate of the likely costs. Clearly, many other factors will also need to be taken into consideration in selecting the preferred locations for key infrastructure.

The primary differences modelled in the options for scenarios 2 (2 bin) and 5 (3 bin) are the location of the EfW facility, with three options considered as below. Detail of the transport options considered are outlined in **Appendix D**.

Table 4-19 Transport options considered scenarios 2 and 5 (EfW)

Scenario	Transfer Station location	Energy from waste facility location
2A / 5A - EfW facility at Neerabup	None (direct delivery)	Neerabup
2B / 5B - EfW facility at Red Hill via Balcatta TS	Balcatta	Red Hill
2C / 5C - EfW facility at Kwinana via Balcatta	Balcatta	Kwinana

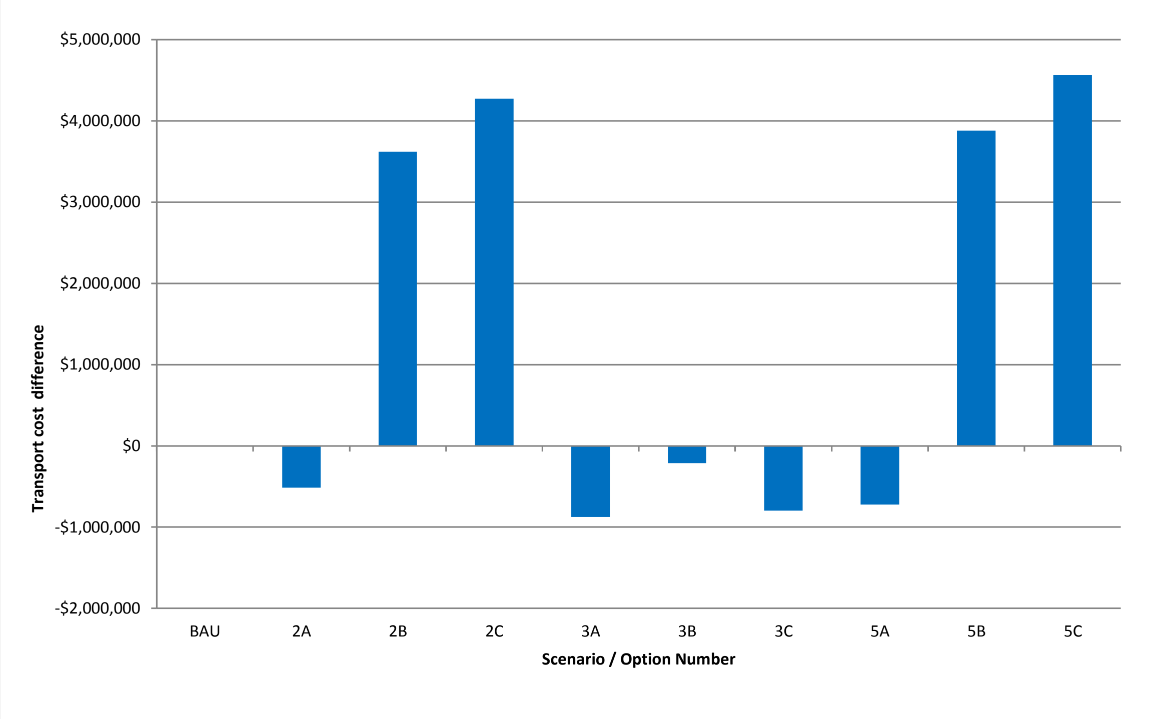
The primary difference assessed in the scenario 3 options is the location of the green waste processing facility.

Table 4-20 **Transport option considered scenario 3 (green waste)**

Scenario	Green waste
3A - All Greenwaste processed at Neerabup	Neerabup
3B - All Greenwaste processed at Hazelmere	Hazelmere
3C - Greenwaste processed at either Neerabup or Hazelmere	Either Neerabup or Hazelmere depending on which is closest for each member council

The modelling results shown in Figure 4-5 indicate that 2A, 5A and all of scenario 3 options result in transport cost savings for the region compared to the BAU facility locations. This is primarily because if Neerabup is used as a dominant site for waste management it is slightly closer than Tamala Park for most councils. For scenarios 2B, 2C, 5B and 5C the waste is taken via a transfer station to the EfW facility, which adds cost, and both Kwinana and Red Hill are significantly further for member councils than Neerabup.

Figure 4-5 **Cost for transport compared to business as usual 2022**



4.6 MULTI-CRITERIA ASSESSMENT – STAGE 2

The transport options were overlayed against the original modelling to provide a further level of assessment of the preferred scenarios for the region. The main differences in the Stage 2 MCA were the modified costs per household due to differences in the transport costs. The social impact and risk ratings were also modified based on issues related to the specific sites. Social considerations included likelihood of residential encroachment on the site and resident concerns about odour, traffic congestion, noise and perceptions of EfW. Risk considerations included issues like – whether the proposed site is already a waste facility, stage of approval and reliable access to markets (e.g. power).

It should be noted that this high level assessment does not constitute a comprehensive and exhaustive site selection process, nor a detailed site suitability appraisal. There are numerous other factors which need to considered in identifying the most appropriate sites for major waste infrastructure and more detailed analysis may be warranted, as detailed in Chapter 7.

Table 4-21 Multi-criteria assessment outcomes – Stage 2

Rank	Alternative	Weighted Score	Cost/hhld/ year 2022	Diversion rate
1	2C: EfW facility at Kwinana via Balcatta TS	91%	$533	86%
2	5C: EfW facility at Kwinana via Balcatta TS	90%	$540	89%
3	2B: EfW facility at Red Hill via Balcatta TS	86%	$531	86%
4	5B: EfW facility at Red Hill via Balcatta TS	85%	$538	89%
5	2A: EfW facility at Neerabup (direct delivery)	85%	$518	86%
6	5A: EfW facility at Neerabup (direct delivery)	84%	$523	89%
7	3A: All Greenwaste processed at Neerabup	80%	$486	47%
8	3C: Greenwaste processed at either Neerabup or Hazelmere	80%	$486	47%
9	3B: All Greenwaste processed at Hazelmere	80%	$488	47%
10	BAU: Locations based on current proposals	79%	$444	36%

The diversion rates are the same within each preferred scenario (ie, 2, 3 and 5) and the cost per household only varies by a small margin. Therefore, the main differentiation in the Stage 2 multi-criteria assessment becomes the social impact and risk levels associated with each site. For the EfW scenarios, it assumes that, compared to the facilities that may be proposed at Red Hill or Neerabup, the proposed facility in Kwinana is more advanced in its planning and community engagement stages and is generally a lower risk site that is appropriately zoned and has low risk of residential encroachment.

As such, the Stage 2 MCA identifies that Kwinana may be the preferred location for an EfW facility for the region. The Kwinana facility is proposed to take 400,000tpa of MSW, therefore there is likely to be adequate capacity for the MRC’s waste. However in the future C&I waste may take some of the capacity and there may be a strategic imperative to have more than one EfW facility in Perth. There are also development, commissioning and operational risks that need to be fully understood. The capacity of the Balcatta facility to act as a transfer station for the region's waste, in addition to its use as a resource recovery facility for bulk waste, household waste, C&D and C&I will also need further consideration.

5 ADDITIONAL WASTE DIVERSION OPPORTUNITIES

The scenarios identified in the MCA as preferred were based mostly on high diversion performance as a key indicator of environmental performance. However, EfW may not be the political preference of the member councils. Additionally the region is supportive of the waste hierarchy. Therefore additional waste diversion opportunities have been considered to determine the feasibility of maximising recovery prior to EfW treatment.

5.1 VERGESIDE BULK WASTE

Currently each council offers a scheduled bulk waste collection from the vergeside. Some councils are considering an on-call service with or without a skip bin. If an on-call bulk waste service is introduced it can be expected to significantly reduce the amount of bulk waste collected. In addition the waste could continue to be landfilled, or it could be further recovered either through kerbside separation or processing in a sorting shed. Bulk waste collection and recovery options will impact the overall diversion and costs for the region.

Hyder has undertaken an analysis on the following options for bulk waste collection to determine expected tonnes collected, potential costs and diversion rates. Under all scenarios it is assumed that mattresses will be separately collected and recovered.

Table 5-22 Bulk waste collection and processing options

Option	Collection type	Processing i	Processing ii	Processing iii
Option 1	Scheduled (except Stirling)	Landfill	Kerbside separation	Sorting shed
Option 2	On-call – with skips	Landfill	N/A	Sorting shed
Option 3	On-call	Landfill	Kerbside separation	Sorting shed

In 2009 the MRC undertook a waste audit to determine the bulk waste composition. The composition is outlined in Table 5-23. Based on the processing assumptions, Hyder has assumed different recovery rates for each material based on how the material is likely to be presented. If recoverable material is collected by separate trucks at the kerbside, it is estimated that approximately 23% would be recovered overall. If all material was collected in compactor vehicles and taken to a bulk waste sorting shed an estimated 39% would be recovered. If material was collected for reuse – prior to compaction an additional 9% could be recovered on top of the kerbside or sort shed separation options.

Table 5-23 Bulk waste composition & recovery assumptions

Recovery assumptions	Composition	Kerbside	Sort shed	Reuse
Mattresses	6%	6%	6%	
Cardboard	5%		5%	
E Waste	6%	4.5%	4.5%	
Timber	17%		5%	
Furniture	16%			5%
Plastics	6%		1%	
Scrap metal	9%	8%	8%	
White goods	4%	4%	4%	
Carpet	4%			1%
Building materials	3%			
General waste	24%		5%	3%
Total	100%	23%	39%	9%

In 2013/14 the region produced 30,430 tonnes of bulk waste to landfill with an average of 120kg presented per household each year. Taking into account population and waste growth this was projected to grow to 36,550 tonnes by 2022. Hyder conducted a review of documented bulk waste participation rates across a number of councils in Australia. The average participation rates were:

- Scheduled service – 60% average
- On call – 30% average
- On call (user pays) – 11% average

In addition, the research showed that households presented an average 93-100kg/year for scheduled collections compared to 82 kg/year for on-call collections. Due to the generally low density housing in most of the MRC member councils, it is expected that the waste generation rates per household would be slightly higher than these average figures. In the modelling below it is assumed that bulk waste tonnages will reduce to 40% of current levels in moving from a scheduled to an on-call service, due to the lower participation and presentation rates. The table below provides a breakdown of the anticipated waste tonnages depending on the waste collection (scheduled or on-call) and processing (kerbside, sort shed, reuse) options, and the anticipated recovery rates for each different collection type.

Table 5-24 Tonnes and diversion rate by bulk waste collection system

Service	2022 - Scheduled (tonnes)			2022 - On Call (tonnes)		
Processing	Kerbside	Sort shed	Reuse	Kerbside	Sort shed	Reuse
Recovered	8,224	14,072	3,289	3,289	5,629	1,316
Waste to Landfill	28,326	22,478	33,260	11,330	8991	13,304
Total collected	36,550	36,550	36,550	14,620	14,620	14,620
Recovery rate	23%	39%	9%	23%	39%	9%

Service	2022 - Scheduled (tonnes)			2022 - On Call (tonnes)		
Contribution to the overall diversion rate*	2.0%	3.4%	0.8%	2.8%	3.4%	2.3%

* In addition to the recovery rate calculated for each base model scenario.

This data indicates that the collection and processing option selected by the region will significantly affect the amount of bulk waste recovered and processed. The additional contribution to the overall diversion rate varies from 0.8% - 3.4% depending on the option selected.

It should be noted that of the additional waste, that will no longer be presented in the vergeside bulk waste stream, Hyder expects a significant amount will continue to be stored in people's homes, some will be taken to charities, a proportion will be self-hauled to existing waste facilities and some will be collected by private waste contractors.

A study was conducted by the MRC in early 2014 to assess the business case for a bulk waste sorting shed to be established at either Tamala Park landfill or the Neerabup RRF. The intention of the sorting shed was to increase the recovery of the member council's bulk verge waste streams, through manual recovery of materials. The business case assumed a much higher volume of bulk waste to be available, and much higher recovery rate potential than assumed by Hyder. Hyder's recovery rates are lower on the assumption that some of the material presented is composite materials (i.e. part of furniture or households goods), will be compacted and therefore difficult to recover or may be treated timber and therefore is not easily recovered. Further, Hyder's tonnage assumptions are based on actual annual data from member councils rather than extrapolated tonnages from a three month period.

5.2 RECYCLING OPTIONS

There is minimal waste audit data available for the region, which would assist in determining the recycling recovery and kerbside contamination rates being achieved by each member council. However based on MRF composition data (average 24% contamination), and the assumed indicative waste audit data adopted from other Perth regions (13.5% recyclables in the garbage bin) it appears that there is likely to be potential to recover more recyclables, and reduce contamination rates.

Member councils could potentially improve their recycling recovery through improved education and bin monitoring. It is estimated that improvements in kerbside recycling could increase recovery by 1-3% for the region. However this additional recovery requires intensive effort and additional costs to engage with the community. If a kerbside waste audit was undertaken it would assist in developing baseline to monitor the effectiveness of campaigns, verifying household recycling behaviours and targeting education campaigns.

Under the modelling it is assumed that each council will continue with its existing recycling processing options, except for the Cities of Joondalup, Wanneroo and Stirling who are currently engaged in interim recycling contracts pending consideration of a joint procurement contract to establish a new MRF in the northern corridor.

5.3 DROP OFF CENTRES

Currently residents from the MRC member councils use the following drop off centres for unwanted households goods and recyclables. Additional bulky waste, hazardous waste and self-haul waste can be taken to these facilities. Each of the sites has a separate area for recyclables and a differential pricing rate to encourage separation of easily recoverable materials. In addition hazardous waste drop off days are hosted within the member councils to encourage correct disposal of hazardous waste.

Table 5-25 Drop off centres within MRC

Facility (Owner)	Material accepted	Council residents likely to use facility
Tamala Park (MRC)	All materials, including free resource recovery of the full range of recyclable and hazardous wastes	Wanneroo & Joondalup
Balcatta (Stirling)	All materials, including free resource recovery of the full range of recyclable and hazardous wastes	Stirling, Vincent, Cambridge, Perth and Victoria Park
Wangara Recycling Centre (Wanneroo)	Oil, batteries, garden organics	Wanneroo & Joondalup
South Perth Transfer Station (South Perth)	Oil, batteries, cardboard, e-waste free. Other waste – at cost	Victoria Park, Perth

The vast majority of households within the MRC have access to a drop off centre within 10km, therefore the existing level of access to facilities is considered appropriate. With the upgrade to the facilities at the Balcatta transfer station, and potential upgrade to facilities at Wangara MRF Hyder has not recommended further development of drop off centres at this stage. However the availability of the drop off centres could be advertised more widely to encourage use of the facilities, particularly if changes are made to the existing vergeside bulk waste collections.

6 ENERGY FROM WASTE – OPTIONS AND LIMITATIONS

As the modelling has identified EfW as a preferred option to achieve the diversion targets, Hyder has provided a discussion on the range of thermal treatment processes for recovering energy from waste. The different forms of thermal energy recovery can be broadly grouped as:

- Pyrolysis;
- Gasification;
- Plasma Gasification; or
- Combustion (also known as incineration).

While all of these technologies can produce net energy outputs, the different technology approaches offer significantly different product options and efficiencies, as well as process scale, technical risk and economics.

In the WA waste market, there are a number of EfW technology providers and project developers offering variations of these technologies. Technologies currently being actively promoted in WA include:

- New Energy Corporation (gasification)
- SITA (fluidised bed gasification)
- Plasco Energy Group (gasification with plasma treatment)
- Phoenix Energy (mass burn grate combustion)
- Martin Bio (mass burn combustion, newer grate system)

It is noted that other providers and technologies would likely express an interest in the EfW procurement, given the likely significant scale of the project. The feedstock to these processes varies. Moving grate style combustion systems can generally accept raw, unprocessed mixed waste material (e.g. MSW), which is often termed the 'mass burn' approach. Fluidised bed systems (combustion or gasification) and most advanced pyrolysis and gasification processes have been more successfully implemented when the waste has been pre-processed into a good quality refuse derived fuel (RDF).

The pre-processing of mixed waste to produce RDF is usually through a Dirty MRF-type process preceding the thermal process. It can vary depending on the quality of fuel required, from basic shredding and metals removal, to more advanced extraction of other recyclables (plastics, cardboard) and inert or hazardous materials. The residuals from MBT facilities can also be used as RDF, as can residuals from clean MRF's processing dry recyclables. In Europe, MBT plants are commonly used to produce RDF, where the organic fraction is 'bio-dried' rather composted, and becomes part of the RDF product.

Hyder has outlined each of the EfW options below, and a summary Table 6-26 (on pg35) provides a comparison of the key aspects of each technology.

6.1 PYROLYSIS

In pyrolysis, the waste is heated in a reactor and there is a complete absence of oxygen in the system. A pyrolysis reactor is generally heated externally, and the high temperature environment causes the feed materials to break down (thermally decompose) into three products: a solid char; pyrolysis gas and pyrolysis oil. The char resembles charcoal and consists primarily of inert non-volatile substances in the waste (such as metals, silica etc.) and carbon.

The quantity of oil and gas which is produced will depend mostly on the pyrolysis temperature: generally a lower temperature (<800°C) leads to more oil and less gas, and vice versa for high temperature processes. Slower processes tend to produce more char.

Both the oil and the gas are combustible and some of the gas can be used as the source of heat to drive the process. The gas can also be cooled, cleaned and converted to electricity. However, reliability issues can arise when the heavy hydrocarbon vapours (tars) condense and block pipework and filters.

A lower temperature pyrolysis process would generally aim to maximise pyrolysis oil production. This oil is often referred to as ‘bio-oil’ and can be used as a precursor for the production of other chemicals or liquid fuels in a ‘bio-refinery’. A number of systems are in development, particularly targeting the production of liquid fuels from tyres and waste plastics. Conversely, higher temperature pyrolysis aims to maximise gas production for conversion into electricity.

The char can also be used as a fuel, often displaying a similar energy content as coal. Char produced from clean organic waste can also be marketed as ‘bio-char’, a very effective soil amendment product and means of long-term carbon sequestration.

While commercial pyrolysis technology has a long history of use on coal and in metallurgical industries, commercial scale operational experience with pyrolysis plants treating waste feedstocks is limited, both in Australia and internationally. There is still a degree of uncertainty around their technical performance, reliability and ability to meet emissions limits. Many consider that pyrolysis of waste is yet unproven at a commercial scale.

Pyrolysis is most likely to be applied at smaller scales (10,000 to 20,000 tpa) and be used for processing of source separated materials such as waste wood, garden waste, tyres and plastics. EMRC is currently obtaining environmental approvals and planning to develop a pyrolysis facility to process untreated wood waste at their Hazelmere site. Other facilities are also in various stages of development, including a project in Ballina (NSW) to process green waste.

It is unlikely that pyrolysis would play a significant role in the processing of MSW from the MRC, therefore this option has not been considered further.

6.2 GASIFICATION

In gasification, the waste is heated in a reactor in a similar manner to pyrolysis, but in this case there is limited oxygen or steam in the system, so that the feed is partially oxidised (partial combustion). Most of the carbon and hydrogen in the waste is converted to a “syngas” consisting mainly of carbon monoxide (CO) and hydrogen (H_2). A solid residue remains consisting of inert ash and char – the inorganic compounds within the waste feed and a relatively small amount of carbon which failed to gasify. The syngas typically contains around 80% of the chemical energy contained within the incoming solid waste materials and has number of potential uses including:

- Burning immediately to raise steam for power generation (most common approach in existing commercial plants)
- Cleaning and use as a fuel in gas engines or turbines, or
- Use as a feedstock for the manufacture of other fuels or chemicals.

There are a number of different gasification processes and process configurations on the market. Different designs of the gasification reactor are available including fluidised bed, moving grate, rotary kiln, and updraft and downdraft reactors. Each is tailored to give certain benefits when gasifying various types of wastes.

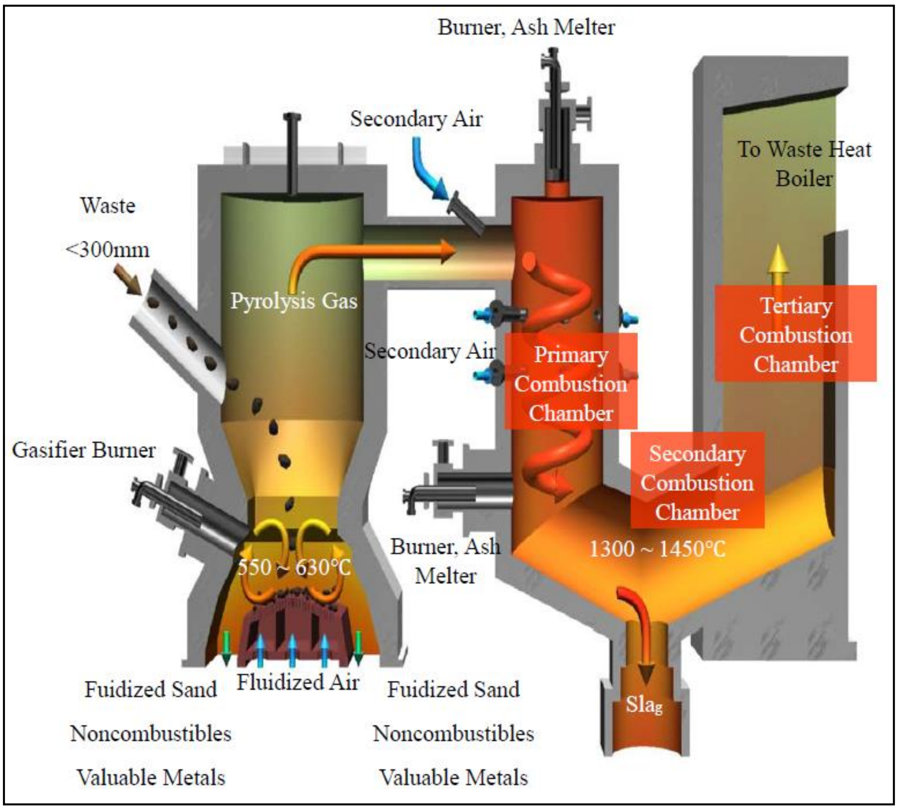


Figure 6-6 Illustration of typical EBARA fluidised bed gasification and ash melting process

Updraft and downdraft gasifiers have been successfully used for many years in the chemical industries for numerous applications. Gasification of waste has been most widely practiced in Japan and to a lesser extent, Korea, where high temperature systems (up to 1800°C) are used to melt the ash (slagging gasifiers) to create a glass-like aggregate that can be recycled. In Japan, this has been driven by a ban on disposing ash to landfill, however melting the ash in this way consumes energy and reduces the overall conversion efficiency of the system.

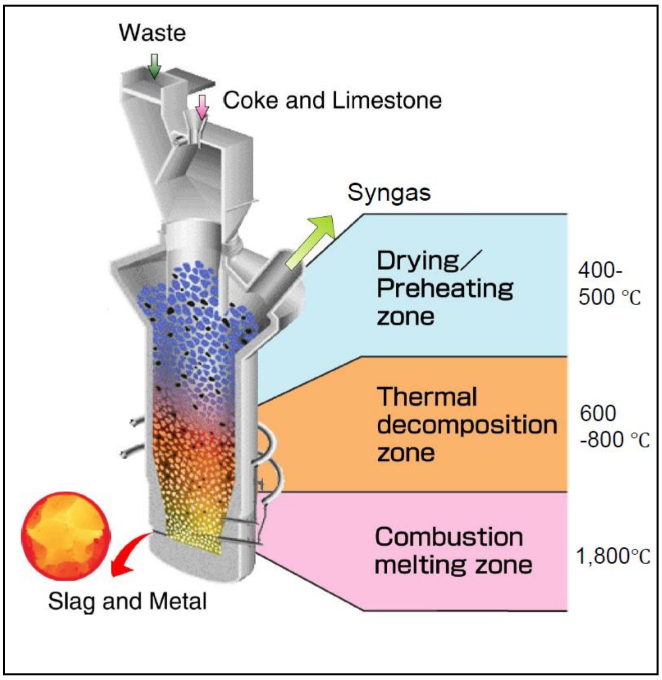


Figure 6-7 Illustration of typical Nippon Steel slagging, updraft gasifier

Typical gasification temperatures are 900 – 1,100°C with air and 1,000 – 1,400°C with oxygen. Air gasification is more widely used because it is cheaper and the cost of oxygen generation infrastructure is usually prohibitive. However the syngas produced contains up to 60% nitrogen and therefore has a lower heating value (4-6 MJ/Nm^3 compared to 10-18 MJ/Nm^3 using oxygen). High temperature gasification can also have the benefit of melting the ash (inorganic content of the input waste) to produce an inert glass-like slag. The high temperatures necessary to melt the ash (typically over 1,600°C) are often produced by adding supplementary fossil fuel such as coke, injecting oxygen or by the use of plasma to provide the necessary heat input (see plasma gasification below).

In addition to CO and H_2, syngas from gasification may contain smaller quantities of methane (CH_4) depending on the reactor type, as well as some of the unconverted reactants such as carbon dust, mineral ash, carbon dioxide (CO_2) and nitrogen (N_2) when air gasification is used. Additionally, traces of other organic and inorganic compounds are produced or released in the gasification process and need to be cleaned from the syngas prior to utilisation.

Many of the commercial waste gasification systems on the market are really two-stage combustion processes, where the gasification chamber produces a poor quality syngas which is immediately burned in a second chamber to produce steam for power generation through a turbine. The syngas from these systems is usually highly contaminated with tars and oils, and is not suitable for other applications except direct combustion.

6.3 PLASMA GASIFICATION

Plasma gasification uses extremely high temperatures in an oxygen starved environment to decompose organic waste materials into basic molecules. The extreme heat and lack of oxygen converts the organic matter in the waste into syngas. The heat source is a plasma arc, which is generated by the input of electrical energy to a gas (usually air). The plasma arc briefly attains temperatures between 3,000 and 8,000°C in the plasma plume, though in most plasma processes waste is not exposed directly to the plasma arc, and the temperature in the reactor may be between 1,000 and 2,000°C.

There are three main variants of plasma gasifiers available for processing waste:

- Direct exposure of waste to the plasma torch (mostly for high-level hazardous waste);
- Plasma assisted gasification of the waste; and
- Plasma heating of the syngas from a separate gasification chamber to produce a very clean and tar-free syngas stream (by ‘cracking’ the hydrocarbons).

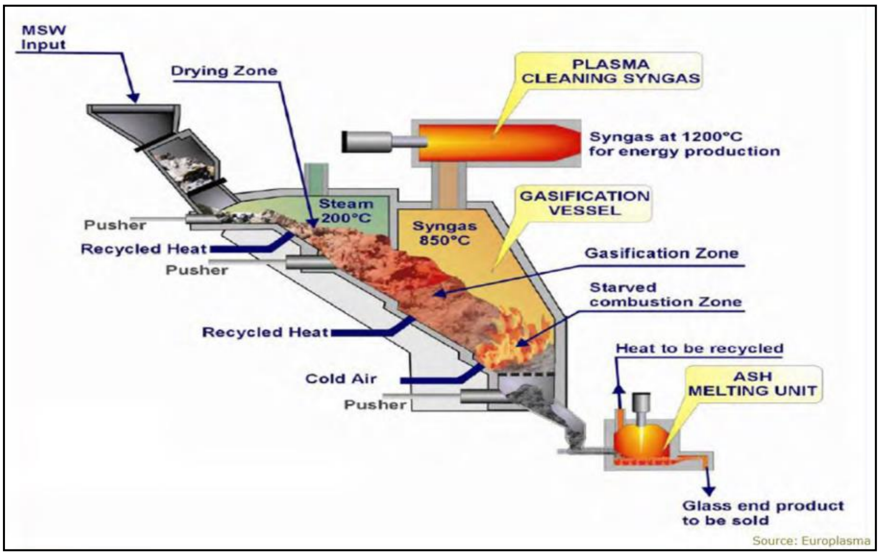


Figure 6-8 Illustration of Europlasma process

The syngas from a plasma gasification process generally requires less cleaning and should not suffer from tar problems that other gasification systems may exhibit. The clean syngas stream from the process lends itself to use in gas engines and turbines, which are more efficient than steam turbine systems. In the future, it could be suitable for use in fuel cells, which would achieve very high conversion efficiencies. The syngas could also be used to produce liquid fuels and chemicals.

Some processes use plasma torches just to melt the ash from the gasification or combustion process in a separate reactor. This is a common approach in Japan where landfill disposal of ash is prohibited. The melted ash forms a stable glass-like product than can be used as an aggregate. However, the energy inputs for this process are significant, and unlikely be financially viable in Australian context.

6.4 COMBUSTION

In combustion, or incineration, the carbon-based components (including plastics) of the waste feedstock are completely burnt (oxidised) in a furnace in an environment containing excess oxygen. Some inorganic components, such as elemental sulphur, will also be oxidised.

The main furnace types are:

- Moving grate
- Rotary kiln
- Fluidised bed

Moving grate systems are the most common worldwide and can be used to treat unprocessed waste (‘mass burn’). All systems accept RDF, however fluidised bed systems generally require a good quality RDF with small particle sizes.

Heat is released into the combustion gases and energy is recovered by raising steam from the hot combustion gases in a boiler. This steam can be then expanded through a steam turbine which drives a generator to produce electricity, or can be used directly as a source of heat for another process (or both, in combined heat and power configuration).

This technology is well established globally, with a large number of technology providers offering a variety of different furnace types and process configurations.

Figure 6-9 provides an example layout of a typical waste incineration process[3] using a moving grate technology.

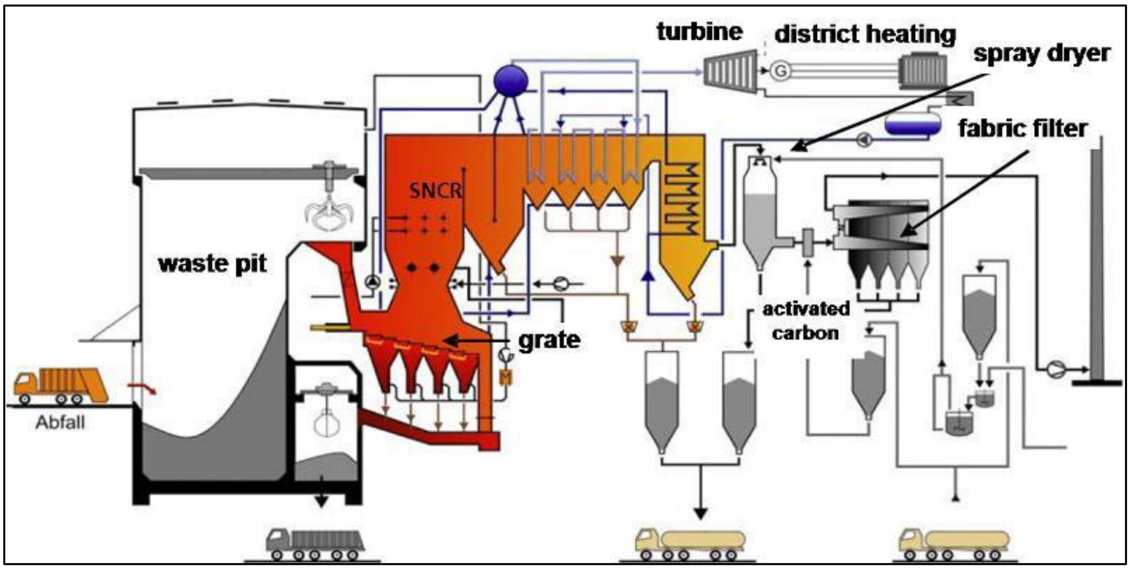


Figure 6-9 Flow diagram of a MSW grate incinerator (Leuna, Germany)

Fluidised bed furnaces feature turbulent mixing of the fuel and gases, often with a heat-carrying medium such as sand, which enables rapid and even heating and combustion of the fuel. This also makes it suitable for higher moisture content fuels such as sludges.

It should be noted that process economics generally dictate that these systems are large. The plant depicted in

Figure 6-9 has a capacity of 390,000 tpa. Most modern facilities are over 100,000 tpa capacity. The energy conversion efficiency of steam turbine systems is low at small scales and the air pollution control systems need to be large to cater for the large volumes of flue gases, due to the excess air inputs. Modern large scale plants include a number of measures to maximise energy conversion, through additional heat recovery systems.

Solid residues from the combustion of MSW are:

- Bottom ash
- Fly ash and air pollution control residues – typically 2% of the feed

Bottom ash is the main residue from the combustion process. It typically represents 10-20% of waste feed input (depending on composition) and contains varying quantities of non-combustible materials such as glass, ceramics, brick, concrete and metals in addition to clinker and ash. The actual quantity and composition will depend on the waste material fed to the process. Overseas, bottom ash is often recycled as a road-base material in civil construction projects. Alternatively it must be landfilled and can be suitable for inert landfills, subject to contamination limits. It is not yet clear whether this would be the case in WA.

Fly ash is the very fine particulate matter carried over from the combustion process which is removed from the flue gas by filters prior to discharge. Typically fly ash is removed with other air pollution control residues, although it can be separately filtered.

Typically, an air pollution control system consists of a wet semi-dry scrubbing system where acid flue gases are neutralised by scrubbing in a solution of lime and water or powdered soda

[3] IEA Task 36 – Chapter 4: Overview of Technologies Used for Energy Recovery, p25

ash. Flue gas emissions of dioxins, mercury and other heavy metals are removed by an activated carbon injection system. Control of dioxins and furans is achieved through a combination of accurate combustion control, rapid cooling of the flue gas and absorption onto the activated carbon. Modern technologies can readily achieve negligible levels of dioxin emissions, well below regulatory limits.

After gas scrubbing, the gases pass through bag filters to remove particulates, including fly ash and the lime and activated carbon particles. In some cases it may be necessary to undertake additional treatment stages to reduce emissions of nitrous oxides which may include flue gas recirculation and either a selective non-catalytic reduction stage or a selective catalytic reduction stage using injection of aqueous ammonia or dry urea.

Fly ash and residue from the air pollution control system (around 2% of the process feed) are generally classified as hazardous waste that can only be disposed in appropriate facilities. The chemical composition of the residue will depend on the waste incinerated, and the type of process and the flue gas cleaning system. Processes to recycle fly ash and air pollution control residues are not generally commercially developed or proven.

It is also possible to utilise plasma melting technology in a combination with a mass burn combustion plant to vitrify the ash resulting from the process. The combination of processes has been implemented by a number of technology providers in Japan.

Table 6-26 Summary of key aspects of major MSW thermal EfW technologies

Aspect	Mass Burn Grate Combustion	Fluidised Bed Combustion	Gasification	Fluidised Bed Gasification	Gasification with Plasma Treatment
Proposed plants and existing reference plants	▪ **Phoenix Energy - Kwinana** (proposed) ▪ **Martin- Bio – site TBC** ▪ Many hundreds of references throughout UK, US, Europe and Asia – common technologies include Martin, HZI, Volund, Keppel Seghers	▪ VISY Coolaroo (Victoria) energy recovery plant processing paper and recycling residues, attached to existing paper mill ▪ Allington EfW plant in UK ▪ SITA-Indaver SLECO plant in Belgium	▪ **New Energy Corporation – Pilbara and Rockingham (WA)** (proposed) ▪ Nippon Steel process – 35 plants in Japan and Korea ▪ JFE – 10 plants in Japan ▪ Enerkem MSW to bio-fuel in Canada (open 2014) ▪ Energos has 8 plants built in Europe, eg Sarpsborg 2 - Norway Isle of Wight - UK Minden Plant - Germany	▪ **SITA – Neerabup** (proposed) ▪ Lahti (full scale demonstration plant) CHP Gasification Project ▪ SITA - Charlton (UK) Eco Park in Surrey proposing to use fluidised bed gasification for RDF ▪ Ebara Corporation – 15 plants in Japan & Korea	▪ **Plasco – site TBC** ▪ Europlasma plant – Morcenx, France (commissioned Feb 2014) ▪ Plasco - Ottawa (Canada) (existing full scale demonstration module, planned commercial plant) ▪ AlterNRG – 2 plants in Japan
Feedstock	MSW and C&I, RDF	Good quality RDF, waste wood (chips), sludges	MSW and C&I, RDF	Good quality RDF, waste wood (chips), sludges	MSW, C&I, RDF, other industrial waste, hazardous waste
Flexibility in feedstock	Providing feedstock is mixed and effort has been made to remove inert material and recyclables this process allows for flexibility in feedstock.	Requires relatively small particle sizes (ie, well shredded RDF). Quite flexible to a wide range of fuel moisture contents and energy contents. Capable of accepting hazardous waste and e-waste	Less flexibility in feedstock as the process is more sensitive to variations in composition, ash content, moisture content, particle size and density	Requires relatively small particle sizes (ie, well shredded RDF). Quite flexible to a wide range of fuel moisture contents and energy contents.	Generally very flexible, can manage higher contamination feedstocks.

Scale	Typically large, to achieve efficiencies of scale and maximise energy recovery efficiency. The Phoenix plant in Kwinana expected to have capacity of 400,000 tpa. Most modern plants range from 100,000 tpa to 300,000 tpa. There are some plants as large as 800,000 tpa, featuring multiple lines. Smaller plants are possible (50-60ktpa) but less cost effective.	Typically large scale VISY Coolaroo plant is 100,000 tpa Allington facility is 550,000 tpa across three lines. SITA-Indaver SLECO plant in Belgium is 466,000 tpa in three lines.	Plants typically range from 10,000 tpa - 250,000 tpa New Energy's Pilbara Project will have capacity from 70,000 - 130,000 tpa Nippon Steel Shin Moji plant – 240,000 tpa Ebara Corporation - Japan - 70,000 tpa Enerkem bio-fuels plant – 100,000 MSW	Lahti RDF gasification plant, Finland processes 250,000tpa SRF (ie, high quality RDF) Proposed SITA Charlton plant will process 55,000 tpa	Typically 50,000-100,000 tpa A standard Plasco module can process around 50,000 tpa Plasco Ottawa plant planned to be 150,000 tpa (3 modules) Europlasma Morcenx plant – 50,000 tpa
Footprint	Kwinana Plant site - 3.5ha Covanta Harrisburg (US) - 4.5ha Coventry facility (UK) - 2ha	Expect similar to grate combustion (2-4 ha)	Expect similar to grate combustion (2-4 ha) Preliminary drawings show 8.7ha site for Pilbara Project (includes MRF) The preferred location for New Energy's facility in Perth is on a 10ha site	Expect similar to grate combustion (2-4 ha)	Plasco's facility in Ottowa (Canada) is located on a 4ha site

By Products	Recyclable metals (2-5%) Bottom Ash (typically 15-25%) APC residues (2-6%) Emissions to atmosphere – (70-75%, CO_2)	As for Grate systems	Recyclable metals (2-5%) Bottom Ash (15-25%) APC Residues (2-6%) Gas cleanup residues and Condensed Tars (2-6%) Syngas (70-80%) (Enerkem produces 60% bio-fuels)	Recyclable metals (2-5%) Bottom Ash (15-25%) APC Residues (2-6%) Gas cleanup residues and Condensed Tars (2-6%) Syngas (70-80%)	Vitrified aggregate product (typically 15-20%) Syngas products (75-80%) Gas cleanup residues (2-5%)
Diversion	Has the potential to divert up 90-95% of the MSW stream from landfill if bottom ash can be recycled (subject to markets), or 75-80% if not The bottom ash by-product may need to be disposed to landfill if a beneficial use is not practical	As for grate systems	As for grate combustion systems	As for grate combustion systems	Up to 95-98% providing market is available for aggregate by-product
Net Energy Conversion Efficiency	Typically 24-27%, but up to 30% (modern large plants), or around 20% for small plants	Approximately 25-27%	Approximately 20-25% depending on technology and feedstock	Approximately 25-27% depending on technology and feedstock	20-30% depending on energy conversion technology (turbine most efficient)
Limitations	Process produces small volumes of fly ash and APC residues that must be handled as hazardous waste, small scale systems not efficient or cost effective	Require more homogeneous feedstock compared to grate systems	Tar production may limit syngas applications to direct combustion with steam turbine	Limited full scale commercial facilities, requires good quality homogenous fuel	Still a developing technology without a proven track record in commercial scale facilities

Capital Cost	Phoenix Energy - Perth - $380M (includes plasma arc gasifier) Recent UK experience - $270M - $370M (150,000 tpa - 350,000 tpa facilites)	Likely to be similar to other Martin Grate VISY Coolaroo was $50M in 2011, but as part of an existing facility	New Energy Corporation - Perth - $180M New Energy Corporation - Pilbara - $180M	LahtiStreams - Finland - $230M	Europlasma Morcenx - $60M

7 INFRASTRUCTURE PLAN

Based on the Scenario 2C which is the preferred option arising from the modelling and multi-criteria assessment, the proposed infrastructure plan for the region consists of the facilities shown in Table 7-27. It should be noted that these facility capacities are based on the required tonnage for MSW only.

Table 7-27 Infrastructure Plan

Processing facility	Capacity required in 2022	Capacity required in 2030	Preferred location
Landfill	60,000 tonnes	74,000 tonnes	Tamala Park (existing) – waste may eventually be transferred to alternative landfill
Mechanical biological treatment	100,000 tonnes	100,000 tonnes	Neerabup (existing)
Transfer station	240,000 tonnes (MSW) + 50,000 tonnes (C&I)	335,000 tonnes (MSW) + 60,000 tonnes (C&I)	Balcatta (with alternative option of Tamala Park
Bulk waste sorting shed	25,000 - 40,000 (includes self-haul)	40,000 – 66,000 (includes self-haul)	Balcatta
Materials recovery facility	75,000 tonnes	100,000 tonnes	Neerabup
Green waste processing facility	32,000 tonnes	34,500 tonnes	Neerabup
Waste to energy facility	240,000 tonnes	335,000 tonnes	Kwinana

Procurement options for each of these facilities will vary. Due to the outcomes of the modelling the proposed facility locations align with existing feasibility and development plans that are already underway. City of Stirling anticipates reconfiguring their transfer station for a range of purposes. This is a high priority project for the City with construction proposed to commence in 2017. Once the transfer station is reconfigured, the bulk waste sorting shed could be constructed. We have assumed that the existing depot, sited alongside the transfer station, would not be included in the reconfiguration.

Table 7-28 outlines considerations in relation to each piece of infrastructure required. Depending on the procurement option selected for each facility, these projects could be run concurrently as they will be at different stages of the procurement/development process. Taking into account the proposed timeframes in the table below, Hyder proposes that the facilities are pursued in the following order of priority by member councils:

1. Transfer station reconfiguration
2. Green waste processing facility
3. Bulk waste sorting shed
4. Materials recovery facility
5. Waste to energy facility

Table 7-28 Infrastructure development priorities

Facility	Issues	Timeframe
Transfer station	Proposed for City of Stirling's Balcatta site as part of overall site improvements.	2.5 years
Green waste processing facility	Currently the value of this product is not being optimised and a new facility is required to replace Wangara	2 years
Bulk waste sorting shed	Dependent on reconfiguration of Balcatta Transfer Station	3.5 years
Materials recovery facility	Temporary capacity is available at existing MRFs throughout Perth however due to expected population growth of Wanneroo, Joondalup and Stirling development is a priority.	3-4 years
Waste to energy facility	The modelling indicates the Kwinana facility as preferred location based on project risks and social impacts, as it has progressed furthest in the planning and development stages however undertaking a competitive tender process would be advisable as there are a number of other competitive options in the market and the procurement process / timeframe should not preclude other options	3-6 years (possibly up to 10 years depending on location, ownership arrangements, operating model and procurement method)
Landfill and MBT	Existing facilities, not a high priority for replacement until 2026+	
Drop off centres	Existing facilities exist, upgrades and additional promotion may occur	

7.1 OWNERSHIP, MANAGEMENT AND PROCUREMENT OPTIONS

One of the fundamental considerations for the infrastructure plan is the ownership arrangements, operating models and procurement options for each infrastructure project.

Under the current governance options the MRC is restricted in its functions as it is focused primarily on the acceptance and processing of residual waste. Hyder has conducted a separate study on the governance options and range of services that could be offered by the MRC, and the advantages and disadvantages of each approach. To optimise the benefits of each of the proposed facilities it will require secure tonnages from the participating councils and a contractual arrangement that provides certainty over the life of the facility. Seeking consensus and commitment amongst the member councils on the preferred options is critical, and will also affect the timeframe for each of the facilities.

There are a number of procurement options that the MRC and its member councils may consider. The most common options are summarised and described below.

Logic dictates that direct costs to the MRC will increase with the more risk that is put onto the Contractor. However, where the MRC takes on inappropriate project risks and those risks are realised, the overall cost to the MRC is likely to be higher. Different organisations have varying appetites for risk, but in general, local governments have a low appetite for risk, given that their funding comes from rate payers and Councils are ultimately accountable to residents to spend that money carefully.

Where the term the MRC is used in this section, it may apply to the relevant member council, for example in the case of Stirling or Wanneroo that may ultimately retain ownership of the site under development. Any commitment and risk undertaken by the MRC is ultimately a risk, and financial impact, for all member councils.

The overarching principle in assessing procurement models should be that risks should be allocated to the party that is best placed and most experienced in managing those risks.

The MRC is not experienced in designing, constructing or operating advanced waste processing facilities (such as EfW) and there are a number of risks associated with those actions.

The procurement and contracting options that may be considered for the project include:

- Build, Own, Operate (BOO) – a Contractor is engaged to design, finance, build, operate and maintain the facility. Under this model the Contractor takes on most of the risk, but also gets the benefits of any upsides (e.g. revenue from third party waste inputs).
- Build, Own, Operate, Transfer (BOOT) – as for BOO, except ownership of the facility transfers to MRC at the end of the contract period, at which point the MRC can either take over the operations, outsource it via a further contract or decommission the facility.
- Design, construct, maintain and operate (DCMO) – the MRC owns, finances and retains control of the facility but contracts out the design, construction and operations of the facility to an experienced contractor (or separate contractors).
- Design and Construct (D&C) – the MRC owns and finances the facility, contracting the design and construction to a specialist contractor. The MRC then operates and maintains the facility with full control.
- Alliance model – the MRC works in partnership with a specialist Contractor to jointly develop the facility, sharing the costs, risks and benefits, with joint control over time and cost decisions.

Options for procurement and management of services where a new facility is required are outlined in the Table 7-32.

Table 7-29 Site ownership, management and procurement options

Site Owner	Procurement/ Management	Scope of contract
Private sector	Putting the service to market without offering a preferred site or land	Guaranteed supply contract (for existing facilities) BOO
Individual council (Council owns the land, organising suitable zoning and development approvals, if not already a suitable waste management site)	Leasing the land to a third party to design, construct, own and operate the facility	BOOT DCMO Alliance model
	Developing and operating the site	D&C, council operate DCMO contract
	Leasing the land to the MRC to manage a processing operation	D&C, MRC operate DCMO
	Leasing the land to the MRC to manage a procurement contract	BOOT DCMO Alliance contract
MRC Assumes the MRC owns the land, on behalf of member councils (ie shared ownership)	Leasing the land to a third party to design, construct, own and operate the facility	BOOT DCMO Alliance contract
	Developing and operating the site	D&C, MRC operate DCMO
	Manage a procurement contract	BOOT DCMO Alliance contract

Each of these options has differing levels of risk and suitability depending on the nature of the contract. It is recommended that if the private sector is expected to finance the facility, minimum contract periods should be stipulated to allow recovery of the capital investment, as follows:

- Bulk waste – 7 years
- Greenwaste – 7 years
- Materials recovery facility – 12 years
- Waste to energy facility – 20 years

In terms of the specific technology risks that apply to each project and treatment process - MRFs, transfer stations, bulk waste and greenwaste processing facilities are all very common and there are a number of experienced contractors and operators within the market to which those risks can be safely outsourced, provided a reputable and experienced contractor is chosen. Energy from waste is newer to the Australian market, globally there are a large range of experienced contractors but their availability to a WA project needs to be considered in the tender assessment.

The lowest risk option is the one where everything is outsourced to an experienced contractor (BOO model). The next level low risk option is an outsourced procurement option with a later transfer of the asset to the MRC (BOOT model). The two variants are by far the most common procurement models for waste processing facilities and provide certainty of future costs for the MRC.

The highest risk option is the D&C model whereby the MRC would take on the operations and maintenance of the facility. Although this option may cost less upfront it should only be considered for facilities where the MRC is experienced in the operation and is well placed to manage the risks effectively. Otherwise it could potentially result in significant cost impacts in the future.

One option for the MRC to play a part in delivery of the project, either in the design and construction phase or in the operations and maintenance phase, is through an Alliance model. The MRC would have to share many of the risks in any alliance contracting model, but can mitigate these by accessing the expertise of the Contractor. This is not recommended for the MRC given the large number of stakeholders involved and the difficulty seeking agreement from member councils if the future costs are less certain.

The following table provides a brief overview of the procurement options that are likely to be most relevant.

Table 7-30 Summary of Key Procurement Options

Contracting Option	Potential advantages to MRC	Potential disadvantages to MRC
Build Own Operate (BOO)	• No capital cost incurred • No operational responsibility • No product marketing responsibility • Specialised operating skills not required • High contractor accountability	• Potentially higher overall cost • Loss of operational control • Resources required to monitor service provision • Long term commitment • Reliance on commercial viability of contractor
BOO and Transfer after x years (BOOT)	• No capital cost incurred • No operational responsibility until post-transfer • No product marketing responsibility until post-transfer • Specialised operating skills not required until post-transfer • Potential for operator training prior to transfer • Special corporate structure not required • High contractor accountability	• Potentially higher overall cost • Loss of operational control until post-transfer • Contractor may potentially economise on maintenance as the transfer approaches • Post-transfer maintenance responsibility • Resources required to monitor service provision • Long term commitment • Reliance on commercial viability of contractor
Alliance partnership	• Access to a wider skills base to develop, operate and maintain the facility – partners leverage off each other's strengths. • Potential to share in any profit from the operation. • Potential for more favourable pricing because of risk sharing.	• Unlikely to achieve by in from all member councils due to unknown costs • Likely that some form of capital investment will be required. • Exposure to commercial risk. • Special corporate structure may be required.
DCMO - MRC finance and ownership with an contracts for construction and operations	• Potentially lower overall cost • Retention of control and ownership • Operational responsibility outsourced	• MRC liable for the capital cost • MRC assumes construction and process risk (that which cannot be put onto D&C contractor) • Retention of product marketing responsibility, with no economy of scale. Exposure to commodity price fluctuations
D&C - Council owns and operates the facility	• Potentially lower overall cost • Full retention of control and ownership	• All operational risk on Council • Council liable for the capital cost • Council assumes construction and process risk (that which cannot be put onto D&C contractor) • Retention of product marketing responsibility, with no economy of scale. Exposure to commodity price fluctuations

Further consideration regarding each of the proposed infrastructure developments are outlined below. Hyder has identified approximate timeframes for each stage. We recognise these timeframes as ambitious but achievable if the MRC and its member councils commit suitable resourcing, priority and political support to the infrastructure plan. The proposed timeframes are considered in the context of the existing contractual arrangements, facility life and waste infrastructure needs of the member councils. They also take into account the aim of reaching the state government waste diversion targets by 2020.

7.2 MATERIALS RECOVERY FACILITY

The Cities of Wanneroo and Stirling are both able to provide a site for a MRF development. If neither of these sites are deemed suitable it is also possible to develop a MRF at Tamala Park. City of Wanneroo has recently closed the Wangara MRF and has identified a suitable alternative site in Neerabup. Stirling have proposed that the MRF could fit onsite at the Balcatta waste facility, alongside the transfer station, bulk waste shed and other household drop off/tip shop operations. It may also be more beneficial to outsource the provision of all or part of this service to the market.

Table 7-31 Recycling facility options

Site	Advantages	Disadvantages
Balcatta	Currently zoned as a waste facility Central and optimal transport distance	Existing high volume of traffic to the facility Availability of space for all proposed infrastructure
Neerabup	Provides an additional waste facility to take pressure off Balcatta. May be preferable for the northern growth corridor	Not currently zoned as a waste facility Greenfield site requires significant planning, approvals and site works
Tamala Park	Currently zoned as a waste facility Joint ownership arrangements of the facility already exist	Slightly further that the other two facilities

Balcatta was slightly preferred based on the transport cost modelling, however it may be worth further investigation of the zoning, approvals and development considerations at Neerabup, as the northern facility may be preferable strategically in the long term, rather than increasing pressure on the Balcatta waste facility. This should be done in conjunction with an assessment of the options available in the market.

7.3 BALCATTA TRANSFER STATION & BULK WASTE

The Balcatta site is considered to be of key strategic importance in the development of waste infrastructure in the northern corridor, given its central location.

City of Stirling has indicated that at a minimum they would like the reconfigured Balcatta transfer station to include: a recyclables drop off area/tip shop prior to the weighbridge, a reconfigured transfer station (suitable for small and large vehicles), a drop off area for C&D wastes and greenwaste and a bulky waste sorting shed and MRF if the space permits. As the increased operations would increase traffic flow to the site, it is possible that two entry points could be used. It is anticipated that C&D waste and greenwaste would not be processed on the site, they would just be stockpiled for offsite processing.

Hyder has assumed that the existing infrastructure on the site would be mostly demolished and removed. It is anticipated the recyclables drop-off area would remain on a similar footprint. Based on this assumption there is around 6.5 hectares of land available for the remaining operations. Hyder investigated the footprints of a number of similar size facilities in Australia to determine what would be required on the Balcatta site shown below in Table 7-32.

Table 7-32 Balcatta Transfer Station infrastructure estimated footprint required

Facility	Footprint required
Transfer station	2ha
C&D drop off	0.5ha
Greenwaste drop off/mulching	0.5ha
Bulk waste sorting shed	1ha
MRF	1ha
Other infrastructure (weighbridge, office & roads)	1.5ha
Total requirement	**6.5ha**

As shown above, based on high level considerations it is feasible to fit all of the operations onto the one site. However a detailed site analysis and traffic modelling, considering both internal and external traffic flows would need to be undertaken. While the MRF could be based at Neerabup, it is helpful to understand that there is potential for it to fit within the reconfigured Balcatta transfer station.

It is likely that the transfer station would be the highest priority within the reconfigured plant. The bulk waste sorting shed is likely to be commissioned within 12 months of the transfer station completion. If the MRF was to be built on this site it should be a higher priority than the bulk waste shed.

As part of the process, consideration would need to be given to possible alternative locations, the preferred ownership arrangements, operating model and procurement methods.

7.4 GREEN WASTE PROCESSING

Hyder has performed a high level assessment of the organics processing requirements under Scenarios 2, 3, 5 and BAU shown in Table 7-33. The processing footprint required depends on whether the option selected is open windrow composting, or aerated/covered composting which requires a smaller footprint. As the sites being considered are all within the metropolitan area an aerated or covered composting system would be preferable to reduce the land required, and reduce odour concerns. The processing footprint does not take into account buffers or other operations on the site, it relates to the area required for pre-processing, composting windrows and screening only.

Table 7-33 Organics processing capacity considerations

Scenario	Source	Tonnage (in 2022)	Processing Footprint	Annual processing cost (capital and operational)
2	Kerbside organics from Stirling and Cambridge, vergeside from rest	31,000	2-5ha	$2 million
5	All Councils (except Stirling) kerbside FOGO with no vergeside, Neerabup processes 70,000 tonnes^.	54,000*	3-8ha	$6 million*
3	All Councils kerbside organics with no vergeside	76,000	4-11ha	$4 million
BAU	Kerbside organics from Stirling and Cambridge. Vergeside from others	31,000	2-5ha	$2million

^Assumes that Neerabup RRF processing only organics would be limited to 70,000 tonnes due to surface area constraints on maturation floor.

*Includes 34,000 tonnes of FOGO additional to what can be processed at Neerabup.

There are four potential site options which are owned by local government and are potentially suitable for a greenwaste processing facility, these include:

- South of Neerabup RRF (MRC)
- Tamala Park (MRC)
- Site opposite Wanneroo's EfW precinct
- Hazelmere (EMRC).

A significant portion of the cost of processing greenwaste is the transport cost, therefore depending on the tonnage being processed, and the available land area it may be preferable to have two sites. Under the preferred scenario 2, a 5ha site would be required to process open windrow organics at a cost of approximately $2 million per year. Table 7-34 compares sites that Hyder has identified as potential locations for greenwaste processing.

Other options may well exist if the provision of services was to be put out for competitive tender.

Table 7-34 Greenwaste processing site options

Site (owner)	Available footprint	Advantages	Disadvantages
South of Neerabup RRF (MRC)	10ha	Land already owned by the MRC, closest residential premises are 800m to south, Neerabup RRF facility already in place which sets precedent, large site allows for greater buffer distances.	Residential encroachment to south, greenfield site, would need further investigation re: planning, approvals and site development

Site (owner)	Available footprint	Advantages	Disadvantages
Tamala Park (MRC)	0.9ha	Land already owned by the MRC, leachate and storm water infrastructure already in place, no buffers required as the operation would sit inside the landfill boundary.	Could only process 18,000t of organics, unless windrows are placed on closed landfill cells with a suitable pad.
Site opposite Wanneroo's EfW precinct (Wanneroo)	TBC	TBC	Greenfield site, would need further investigation re: planning, approvals and site development
Hazelmere (EMRC)	4ha	Close transport for southern members, Planning, approvals and site development already in place for mulching.	Processing MRC greenwaste would require the majority of the site, EMRC may prefer to continue only as a mulching, not a composting operation due to limited buffer distances.

Under the preferred scenario 2 Neerabup is the only site able process all of the MRC's organics in one location. An alternative option is decentralised processing: Tamala Park could process around 18,000 tonnes per year, leaving 13,000 to be processed at a facility such as EMRC's Hazelmere. This could reduce transport costs as the northern Councils would use Tamala Park and the southern Councils Hazelmere.

Hyder has not investigated private sites that could be used for open windrow composting as there are a large number of organisations currently accepting greenwaste in the outer metropolitan and regional areas. An expression of interest could identify such sites. If an EOI was conducted it is recommended that it be modelled on councils dropping the material to centralised drop off locations such as Balcatta, Wangara and Tamala Park, with the contractor offering off-site processing and a collection service from these locations.

7.5 ENERGY FROM WASTE

Based on the modelling, the preferred option is to maintain 2-bin systems (except those already committed to 3-bin) and use the Kwinana EfW site. However, in Hyder's view it is preferable to put the EfW processing option to the market as there are some EfW providers that have progressed with sites and planning processes that are likely to have capacity for the MRC's waste, thereby reducing the overall project risk. There are also providers that are in the process of securing sites (including Neerabup) and approvals that with guaranteed tonnages from the MRC may be able to provide competitive options.

If the MRC were to go to market for EfW, it is timely to do so while there is significant interest in this sector in WA, and there is no single company dominating the market.

A key decision is the amount of secure tonnage that is to be offered to the market – the modelling projections indicate 240,000tpa of waste available in 2020 and 335,000tpa in 2030 (in the preferred Scenario 2). However tendering for the full long-term capacity may leave significant capacity under-utilised at cost in the medium term. In the long-term, it is likely that other waste processing options will be available. The preferred scenario based on the modelling is for a 2-bin collection system, however based on the proposed changes to the Waste and

Resource Recovery Act, the waste hierarchy and policy decisions, it would be prudent to consider that a 3-bin system may be implemented at some point during the life of the project. Therefore it is suggested that the MRC go to market with an EOI but consider:

- The preferred procurement model
- Offer a site within the MRC, but also permit the proponents to use their own site
- Proven gasification or combustion technologies as the preferred processing options
- Determine appropriate guaranteed tonnages based on medium term projections and allowing for the region to switch to a 3 bin collection system
- A requirement for pre-processing waste
- Appropriate allocation of risks to the party best placed to manage those risks, and
- Offer as much certainty as possible within the contract to create a competitive environment for tenderers.

7.6 LANDFILL AND MBT

It is anticipated that Tamala Park will continue to have sufficient capacity until 2024 at current inputs. With a reduction in waste going to landfill, its life should be extended beyond that time. On closure it may be preferable for Tamala Park to be redeveloped into a transfer station suitable for small and large vehicles. Hyder understand there are a number of private operators currently planning landfill developments in semi-rural regions within 1.5 hours of Perth. On that basis the MRC may be able to go to the market to provide future landfill capacity.

At a similar time (around 2029), the Neerabup RRF plant will have reached the end of its 20 year contract period. As part of the Tamala Park closure and redevelopment plan, options for the 100,000tpa of material processed at the Neerabup RRF should be considered.

Investigation of a future landfill facility and transfer station is currently the lowest of the priorities for the region but should be considered once the initial waste infrastructure plans (MRF, EfW and Balcatta) are secured. If the market is unable to offer a suitable solution and the MRC are required to secure a new facility, planning will need to commence in the short term.

8 RECOMMENDATIONS

Hyder has conducted a series of modelling analyses in consultation with the member councils to arrive at the preferred scenario 2C. The modelling is based on a range of assumptions that do not fully account for the political and social considerations of implementing the preferred model. However, the outcomes do provide for a broad direction, taking into account the best interests of the region as a whole. To progress in implementing the infrastructure plan, it is recommended that the MRC and its member councils:

1. Agree on a broad waste infrastructure direction as outlined in the infrastructure plan, and seek endorsement of the plan from their respective councils.
2. Agree to commence discussions regarding the preliminary work required to develop the appropriate business plans and procurement options for each infrastructure project.

Table 8-35 Recommended infrastructure and preferred locations

Processing facility	Capacity required	Preferred location
Landfill	74,000 tpa (existing)	Tamala Park
Mechanical biological treatment	100,000 tpa (existing)	Neerabup
Materials recovery facility	100,000 tpa	Neerabup
Transfer station	300,000 tpa	Balcatta
Green waste processing facility (open windrow)	35,000 tpa	Neerabup
Bulk waste sorting shed	40,000 tpa	Balcatta
Waste to energy facility	250,000 tpa	TBC – market to determine

3. Agree to the actions outlined in this plan when infrastructure solutions are being considered by the MRC or its member councils, which includes bringing any proposed infrastructure solutions which may impact on the region to the attention of both the MRC and the Strategic Working Group.
4. Agree to support the MRC pursuing regular kerbside waste audits to inform the regional waste strategy and monitor progress on system changes.

APPENDIX A

MODELLING ASSUMPTIONS

Table 8-36 Modelling assumptions

Variable	Assumed Value	Units
Waste generation annual growth per capita	1% declining down to zero by 2030	% pa
CPI Rate	2.5%	
Landfill Cost Escalation	3.5%	
Collection parameters		
Bin lift rates	Council Specific	$/lift/hhld
New MGBs (240L)	$45.00	$/bin
Kitchen Caddy	$17.70	$/hhld ($6 caddy + 1 yr of liners $11.70)
Garden organics capture rate	90%	% of all generated GO
Food organics capture rate	60%	% of all generated FO
'Other' organics capture rate	60%	% of all generated other organics
Technology performance characteristics for MCA (Environmental)		
Landfill		
Net electricity exported - garbage	80	kWhr/tonne
	0.288	GJ/tonne
MBT - Aerobic composting, Producing compost only		
% recyclables recovered	5%	of input
Stabilised organic product	28%	of input
Net electricity exported - tunnel composting	-85	kWhr/tonne
	-0.306	GJ/tonne
MBT - Aerobic composting, Producing compost & RDF		
% recyclables recovered	5%	of input
RDF product	30%	of input
Stabilised organic product	25%	of input
Net electricity exported - tunnel composting	-85	kWhr/tonne
	-0.306	GJ/tonne

Variable	Assumed Value	Units
Thermal EfW - Raw MSW		
% metals recovered	3%	of input
Ash recycling to aggregate	5%	of input
Net CV fuel	8	MJ/kg
Net energy conversion efficiency	27%	
Net electricity exported	2.16	GJ/tonne
	600	kWhr/tonne
Thermal EfW - RDF		
% metals recovered	0%	of input
Ash recycling to aggregate	5%	of input
Net CV fuel	12	MJ/kg
Net energy conversion efficiency	27%	
Net electricity exported	3.24	GJ
	900	kWhr/tonne
Existing Facility Type	Gate Fee (ex. Levy $2014)	
Landfill	$92	per tonne
Neerabup MBT	$106*	per tonne
Anaeco MBT	$180	per tonne
Future Facility Type		
Landfill	$80	per tonne
MBT Processing compost only	$180	per tonne
MBT producing compost and RDF	$200	per tonne
Dirty MRF producing RDF	$180	per tonne
EfW processing Raw MSW	$150	per tonne
EfW processing RDF	-	per tonne
Organics Processing		
3 bin system (GO)	$55	per tonne
3 bin system (FOGO)	$150	per tonne
3 bin system (All organics)	$180	per tonne

*Note we understand that this is lower than the gate fee currently being charged at the Neerabup MBT, but given that it has been applied consistently across all the modelling, the relative modelling results are still valid.

APPENDIX B

DETAILED MULTI-CRITERIA ASSESSMENT OUTCOMES

Qualitative Score	Numerical Equivalent
✓✓	5
✓	4
○	3
×	2
××	1

Stage 2 MCA Criteria - 2022 (with transport options)

Criterion		Scenario BAU: BAU based on current practice, with Stirling and Cambridge on 3-bin GO, and existing RRF	Scenario 2: As per BAU, some general waste to Neerabup, remaining MSW+bulk+MRF residuals to EfW			Scenario 3: All councils with 3-bin GO, general waste to Neerabup or landfill			Scenario 5: All councils with 3-bins, Stirling GO only, others for all organics, MSW+bulk+MRF residuals to EfW		
		BAU: Locations based on current proposals	2A: EfW facility at Neerabup (direct delivery)	2B: EfW facility at Red Hill via Balcatta TS	2C: EfW facility at Kwinana via Balcatta TS	3A: All Greenwaste processed at Neerabup	3B: All Greenwaste processed at Hazelmere	3C: Greenwaste processed at either Neerabup or Hazelmere	5A: EfW facility at Neerabup (direct delivery)	5B: EfW facility at Red Hill via Balcatta TS	5C: EfW facility at Kwinana via Balcatta TS
ENVIRONMENTAL											
Waste diverted (tonnes & diversion %)	Tonnage of waste diverted from landfill.	147,000 t 36%	353,000 t 86%	353,000 t 86%	353,000 t 86%	193,000 t 47%	193,000 t 47%	193,000 t 47%	366,000 t 89%	366,000 t 89%	366,000 t 89%
Resources recovered (tonnes)	Recovery of recyclable materials. Includes kerbside-collected household recyclables, sorted recyclables at RRF's. For thermal treatment, there may also be potential to use bottom ash as aggregate for construction activities	63,000	78,000	78,000	78,000	63,000	63,000	63,000	73,000	73,000	73,000
	Recovery of stablised organics / compost product	82,000	82,000	82,000	82,000	129,000	129,000	129,000	119,000	119,000	119,000
Net energy balance (GJ)	A relative assessment of the energy produced such as electricity from biogas or waste combustion and energy consumed, such as mains electricity, gas, liquid fuels. "+" is net energy generated, "-" is net energy consumed.	4,000 GJ	515,000 GJ	515,000 GJ	515,000 GJ	-8,000 GJ	-8,000 GJ	-8,000 GJ	478,000 GJ	478,000 GJ	478,000 GJ
FINANCIAL											
Financial cost ($/hhld/yr)	Region wide cost per household	$444/hhld	$518/hhld	$531/hhld	$533/hhld	$486/hhld	$489/hhld	$487/hhld	$524/hhld	$538/hhld	$540/hhld
SOCIAL											
Odour, visual amenity, and emissions perception	Impacts on the community related to facility siting and technology. Includes the potential for different types of technologies to generate odours and the potential for successful odour control, the typical size and potential intrusiveness and the potential for litter generation, and community perception of the potential for toxic emissions from different processes.	✓	×	○	○	✓	✓	✓	×	○	○
	Impacts on the community related to the collection system	✓	✓	✓	✓	✓	✓	✓	○	○	○
RISK											
Geographic / location	Risks associated with factors such as locational characteristics, zoning, access and current and future uses.	○	×	×	○	○	○	○	×	×	○

APPENDIX C

WASTE INFRASTRUCTURE LOCATIONS MAP

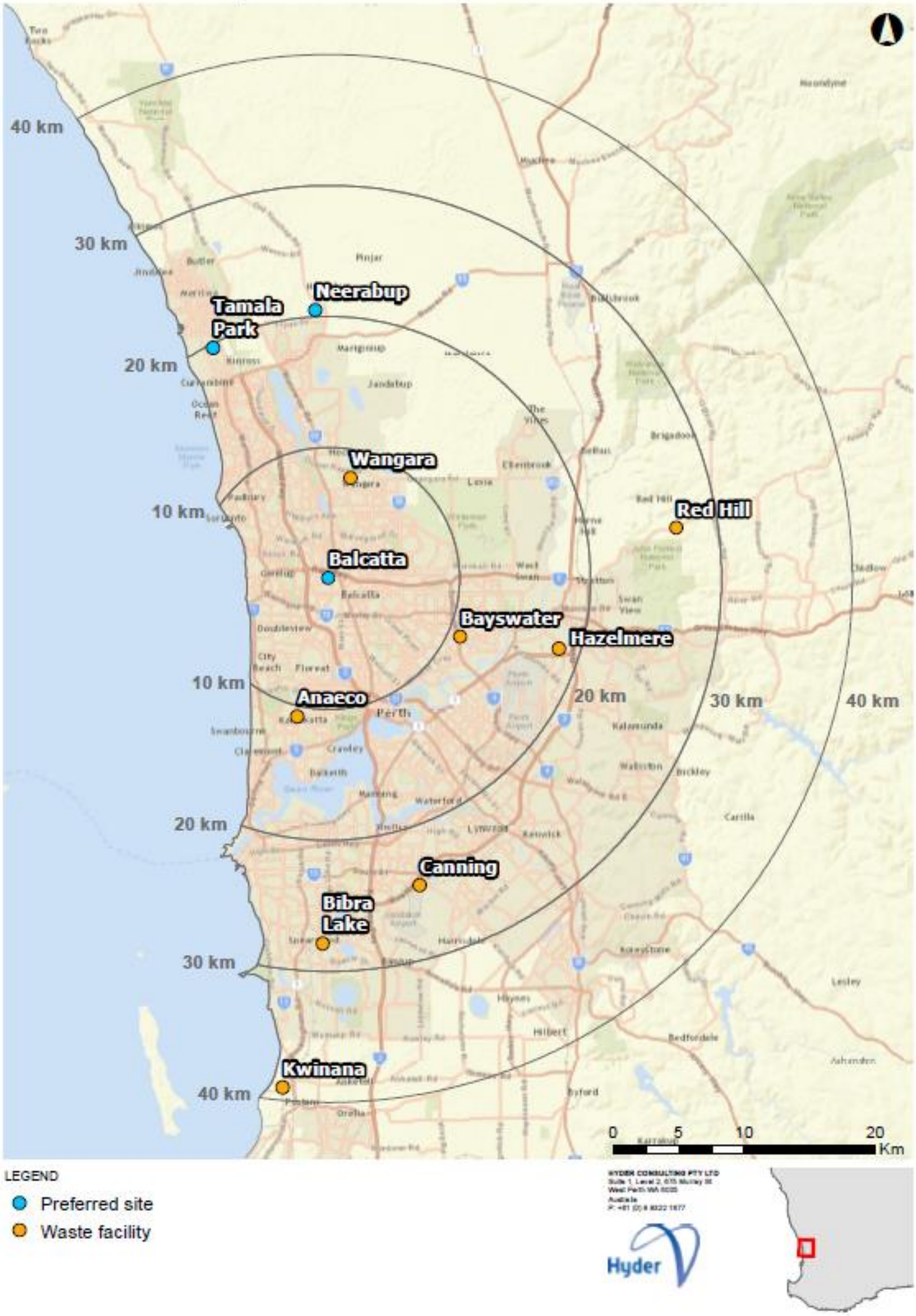


Figure 8-10 Waste infrastructure location map

APPENDIX D

DETAILED TRANSPORT OPTIONS

Table 8-37 Scenario 2a – 2c – detailed transport assumptions

Transport modelling Option 2a

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	Neerabup
Joondalup	Tamala Park	N/A	Balcatta	Neerabup	Neerabup	Neerabup	Neerabup
Perth	Tamala Park	N/A	Balcatta	Bayswater	Neerabup	Neerabup	Neerabup
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	Neerabup
Victoria Park	Tamala Park	N/A	Balcatta	Bayswater	Hazelmere	Neerabup	Neerabup
Vincent	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	Neerabup
Wanneroo	Tamala Park	N/A	Balcatta	Neerabup	Neerabup	Neerabup	Neerabup

Transport modelling Option 2b

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Red Hill
Joondalup	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Red Hill
Perth	Tamala Park	Balcatta	Balcatta	Bayswater	Neerabup	Neerabup	Red Hill
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	Red Hill
Victoria Park	Tamala Park	Balcatta	Balcatta	Bayswater	Hazelmere	Neerabup	Red Hill
Vincent	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Red Hill
Wanneroo	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Red Hill

Transport modelling Option 2c

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Kwinana
Joondalup	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Kwinana
Perth	Tamala Park	Balcatta	Balcatta	Bayswater	Neerabup	Neerabup	Kwinana
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	Kwinana
Victoria Park	Tamala Park	Balcatta	Balcatta	Bayswater	Hazelmere	Neerabup	Kwinana
Vincent	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Kwinana
Wanneroo	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Kwinana

Table 8-38 Scenario 3a- 3c detailed transport assumptions

Transport modelling Option 3a

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	N/A	Balcatta	Bibra Lake	Neerabup	Neerabup	N/A
Joondalup	Tamala Park	N/A	Balcatta	Balcatta	Neerabup	Neerabup	N/A
Perth	Tamala Park	N/A	Balcatta	Bayswater	Neerabup	Neerabup	N/A
Stirling	Tamala Park	Balcatta	Balcatta	Balcatta	Neerabup	Anaeco	N/A
Victoria Park	Tamala Park	N/A	Balcatta	Bayswater	Neerabup	Neerabup	N/A
Vincent	Tamala Park	N/A	Balcatta	Bibra Lake	Neerabup	Neerabup	N/A
Wanneroo	Tamala Park	N/A	Balcatta	Balcatta	Neerabup	Neerabup	N/A

Transport modelling Option 3b

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	N/A
Joondalup	Tamala Park	N/A	Balcatta	Neerabup	Hazelmere	Neerabup	N/A
Perth	Tamala Park	N/A	Balcatta	Bayswater	Hazelmere	Neerabup	N/A
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Hazelmere	Anaeco	N/A
Victoria Park	Tamala Park	N/A	Balcatta	Bayswater	Hazelmere	Neerabup	N/A
Vincent	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	N/A
Wanneroo	Tamala Park	N/A	Balcatta	Neerabup	Hazelmere	Neerabup	N/A

Transport modelling Option 3c

Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	N/A
Joondalup	Tamala Park	N/A	Balcatta	Neerabup	Neerabup	Neerabup	N/A
Perth	Tamala Park	N/A	Balcatta	Bayswater	Neerabup	Neerabup	N/A
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	N/A
Victoria Park	Tamala Park	N/A	Balcatta	Bayswater	Hazelmere	Neerabup	N/A
Vincent	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	N/A
Wanneroo	Tamala Park	N/A	Balcatta	Neerabup	Neerabup	Neerabup	N/A

Table 8-39 Scenario 5a-5c transport assumptions

Transport modelling Option 5a							
Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	Neerabup
Joondalup	Tamala Park	N/A	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup
Perth	Tamala Park	N/A	Balcatta	Bayswater	Neerabup	Neerabup	Neerabup
Stirling	Tamala Park	Balcatta	Balcatta	Balcatta	Neerabup	Anaeco	Neerabup
Victoria Park	Tamala Park	N/A	Balcatta	Bayswater	Hazelmere	Neerabup	Neerabup
Vincent	Tamala Park	N/A	Balcatta	Bibra Lake	Hazelmere	Neerabup	Neerabup
Wanneroo	Tamala Park	N/A	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup
Transport modelling Option 5b							
Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Red Hill
Joondalup	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Red Hill
Perth	Tamala Park	Balcatta	Balcatta	Bayswater	Neerabup	Neerabup	Red Hill
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	Red Hill
Victoria Park	Tamala Park	Balcatta	Balcatta	Bayswater	Hazelmere	Neerabup	Red Hill
Vincent	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Red Hill
Wanneroo	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Red Hill
Transport modelling Option 5c							
Council	Landfill	Transfer Stations	Bulk Waste Sorting and Reuse Shed	Materials Recovery Facility	Green Waste Processing	Mechanical Biological Treatment	Waste to Energy Facility
Cambridge	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Kwinana
Joondalup	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Kwinana
Perth	Tamala Park	Balcatta	Balcatta	Bayswater	Neerabup	Neerabup	Kwinana
Stirling	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Anaeco	Kwinana
Victoria Park	Tamala Park	Balcatta	Balcatta	Bayswater	Hazelmere	Neerabup	Kwinana
Vincent	Tamala Park	Balcatta	Balcatta	Bibra Lake	Hazelmere	Neerabup	Kwinana
Wanneroo	Tamala Park	Balcatta	Balcatta	Neerabup	Neerabup	Neerabup	Kwinana