MARKET DEVELOPMENT STUDY USED GLASS

For

WESTERN AUSTRALIA

WASTE MANAGEMENT BOARD

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DEFINITIONS

**Beneficiation**: The process used to clean used glass to a known specification for reuse into bottles.

**Commingled Collection** *: Pick-up and transportation of mixed dry recyclable materials.

**Contaminant** *: Undesirable substance or object in contact or mixed with a material.

**Cullet**: Used glass recovered from the recycling process

**Flint**: Clear glass

**Gm**: Unit of measure – grams of weight

**Glass fines**: Broken glass less than 60 mm in diameter

**Light-weighting**: Using less material to make the same container

**Materials Recovery Facility**: A plant that uses a combination of manual and mechanised equipment to separate recyclables into product type and glass by colour.

**Recyclable** *: Able to be recovered, processed and used as a feedstock, replacement for raw material for the manufacture of useful new products through a commercial process.

**Segregation**: Keeping the components of assorted waste streams separated.

**Source Separation** *: Physical sorting of the waste stream into its components at the point of generation.


ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>ACG</td>
<td>Aluminium Can Group</td>
</tr>
<tr>
<td>AGT</td>
<td>Australian Glass Technologies</td>
</tr>
<tr>
<td>AWT</td>
<td>Alternate Waste Technologies</td>
</tr>
<tr>
<td>CCA</td>
<td>Coca Cola Amatil</td>
</tr>
<tr>
<td>CWC</td>
<td>Clean Washington Centre, USA</td>
</tr>
<tr>
<td>DEC</td>
<td>Department of Environment and Conservation</td>
</tr>
<tr>
<td>DoE</td>
<td>Department of Conservation</td>
</tr>
<tr>
<td>MGB</td>
<td>Mobile Garbage Bin</td>
</tr>
<tr>
<td>MRF</td>
<td>Materials Recovery Facility</td>
</tr>
<tr>
<td>NPC</td>
<td>National Packaging Covenant</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>OI</td>
<td>Owens Illinois</td>
</tr>
<tr>
<td>PAS</td>
<td>Purchase Acceptance Standard</td>
</tr>
<tr>
<td>RRRS</td>
<td>Resource Recovery Rebate Scheme</td>
</tr>
<tr>
<td>RTA</td>
<td>Roads and Traffic Authority</td>
</tr>
<tr>
<td>SMRC</td>
<td>Southern Metropolitan Regional Council</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WMB</td>
<td>Waste Management Board</td>
</tr>
<tr>
<td>WRAP</td>
<td>Waste Resources Action Programme – United Kingdom</td>
</tr>
<tr>
<td>ZWSA</td>
<td>Zero Waste South Australia</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

Owens Illinois (OI), formerly known as ACI Glass Containers, is the world’s largest producer of bottles and is responsible for manufacturing more than 90% of Australia’s domestic glass bottles. OI closed its Perth-based manufacturing facility in 2003 after over 50 years of operation, due to increasing commercial pressure from international imports, and relocated all production to South Australia. This decision, whilst made on economic grounds, has led to the current dilemma regarding what to do with the glass sold and recovered in Western Australia (WA), given the lack of local alternative markets. With high interstate transport costs, the movement of materials interstate can only be seen as an interim measure.

Nationally, Australia is currently recovering 35% or 278,000 tonnes of used glass containers. It is estimated, based on national sales, that WA generates between 80,000–90,000 tonnes per year of container glass and is currently recovering for recycling approximately 20,000 tonnes, or 23%. In order to meet the National Packaging Covenant target for glass recovery of between 50–60% by the year 2010 additional 125,000 tonnes per annum are required.

For glass to remain competitive in its traditional markets against other packaging forms, that is, plastics and aluminium, manufacturers undertook research and development into the light-weighting of containers – today a beer stubby is 27% lighter than the same bottle 20 years ago.

However, while manufacturers were reducing their costs, so were local governments on behalf of their constituents. Due to occupational health and safety concerns and increasing costs, councils have almost universally introduced the co-collection or commingling of recyclables in mobile garbage bins, typically collected on a fortnightly basis, using highly automated collection vehicles. These recyclables are then delivered to a Materials Recovery Facility (MRF) where they are separated by product type, that is, paper, plastics and glass, using a range of mechanical and manual processes.

The NSW Glass Compaction Study found that a minimum of 19.4% of glass containers in a commingled collection will be broken during the collection cycle at a compaction setting of 120 kg/m³. Further breakages also occur during the sorting phase at a MRF. A recent Used Glass Study in Queensland has identified that between 22–70% of the product placed in the bin by the householder will not meet the buyer’s specification for reuse in the manufacture of new bottles. This specification requires the glass to be > 60 mm in size.

Prior to the 2003 plant closure, OI paid $72 per tonne in Perth for colour-sorted glass, with additional transport subsidies paid for regional, rural and remote locations to offset some of the freight costs associated with moving the material to the metropolitan area. After the manufacturing plant closed in Perth, the local price dropped to $40 per tonne to offset the added cost to transport the material interstate by rail, estimated to cost OI approximately $80 per tonne.

At the same time as implementing the price decrease, the company also introduced and enforced its new national glass acceptance specification, which specifies a maximum of 25 gm per tonne of any specified contaminants, with a minimum glass particle size of
60 mm. As a result, an increasing amount of glass now fails to meet the size specification and all undersize glass, termed “glass fines”, continues to be landfilled.

In 2005 the Department of Environment engaged consultants GHD to undertake an analysis of the current cullet supply chain, identify the current status, issues, threats and opportunities for post-consumer glass in WA and identify strategic issues for future glass recovery and management. The report, titled Glass Recycling Review Assessment, states that the most significant restriction for continued and exponential growth of used glass collected in WA is the lack of a local market.

The Waste Management Board engaged APC Environmental Management to investigate and report on any potential markets for used glass in WA, and assess their long-term commercial viability.

As part of the research undertaken in preparing this report, an extensive literature review and detailed consultation with key stakeholders were undertaken, intrastate, interstate and internationally. Forums were facilitated with representatives of local and regional councils, commercial collectors and MRF operators. Any resultant change in price paid or product specification will impact on these groups most, as service-providers or processors of the collected materials.

A significant amount of research, market analysis, research, trials and commercialisation of technologies has been completed by a small number of specialist organisations locally, nationally and internationally. The research has identified that viable alternatives for the reuse of glass do exist in some situations.

It is apparent that nearly all of the market development studies and programs that have been completed, both within Australia and internationally, have been principally driven by Government and their associated agencies. Therefore, most of the available reports focus on the expected applications and projected benefits, rather than real commercial outcomes and quantification.

Processed glass can be successfully used as a substitute for virgin raw materials in the manufacture of abrasives, concrete, bricks and water filtration. However, the most significant limiting factor is in achieving the economic balance between processing and substituting glass for virgin raw materials that are typically of low value and in abundant supply. One of the typical properties of a product for which we are looking to substitute glass is a core structure of silica or sand, inferring immediately that most alternatives are likely to be sand-based applications or silica replacements.

In the case of WA, some of the sands are widely recognised as being among the purest silica-based, and lowest in iron content found anywhere in the world. Therefore, reusing glass as a possible alternative to cheap high-grade sand or silica applications provides its own challenges.

A number of opportunities have been identified and quantified, together with a range of pertinent commercial aspects that could detract from or hinder market development of the identified opportunities. Irrespective of the opportunity, all alternatives will require some beneficiation of the glass before it can be reused.
While initial markets will be focused on the high-value applications, these can only displace low quantities of product, whereas low-value applications consume large quantities of product. Higher value end-markets will require market development for acceptance and customer confidence to be developed over time. This will also occur through trials and use of the reused glass. The local market opportunities identified include:

**Immediate opportunities**
- Continued glass bottle production (OI)
- Asphalt (Pioneer Road Services)
- Abrasive market (Total Corrosion Control)
- Concrete and road base (Government Contractors)
- Non-engineered construction applications (Government Contractors)

**Longer term solutions**
- Brick fluxing and additives (Midland and Austral Brick)
- Block-making moulds (Glass Block Technologies)
- Water filtration opportunities

A number of local companies and industry sectors were identified as primary opportunities for developing a local market, and all expressed either an immediate desire to use glass or a willingness to consider or trial its use.

Glass, provided it is free of contaminants, particularly paper, metals, plastics and organic residues, has a major application in replacing virgin aggregates in non-structural, low-grade construction markets.

The asphalt sector was identified as an immediate opportunity, whereby between 5,000–10,000 tonnes of glass could displace crusher or quarry dust or sand aggregates. However, the economics may limit this opportunity, as, while raw material market pricing fluctuates in direct proportion to the demands of the construction industry generally, quarry dust is often free at the quarry gate and sand is typically about $3.00 per tonne at the quarry. Depending on transport distance, local transport costs are typically between $4.50 – $9.00 per tonne. This results in total costs of about $4.50–$12.00 per tonne delivered for product.

The abrasives sector is one of the most promising markets; the current purchase cost for the abrasive garnet material used in this sector is estimated to be between $150 and $200 per tonne. However, under the current Worksafe Regulations, Code of Practice, Abrasive Blasting products containing crystalline silica dioxide or a recycled material that has not been treated to remove respirable dust are excluded. This regulation does not apply in other States where glass is used and would need to be revoked prior to any investment, given this market’s pivotal status.

Other opportunities include as road-base and backfill, however, the glass must be crushed to a nominal size and cleaned of contaminants. The aggregates and sands that glass must displace are cubic in shape, so they fill voids and bind more effectively, while glass is flat and must be processed into a cubic or spherical form to gain the technical and engineering benefits.
If glass is crushed and made more cubic in shape, the market opportunities in this sector are significant in non-engineered and non-structural applications within the construction sector. A paramount barrier to this opportunity is that virgin aggregate is available between $3.00 per tonne or $7.50–$12.00 per tonne delivered, and it would be questionable whether, after processing used glass, it can compete in the market-place. Market pull is required by requiring procurement managers and engineers from local and state government departments and agencies to modify specifications to incorporate the use of recycled glass in suitable applications.

Significant work on the use of glass in the brick industry has already been undertaken, and Midland Brick has expressed a willingness to develop this alternative market. Whilst trials in the eastern states have been highly successful, the base clay material available in the west is fundamentally different and trials to date have shown that a 5% addition of used glass has darkened the brick colour.

It has been identified that a gate fee rather than an income stream is likely to be applied to process glass fines, while a small revenue stream of up to $10 per tonne may be possible for cleaner glass product. Therefore, a critical issue to be addressed is security of supply, as the key competition to reprocessing will be cheap landfill.

The level of processing to remove contamination, including pyro-ceramics for some applications, adds cost to the process and reduces any plant’s viability. The community must continue to be educated and made aware that items such as microwave plates, glass cookware and glassware are not recyclable and should not be placed in the recycling container for collection. Educational messages promoting “bottles only” rather than glass recycling may assist the community to differentiate between these items.

If the quantity of glass fines is added into the equation, we are seeking a market that can cope in the short term with potentially between 25,000 to 30,000 tonnes per annum. With a continued drive for diversion and recovery to reach the NPC target of 55% for all glass containers, alternate markets must have a capacity to consume a minimum of 55,000 tonnes per annum.

From our evaluation of the Western Australian market and the identified alternatives available for the reuse of glass, a more fundamental issue needs to be addressed in developing the solution for the state. This issue is how we might transition from a situation in which collectors and processors have received value for the material to a situation whereby, regardless of the use, any alternate application will require the material to have a substantially lesser or negative value to the collector and processor if it is to compete against low-value high-quality raw materials.

The cost to process used glass is totally dependent on and directly impacted upon by many local market factors, including the market value of competitive products, landfill disposal costs and transport logistics.
## Alternate Used Glass Applications Compared with Primary Material Types

<table>
<thead>
<tr>
<th>Application</th>
<th>Process type</th>
<th>Competitor Material</th>
<th>Price $ Tonne (Virgin)</th>
<th>Recycled Glass Cost</th>
<th>Likely Market Size Tonnes</th>
<th>Identified Local End-user</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass cullet</td>
<td>Beneficiation</td>
<td>Sand, Soda, Lime</td>
<td>$91</td>
<td>+ $125</td>
<td>40,000</td>
<td>OI</td>
<td>OI compares recycled batch cost to virgin batch price.</td>
</tr>
<tr>
<td>Asphalt plants</td>
<td>Crushing / Mixing</td>
<td>sand and aggregates</td>
<td>5–12</td>
<td>+ $33</td>
<td>&gt; 5,000</td>
<td>Pioneer Road Surfaces</td>
<td>Will use as much as it can get, provided the cost is comparable to virgin.</td>
</tr>
<tr>
<td>Abrasives</td>
<td>Crushing and pulverising</td>
<td>Garnet and slags</td>
<td>$110–$135 tonne (Distributors retail for $168–$210/T)</td>
<td>$120–150</td>
<td>&gt; 5,000</td>
<td>Total Corrosion Control and others</td>
<td>The market can be developed, but initially it will compete with locally produced cheap garnets. Market size significant and accessible now.</td>
</tr>
<tr>
<td>Construction areas</td>
<td>Crushing</td>
<td>Aggregates</td>
<td>$ 2-8</td>
<td>+ $33</td>
<td>Unlimited</td>
<td>Road base, paths drainage</td>
<td>Can use all glass collected but cost of clean-up and shaping pushes the cost up.</td>
</tr>
<tr>
<td>Cement Applications</td>
<td>Residual</td>
<td>Fly Ash</td>
<td>$ 5</td>
<td>+ $68</td>
<td>50,000 +</td>
<td>Blue Circle</td>
<td>Glass needs to be ground to a powder, and against fly ash this is prohibitive in cost.</td>
</tr>
<tr>
<td>Concrete</td>
<td>Crushing and Batching</td>
<td>Aggregates</td>
<td>$ 2-8</td>
<td>+ $33</td>
<td>Unlimited</td>
<td>All concrete batching plants</td>
<td>Glass needs to be shaped, but the use in concrete applications is substantial if the cost barrier can be overcome.</td>
</tr>
<tr>
<td>Brick-making and Fluxing</td>
<td>Grinding and Pulverising</td>
<td>Diorite dust Quarry dust, slag</td>
<td>$ 2-8</td>
<td>+ $38</td>
<td>28,000 +</td>
<td>Austral and Midland Brick</td>
<td>Need to overcome technical issues, whereby the use of glass changes brick colours in the kiln process.</td>
</tr>
<tr>
<td>Clay pavers/roof tiles</td>
<td>Grinding and Pulverising</td>
<td>Fluxing agents</td>
<td>Unknown</td>
<td>+ $38</td>
<td>5,000 +</td>
<td>Austral and Midland Brick</td>
<td>Need to overcome technical issues of tiles sticking together in kilns.</td>
</tr>
<tr>
<td>Water filtration systems</td>
<td>Grinding and Pulverising</td>
<td>Processed sand</td>
<td>Estimated at $80 -120</td>
<td>Cost of using glass is estimated at about the same, possibly higher.</td>
<td>20,000 T 3,000 T over 5 yrs</td>
<td>Water/ sewerage treatment plants, pulp and paper plants swimming pool filter replacement</td>
<td>Significant market end-use but will need to be developed locally. This application is growing rapidly due to recent health issues surrounding the use of sand and the fact it’s been proven now to hold and distribute bacteria whereas glass doesn’t.</td>
</tr>
<tr>
<td>Block-making Systems</td>
<td>Grinding and Pulverising</td>
<td>Fine aggregates</td>
<td>&lt;10</td>
<td>+ $33</td>
<td>Not known</td>
<td>Glass Block Technology</td>
<td>Unlikely major user, market will need to be developed.</td>
</tr>
</tbody>
</table>

* The sales price estimated assumes a gate fee of $12.00 per tonne has been paid to the processor to take the material (not shown in this price) and allows for an estimated production cost only and marginal profit. Real pricing will vary, depending on the commercial arrangements in place and competitive nature of other materials protecting their market dominance.
It is estimated that for glass fines to be processed for value-adding into other products, a gate fee of at least $15.00 per tonne must be applied to accept the product from a collector, with an anticipated 20% residual to landfill rather than the current 100%. In contrast, glass > 60 mm, and largely free of contaminants, may have a value of $10.00 per tonne, compared to the current price paid by OI of $40.00 per tonne for the same.

MRF operators would need to change their current operations to offset this cost structure change. However, our analysis shows that MRF operators are currently losing on glass processing and that with markets for both fines and larger product, the financial situation may actually improve. It is suggested that a cost model be developed and assistance offered to councils, their contractors and MRF operators to assess the real financial impact of changing from a positive colour sort (current system) to a negative sort removing contamination only (future system) with an outlet for all unsorted glass greater than 60 mm and glass fines.

Regional and rural communities will need to address the use of glass locally where possible, and government should assist with the transfer of knowledge and skills to councils and interested parties in these regional and rural areas. Where local reuse is not achievable, the provision of transport subsidies to offset the cost of moving glass to the metropolitan area for processing could be considered.

Significant immediate and long-term opportunities have been identified within this report that have the capacity of consuming all of WA’s used container glass. Whilst these markets have been identified as being substantial, it will take time to position the product against its competitors. This challenge should not be underestimated.

We can confirm that business opportunities do exist in WA for an entrepreneur, however, a lead time of between 18 months to three years will be required to fully establish a viable presence in the state, with a minimum processing capacity of 7,000 tonnes per annum and an substantial initial capital investment of greater then $500,000 excluding land and buildings.

Government assistance in the form of grants or direct funding for the purchase or lease of land, buildings, plant and equipment, the conducting of feasibility studies, trials to demonstrate alternate local uses, publication and promotion of results to assist in market development and market acceptance are some key areas for which the government can provide support.

The report identifies actions and makes specific recommendations that could be undertaken by the Waste Management Board (WMB) to assist in the establishment of short-, medium- and long-term viable markets for used glass in WA. It is strongly suggested that the WMB continues to take a leadership position on this critical issue and facilitates a dialogue with all parties in an open and transparent manner.
The following are recommendations from this study:

1. That a broad, common-themed community educational recycling awareness program be developed and implemented State-wide immediately, communicating the key message of “bottle and jar recycling”. The program must identify that household cookware, glassware and light globes are non-recyclable.

2. The WMB should enter into discussions with the appropriate staff at the Department of Consumer Protection in relation to the exclusion of “products made from used container glass” in the Worksafe Regulations, Code of Practice, Abrasive Blasting. This prohibition is not present in other state legislation where used glass is part of these applications. Its presence will severely impact on the future business viability as it removes a vital high-value market for processed used container glass.

3. That the WMB hold a forum for procurement managers and engineers from local and state government departments and agencies to showcase the available research and applicability of using glass as a substitute for virgin excavated materials. Each department or agency is then to be set a time-frame within which it is to modify specifications to incorporate the use of recycled glass in suitable applications.

4. That the WMB hold a forum for the concrete and cement industries together with procurement managers and engineers from local and state government departments and agencies, to showcase the available research and applicability of using glass as a component in concrete and cement. Each department or agency is then to be set a time-frame within which it is required to modify specifications to incorporate the use of recycled glass in suitable applications.

5. That the state government issue an “Expression of Interest” nationally and internationally, seeking interest from potential operators to set up a reprocessing operation in the state to process used glass and to identify the terms, conditions and support required to make such an investment decision.

6. That the state government consider what support it may be able to offer in the form of grants, direct or indirect funding for the purchase or lease of land, buildings, plant and equipment, the conduct of feasibility studies, trials to demonstrate alternate local uses, publication and promotion of results to assist in market development and market acceptance.

7. That a cost model be developed and made available to all commercial, council collection contractors and council officers to enable each operator to assess what the likely financial impact of changing from the current revenue stream to an alternate approach will have on the organisation.

8. In collaboration with the commercial collectors the Government and collectors determine if there is a method of recovering glass from sectors not serviced with kerbside collections and what if any support or mechanisms are necessary to support this service provision.
9. Regional and rural communities will need to address the use of glass locally where possible. Government should provide support and skills to transfer knowledge to councils and interested parties in these regional and rural areas.

10. Where local reuse in regional and rural areas is not achievable, consideration should be given to providing transport subsidies to offset the cost of moving glass to the metropolitan area for processing as costs may become prohibitive relative to the revenue stream which will be generated.

11. The WMB should seek to conduct a forum to disseminate information contained in the GHD Glass Recycling Review Assessment Report 2005 and this study to participants. It is suggested that such a forum should specifically involve O-I, fillers and users of glass packaging, commercial and council collectors, recycling contractors, MRF operators, local, regional and state government stakeholders and potential end-users identified in this report.

12. It is strongly suggested that the WMB continues to take the leadership position on this critical issue and facilitates a dialogue with all parties in an open and transparent manner.
1.0 INTRODUCTION

Glass recycling in Queensland and across Australia faces many challenges.

Continuing moves to lightweight glass packaging by industry in an effort to contain escalating production costs as well as to remain competitive against overseas imports have been at odds with the evolution and automation of the kerbside collection systems. Fortnightly collections of mobile garbage bins for commingled product delivered to Materials Recovery Facilities (MRFs) for sorting are now the principal method of recovering used glass containers nationally.

The strengthened National Packaging Covenant, endorsed by the Environmental Protection and Heritage Council (EPhC) on 1 July 2005, includes a national recycling rate of 65% for used packaging.

The availability of viable long-term markets for used glass collected through kerbside and commercial collection systems has been identified as a priority issue for the Western Australian Government given the recent closure of the only glass container manufacturing facility in Western Australia (WA).

Market development opportunities for recovered glass and glass fines and the products produced will also need to be addressed if the desired targets for glass recycling are to be achieved.

APC Environmental Management was appointed to investigate any potential markets for used glass in Western Australia and to assess their long-term commercial viability.

This report seeks to:

- Identify current and potential market opportunities for used glass
- Identify possible threats to such opportunities through market competition
- Quantify the estimated market size of each identified potential market
- Undertake an economic assessment of the viability of each potential market identified
- Identify and detail likely future trends
- Identify and discuss regional variation and opportunities.

As part of the research conducted in preparing this report, extensive stakeholder consultation was undertaken. This process identified pertinent commercial aspects that would detract from or hinder market development of the identified opportunities.

The report identifies actions and makes specific recommendations that could be undertaken by the Waste Management Board (WMB) to assist in the establishment of short-, medium- and long-term viable markets for used glass in Western Australia (WA).
2. GLASS PRODUCTION AND CONSUMPTION

From our earliest origins, man has been making use of glass. Historians have discovered that obsidian – natural glass made within the mouth of a volcano when the intense heat of an eruption melts sand – was first used by man as tips for spears.

The oldest examples of glass were in the form of Egyptian beads, dating from 12,000 BC. It was not until 1,500 BC that the first hollow glass container was made by covering a sand core with a layer of molten glass.

Glass-blowing became the most common way to make glass containers from the First Century BC. However, the glass made during this time was highly coloured, due to the impurities of the raw material. It was not until the First Century AD that colourless glass was produced and then coloured by the addition of colouring materials.

The skills and technology required to make glass were closely guarded by the Romans, and it was not until the Roman Empire disintegrated that skills for glass-making spread throughout Europe and the Middle East.

The modern glass industry really started to develop in Britain after 1887, when the first machine capable of producing 200 bottles per hour was developed. Less than twenty years later, in 1903, the first fully automated machine capable of making 2,500 bottles per hour was developed in America, by Michael Owens from major glass manufacturers Owens of Illinois.

Owens Illinois (OI), formerly known as ACI Glass Packaging, is the world’s largest producer of bottles¹ and is responsible for manufacturing more than 90% of Australia’s domestic glass containers. The remaining 10% of the market is shared by AMCOR and imports, either from Asia, Europe or Saudi Arabia.

AMCOR’s one production facility, located in South Australia, solely manufactures wine bottles, of which 20% is consumed by the local market and the remainder exported.

OI operates glass production plants in South Australia, Victoria, New South Wales and Queensland, where it buys and uses cullet in its production cycle. While plants are capable of making millions of glass containers a day, the sector operates in a fiercely competitive global market in which quality, design and service levels are critical to maintaining market share. OI closed its Perth-based manufacturing facility in 2003 after over 50 years of operation, due to increasing commercial pressure from Asian and international imports.

Few of us can imagine modern life without glass. It features in almost every aspect of our lives. Glass packaging is used for many products, wines, spirits, beers, medicines, cosmetics and a wide range of foodstuffs.

¹ OI web site http://www.o-i.com/, 2006.
2.2 The Glass Manufacturing Process

Glass is composed of three commonly found raw materials:

1. Sand – provides silica as the base material
2. Soda Ash – used to reduce the melting point
3. Limestone – to increase the hardness.

Depending on the final application, that is, bottles/jars, windows/doors or drinking wares, a multitude of minor minerals are added to the batch to produce a specific product, including elements to create colour, for example, nickel for green glass or iron for brown or amber products.

To produce glass containers, a “batch” is created which comprises a mix of raw or virgin materials as outlined above and “cullet”, which consists of used glass containers recovered for recycling and collected typically through council or commercial collection programs.

The collected used glass is typically colour-sorted at a Materials Recovery Facility (MRF) where collected mixed or commingled recyclables from kerbside or commercial programs.

The colour-sorted glass is then delivered to a “beneficiation” plant which is essentially the cleaning and removal process of contaminants – caps, corks, lids, labels, stones, rocks and dirt, and prepares the recycled glass according to quality, colour and size for remelting at a glass-making facility.

Once delivered to a beneficiating operation, the glass is typically stored in loading bays according to its colour, until it is ready for processing. Once loaded into a hopper, it passes over a series of screens and, dependent on the size, is then conveyed to a visual inspection point.

Operators visually check as the glass passes through on conveyors, and they remove any obvious foreign materials such as ceramics, stones, and plastic. It is at this point that large pieces of pyrex or pyro-ceramics, if detected, are removed. Pyro-ceramics, which include ceramics, porcelain – china cups & plates – and Pyrex (ovenware, as well as Corning-ware cookware), are extremely difficult to identify and remove, as pyro-ceramics are usually of the same density and clarity as glass, are largely undetectable and must be removed manually.
Beneficiating plants typically use steel rollers to crush the glass into smaller pieces of between 10 and 50 mm, and after crushing the glass, it is then carried to vibrating “bar screens” or similar technology that remove paper, wine corks and other larger items of waste. During the screening process the glass passes under strong vacuum ducts, where paper from bottle labels, small pieces of plastics and other items can be lifted off.

Vibrating screens are typically used and have mesh bases. The mesh is about 12–19 mm square; small items of stone and ceramic pass through the mesh and into a waste chute.

Metal caps and lids are removed by either magnets for steel or eddy currents for aluminium. These are stored for recycling. The glass continues through the plant, again going over a series of electronic sensor eyes until all contaminants are removed, and the product meets the final Purchase Acceptance Standard (PAS) for the remelting facility to which it delivers.

A final visual check is often made before the process is finished.

Processed glass cullet drops off the end of the conveyor system into loading bays, from where it is then transferred to bunkers to await transportation to the glass manufacturing facility it is supplying.

The recycled glass classified as “cullet” is now furnace-ready and is added to the batch mix in set proportions to the virgin materials.
The actual process of making glass is described in the following steps.

**Step 1: Glass Melting.** The batch containing cullet, sand, soda ash, limestone and other raw materials is fed into gas-fired furnaces (all materials together) at an average temperature of 1,500 degrees Celsius.

**Step 2: Container Forming.** The molten glass is conveyed in a continuous feed to moulding machines, which then “cut” the molten glass into “gobs” or globules that drop into moulds of various shape and sizes. Air is blown into these inverted moulds and the hot globules of molten glass form the container shape, depending on the size and style of bottle or jar being produced. The moulds are then inverted so the base is in contact with a surface, and the new containers are released from the moulds. Formed glass containers leave the machine, crossing a cooling plate where they are cooled rapidly from liquid state to a solid form.

**Step 3: Container Conditioning.** The formed containers are loaded into an Annealing Lehr, where their temperature is brought back up close to the melting point, then reduced, as this reheating and slow cooling eliminates the stress in the containers, making them stronger and shock-resistant. The temperature of the containers is further reduced and an exterior coating is applied to the bottles to increase line mobility, reduce abrasions and to maintain the inherent strength of the container.

**Step 4: Automatic Inspection.** The manufactured containers then pass through a series of quality control inspection points where instruments and trained personnel physically and optically test the quality of the containers. Rejected containers are recycled back as cullet into the furnace.

**Step 5: Product Handling and Packaging.** New containers are placed on pallets, and stacked in layers between 5 to 15 containers high, strapped for stability, palletised with plastic wrap and despatched to the customers for filling.²

Fillers set performance standards on manufacturers; these standards can be as high as one failure per 1,000,000 bottles on a filling line. To meet these expectations, quality standards or specifications for the recycled material must be enforced. All cullet must comply with the OI buyers specification and must compete in comparative terms with virgin batch materials on price to be economic. Cullet, can be reused indefinitely. The key contaminant in cullet is pyro-ceramics and the allowable tolerances for this material are extremely low. The allowable maximum is set at 25 grams per tonne but is under review. Anything higher can inhibit the remanufacturing process.

² Source: http://www.o-i.com/about/corporate/glassmfg.asp.
There is a strong business case for recycling glass, as every batch requires a minimum of 20% cullet for production efficiencies, but the process can accommodate as much as 45%. Recycled glass provides the following key advantages:

- **Energy Savings** – cullet requires a lower firing temperature and re-melts at a lower temperature than virgin material. The energy savings associated with cullet use vary, depending on the efficiency of the furnace, its age, the amount of glass being produced, the proportion and type of cullet in a single batch. Glass with 100% cullet will use 20–35% less energy than glass made wholly from raw materials.3

- **Extends Furnace Life** – the lower firing temperature prolongs the furnace life by up to two years, lowers the maintenance and operational costs and improves furnace efficiency. The estimated cost of a new furnace is some $15 million.4

- **Emission Reductions** – using cullet lowers the emissions from the furnaces and reduces greenhouse impacts.

Resource conservation is an added benefit, but not the primary driver for using cullet in production. However for every tonne of cullet used, 1.1 tonnes of raw materials are conserved.5

### 2.2 Australian Glass Production

The Australian Bureau of Statistics (ABS) Report titled *Manufacturing Production and Commodities Produced* sets out production values and provides the most currently available data on manufacturing outputs for glass production for the period 1995–98. Reporting of production statistics to the ABS stopped in mid-1998, and no additional published information is available for reference beyond this date.

It is our understanding that production reporting ceased due to “commercial in confidence” implications. There are only two glass bottle manufacturers in Australia, AMCOR and Owens Illinois (OI) and only one float glass manufacturer producing sheet and window glass, Pilkington. Glass imports are also not publicly reported.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Float Glass and polished Glass</td>
<td>784.3</td>
<td>682.7</td>
<td>737.6</td>
</tr>
<tr>
<td>Container Glass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decorative Glass</td>
<td>47.8</td>
<td>26.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Motor Vehicle Glass</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Safety Glass, Doors etc</td>
<td>226.9</td>
<td>268.5</td>
<td>238.8</td>
</tr>
<tr>
<td>Other</td>
<td>60.5</td>
<td>52.7</td>
<td>32.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1065.5</td>
<td>1030.4</td>
<td>1011.9</td>
</tr>
</tbody>
</table>


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4 Pers com OI, June 06.
Owens Illinois (OI), formerly known as ACI Glass Containers, is the world’s largest producer of bottles and is responsible for manufacturing more than 90% of Australia’s domestic glass bottles. The remaining 10% of the market is shared by AMCOR and imports, either from Asia, Europe or Saudi Arabia.

AMCOR’s one production facility, located in South Australia, solely manufactures wine bottles, of which 20% is consumed by the local market and the remainder exported.

OI operates glass production plants in South Australia, Victoria, New South Wales and Queensland, where it buys and uses cullet in its production cycle. OI closed its Perth-based manufacturing facility in 2003 after over 50 years of operation, due to increasing commercial pressure from Asian and international imports, and relocated all production to South Australia. This decision, whilst made on economic grounds, has led to the current dilemma within the state as to what to do with the glass sold and recovered, given the lack of available markets and the high transport costs of moving glass interstate.

### 2.3 Western Australian Container Glass Consumption

Stakeholders interviewed in the process of preparing this report agreed that state-based glass sales statistics and the correlation with actual recovery of used glass containers was very difficult to accurately determine, due to a significant number of factors.

The process of production and filling of glass products is only a very small element in understanding the sales chain of a product, to which a complicated distribution, consumption and recovery process must be added.

The flow chart below outlines the typical supply chain as it applies to container glass.

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A fundamental lack of real information from a local perspective causes concern in respect of the ability to accurately predict and obtain local tonnages available for recovery. We have attempted to identify local quantities based on nationally available information, inclusive of publicly available reports as well as through detailed discussions with numerous stakeholders, in an effort to produce reliable per capita consumption figures for WA.

It is important to quantify the state’s current and potential availability of tonnages consumed versus recovery, to ensure that, from a market development point of view for product reuse, the base tonnage available can in fact support new or developing alternate uses for the product. It is essential that supply can meet the expected demand and that demand can consume the available supply.

2.2.1 Australian Production

Australia’s total production of glass containers by AMCOR Packaging and OI is estimated to be about 1 million tonnes, inclusive of both domestic sales and exports. AMCOR produces only wine bottles, whilst OI produces bottles, jars and a limited number of other containers. AMCOR claims a production capacity of approximately 200,000 tonnes but exports more than 80%. OI produces the balance of Australia’s production, currently estimated to be about 800,000 tonnes. On the basis of interviews with both manufacturers it is estimated that the local domestic production of glass is assumed to be 800,000 tonnes. Exports therefore account for approximately 200,000 tonnes.

2.2.2 Beer Sales

OI is the only manufacturer of beer bottles in Australia. According to AC Nielsen Statistics, in 2004–2005 more than 1,720 million litres of beer were produced for consumption in Australia. Fillers advised that the traditional 750 ml units are now insignificant, as most beer is packaged in 375 ml units. The glass bottle share of the beer market has been estimated at about 3.0 billion units of 375 ml, or approximately 33% of the total production.

2.2.3 Wine Sales

OI and AMCOR both produce wine bottles, with Amcor’s production totalling more than 80% for the export market. OI’s production is predominantly focused on domestic sales. According to the Australian Wine and Grape Industry, 2005 wine consumption in glass was estimated at 180.6 million litres or 240 million 750-ml equivalent bottles in the period 2004–05.

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8 Interview with Mr Warwick Hassan Illinois, Glass Manufactures.
9 Interview with AMCOR Management.
10 Interview with Mal Mathews ACG.
11 Interview with Mal Mathews ACG.
12 1329.0 – Australian Wine and Grape Industry, 2005 ABS.
2.2.4 Spirits and Mixed Drinks Sales

The ABS report on the Australian Wine and Grape Industry, June 2005, states that alcoholic mixed drinks and spirits accounted for more than 32.768 million litres. Spirits were reported at 18.896 litres whilst mixed spirit drinks accounted for 13.872 million litres. Glass is estimated at 100% of spirits production and 70% of the mixed drink market. Spirit bottle production is therefore estimated at 251.9 million units of 750-ml equivalents and the mixer market represents 258.9 million units of 375-ml equivalents. The report is unclear as to the percentage of imported spirits versus locally produced products or exports.

2.2.5 Soft Drink Sales

Limited container glass is used by the soft drink industry due to competition from the light-weight, high-capacity plastic PET bottle and multi-unit aluminium packaging. Coca Cola Amatil has recently reintroduced a range of new shaped glass bottles however all bottles are imported. Cadbury Schweppes and a number of smaller producers, such as Bundaberg Drinks, and Wimmers Cordials, use a 375-ml bottle, but actual production quantities are not publicly reported, nor were they made available during the preparation of this report.

2.2.6 Imports and Exports

It was reported by stakeholders interviewed that significant quantities of both empty and filled glass bottles are imported into Australia, primarily from Saudi Arabia, Indonesia, Europe and China. OI, from time to time, imports empty bottles to supplement local production shortfalls, as do all beer and wine producers.

All blue coloured glass containers sold in Australia are imported, as Australia has no production capacity for this coloured material.

The actual quantities of imported bottles are not publicly reported, nor were they made available during the stakeholder discussions, as this information is deemed “commercial in confidence”.

We identified one large importer from France with an Australian sales office in South Australia that supplies many small boutique wineries throughout the nation. It was reported that empty imported wine bottles could account for as much as 10%–15% of Australia’s wine bottle sales. Based on this information and using the ABS statistics of Australia’s wine sales in glass as being estimated at 123,000 tonnes of glass product, then imports alone could account for as much as 12,000–18,000 tonnes of imported product.

Information reported by the ABS gives estimates of Australia’s wine exports and substantiates stakeholder-provided information that more than 200 million 750-ml equivalent units are exported. “The countries exporting the largest volumes of wine in

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13 Interview with Mal Mathews, ACG.
14 Information supplied from OI.
15 Stakeholder discussions with OI, Lion Nathan and Fosters.
16 Information supplied by Glass Block Technologies.
17 Phone call with Wine and Brandy Producers in Adelaide.
2002 were reported as being, in order, France, Italy, Spain, Australia, Chile, USA and Germany, accounting for 79.8% of total world wine exports. Australia exported 471.5 million litres of wine or 41.0% of its wine production.18

The report is unclear as to the method of distribution of the wine (packaged or in bulk), however, stakeholder interviews with both manufacturers of glass containers confirmed export estimates to be in excess of 200 million units per annum. Using the ABS figures of export production at 471 million litres and a wine bottle capacity of 750 ml per unit, with a bottle weight of 513 gm, total glass exported from Australia could exceed 300,000 tonnes annually. On the basis of this information, it is concluded that it is possible that glass exports could greatly exceed industry estimates if all wine produced for export were in locally produced glass bottles.

In the highly competitive wine market, product differentiation is a key marketing tool. In 1990 there were two shades of green glass bottles; by 2003 there were five shades of green – emerald, antique, French green, classic and Georgia green

2.2.7 Food

The available quantities of glass packaging generated from the food sector cannot be calculated with any accuracy, or confidence. The supply chain of food packaged in glass that is sold by both retailers and wholesalers is very fragmented, with no information is publicly available for reference.

It is assumed to be significant, but actual tonnages imported, exported or sold in the state are not referenced in this report, and are unknown.

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18 ABS 1329.0 – Australian Wine and Grape Industry, 2005.
2.2.8 Summary

Based on the information provided above, the following estimates of the actual quantities of total used glass availability can be concluded.

**Table 3 Total Available Used Glass Nationally**

<table>
<thead>
<tr>
<th>Producer (Glass Only)</th>
<th>Estimated Units Filled (Millions)</th>
<th>Estimated Unit Weight</th>
<th>Total Available Tonnage (000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer</td>
<td>3,000</td>
<td>208 grams (375ml)</td>
<td>624,000</td>
</tr>
<tr>
<td>Wine</td>
<td>240</td>
<td>513 grams (750 ml)</td>
<td>123,120</td>
</tr>
<tr>
<td>Spirit</td>
<td>252</td>
<td>513 grams</td>
<td>129,276</td>
</tr>
<tr>
<td>Mixer</td>
<td>259</td>
<td>208 grams</td>
<td>53,872</td>
</tr>
<tr>
<td>Imports</td>
<td>Not Determined</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.751</strong></td>
<td></td>
<td><strong>930,268</strong></td>
</tr>
</tbody>
</table>

These estimates have been calculated in an effort to determine the minimum available product and confirm industry estimates that domestic availability is between 800,000 tonnes and 930,000 tonnes. During the development of the National Packaging Covenant it was agreed that used glass container consumption in Australia is currently around 850,000 tonnes. Based on an Australian population estimate of 20.65 million people\(^{22}\), the consumption is estimated to be between 38 and 45 kg per person per annum.

According to the *Summary Report of Waste to Landfill Perth Metropolitan Area*, February 2003, commissioned by the DoE, it was calculated that on a per capita basis waste arising from the domestic and commercial and industrial sectors totalled 840 kilograms per annum. Based on audits conducted by Murdoch University over the same period, glass in the audited waste streams was estimated at 5.8%. This concludes that glass consumption per person is 48.72 kg per annum. On the basis of the calculations from both production and waste audits, we can therefore conclude an estimate of somewhere between 45.04 kg – 48.72 kg per person should be possible for recovery across the state.

With a state-based population estimated at 1.883 million people (2001)\(^{23}\), the total available estimated used bottle and glass production in the state is therefore calculated to be between 84,735 tonnes and 91,739 tonnes, using the calculations set out above. According to OI estimates, the consumption of glass within WA is calculated to be 80,000 tonnes.\(^{24}\) On the basis of our calculations, which have been cross-referenced with extensive stakeholder information and other publicly available reports, we can conclude that the product availability of used container glass within the state is estimated and confirmed to be between 80,000–90,000 tonnes.

\(^{19}\) Information Supplied by OI.
\(^{20}\) Assumes a total of both import and locally produced tonnes.
\(^{1}\) Assuming same weight calc as a wine bottle as information on the actual weight is unavailable.
\(^{21}\) May include export quantities for beer products.
\(^{22}\) ABS Website, May 2005.
\(^{24}\) Pers comm., W Hassan OI, April 2006.
2.4 Used Glass Recovery in WA

Historically, glass bottles used by the beer, milk and soft drink industries were recovered via a returnable system, delivered to a centrally located plant for washing and returned to the filler and the cycle continued. New bottles could be manufactured with cullet obtained from returnable bottles which failed quality-control inspections at the washing or filling plants, where contamination from other non-glass items was not an issue.

The traditional methods for collecting glass for recycling was via secondary scrap and bottle dealers and strategically located “glass igloos” (permanent containers, colour-coded, to which members of the public could deliver used glass containers) usually located in high-density areas such as shopping centre car-parks.

In the 1980s, more than 250 sites were located throughout the metropolitan area and accounted for more than 3,000 tonnes of glass. Glass was also recovered from a dealer network across the state.

From the period of the mid-1980s, when the aluminium can was introduced by the Swan Brewery, then owned by The Bond Corporation, beer production in glass gradually eroded from a high of 83% of production to a current package share estimated between 52 - 55%. In addition, soft-drink manufacturers started converting from a returnable glass bottle (each weighing as much as 1 kg) to light-weight plastic PET bottles and multi-packs of aluminium cans for their products.

For glass to remain competitive in its traditional markets against other packaging forms, that is, plastics and aluminium, manufacturers continue to undertake research and development to minimise batch size and cost. The re-design and light-weighting initiatives are directly in response to consumer and customer preference and competition from other packaging forms.

Product redesign has assisted manufacturers in reducing overall environmental impacts by reducing resource use, reducing energy consumption and improving transport and distribution principally through light-weighting (using less material to make the same container). This has been achieved by reducing the wall thickness as well as extending the neck of bottles and modifying the glass lip.

The weight reduction has been substantial in real terms, as historically, to make a returnable stubby, it was reported that in the mid-1980s a bottle weighed as much as 285 grams. By 1990 the one-way bottle weighed 245 grams and by 1997 it was claimed to have been reduced to 180 grams. OI advises that the industry average weight for a stubby is now 208 grams. A spokesman at Lion Nathan confirmed the weight of its core products as being at 185 grams, with specialty beers at 230 – 245 grams. The 375ml and 340 ml containers account for more than 90% of total glass bottle sales.

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25 Mike Roddy, OI, April 2006.
27 Email from W. Hassan, OI, April 2006.
Collection methods for glass have also changed over time. The community-based “drop-off” centres that traditionally recovered glass bottles were phased out for the more favoured methods of multi-material or commingled kerbside collection methods. Kerbside collections are deemed to be capable of recovering a greater quantity and range of products more effectively and efficiently and, combined with the drive for landfill diversion, have now become mainstream in all metropolitan local council areas and are increasing in regional and rural areas across the state.

Collection systems have evolved over the last decade from bags and crates to fully automated side-loading mobile garbage bins (MGB) collections with centralised sorting at Materials Recovery Facilities (MRFs).

As light-weighting of containers, up to 27% less glass to make today’s beer stubby, continued, quality standards increased as the tolerances in the older-style thicker bottles had been eroded. New specifications were developed for suppliers delivering recycled glass to enable the production of new bottles to meet the increasing customer demands and tighter quality controls.

The move to more fully automated collection systems and the use of MRFs for colour-sorting has resulted in a substantial loss of incoming product.

The process of both light-weighting of glass bottles and the current practices used to collect commingled recyclables has, in fact, had a devastating impact on the actual real yields of the recovery of glass around Australia.

APC was commissioned in 2004–05 by the New South Wales Jurisdictional Recycling Group to identify, quantify and report on the impacts of collection vehicle compaction on glass recovery. It was identified through this investigation that the breakage of glass in fully commingled loads was estimated at a minimum of 19.4% of all glass when loads were compacted at 120 kg/m³ in the collection vehicle.28

Further, the report statistically verified that for every 10 kg/m³ increase above the 120 kg/m³ base, glass breakage increases at the rate of 2.9%. If the compaction ration in trucks were set at 200 kg/m³ it could be concluded that the amount of breakage expected would be about 42.6% of all glass collected.

Source; APC, Glass Compaction Study

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The report also identified that the quantity of glass broken below 50 mm in size in fully commingled loads was estimated to be 26.6% at the 120 kg/m³ rate and that as the loads’ density increased so did the quantity loss of sub-sized material.

The report confirmed that overriding of manufacturers’ settings for compaction occurred on a regular basis, and that this was usually done by drivers to enable them to maintain collection productivity rates, as well as reducing collection times and ensuring that incentive payments by companies to drivers was maintained. This report quantified what the industry feared and understood to be standard collection practice.

A recent Queensland study has revealed that, typically, the combined loss rate for glass containers from the collection and sorting phase is confirmed to be between 34% and up to 75% of that placed in the collection bin by the householder. A Queensland-based average of at least 50% was confirmed from MRF operators across the state.

The chart above demonstrates the size fraction of glass fines both from the collection vehicle and at the MRF which are currently not recovered.

The chart above demonstrates the size fraction of glass fines both from the collection vehicle and at the MRF which are currently not recovered.

The price paid by OI for glass had for many years remained constant and agents, community groups and the dealer network received a payment of $72.00 per tonne for the product. Recyclers from the regional and rural areas were paid a transport subsidy to assist in offsetting the freight costs, typically on backloads, incurred in moving the glass from rural areas to the manufacturing plant in Perth.

OI estimates it paid $25 million nationally in 2003, to councils and contractors for cullet, based on an average fee of $72/tonne. In addition, it also paid for this material to be beneficiated prior to being incorporated into the re-manufacturing process.

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29 Queensland Used Glass Study for The QLD EPA/JRG.
When OI closed the local manufacturing plant and changed the method and location of delivery and the quality specifications, it also altered the pricing structure. Since 2003, a price of $40.00 per tonne is now paid for material delivered to Railroad Transport at Kewdale for shipment to Adelaide. It is estimated that the interstate transport cost is around $80/tonne.

The new national glass acceptance specification was also introduced, specifying a maximum of 25 gm per tonne of any specified contaminants with a minimum particle size of 60 mm. As a result, an increasing amount of glass fails to meet the size specification and all undersize glass, termed glass fines, is presently landfilled.

While the new commingled kerbside collection system has assisted in increasing the range of materials which can be recovered, it has had a devastating impact on glass recovery. Nationally, recovery of glass containers is estimated at around 35%, well short of the agreed target of 50–60% by 2010 under the National Packaging Covenant (NPC). To reach the NPC target, an additional 125,000 tonnes will need to be recovered nationally.

Victoria was the first state in Australia to recover glass fines down to 8 mm in size though the investment by Visy Recycling in optical sorting equipment The current state-based figures reflected in Table 4 below report tonnes of glass recovered for beneficiation by state. The table does not reflect the actual tonnes collected and lost as fines to landfill from the MRF and beneficiation processes.

The table below reflects glass fines recovery in Victoria, whereas in all other states these are excluded and thus based on estimates from stakeholders. These figures could be underestimated on average by at least 50%, according to studies and responses across the nation.

Table 4 Current Glass Recovery in Australia, 2004

<table>
<thead>
<tr>
<th>Glass Recovery Tonnes</th>
<th>NSW</th>
<th>Vic</th>
<th>SA</th>
<th>Qld.</th>
<th>WA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90,000</td>
<td>70,000</td>
<td>48,000</td>
<td>50,000</td>
<td>20,000</td>
<td>278,000</td>
</tr>
</tbody>
</table>

The DoE commissioned a Glass Recycling Review, which was conducted by GHD in September 2005 and analysed the Department’s Resource Recovery Rebate Scheme (RRRS) payment estimates. Its assessment was that in 2005 the state recovery rate for glass from kerbside collection programs totalled 12,998 tonnes, as detailed below:

Table 8 Glass Recovery by Tonnes and Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Tonnes Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perth Metropolitan Area</td>
<td>8,838</td>
</tr>
<tr>
<td>Kwinana/Peel</td>
<td>1,891</td>
</tr>
<tr>
<td>Mid West Gascoyne</td>
<td>28</td>
</tr>
<tr>
<td>North West</td>
<td>101</td>
</tr>
<tr>
<td>South Coast</td>
<td>527</td>
</tr>
<tr>
<td>South West</td>
<td>1,246</td>
</tr>
<tr>
<td>Swan Goldfields</td>
<td>367</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12,998</strong></td>
</tr>
</tbody>
</table>


30 Allen Mitchell, General Manager, Visy Recycling.
It can only be concluded that the difference between the reported figures and industries’ estimates are that commercial collectors from the Perth metropolitan area and several other regions of the state were not recorded. Contact with three commercial collectors revealed that their quantities were not recorded by GHD, which concentrated on kerbside collection programs, given that the bulk of the quantity of glass originates from that source.
3.0 LITERATURE REVIEW

To assist the consultants’ understanding of previous research and developments in relation to markets and opportunities for used glass packaging, a review of available reports was undertaken locally, nationally and internationally. The Department of Environment provided a copy of a recently completed but unreleased report titled *Glass Recycling Review Assessment*, prepared by GHD.

Two key organisations globally have sponsored extensive programs in the development of applications and markets for recycled glass. Both of these agencies have undertaken a significant amount of work relevant to this study, and a summary of some of the key reports is provided in the bibliography. These organisations are:

- Waste and Resources Action Program (WRAP), UK
- Clean Washington Centre (CWC), USA

Additional reports were reviewed and referenced, if appropriate. The complete list of documents reviewed is contained within the bibliography. A summary of key documents is provided to assist the reader in understanding the rationale for determining outcomes in this report.

1. Glass Recycling Review Assessment, GHD, 2005
2. Feasibility Assessment of Generating Crushed Glass Fines for Markets, Professor Sorrell, 2004
3. Market Study for Recycled Glass in the South Island of New Zealand, 2005
5. PAS 102, Specifications for Processed Glass for Selected End Markets, WRAP, UK, 2004
6. Value-added Utilisation of Waste Glass in Concrete, USA, 2002
7. Summary of Affirmative Procurement Post Consumer Recycled Glass Abrasives, USA, 2000

A further report by Peter Harkins of Controlled Environment titled Equipment For recycling Glass has also been extensively used and is referenced in Chapter ??? and is therefore not summarised under this section.

A summary of these key documents is provided below.
3.1 Glass Recycling Review Assessment, GHD, 2005

This document was prepared for the WMB and examines and provides an analysis of the current cullet supply chain. It identifies the current status, issues, threats and opportunities for post-consumer glass in WA and identifies strategic issues for future glass recovery and management.

The report states that the most significant restriction for continued and exponential growth of used glass collected in the state is the lack of a local market. The current transport of cullet to South Australia by rail is not a long-term viable option for glass arising in WA, which must compete on economic and performance standards with interstate-generated volumes.

The report provides a summary of the key issues and impediments to sustaining post-consumer glass recovery in WA. A brief assessment of the alternative markets potentially available is included.

3.2 Feasibility Assessment of Generating Crushed Glass Fines for Markets Professor Charles C. Sorrell, University of NSW, 2004

The NSW Jurisdictional Recycling Group commissioned this 600-page report, which is the most comprehensive and substantive body of work undertaken in Australia on alternate markets. It is current and written in the Australian context, but focuses on NSW markets and pricing. The report presents a detailed desk-top analysis of the most promising and technically mature applications for recycled glass, including a review of currently available technologies, applications, products, markets, infrastructure and estimates of costs associated with the implementation of the technologies required to commercialise these applications.

The report is presented in four parts:

Part 1: Technology review – to identify the most promising and technically mature applications for recycled glass

Part 2: Survey of infrastructure – the infrastructure requirements and alternatives for the implementation of the technologies required to commercialise these applications

Part 3: Economic analysis of Australian cement and aggregates industries – economic factors as they relate to these sectors


The executive summaries of each section are provided in Appendix 1 and key findings are summarised below. An electronic copy of the full report is provided separately from this report.

Part 1 outlines the materials and markets for used container glass and surveys in detail the technologies and markets for primary (can be repeatedly recycled) and secondary (recycled once and used in long-life applications) cullet, as shown in Table 5 below.
Table 5 Primary and Secondary Cullet Markets

<table>
<thead>
<tr>
<th>Primary Cullet Markets</th>
<th>Secondary Cullet Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Glass</td>
<td>Concrete Aggregates</td>
</tr>
<tr>
<td>Flat Glass</td>
<td>Construction Aggregates</td>
</tr>
<tr>
<td>Fibreglass</td>
<td>Pavement Aggregates</td>
</tr>
<tr>
<td>Fluorescent Lighting</td>
<td>Landscaping Aggregates</td>
</tr>
<tr>
<td>Cathode Ray Tubes</td>
<td>Mineral Products</td>
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<tr>
<td>Blasting Abrasives</td>
<td></td>
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<tr>
<td>Water Filtration Media</td>
<td></td>
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<tr>
<td>Structural Products</td>
<td></td>
</tr>
<tr>
<td>Domestic Products</td>
<td></td>
</tr>
</tbody>
</table>

The technology, applications, products and markets associated with recycled glass were assessed in terms of two criteria:

- Potential for large-scale (by volume) utilisation of waste glass
- Demonstration of the technical maturity of the process and product

The report has identified five leading potential avenues for commercialisation; these are shown in Table 6 below.

Table 6 Potential Avenues for Commercialisation of Recycled Glass

<table>
<thead>
<tr>
<th>Application</th>
<th>Market Volume</th>
<th>Technical Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate in Portland Cement Concrete</td>
<td>Very Large</td>
<td>Mature</td>
</tr>
<tr>
<td>Pozzolan in Portland Cement Concrete</td>
<td>Very Large</td>
<td>Not Mature</td>
</tr>
<tr>
<td>Unbound Construction Aggregate</td>
<td>Very Large</td>
<td>Mature</td>
</tr>
<tr>
<td>Blasting Abrasive</td>
<td>Small</td>
<td>Mature</td>
</tr>
<tr>
<td>Water-filtration Media</td>
<td>Large</td>
<td>Not Mature</td>
</tr>
</tbody>
</table>

Each of the potential applications was explored in detail and the following conclusions drawn:

- Glass as a fine aggregate in concrete is a suitable application for recycled glass.
- More data is required before glass can be recommended as a pozzolan in concrete.
- The amount of energy required for fine grinding to achieve pozzolanic activity in glass may be excessive.
- Unbound construction aggregate is appropriate for a commodity produced from the glass that is out-of-size from that used as fine aggregate in concrete.
- Glass for use as blasting abrasive and water filtration media can be produced with minimal change to the process but these products are not recommended at present.
- The scale of the required infrastructure is such that a portable glass recycling system for glass as fine aggregate in concrete is not recommended.

A complete range of infrastructure required for a glass recycling plant was explored and detailed. Appropriate technologies, indicative price and plant design were formulated, and these are presented graphically. This section also contains:

- A condensed tabulation of potential Australian secondary markets for recycled glass
- An edited text of a report on equipment for glass recycling
- An extensive tabulated survey of infrastructure suitable for glass recycling, including brief technical specifications, prices and corporate contacts.

Part 3 surveys a range of data for the materials that were nominated by the NSW DEC for potential replacement by recycled glass:
These were:

- the construction commodities Portland cement (pozzolan)
- fine aggregate (sand), and
- coarse aggregate (crushed stone and gravel).

For these three types of materials, the following areas were explored: types and definitions of products, applications for products, production and economic data.

Part 4 of the report surveys a range of equipment suitable for the processing of waste glass into materials that were identified in Part 1. Issues with lack of data provided a substantial constraint and data that was supplied was often framed as a best-case scenario. The report concluded that the only means of obtaining true data would be to commission trial studies from the manufacturers.

The economic analysis was undertaken to provide indicative costs per year of operating the equipment, and the cost per tonne of recycled glass. The key conclusions were:

1) **Glass as Pozzolan**: This product is associated with high costs and low throughput rates. It is possible but unlikely that glass powder of particle size <10 µm can replace Portland cement economically. There are other high-value-added possibilities that are worth investigating.

2) **Glass as Fine Aggregate in Concrete**: This product can be produced relatively inexpensively and with high throughput rates. The low price of sand would make profitability in this market difficult.

3) **Glass as Coarse Aggregate in Non-concrete Applications**: This product (<19 mm) can be produced extremely inexpensively with high throughput rates. The anticipated shortage of crushed stone and gravel in the Sydney region would enhance this situation.

4) **Sorting**: Sorting ferrous metals, non-ferrous metals, and ceramics and stone from glass as well as sorting glass according to colour can be done quite inexpensively.

However, when reviewed by Mr Jim McLeod, Managing Director of Australian Glass Technologies (AGT), the most experienced large-scale glass recycler in Australia, with over 20 years’ experience and an operation producing over 10,000 tonnes per year of recycled glass, Mr McLeod claimed the study underestimates, sometimes substantially, the actual costs of the operation. The projected costs of crushing may be out by a factor of ten and sorting by a factor of four over the indicative operational costs calculated in this report.

3.3 Market Study for Recycled Glass in the South Island of New Zealand, Chris Thomas, May 2005

The objective of this study was to identify the status of glass recovery in the South Island of New Zealand and to evaluate market and enterprise opportunities for recovered glass in the region. The report found a number of viable opportunities to establish or expand markets for recovered glass existed, however, the opportunities varied considerably.
Market development study – Used Glass

Market opportunities identified for glass cullet were:

- General fill / backfill
- Road/highway construction
- Glassphalt, glass used in asphalt
- Pipe and paver bedding
- Landfill cover
- Sandblasting and abrasives
- Recycled glass in golf courses
- Recycled glass in landscaping and decorative aggregates
- Filtration and drainage
- Ceramics.

High-value markets such as ceramics, decorative aggregates and sandblasting abrasives tend to have high-quality requirements and consume low volumes of waste glass. Low-value markets, such as construction aggregates and filtration media, usually have lower quality requirements, but have the potential to consume higher volumes of waste glass.

The report identified the key barriers to market development as:

- Lack of information
- Lack of technical expertise
- Lack of marketing expertise
- Lack of standards and specifications
- Access to the resource
- Competing products.

3.4 PAS 101 Recovered Container Glass – Specification for Quality and Guidance for Good Practice Collection, WRAP, United Kingdom, 2003

The Waste and Resources Action Programme (WRAP), in association with the British Standards Institution and with the support of 14 key UK used container glass recycling stakeholders set the minimum quality standards for recovering used container glass intended for reprocessing. It was developed in an attempt to harmonise various independent specifications and to provide a comprehensive specification for all raw container glass collected in the United Kingdom for recycling.

It introduced a four-tier grading system for raw cullet quality, grades A to D, according to the degree of colour separation, contamination and particle size, as well as setting out controlled test methods used to verify that the required quality is met for each specified grade in the event of dispute.

It established detailed limits for: colour specifications, contamination limits and particle sizes. According to the grades of glass being managed and in line with the set specifications, the PAS also aligns these to collection practices from:

- Kerbside collection and separation
- “Bring Sites” or bottle-bank locations
- Commercial site collection systems
- Transportation, handling and storage
- Delivery to reprocessor.

3.5 PAS 102 – Specifications for Processed Glass for Selected End Markets, WRAP, UK, 2004

The Waste and Resources Action Programme (WRAP), in association with the British Standards Institution, and more than 24 key secondary glass re-processors and users of reprocessed container glass, set minimum quality standards for using reprocessed glass in the following secondary sectors:

- Glass use in ceramic sanitary-ware production
- Glass use as a fluxing agent in brick manufacture
- Glass in sports turf and related applications (for example, top-dressing, root zone material or golf bunker sand)
- Glass as a water filtration media (in applications for waste water treatment)
- Glass use as an abrasive.

Specific matters relating to colour, contamination limits and particle-size requirements for each sector are specified, in addition to test methods as appropriate, in substantial detail.

The document provides for detailed cross-referencing to virgin product standards according to British Registered standards, and addresses the use of glass from four clear perspectives, these being:

- Applicability of glass use in the application
- Requirements and standards, if necessary, for colour
- Contamination limits
- Particle sizes and ranges

The document provides detailed bibliographies, as well as relevant technical responses where applicable.

3.6 Value-added Utilisation of Waste Glass in Concrete, Ahmad Shayan, Chief Research Scientist, ARRB Transport Research, Vermont South, USA 2002

Dr Shayan has more than 22 years’ experience in the assessment of concrete deterioration and its prevention and in also utilising waste materials in concrete. His paper was presented in Melbourne in 2002 at the IABSE Symposium and outlined the results of his research in using post-consumer glass to displace his company’s virgin or raw material feedstock, the processing of this glass to a fine aggregate, coarse aggregate and powders and the application of these products in concrete.

The report discussed in detail the impacts glass has from a chemical reaction between the silica-rich glass particles and the alkali in the pore solution of concrete, that is, the alkali–silica reaction.
Particle sizes:

Coarse Glass Aggregates 12 mm – 4.75 mm  
Fine Glass Aggregate 4.75 mm – 0.15 mm  
Glass Powder < 10 um

The research found that “there is great potential for the utilisation of waste glass in concrete in several forms including, fine aggregates, coarse aggregates and glass powder. It has been concluded that 30% Glass Powder could be incorporated as cement or aggregate replacement in concrete without any long-term detrimental effects.

“Up to 50% of both fine and coarse aggregates could also be replaced in concrete of 32 MPA strength grade with acceptable strength development properties”.

3.7 Summary of Affirmative Procurement Post-consumer Recycled Glass Abrasives, CWC, USA, 2000

The report was commissioned by CWC’s Recycling Technology Assistance Partnership (ReTAP), through a grant from the U.S. Environmental Protection Agency, with supporting funds from the National Institute of Standards and Technology Manufacturing Extension Partnership (NIST MEP).

The objective of the project was to identify opportunities within the federal government procurement processes that could be used to stimulate market development and continuity of supply for selected recycled goods. Glass was selected as one product due to the excess supply of cullet and the inability of the glass bottle manufacturers to use the collected quantities.

The investigation found that for the continued viability of glass recycling, new large-volume markets for recycled glass must be developed. In terms of value and volume potentials, the only promising market for glass was identified as abrasive blasting media. The economics were challenging, with processing costs in the US $40–70/ton range and potential revenues of US $85–90/ton. Abrasive media should be considered a “base-load” market for any other market contemplated for finely ground glass. The other identified markets for glass – filtration, fillers, textures, flooring, specialty sands – are far smaller markets and considered not viable.

The project delivered a number of demonstration pilots and achieved the following:

- Cleaning fuel storage tanks at the Manchester Fuel Depot (WA) and Eielsen Air Force Base (AK), Interstate Coatings of Seattle with recycled glass
- The Marine Corps Logistics Base in Barstow, CA replaced plastic media with recycled glass in one of its four blasting rooms
- The Bureau of Reclamation’s facility at the Grand Coulee Dam now uses recycled glass abrasive mediums in successfully removing vinyl coatings and primers from dam gates and parts
- Scott Air Force Base (IL) was the first federal facility to require the use of recycled glass abrasives in a service contract for base maintenance services.

Post consumer recycled glass abrasives are now listed in the EPA’s revised listing of Comprehensive Procurement Guidelines.


This document sets out in detail the issues arising from producing glass grain sizes, dry milling of glass, screening and air classification systems of glass, metals and contaminants recovery and types of equipment available for the production and processing of products.

3.9 Glass Market Development Strategy, C4ES, 1999

The report was commissioned by EcoRecycle Victoria to determine available options for the use of glass fines unable to be beneficiated at the time due to particle size and levels of contamination. The report found that the best opportunities for alternatives existed in the abrasive media and traction control markets. For regional areas, uses of glass fines would have application in construction and road base. However, a key outcome was to maintain the focus on the primary use of cullet that was being processed back into new bottles and at the same time develop alternate markets for the fractions incapable of being used in this application. It recommended changes to the collection system to reduce breakage and also recommended modifying MRF design to accommodate a higher fraction of recovery.

C4ES reported that an additional 20,000 tonnes of product estimated to be going to landfill was likely to be able to be recovered through the use of optical glass sorting equipment at the beneficiation plant. An additional 4,000 tonnes of plate glass could be diverted for reuse as glass beads, currently being imported to Victoria.

3.10 Value Adding to Recycled Waste Streams from MSW: Glass and Plastics
PMJ, Fisher & Associates, August 1997

This report was commissioned by Energy Developments to investigate options for glass recovered from the company’s developing “Waste to Energy” facility. The report identified that glass recovery from mixed residual bin systems was incapable of being economically recovered and reused for bottle production, however, lower grade applications did exist. The report concluded on an economic basis, that glass reuse in low-grade drainage and construction aggregates was the most effective reuse for glass recovered from a mixed residual bin system.

The report also identified six separate high-definition automated optical sorting systems for the identification and removal of contaminants.
4.0 STAKEHOLDER CONSULTATION

To ensure a complete assessment of the range of options, and identification of the opportunities, issues, challenges and impacts on the current system were fully understood, an extensive stakeholder engagement process was undertaken.

In addition to the international and national consultation process, two forums for key stakeholders were held with local and state government representatives, as well as representatives from the collection and reprocessing sectors. Where key re-processors or MRF operators could not attend the forums, separate meetings were arranged to ensure their input, ideas and issues were considered.

The stakeholder list can be summarised as follows:

- Manufacturers of glass containers
- Key industry stakeholders
- State governments
- Local government
- Collection contractors
- Commercial collection contractors
- Manufacturers of products for which glass could be substituted in long-life applications.
- Potential end users
- Re-processors of glass

The outcomes of these discussions and forums are referenced in this section and issues raised are discussed throughout the remainder of the report.

4.1 Manufacturers of Glass Containers

Interviews were held with representatives of the two glass manufacturing facilities in Australia.

AMCOR Packaging:
- Mr Gary Jenkins, General Manager, Recycling, Victoria
- Mr Jamie Young, Recycling Manager, Western Australia.

Owens Illinois:
- Mr Warwick Hassan, Manager Environment, Victoria
- Mr Craig Mynott, Strategic Procurement Manager, South Australia
- Mr Mike Roddy, Manager, Western Australia.

Discussions with this group focused on glass bottle production matters, product sales, quality, marketing, product stewardship and issues directly related to supply of cullet and production of new glass.

OI reaffirmed its position that glass recovery from Western Australia was uneconomic and not sustainable in the medium to long term, given the two-tiered approach of transport and beneficiation, as well as payment of transport subsidies to regional and
rural areas. OI is very surprised that glass recovery has increased since the decrease in market price paid per tonne. The current rail transport to Adelaide is costing in the range of $80/tonne and, although pleased with the continued community support, the company cannot continue to absorb the financial impact in the longer term.

OI expressed the desire to withdraw from the Western Australian market as soon as possible unless glass can be delivered to Adelaide at a beneficiated quality equal to or less than the virgin batch price. Its decision-making is primarily based on economics, as it was when the decision was made to close the manufacturing facility.

The company expressed the view that it would like its customer base to assist in shared product stewardship.

4.2 Glass Container Fillers

Interviews were held with the following companies, which extensively use glass packaging for product sold in Western Australia:

- Fosters Group – Mr Russell Peel, Group Vice President, Health Safety & Environment, Vic
- Lion Nathan – Mr David Carter, Group Director, Environment & Technical Projects, NSW
- Coca Cola Amatil – Ms Olivia Tyler, National Environment Manager, NSW
- Yatala Brewery – Mr Noel Jago, General Manager Operations, Queensland
- Bundaberg Drinks – Ms Trish Hielscher, Production and Warehousing, Queensland.

Discussions with this group focused on distribution, quality control, light-weighting, product stewardship, market size and promotional programs, as well as general project issues.

The group was very concerned that OI was withdrawing from the Western Australian market and was attempting to find ways of assisting the situation. The companies were concerned that any decision by OI to withdraw from taking glass back from within the state would place glass at a disadvantage and leave it isolated for other legislative impacts, such as the current “Deposit Legislation” inquiry. They believed this was premature, given the NPC was not even halfway towards the mid-term review in 2008. The brewers considered that with Coles and Woolworth’s, which collectively now control at least 50% of Australia’s retail sales for alcohol, in addition to supermarket glass packaging, should be more accountable.

The brewers were willing to assist with identifying the quantity of glass product sold in WA, however only one, Lion Nathan, provided data, hence our calculations of quantities sold within the state can only be based on national averages weighted back to a per capita basis.

The individual companies use the Australian Food and Grocery Council Packaging Stewardship Forum (formerly BIEC) to deliver programs and funding of these on the ground.
4.3 MRF Operators and Recycling Contractors

To gain the collective views of MRF operators and recycling collection companies a forum was held with invited stakeholders on the 4th April to identify issues associated with recovery and market sustainability of post-consumer glass packaging, specifically to discuss the budgetary impacts on processing glass from kerbside recycling programs and issues associated with recovery and market sustainability of post-consumer glass.

The following persons either attended the forum or participated in one-on-one meetings.

Cleanaway:
- Mr Bill Marchbank, W.A. Business Development Manager
- Mr Rob Morris, Resource Recovery Manager
- Glen Chisholm, Site Coordinator, Bayswater MRF
- Roads and Robinson – Mr Mike Roads, Director
- Southern Metropolitan Regional Council – Mr Peter Mulla, MRF Manager
- Green Recycling – Mr Sayn Chi, MRF Manager, Bunbury
- Kattanning Recyclers – Mr Alan Sandwell, Commercial Collector, Kattanning.

These interviews focused on commercial matters, glass recovery within their operations, financial discussions re collection and operation costs, compaction ratios, market, reprocessing and product recovery matters.

This group of operators was the most vocal, and expressed a deep concern as to the current cash flow impacts the decrease in glass revenue is continuing to have on their businesses and the implications for long-term contractual arrangements.

The MRF operators indicated that whilst glass clearly was a cost to them, it continued to provide a direct cash flow to the business which if lost would directly impact on their operations. Although current contracts precluded their ability to recover this current loss, in the future these losses would have to be made up and factored into all new contracts with councils. They indicated that councils will, in the long term, have to contribute to the cost of glass-processing in recyclables. Collectively, all MRF operators felt their concerns regarding increasing glass fines and decreasing revenues were being ignored by both state and local government, and that they were being left to directly carry the financial burden.

It was clearly apparent that MRF operators were incurring significant costs in their ability to meet the OI specification of 60 mm and above for glass recovery. Should all glass be potentially recovered, that is, > 60mm and glass fines it was observed that while some modification maybe required in MRFs’ designs, substantial savings in utilising less labour for sorting, as well as avoiding additional landfill costs, would likely offset the lower revenue to be gained for all glass products.

The commercial collectors were very concerned about the impact of decreases in glass revenues on commercial clients. They indicated that they had already attempted to recover some of the losses already incurred, through increasing collection charges to customers. However, clients will cease to separate when it becomes uneconomical against competing general waste collection charges, should this occur.
Stakeholders advised that any further drop in the price paid for glass would place a serious financial impost on their businesses, and they would need to reassess their business operation.

4.4 Local Government

To gain the collective views of local government, a workshop was held with invited stakeholders on the 4th April to identify issues associated with recovery and market sustainability of post-consumer glass packaging, and to discuss the budgetary impacts on kerbside recycling programs.

Participants in the workshops included:

- Mr Bernard Ryan – Western Australia Local Government Association
- Mr Tim Yowe – Southern Metropolitan Regional Council
- Ms Jan Grimody – South Eastern Metropolitan Regional Council
- Mr Bernie Burnett – Western Metropolitan Regional Council, Town of Mosman Park
- Mr Kyle Boardman – City of Mandurah
- Mr Mike Pennington – City of Wanneroo
- Mr Ron Boucher – Geraldton Regional Council.

In addition further meetings and discussions were held directly with other participants, including:

- Mr Stewart Mc Call – Southern Metropolitan Regional Council
- Mr Viet Nysen – City Of Stirling.

Discussions with this group of stakeholders focused on councils’ collection issues, revenue impacts, political impacts, market use and acceptance of glass products in their operations, in addition to key project directives.

SMRC indicated that it is not currently directly impacted upon by further prospects of decreasing glass prices, as it has directly contracted to a third party for the next two years to process glass for it at a cost of $20.00/tonne. We were unable to determine the full commercial arrangements or how the agreement is structured.

All stakeholders from local government expressed a variety of views, but many were indifferent and critical of the industry’s current position. Given that glass is inert and has minimal impact on the environment in rural and remote areas, to divert it for use as fill or drainage medium at landfill was considered an appropriate use.

They collectively expressed the view that the price of glass had little impact on their current kerbside collection charges, and that glass appeared, through recent waste composition studies, to be reducing in some waste streams, while plastics and aluminium were increasing.

Alternate waste re-processors were concerned about diverting all packaging and non-packaging glass from the residuals bin, given that glass contaminates the organic stream and increases wear and tear on plant and equipment, leading to increased maintenance.
Local government did not believe that it could stimulate demand for secondary use applications for glass in road or construction sectors, and felt this was the responsibility of state government, OI and glass fillers.

Local government representatives believed that a forum should be held to bring all the stakeholders together, including OI, its customers – the fillers, collectors, MRF operators and councils – to collectively and rationally discuss the way forward in relation to the problem. They lacked confidence and belief in industry responses to date.

Collectively, they considered that Deposit Legislation would provide an answer to the current issues, as well as a mechanism for councils to recover funds expended by them on recycling services.

4.5 Commercial Collectors

4.5.1 Damien Cole, Director, Damien Cole Group

The company has been operating a tallow, meat and bone collection program for over 13 years in metropolitan Perth and currently has an 80% market share. The company collects and processes for rendering about 1,500 tonnes per week. When the Group entered the market, it was paying 15 cents per kilo to have access to the waste meat product, however, it was able to change the dynamic of the industry such that today, customers pay $15 per service. As a result, there has been no decrease in the quantity of material provided, and other competitors have followed the “user-pays” approach.

The company was and is seeking to expand operations and services to offer an integrated waste service, given that it is within proximity of every retail area daily, and can build on the company’s sophisticated collection, tracking and accounting systems already in place. Business opportunities exist where complementary services can be replicated.

The company started a commercial glass collection in July 2004 and provided colour-coded 120-litre bins into which glass was colour-sorted by the more than 100 clients, including wineries and breweries. Minimum breakage occurred, and the collectors undertook a positive sort whereby any ceramic, contamination or considerably broken material was placed back into the clients’ waste bins.

The collected material was delivered to a company owned and designed crushing or beneficiation plant operating on a five-tonnes-per-day throughput, but with a processing capacity of 12 tonnes per day. The crushed material met the AMCOR specification and was railed to Adelaide, and a price of $110 per tonne was paid.

4.5.2 Mr Mitchell Ross, Perth Glass Recycling

This company currently collects glass from most of Perth’s hospitality sector and operates the commercial recycling operation for Visy Recycling. Issues of particular relevance included collection and operation of a glass beneficiation plant for reprocessing and the impacts on his businesses in the event that the current financial incentives for recycling were to change, together with the impacts of alternate market development.
An inspection of the collection and recycling operation was undertaken, in addition to interviewing management and operational staff.

### 4.6 Re-processors

The following stakeholders were consulted:

- **Visy Glass**
  - Mr Matt Wright, Site Manager, Queensland
  - Mr Murray Chrystal, Site Manager, Victoria
  - Mr Len Little, National Quality Manager, Victoria.

Visy currently undertakes all beneficiation of glass for OI nationally. Optical glass sorting equipment has only been installed in one Victorian beneficiation plant, at Laverton in Victoria, which is owned and operated by Visy Recycling and is now capable of recovering glass by colour down to 8 mm in size. Discussions relating to glass beneficiation, reprocessing, fines sorting, contamination, collection equipment, market reuse, research and other operations were conducted with this group.

- **Damien Cole Group**

The company undertook a commercial collection of glass which was delivered to a company owned and designed crushing or beneficiation plant. The crushed material met the AMCOR specification and was railed to Adelaide.

Whilst this was a successful operation, the viability was volume-sensitive. Due to existing competition in the market place from Perth Glass Recycling, the company was unable to obtain sufficient quantities of material to make the operation viable. While customers were willing to pay to have the glass removed, given its high weight ratio, Perth Recycling was, however, offering a free collection service. It was therefore difficult to impose any collection costs to offset the operational costs.

The company decided to postpone operations and the crushing plant is still in storage. Re-activating the collection and crushing plant would take approximately one month.

### 4.7 Re-processors of Glass Fines

In 1994, Pollution Solutions (Remediation Pty Limited, Tasmania) designed and constructed a $2 million facility in Tasmania, for processing glass cullet for various applications in the construction and materials market to users such as Boral, Pioneer and CSR Readymix. The project was completed in March 2000, funded by ACI Glass Packaging (now OI) with the research conducted by Coffey Geoscience, the Materials Division of the CSIRO and the Australian Road Research Board (ARRB). The research demonstrated that cullet (broken glass) had a number of potential applications, including as a cement replacement at up to 30% in mine back fill (stope), as a filler in asphalts to replace or partly replace lime, as an aggregate replacement, and in concrete as both a partial pozzolanic and as a substitute for both sand and aggregate. This company could not be contacted.
Australian Glass Technologies (AGT) has pioneered technology and applications for processed glass fines and now exports processed glass fines for various applications including abrasives, concrete, brick making and water filtration, both nationally and to the developing Asian market. The company, with over 20 years’ experience currently produces between 10,000–12,000 tonnes per year of recycled glass. The company is Queensland–based, with the plant currently located adjacent to the recently acquired Visy Gold Coast MRF. (Visy acquired the MRF assets of Cleanaway Queensland in the Brambles recent sale of Cleanway assets).

Mr Jim McLeod, Managing Director, and Mr Mark McLeod, Operations Manager, were met on five separate occasions during the preparation of this report. Pivotal to the development of glass reuse for alternate markets was the need to gain an understanding and appreciation of the opportunity, threats and issues relating to financial and operational drivers, process impacts, product performance, market opportunities, pricing and other related matters from the only business currently operating successfully in this sector. An inspection of the plant, its operations and product outputs was provided in confidence.

Our discussions concluded that any business opportunity in Western Australia would be based on high value-added markets, from which other sectors could be developed. The re-processor reiterated the need for a gate fee to be applied, but that as markets were developed, this figure could be negotiated over time.

Experience has shown that in any new market, existing suppliers of abrasives are very protective of their position and will use all possible means to protect their position. If issues relating to OH&S prevailed, this could be used by competitors to preclude market entry through the dissemination of misinformation which could have long-term detrimental impacts on this important future market.

AGT is interested in entering the WA market, however, needs security of supply and may require a gate fee to offset processing. A lead time of up to between 18 months to three years will be required to fully establish a viable presence in the state. Government assistance with infrastructure establishment, planning approvals and grants for market development and procurement of equipment would be the most appropriate assistance.

Peter Harkins of Controlled Environment are Agents in Australia for Andela glass crushers and currently own and operate a glass crushing operation at Wollongong in NSW. Peter was a former Manager at Visy Glass and undertook considerable research into alternate markets for the company. He advised in his view product-sizing should not be adapted to the specific markets, but rather markets should be found for the spectrum of sizes that the processing plant produces. This may mean that 80% of product produced is sold at $20 per tonne or less while the other 20% is sold at a premium of perhaps $200 per tonne. This is likely to be far more cost-effective than attempting a smaller throughput for an exact size range and selling 100% of the output at $200 per tonne.

The Australian Bale Press Company in NSW are major designers and installers of MRF equipment and increasingly are incorporating glass crushers into new plant designs. The company also has a commercial interest in the first glass crushing plant in NSW based at the Earthcare MRF at Somersby. A separate company under the leadership of George
Gibson has now been created to deal specifically with glass processing given its unique characteristics.

The key competition to reprocessing is landfill pricing. The government needs to review landfill pricing and the application of the landfill levy, which currently differentiates between insert and putrescible material and has recently been increased, effective from July 1st 2006.

A major concern expressed was regarding the ambiguous nature of the current regulations precluding recycled material being used as an alternate abrasive substitute. The regulations would have to be clarified and possibly amended to allow abrasives from container glass to be used before any investment was made, given its pivotal market. AGT and Controlled Environment have fully certified Material Safety Data Sheets substantiating glass’s safety for use as an abrasive.

4.8 Potential Users of Reprocessed Glass

With an understanding of the potential alternate use for reprocessed used glass local meetings and interviews were held with identified local companies and industry sectors that have been identified as primary opportunities for developing a local market for glass reuse.

These included:

*Western Australian Companies:*

- Glass Block Technologies International – Mr Bill Burke, Managing Director
- Australian Abrasives Association – Mr Graham Gaunt, Past National Director
- Total Corrosion Control – Mr Tony Iennello, Managing Director
- Midland Brick – Mr Stuart Collier, Technical Manager
- Pioneer Road Services
- Mr Graham Henderson, General Manager, Western Division
- Ms Meda Sicoe, Technical Manager
- Mr Terry Gleeson, Asphalt Manager

*Interstate Users:*

- Blue Circle Cement – Mr Greg McAlister, General Manager, NSW
- Alex Fraser Recycling Industries – Mr Jamie McKellar, Managing Director, Victoria
- Queensland Recycling – Mr Mark Chandler, General Manager, Queensland

Matters relating to product opportunity and reuse, current operating practices, pricing-related issues, competitor materials, environmental stewardship, financial and commercial discussions, as well as technical matters relating to used glass were discussed.

All participants were more than accommodating and expressed either an immediate desire to use glass or a willingness to consider or trial its use. Mainstream markets currently using glass in the Eastern States, such as the brick and tile industry, are problematic, as is the construction sector, based on technical limitations on raw material supply.
The asphalt sector was identified as an immediate opportunity, but economics may limit this opportunity. As identified in other sections of this report, many alternate users have been identified, but overall financial issues will limit real growth and long-term options, compared to the price of raw materials currently used.

In summary, there is general genuine interest from all stakeholders, despite some expressing technical or financial limitations on using glass in their operations.

4.9 Government Stakeholders

Contributions were sought from interstate and international agencies, including:

**Government – International:**
- Waste & Resources Action Programme, UK – Mr Andy Dawe, Technical Programme Manager, Glass

**Government – nationally:**
- Zero Waste SA – Mr John Blumsdon, Project Manager
- NSW DEC – Mr Rod Clare, Sustainability Officer.

Issues discussed with these stakeholders related to market development and government drivers in the United Kingdom, NSW and SA. All participants in this group expressed a genuine interest, although from a higher or more strategic view. The overall policy perspective and related issues were expressed, and all acknowledged complexity in the development of alternate markets, regardless of the product.

Issues such as market acceptance, transport, market development and competition with imports were raised, and from this sector the most promising development has come from actions of the NSW DEC, which has completed significant commercial evaluation of the use of used container glass in road-making and other construction applications. The Department indicated that it will be releasing their specification and report on commercial use prior to August 2006. The NSW DEC can provide an excellent source of local knowledge and information and should be consulted as Western Australia develops its plans.

ZWSA has recently announced funding to assist with the establishment of infrastructure necessary for the state to meet its targets and goals outlined in the SA Waste Strategy 2005–10.

### SA takes aim at C&I waste as funding for infrastructure announced

Seven grants totalling $1.3 million have been awarded to help divert an estimated 130,000 tonnes of commercial and industrial waste from SA landfills. "One of the key targets of our strategy is for a 30% increase in the recovery and use of [C&I] waste materials by 2010," said Environment Minister Gail Gago. "We need to invest in infrastructure to achieve this target. The grants have stimulated investment by industry for infrastructure projects, which in many cases, would have been delayed or not happened [without the grants]."

Plastics Granulating Services, the state's largest processor of post-consumer plastics, will receive $250,000 for an extruder, washing plant and compaction press that will enable it to process more difficult plastic wastes, including heavily soiled films and plastics with high moisture levels.
5.0 APPLICATIONS

A significant amount of research and market analysis has been completed by a small number of specialist organisations throughout the world, which have identified that viable alternatives for the reuse of glass do exist. The most significant limiting factor, however, is (for most of the applications,) achieving the economic balance between processing and substituting glass for other virgin raw materials typically of low value and in abundant supply.

The typical properties of a product to which we are looking to substitute have as their core structure silica or sand, inferring immediately that most alternatives are likely to be sand-based applications or silica replacements. This is confirmed by most of the development work carried out globally.31

In the case of Western Australia, some sands are widely recognised as being among the purest silica-based, and lowest in iron content found anywhere in the world. Therefore, reusing glass as a possible alternative to cheap high-grade sand or silica applications provides its own challenges to economic modelling.

Whilst it is desirable to include environmental and social considerations in any evaluation, typically business decision-making is made on an economic basis for low-margin high-volume sales.

In determining the possible alternatives for the used glass, we identified and investigated an extensive array of alternate uses based on our previously described research methods, including:

- a comprehensive international internet search, as detailed in the bibliography
- an evaluation of numerous publicly available reports
- consultation with current re-processors and users of recycled cullet.

It is clear that nearly all of the market development studies and programs that have been completed both within Australia and internationally have all been principally driven by governments and their associated agencies. Therefore, most of the reports available focus on the expected application and its projected benefit, rather than a real commercial outcome and quantification. Whilst the glass manufacturing sector, in principal, supports the alternate use of glass, it has only taken a financial involvement to fund market development work in Tasmania, with governments endeavouring to fill this void in other states.

The Waste and Resources Action Programme (WRAP), United Kingdom has in our opinion, undertaken arguably the most comprehensive and extensive market development research, trials and studies with definitive commercial value, documented and published findings from an international perspective. Many of the developed applications now have accreditation with the British Standards Institution.
Leading Australian industry players\textsuperscript{32} confirm our view and agree that WRAP’s financial analysis of many applications mirrors the Australian situation very closely. Therefore, we conclude that the WRAP Research is valid in an Australian context, contains relevant background information and provides excellent reference material. These reports have been provided in electronic form accompanying this report.

More recent development work has been undertaken by the Sustainability Branch of the NSW Department of Conservation (formerly Resource NSW), in conjunction with the NSW Roads and Traffic Authority and Boral, with impressive results.

In New Zealand, the Zero Waste New Zealand Trust has completed and compiled an extensive analysis of possible applications, particularly relevant to its needs. The analysis certainly confirms most other work completed internationally as to the possible reuse applications.

A summary of potential applications for post-consumer glass which have been extensively researched and reported are listed below:

\begin{table}
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Use} & \textbf{Application} \\
\hline
Glass bottle production & Cullet recycled to make new bottles \\
Sand/abrasive grit blasting & Sand blasting and abrasive industry \\
Insulation batts & Roofing and wall batts \\
Asphalt (glassphalt) & Road-making and asphalt works \\
Construction and road aggregates & Non-engineered aggregate replacement \\
Sports turf/drainage & Golf course, parks and drainage use \\
Brick-making & Fluxing and fill use \\
Water filtration & Water filtration and sewerage \\
Anti-termite barrier & Use as a barrier application \\
Concrete aggregate & Use in Concrete \\
Alternate day cover & Cover material used in landfills \\
\hline
\end{tabular}
\caption{Potential Applications for Used Container Glass}
\end{table}

5.1 Glass Bottle Production

Incorporating used glass in the manufacture of new glass containers is the highest resource use for this commodity. Australia currently has two glass container manufacturers, Owens Illinois (OI) and AMCOR. OI manufactured glass containers in WA for over 50 years, until 2003 when the local plant was closed, as it had become uncompetitive against cheaper imports. AMCOR has one plant in South Australia, specialising in wine bottle production for the local and export market.

Both companies operate on similar principles, whereby incoming cullet must meet predetermined quality specifications and be cost-competitive with virgin batch prices, as a general position. As collection systems have become increasingly automated and with commingled systems becoming the norm, glass must be colour-sorted, typically at MRFs, and then delivered for beneficiation where further cleaning, grinding and screening occurs.

\textsuperscript{32} Mr Jim McLeod, AGT
A possible alternate market for glass cullet is as feedstock for mini-melt mills, small re-melt and bottle-making plants capable of using small quantities of glass and manufacturing specifically for boutique wine- and beer-making operations.

Whilst this may have been an option for WA, it appears that the proximity to the Asian and Middle East and the current pricing of imports precludes such an operation from becoming viable in the foreseeable future.

5.2 Sand/Abrasive Grit Blasting

Processed used glass can be used as an abrasive blasting medium, in engineering and similar roles. The glass must be crushed and screened to a size no larger than 1.5 micron. It must be free of contaminants, that is, paper, plastics and dust but Pyrex and inert materials – dirt, dust and stones – can be included, provided they meet the particle size and are kept to a minimum.

The process of crushing and cleaning or beneficiation must be closely managed, as without proper quality controls the shape and size of the product will be too varied for proper application.

Critical to the use in this application of used glass is the shape of the processed glass, as the cullet must be converted from its flat structure to a cubic shape for benefit. This requires specific crushers to be used and, as the glass in itself is highly abrasive, this directly impacts on the type and quality of equipment that can be used. Simply crushing and screening glass will only produce a very low-quality product, with a corresponding low market value. Cubic-shaped particles or grain in shape enables the product to more readily remove paint and other materials and directly compares to the virgin sand or garnet material mainly used in this sector.33

Colour is not an issue, so the raw feedstock can be refined from fines generated during the collection and processing at a MRF. The material is best used in outdoor applications, as glass has one significant drawback due to its powder residues: causing skin irritations, particularly under gloves and collars when workers are using it in poorly aerated environments.

5.3 Insulation Roofing and Wall Products.

Recycled glass can be used as an ingredient in the manufacture of fibreglass insulation products. The feedstock material is usually sub-200 micron and is generated by melting, screening and spinning the product. The manufacturers of the insulation generally prefer to use recycled plate glass as its consistency and quality are usually superior to used container glass.

The production cycle requires the glass to be melted at more than 1500 degrees Celsius and, when discharged from the furnace it flows over a series of fine screens. Thus it is imperative no contaminants are contained in the material stream as it is discharged. Ceramics are of particular concern if contained in the mix, as these can severely impact on the operation as a safety issue and with regard to cleaning of the screens, as well as creating hot glass overflows and poor consistency in the glass fibre production outputs.

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33 Interview with Mr Jamie McKellar, Alex Fraser, Mr Greg McAlister, Blue Circle Cement, Mr Mark Chandler, March 2006, Queensland Recycling.
5.4 **Asphalt Aggregate Use (Glassphalt)**

Asphalt that contains glass cullet as an aggregate or filler is sometimes called “glassphalt”, which is basically the same as conventional hot-mix asphalt, except that it may contain up to 30% glass cullet.

There are a number of recorded uses in the USA and Europe of glass fines as a road base or additive to the asphalt surface of secondary or private roads. An inherent problem with the glass is its low compressive strength. Consequently, it is necessary to use it only as filler within conventional road base mixtures. The use of glass fines in asphalt (“glassphalt”) can result in a “hungry mix”, deficient in binder unless additional binder is added into the mix.\(^{34}\)

The research to date reports that if properly batched and laid, it poses no issue to users of the surface and has benefits over conventional asphalt, as it may hold heat longer after batching, in transport and laying. This benefit may prove useful in situations where roadwork is conducted in cold weather, or when long periods of post-mix transportation are necessary.

The research also suggests it may have superior anti-water penetrating properties as well as some reflective benefits. These attributes are directly a result of the particle size, percentage used and in the way it is laid.\(^{35}\) Significant research has been completed both in the UK and by Pioneer Road Services, Midland, Perth.

5.5 **Replacement of Virgin Aggregates in the Construction Sector**

Glass, provided it is free of contaminants, particularly paper, metals, plastics and organic residues, has a major application in replacing virgin aggregates in non-structural, low-grade construction markets.

The cleaned cullet can be used in various general applications including general backfill, general construction purposes such as site grading, filling under slabs, backfilling beside foundations, utility trenches, roadways, gutter drains, behind retaining walls and landscaping, provided the use does not contravene specific engineered requirements.

Research suggests that for drainage applications such as retaining wall backfill and drains, the permeability of minus 7 mm cullet material is about the same as that of natural sand and the permeability of the minus 20 mm cullet material is about the same as that of natural gravel. Therefore, fill material made of 100% cullet could be used for construction of drainage facilities and to displace virgin aggregates in these applications.

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34 Dr Ron Wainberg, Strategic Waste and Resource Management Plan, Rottnest Island Authority, APC.

Trials in the USA have found that:

The use of 100% waste glass as pipe backfill aggregate appears to be a viable alternative to conventional pipe backfill material, based on the initial assessment of field performance. However, compaction efforts must be closely controlled in order to achieve complete, tight compaction and prevent settlement. Also in order to provide users with a means of control for acceptance, it will be necessary for the glass to be provided to continually meet a gradation acceptable for this use, as is the case for all aggregate products supplied (U.S. Department of Commerce – National Technical Information Service).

The NSW DEC, in conjunction with the NSW Roads and Traffic Authority, has conducted commercial trials and is expected to release the specification on the use of glass by August 2006. This specification shows that glass has a wide range of applications in these sectors.  

5.6 Sports Turf, Golf Courses, Parks

WRAP in the UK has conducted a significant amount of research and demonstrated that used glass, if beneficiated, is a suitable substitute for natural sand in sports turf applications, especially in golf courses and bowling greens.

Research reports confirm that a typical golf course can use between 2,000–3,000 tonnes of sand per year for bunkers, divot repairs, and dressing of fairways, greens and tees. In the UK and USA, trials have shown that a significant proportion of this could be replaced by glass sand.

5.7 Rehabilitation of Sensitive Environments

Research from WRAP has confirmed that glass has excellent properties for use as a drainage medium in sensitive environmental areas, particularly wetlands and grass regeneration locations, as its shape and structure actually promotes better root growth than sand, and allows for better water penetration and flow.

5.8 Brick-making

Used glass, provided it is sized to at least 250 microns, has an application in brick-making. Research from the UK and from within Australia shows that the addition of glass in bricks can assist in reducing the energy costs of production, as well as building a better brick.

Boral currently uses recycled glass powder in its brick manufacture in NSW and also in tile firing. Glass can be used as a filler, in the fluxing process and colouring, but must meet critical laboratory standards and firing conditions. In Western Australia it has been identified that technical limitations will need to be overcome before this sector opens to an opportunity.

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36 NSW DEC presentation May 2006 Queensland Mr Rod Clare.
37 Mr Jim McLeod, March 2006.
5.9 Water Filtration Medium

Processed and clean glass has a wide application as a water filtration medium and in most applications where sand or similar aggregates are used for the same purpose.

WRAP in the United Kingdom has conducted an enormous body of work and concluded that there are significant benefits in several applications, provided the material is processed and prepared properly.38

5.10 Concrete Aggregates

It is widely reported that glass can be used to substitute some of the aggregates used in concrete production. The development work completed by WRAP and CWC has proven the commercial application and acceptance of the product.

One of the drawbacks of using recycled glass is that some chemical reactions can occur that may reduce the strength of the concrete or cause it to crack. These chemical reactions occur as a result of the cleanliness of the product and are usually caused by sugar reactions from residues of non-compliant processed glass, which causes reactions with the alkali content in the cement. This issue is overcome by applying strict processing and quality standards to the process and operations.

There have been a number of trials in which crushed glass has been used as a cement extender and a replacement for fine sand within the concrete mixes. The NSW EPA undertook trials of the use of glass fines in a number of concrete pavement materials. Glass fines were added in different proportions to concrete samples to find the optimum level. The results indicate that there has been negligible impact on compressive strength. In fact, an improvement in pore space within the concrete was apparent.

In NSW, Blue Circle Cement, in partnership with the NSW Roads and Traffic Authority and the DEC, has conducted extensive trials and standards for this application will shortly be released.

5.11 Landfill Applications

Glass fines are suitable media for landfill cover and have been successfully used overseas and in Australia. The glass can be mixed with green waste or clays and can provide durable alternatives to clay or other fill. The design of a final landfill capping includes a drainage layer. Screened and crushed glass fines are a suitable material for use in this application.

Trials in Australia have been conducted by Waste Service NSW, now trading as WSN Environmental Solutions, wherein glass fines were trialled at its Belrose Landfill in Sydney. The trial results indicated that glass fines are an acceptable material for daily landfill cover. The use of cover material must be approved by the local regulatory authority.

Glass fines have been used in small quantities as a substitute for aggregate around the leachate lines within landfills. However, an issue with the use of the fines as drainage media in landfills is an increase in the Biological Oxygen Demand (BOD) of the leachate, as a result of the sugars and other organic materials that had adhered to the broken glass from the product that the glass had contained.

Another issue is that lines have been found to have become completely encased in an impervious cementitious layer. This occurs because very fine glass particles (<1 mm) mix with the metal precipitates from the leachate and form an impervious cement-like layer around the filter sock of the leachate line, effectively blocking it.

The use of untreated glass fines as substitute aggregate in drainage lines is not recommended unless pre-treatment has been carried out. Vacuuming, screening and washing of fines would be required before they would be suitable for use as drainage aggregate.39

39 Dr Ron Wainberg, Strategic Waste and Resource Management Plan, Rottnest Island Authority, APrince Consulting.
6.0 GLASS REPROCESSING – THE PROCESS, EQUIPMENT AND COST

The major challenge for any glass crushing operation is not the crushing and screening but the separation of contaminants from MRF residual, which is labour- and capital-intensive. The difficulty concerns the extraction of foreign material including bottle tops, plastic bottles, paper and household waste.40

Information from manufacturers and manufacturers’ agents regarding plant and equipment is difficult to obtain, as when approaches are made for capital costs, operational costs and technical data, particularly when sensed for the purposes of a report, these are not well supported as they represent substantial effort with few prospects of sales.

Glass is four times as abrasive as quartz, so equipment used in the sector tends to be of the impact variety rather than the abrasive variety, due to the wear on equipment. Most crushing equipment is developed from the mineral processing industries, where units tend to:
- be very robust
- require relative low maintenance
- be a non-hazardous operation
- be readily serviced by local agents
- be capable of achieving large throughput rates
- have a second-hand value.41

6.1 Typical Glass Reprocessing Equipment

The following information is sourced from a report by a leading recycled glass expert, equipment agent and reprocessor from NSW, which states, inter alia42: “The major challenge of any glass crushing operation is not the crushing and screening but the separation of contaminants from the MRF residual which is labour and capital intensive”.

The types of equipment necessary for and applicable to the glass recycling industry are as follows:

6.1.1 Storage – outside bunkers are the most common and are preferably under cover, so that during heavy rainfall the material remains dry. Wet cullet can reduce throughput significantly, particularly when screening. Fine particle sizes, for example, abrasives, will agglomerate, resulting in a non-saleable product. The disadvantage of internal storage is that increased dust can affect equipment. It is important to have an immediate beneficial use for crushed glass, as its storage in open stockpiles can cause issues including:

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40 Peter Harkins, Manager, Controlled Environment.
41 Peter Harkins, Manager, Controlled Environment.
42 Equipment for Recycling Glass by Peter Harkins, Controlled Environment.
• Testing of run-off of stormwater leaching from some glass stockpiles indicates a very high pollutant load (BOD$_5$ of 2630 mg/L and nitrogen at 110 mg/L), well in excess of the levels allowable for discharge to freshwater
• The organic residues in the glass can emit an odour
• Birds may feed on the organic residues within the glass
• These organics are likely to attract other vermin and vectors.

6.1.2 **Hopper** – most plants will benefit from a surge hopper with a capacity to hold up to 10 tonnes of material for feeding of the crushers.

6.1.3 **Internal handling** – the use of conventional conveyors with rubber or synthetic belts is suggested. Where elevation is required, ribbed conveyors rather than those with cleats should be used, as cleats are prone to damage. Conveyors should be of a concave type similar to that used in mineral processing. Speed should be kept low to reduce wear.

6.1.4 **Pre-screening** – feeding already small pieces of glass into crushing and pulverising equipment is undesirable, as it requires additional energy and tends to reduce throughput rates. A pre-screening operation to capture a desired size range to bypass the primary crusher is desirable, through the use of a trommel or vibrating screen with an average size of greater than or equal to 6 mm.

6.1.5 **Metal removal** – a magnetic head or belt should be provided over the conveyor to capture any ferrous metal prior to processing; this will prevent damage to downstream equipment.

6.1.6 **Milling equipment** – a variety of different pulverisers and mills are used throughout the glass industry, and no single piece of equipment suits all applications. The main types of pulverising, crushing and milling equipment are outlined below:

• **Ball mills** – generally extremely heavy, require large horsepower drives. A small machine in the order of 2 m x 1.5 m would require 70–100 Hp. Most overflow design mills cannot produce large volumes of material at, say, 20 mm, but can produce volume at less than 50–100 um. A typical system described could produce up to 5,000 tonnes per annum.

• **Disc mills** – normally much lighter than ball mill systems. The principle is two opposing rotating plates. They are generally restricted to one size grade and require a medium (50–60 Hp) power source. The feed system for this type of mill does not lend itself to raw cullet, and the plates are susceptible to abrasive wear.

• **Hammer mills** – can be of medium to light construction, with power requirements from 30 Hp. The principle is a rotating drum with knife blades. They are susceptible to wear from products such as cullet. Hammer mills will cope to some degree with contamination but struggle with plastic bottles and metals. Aluminium and ferrous cans can cause blockages. These mills require regular maintenance, and replacement costs of hammers and liners may be as high as $5 per tonne.
• **Andela** – this is a type of pulverising screw type hammer mill, with spiralling hammers. Product is screwed through the machine to a large outlet. This equipment has been specifically designed for kerbside recycling and copes with contamination – because of the screw mechanism it has the ability to retain the debris of large pieces rather than shredding them, making downstream recovery easier. This type of mill is ideally suited to MRF rejects and MRF glass product.

![Andela glass crushing equipment](image)

• **Vibrating Kinetic Energy mills** – the principle is one or more horizontal cylinders mounted on a vibrating base. The cylinders are partially filled with a round ball charge, similar to a ball mill. Power requirements are low and, depending on the feed and vibration rate set, can produce a range of material from <5 um to 50 mm.

• **Vertical Impactors** – are common in the industry, particularly for beneficiation for glass bottle manufacture and size reduction for glass bead manufacture. The units are designed to cause an impact of glass on glass; they are unsuitable for handling most types of contamination and should only be used with glass free of contamination.

![Vertical Impactor used at Earthcare, NSW](image)

• **Cone/rolls and other sizing crushers** – are not used to any extent in the glass industry, owing to their inability to cope with contamination and their accelerated wear, due to glass abrasion.
• **Glass breakers or pre-breakers** – these are often used in MRFs to increase the storage density and to allow the escape of liquids and the removal of bottle caps.

6.1.7 **Product size screening** – as in the milling equipment, different screens are required for different purposes in glass processing:

- **Trommels** – slowly rotating drums, inclined with cylindrical screens into which product is fed at one end, and from which it tumbles downwards. Particles smaller than the screen mesh pass through the screen wall into sheets below, while larger fractions pass out through the lower ends. These units are suitable for separating crushed glass from contamination such as paper and plastics. A limitation is that if multiple screen sizes are included in a single trommel, all the product to be screened must pass over the finer screen, and this reduces the throughput rate.

- **Sifting-type screens** – are usually rectangular in shape and do not have a vertical component. They are usually slightly inclined and can be stacked. These screens are ideal for fine-size separation for applications such as glass bead production and blasting abrasives, however, clogging of screens can occur.

- **High-G screens** – are similar to the sifting screens described above, except that they have a vertical component to their motion, which lifts and throws the material forward. These screens are useful for the sizing of abrasives.

- **Rotary screens** – are not well suited to glass sizing but are known to perform adequately in glass abrasive production, although at a slow rate.
• **Mogensen Sizers** – have been used for very effective glass gradings and should be considered as alternatives to sifting and High-G screens.

In all fine-screening installations, a dust collector is necessary, as screening generates large amounts of dust. Screening closures or the application of a light mist are possible methods of dust control.

**6.1.8 Washing** – washing of MRF reject product has benefits in that it eliminates contamination and odours, it is a relatively inexpensive operation, usually in the form of a rotating drum with water in the bottom and a vein or veins to stir and mix the glass. Washing can reduce equipment wear and increases throughput rate by improving the ease of screening. Wash water needs to be recirculated through a coarse filter. If washing is carried out concurrently with other processes, it is necessary to include drying equipment.

The washing of product will greatly increase internal plant loads, in particular, wastewater management systems, and these should be thoroughly investigated prior to their introduction. The greatest impact on the business will be the capability of the operation to manage the wastewater residues, which typically will have a high organics loading and thus require specialist and costly disposal solutions.

**6.1.9 Drying** – rotary dryers may be necessary additions, particularly for the production of less than 1.5 mm product, if storage is outside. Drying will accelerate milling and screening and may be necessary to stop product agglomeration. Milling and screening will achieve the same degree of drying.

**6.1.10 Colour-sorting** – is only necessary for supply of glass to the container industry.

**6.1.11 Dust control** – dust extraction equipment is necessary as glass processing generates a large amount of dust and reduces the amount of unwanted fines in the product. The use of centrifugal bag-type extraction equipment is recommended, as cartridge-type elements are easily over-loaded. Glass in the air-stream is extremely abrasive.

**6.1.12 Packaging** – glass product is usually packed into one of three forms:
1. Bulked into tippers or shipping containers, a conveyor or loader is required.
2. Bulker bags of 500 kg – 1.5 tonnes
3. Sacks of 5–25 kg for bulk use

**6.1.13 Configurations** – many configurations are possible, including:

• **Attached to an existing MRF** – a reject MRF conveyor would feed directly into a hopper. Direct feed from the MRF eliminates double-handling and the need for infeed bunkers. The hopper feeds onto a conveyor with belt magnets above, leading to an Andela pulveriser, then to a conveyor leading to a trommel for removal of contamination, and resulting in two streams of mixed cullet, < 10 mm and < 3 mm, with the finished product stored in bunkers. With a throughput of between 1–10 tonnes per hour, a waste stream of 1–2m³ per hour of uncompacted waste could be expected.
This product could be used as roadbase or sub-base or could be further refined. The estimated installation cost is $400,000, excluding building, awnings and dust collection. A typical configuration is shown below.

- **Mobile plant for construction aggregate** – transported in a semi-trailer for use in processing stockpiles at various locations. The plant would include all of the items listed in the preceding section, with a hopper being loaded from a front-end loader. The out-feed would be fed off a conveyor onto the ground or pavement slab. The plant would most likely be contained in a single purpose-built trailer; the cost would be in the order of $500,000, assuming power is available or a generator would be hired for the purpose. The operating costs for mobile plants are generally higher than those in a fixed location. However, they are ideal for smaller volumes in rural areas which do not justify a permanent plant. Feedstock would be MRF reject, or kerbside glass waste.
6.2 Glass Crushers in Australia

There are no glass-crushing units currently manufactured in Australia.

6.2.1 Andela

One equipment manufacturer, Andela from USA, has sold and commissioned a number of units in Australia, principally in NSW. The Andela Glass Pulverizer is ideally suited to MRF glass product and rejects, having been specifically designed to handle kerbside recycling. The unit accepts all kinds of glass and pulverises it into an aggregate, the consistency of sand and fine gravel.

The unit copes well with most types of contamination such as steel cans and plastic bottle caps, which, due to the type of mechanism used, can pass through the unit without causing damage. The unit retains contamination as large pieces, making downstream sorting considerably easier than that of convention pulverising equipment.

These units have been successfully installed at the end of MRF conveyors, typically located outside undercover MRFs to minimise the abrasive nature of the dust emanating from the process, and are used to crush the glass fines to a consistent size. Currently five units are in operation in New South Wales:

- 2 x 20-tonne-per-hour machines operated by Thiess at the Canberra and Thornton MRFs
- 1 x 10-tonne-per-hour machine operated by Thiess at the Wollongong MRF
- 1 x 1-tonne-per-hour machine operated by JR Richards at Orange MRF
- 1 x 1-tonne-per-hour machine currently being installed and commissioned at the JR Richards MRF at Port Macquarie.

Visy Glass had a 10-tonne-per-hour machine in Victoria, however, the current status and location of the unit is not known.
The Andela unit is a pulverised or screw-type hammer-mill into which product is introduced to a series of spiralling hammers and screwed through the machine to a large outlet. It is recommended that a magnetic head be installed prior to the pulverising unit to reduce any potential damage from heavier metal items.

The barrel design of the unit means that glass enters at one end and exits at the other after passing through 30–100 double-hinged hammers. The unit is lined with replaceable liners, with the gap between the breaker bar and the apron determining the particle size. The output of the unit is typically glass fragments of less than 10 mm in size.

Glass is top-fed above a central rotor. The rotor is horizontally orientated and has a continuous breaker bar attached to it, which propels the glass against one or more aprons. The unit is lined with replaceable liners and the product is discharged directly out the end.

After being processed in the pulverising unit, the material is passed through a trommel for size separation. Typically the trommel screen sizes are 0–3 mm, 3–10 mm, and waste is discharged at the end.
6.2.1.1 Capital Costs

A one-tonne-per-hour unit would cost approximately $63,000, however, with the associated hopper, in-feed and out-feed equipment, the complete system could be in the range of $160,000–$170,000. This would be suitable for a small MRF processing 3–5 tonnes per hour.

A larger 10-tonne-per-hour machine has a double barrel and separate screens and the unit cost is between $300,000–$400,000, while a 20-tonne-per-hour machine, currently not in operation in Australia, would cost approximately $500,000. A new five-tonne-per-hour plant is currently manufactured, however, is not in use in Australia at this time.

6.2.1.2 Operating Costs

Data provided by equipment manufacturers often relate to best-case scenarios, and organisations using equipment will not divulge the true costs, due to commercial-in-confidence issues, knowing the information will become public knowledge. The performance of units is also highly variable, depending upon the rate of wear and tear, and the resulting maintenance costs vary significantly.

An economic analysis undertaken by Professor Sorrell at the University of NSW as part of the NSW JPG project, when reviewed by Australian Glass Technologies, indicated that from that company’s direct experience with units that were similar to those assessed, the economic analysis of operating costs tended to be underestimated, sometimes by a factor of up to ten times. Professor Sorrell concluded that more accurate data can only be obtained by commissioning trial studies from manufacturers.

Care should be taken when calculating wear during glass processing on a tonnage basis, as wear tends to occur on a time basis rather than a volume basis. Maintenance caused by wear and tear and power costs account for approximately $5–$8 per tonne processed, provided the machine runs at optimum capacity.

It is much better to run a well-loaded machine flat out for two hours than to run it slowly for four hours. Crushing in batches after stockpiling of glass occurs in many situations. Hammers and drums wear out while the machine is operating whether or not glass is going through. As one side of each hammer will wear, it needs to be turned to the other side at around 250 hours. Hammers therefore have a life expectancy of 400–500 hours at a replacement cost of $5,000. The unit must be cleaned weekly and hammers inspected and planed every two hours of operation. Hammers should be changed every 400 hours and liners changed every 800 hours. Changing hammers would typically require two people half a day.

The hopper’s capacity can be up to 12 tonnes. It is not necessary for an attendant to be with the unit at all times, however, the unit needs to be monitored at least once or twice during the shift.

We are advised that other brands and specifications are similar, and costs are relatively similar.
6.2.2. Vertical Impact Crushers

6.2.2.1 Capital Costs

Australian Bale Press, at its Earthcare facility in Somersby near Gosford in NSW, operates a Svedala Vertical Impact Glass Crusher.

![Svedala installed at Earthcare NSW](image)

The unit can run on 1–7 tonnes per hour, however, at low volumes it is very expensive to operate. An advantage of this unit is that it has lower maintenance costs overall, and it tends to be installed in large MRFs. The capital costs are around $110,000.

6.2.2.2 Operating Costs

The plates and hammers need to be replaced every two months (assuming seven tonnes per hour, six days per week, 24 hours per day of operation) at a cost of approximately $1,500 per set. The rotor needs to be balanced and hard-faced every three months or 1,700 hours, at a cost of approximately $1,200–$2,000, and replaced every 5,000 hours.

### Vertical Impact Crusher Operating Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Replacement Frequency</th>
<th>Cost Each Time</th>
<th>Cost per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trail plates and hammers</td>
<td>1,100 hours</td>
<td>$1,500</td>
<td>$1.36</td>
</tr>
<tr>
<td>Rotor balanced and hard-faced</td>
<td>1,700 hours</td>
<td>$2,000</td>
<td>$1.18</td>
</tr>
<tr>
<td>New rotor</td>
<td>5,000 hours*</td>
<td>$10,000</td>
<td>$2.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$4.54</strong></td>
<td></td>
</tr>
</tbody>
</table>

Operating costs excludes power and based on seven tonnes per hour throughput
* Estimate for calculations only

6.3 Cost Estimate of Glass-crushing Plant Components

It is not possible to accurately cost a plant without a floor plan, plant design, known quantity of feedstock, location for transport of feedstock and output to market, product ranges to be manufactured and method of dispatch. However, the information provided below provides the reader with a sense of the equipment and indicative value of such.

---

6.3.1 Feedstock

6.3.1.1 Transportation costs – variables are enormous and road transportation complex. Crushed glass cullet typically weighs 1,500–2,000 kilos per m³. Indicative costs would be 12–15 cents per tonne per kilometre for coarse material.

6.3.2 Infrastructure

6.3.2.1 Land – not possible to estimate, as the location of the plant is unknown.

6.3.2.2 Structures – the cost of structures depends on location, size and nature. The price for bulk storage sheds of high tensile steel, with a 3.6-metre ceiling height, is $6,000 per 100 metres of floor space, plus labour.

6.3.2.3 Services – power, water, and compressed air depend on the nature and location of the building, and the costs are therefore unknown.

6.3.2.4 Storage – for covered storage bunkers, an indicative cost for 5 x 5 x 4.5 metres = $7,500.

6.3.2.5 Materials Handling – for a front-end loader, the standard equipment used for handling large amounts of material in batches, an indicative cost for a two-tonne capacity is $90,000. For a six-tonne capacity, the cost is $200,000.

6.3.2.6 Forklift – this is standard equipment used to handle smaller amounts of material typically packaged, that is, bagged. The indicative cost for a two-tonne capacity is $25,000.

6.3.2.7 Conveyors – rubber or synthetic belts are most suitable, costing $2,000–$3,000 per metre.

6.3.2.8 Feed Hopper – a standard materials-handling unit, storing and maintaining a constant supply of raw materials. They have various feed configurations, and cost $10,000.

6.3.2.9 Magnetic Head – Overhead belt magnets are stationary permanent magnets that are placed above the belt for lifting of magnetic materials. An indicative cost is $9,000.

6.3.2.10 Crushing units – primary crushers are many and varied and range in price from $30,000–$100,000.

6.3.2.11 Dust Control – glass-crushing requires appropriate extraction and filtering equipment to be fitted and appropriate personal protective equipment to be used. Most dust systems are designed to reduce dust levels with an extraction and collection system that consists of the following components: negative pressure ducting, a trommel, a drop-out box, gas cyclone, bag house and an extraction fan. Alternatively, a plant-wide misting system or controlled humidity system are possible means of dust suppression. The cost of such systems is unknown.

6.3.2.12 Weighbridge – weighbridges can vary in price from $20,000–$50,000.
Refer to Appendix 1 for a full list of suppliers and costing of equipment.

6.4 Confirmation of Plant Costs

Industry experts confirm that operating costs for a standard plant processing 40 tonnes per week would be around $10 per tonne processed plus power. To construct a basic plant with a four–five tonne per hour throughput (operating one day per week) would cost around $200,000 comprising:

- **Crusher** $40 – $60,000
- **Hooper** $10,000
- **Conveyors** $10,000
- **Trommel** $30,000
- **Electrics** $20,000
- **Output conveyors** $30,000
- **Labour installation** $40,000
- **Total** $180,000

Peter Harkins of Controlled Environment estimated the cost to establish and operate a glass recycling plant to manufacture glass to be used in the top-end market of blasting abrasive would be in the range of $500,000–$1,000,000, depending on cullet quality. Throughput would need to be at least 500 tonnes per month, which equates to four tonnes per hour on the basis of eight hours per day, five days a week of operation. The cost of production is estimated to be $70–$80 per tonne, with $60 per tonne being seen as a minimum.

AGT Directors confirm the cost of establishing their Gold Coast facility is estimated to be greater than $600,000, excluding the building and lease arrangements, as it is housed as part of the operating MRF facility. In Queensland it has taken AGT two years to establish reliable markets for all of its outputs.

It is estimated that a minimum of 7,000 tonnes of glass inputs would be required to establish a viable plant in WA, subject to the immediate and short-term market opportunities for the processed product. The most likely viable high-end use is as abrasive media.
7. **IDENTIFICATION OF LOCAL MARKET OPPORTUNITIES**

All the research and stakeholder discussions confirm that the alternatives available for the reuse of glass are replacing and displacing the use of virgin aggregates, being sand or silica-type raw materials.

From our evaluation of the Western Australian market and the identified alternatives available for the reuse of glass, a more fundamental issue needs to be addressed in developing the solution for the state from the outset. This significant issue is how we might transition from a situation wherein collectors and processors have received value for the material (although this is now greatly diminishing in return) to a situation wherein, regardless of the use, any alternate application will require the material to have a substantial lesser or negative value to the collector and processor if it is to compete against low-value, high-quality raw materials.\(^4^4\)

All solutions, both immediate and longer term options will require some beneficiation of the glass before it can be reused. Currently the MRFs produce two product streams: either as 60 mm plus which is positively sorted and relatively free of contaminants or a 60 mm minus, which is highly contaminated with labels, lids and ceramic.

The beneficiation process can consist of a simple crush and blow operation to remove contaminants for low-grade applications, however, for the higher value end-markets the material will require a more sophisticated cleaning process to be completed as is detailed in the previous section of this report. For an investment to be made in a processing facility and market development of the identified opportunities undertaken, it is critical that current volumes of glass recovery are maintained to enable a return on the investment to be made.

There are several immediate strong market alternatives for the product within the state however, we must also report that the value of the material that the glass will be competing with initially is virtually valueless, that is, as a delivered processed material its competitor has a value of $4.50 - $12 per tonne to the operator. Higher value end-markets are available but will require market development to gain acceptance and customer confidence which will be built and developed over time through with published and promoted results.

The local market opportunities identified include:

**Immediate opportunities**
- Continued glass bottle production (OI)
- Asphalt (Pioneer Road Services)
- Abrasive market (Total Corrosion Control)
- Concrete and road base (Government Contractors)
- Non-engineered construction applications (Government Contractors)

**Longer term solutions**
- Brick fluxing and additives (Midland and Austral Brick)
- Block-making moulds (Glass Block Technologies)

\(^{44}\) Stakeholder interviews and literature research documents
• Water Filtration opportunities

7.1 Immediate Opportunities

7.1.1 Glass Bottle Production

In order to develop long-term opportunities for the reuse of glass, a transition period or interim arrangement to continue the current system is required. It is imperative that the glass manufacturing sector continue to use glass in bottle-making, as this will be a necessary relief valve and enable a transition to a more sustainable position. It is important to prevent a collapse of the current recovery of glass tonnes and to guarantee a feedstock for alternate uses through maintenance of the current collection system.

Limiting Factors and Challenges

OI has expressed a growing concern as to the increasing levels of contamination, in particular the impacts of pyro-ceramics being included in recovered glass and the failure of loads of recovered glass delivered to South Australia which fail to meet the company’s quality specification. This problem, unless it is addressed, will erode any resolve the company has to continue to purchase cullet from this state.

As a matter of priority, the community must be educated and made aware that items such as microwave plates, glass cookware and glassware are not recyclable and should not be placed in the recycling container for collection by commercial or kerbside collectors.

A possible solution is that the educational message of glass recycling be replaced with “bottle only” recycling messages to assist the public to differentiate between the items.

Current AWT service–provider, SMRC, who are endeavouring to recover an organics fraction from a residuals bin and directing its communities to place all glass items in the recycling bins. We understand the SMRC is seeking to invest in further technology to crush the glass recovered. Dialogue with the SMRC or other planned AWT operators’ to ascertain their communication programs and content should be considered.

Some service-providers with AWT plants are informing their constituents to place all glassware in the recycling bin. This is at odds with the state-wide message, will no doubt lead to community confusion and will need to be addressed.

Continued placement of ceramics in commingled or glass-only collections may also impact on the longer term higher value reuse applications, but ironically will have little or no effect in the abrasives or low-value construction sector applications.

Recommendation

1. That a broad, common-themed community educational recycling awareness program be developed and implemented State-wide immediately, communicating the key message of “bottle and jar recycling”. The program must identify that household cookware, glassware and light globes are non-recyclable.
7.1.2 Glass Reuse into Asphalt

Discussions were held with the General Manager, Asphalt Manager and Technical Manager of Pioneer Road Services, located at Midland, and revealed the company had reviewed a considerable amount of international research on glass being used in asphalt, however, that most of the studies were completed on applications where weather extremes and conditions, as well as road structures, were quite different from those in Western Australia.

The company has already completed trials in several locations in the Perth metropolitan area, using glass in asphalt, and has completed the preliminary technical work required to measure its performance. The trials were undertaken several years ago with the intention of substituting clean glass fines, sized to a specification, to replace virgin aggregates.

Pioneer expressed the view that it could use up to 5,000 tonnes of glass as a trial. The glass would be required to be crushed, cleaned of debris and screened to a size of 3 mm minus. The remaining technical and development work to prove its application would be at Pioneer’s expense. The testing regime will require monitoring of the weather conditions, surface wear, skid resistance and other criteria to prove its appropriateness and durability in the Western Australian climate. Pioneer sought an exclusivity arrangement until such time as the results of its application and suitability could be confirmed.

Subject to the results, Pioneer may be able to use up to 10,000 tonnes of product per annum over the longer term.

Limiting Factors and Challenges

A fundamental issue of economics needs to be addressed if this application is to be commercialised. Pioneer stated that the glass substitute would displace quarry dust or sand aggregates and the cost of these to the company is estimated at between $2.00 and $5.00 per tonne delivered. Pioneer sees the application as having some marketing advantage in the short term, and is prepared to complete all the remaining technical work required at its expense to assess and assist in developing the market.

The cost of the competitive materials is an issue and will require the suppliers of processed glass to incur a negative cost, as the cost of receiving, processing to specifications and delivering the material will be greater than the current price paid for the competitive materials.

7.1.3 Glass Reuse into the Abrasives Market

Discussions were held with one of Western Australia’s largest sand-blasting and corrosion control companies – Total Corrosion Control at Kwinana. The company’s Managing Director, Mr Tony Iaennelo, expressed a willingness to re-examine the use of glass as a substitute for the virgin aggregates he currently uses. Several years ago he used a product purchased from Visy Glass and found it to be quite capable in competing as a blast cleaning medium, however, several issues needed further consideration.
The company currently uses garnet blasting abrasives in its corrosion control operations and, like all other sandblasting and abrasive operations in the state, procures most of the product from GMA Garnet, based at Geraldton. The current purchase cost for the abrasive garnet material of between 45 and 55 microns is estimated to be between $150 and $200 per tonne.

The Managing Director expressed the desire to look at alternatives to the garnet, provided they were comparable both in cost and performance. He indicated a preparedness to assist in developing an alternate application for the material, particularly as it was now in use in Queensland, NSW and Victoria.

Limiting Factors and Challenges

Irrespective of the application, any dust-generating process, such as the crushing of glass, requires appropriate extraction and filtering equipment to be fitted and appropriate personal protective equipment to be used. Peter Harkins previously Visy Glass Manager and currently Director of Controlled Equipment, agents for Andela equipment in Australia advised that to his knowledge after extensive research there are no recognised health risks associated with the production of glass fines contributing to the respiratory disease silicosis.

However, we have identified that according to the Western Australian Department of Consumer Protection Worksafe Regulations, Code of Practice, Abrasive Blasting, section 2.2.2 and 2.2.3 specifically precludes the following materials from use in the Western Australian abrasives sector.

- A substance that consists of or contains crystalline silicon dioxide as an abrasive material in abrasive blasting except where less than 2% dry weight of crystalline silicon dioxide is present as a contaminant and
- A recycled material that has not been treated to remove respirable dust.

Peter Hawkins offers this opinion: The Crystalline Silica referred to is not applicable to glass, as glass is Amorphous Silica and is likely to be directed at the use of sand as an abrasive media. However, the reference to a recycled media is obscure, in that any blasting will produce respirable dust regardless of the media. Possibly they mean particles which can not be easily expelled from the lungs when inhaled, such as Crystalline Silica or alternatively that the raw material before blasting does not contain a significant amount of fines. Glass for blasting has the fines removed.

This code will be required to be reviewed and amended if used glass is to be a substitute material for garnet. Recycled glass is currently used as a blasting abrasive in Queensland, New South Wales and Victoria and is compliant with all safety codes and Material Safety Data Sheets for its application in those states.

Previous use of recycled glass had highlighted issues for workers where the product was used in closed booths, as the glass powder resulting from the abrasive process was found to irritate workers, particularly where it came into contact with skin. Therefore the company would need to review the personnel protective equipment used by its employees.
The local producer of the garnet is based in Geraldton and produces most of the world’s abrasive product. Competitive pricing and positioning may be an issue and market entry may be tougher than for other alternate applications.

Recommendation

2. The WMB should enter into discussions with the appropriate staff at the Department of Consumer Protection in relation to the exclusion of “products made from used container glass” in the Worksafe Regulations, Code of Practice, Abrasive Blasting. This prohibition is not present in other state legislation where used glass is part of these applications. Its presence will severely impact on the future business viability, as it removes a vital high-value market for processed used container glass.

7.1.4 Glass Reuse into Road-base, Drainage and Backfill Applications

Considerable development work has been completed and numerous reports are available on the use of glass in applications for road-base and backfill use, both in Australia and internationally. If used glass is to be used in these applications it must be presented similar to its virgin competitor and must be relatively clean, that is, it is preferred that it has been crushed to a nominal size and cleaned of excess paper, plastics and other contaminants.

Particle size is not a real factor in its use, but shape is for the application. Depending on the use, most reports suggest a range of sizes in line with its virgin competitor as being preferable. The primary reason for this is due to the fact that glass is classified as being in a liquid state, not a solid form, therefore it largely presents as always being fairly thin and flat in shape. Aggregates and sands, however, being of a solid form, present as cubic in shape and for glass to compete with its virgin counterpart it must be processed more into a cubic or spherical form to gain the technical and engineering benefit. Thin, flat material has limitations in its compaction and binding ability, whereas a cubic-shaped material fills and binds more effectively.

If glass is crushed and made more cubic in shape, the market opportunities in this sector are significant.

The use of virgin aggregates excavated from quarries is extensive, and used glass provides an immediate environmental benefit if it can be used in displacing some of these virgin materials. It is very difficult to accurately determine actual tonnes consumed as fill, roadbase and construction applications, however, conservatively many millions of tonnes of aggregates are mined, crushed, transported and reburied as road base nationally, whereas used glass is known to be a suitable candidate for substitution.

The most immediate market for cleaned and crushed used glass is through procurement and specification tender processes whereby local and state government agencies can create a market pull or demand for the material. Specifications need to remove the limitation of using only virgin aggregates in non-engineered and non-structural applications within the construction sector.
Used glass can be used to displace these finite virgin materials in many applications, but a lack of willingness by engineers, government procurement officers and government agencies to specify alternatives is a fundamental barrier to developing this market.

**Limiting Factors and Challenges**

Economic considerations are a paramount barrier to this opportunity as virgin aggregate is available free or at $3.00 per tonne and at between $4.50 - $12.00 per tonne delivered depending on distance from quarry. It would be questionable whether after processing used glass, it can compete in the market-place.

In considering this opportunity the broader social and environmental benefit must be considered in addition to the economics. In sustainability terms it makes little sense for a community to mine a finite resource, crush and transport it, only to rebury it again somewhere else, when a product already mined and used could, with some reprocessing, fill the void and displace this environmentally unsustainable process.

A change of mindset by industry and a willingness by government to become the driver for change is required to lead this opportunity.

**Recommendation**

3. *That the WMB hold a forum for procurement managers and engineers from local and state government departments and agencies to showcase the available research and applicability of using glass as a substitute for virgin excavated materials. Each department or agency is then to be set a time-frame within which it is required to modify specifications to incorporate the use of recycled glass in suitable applications.*

**7.1.5 Glass Reuse in Concrete and Cement**

Glass has a significant application in this sector, both in its use for concrete aggregate replacement, decorative applications and in the actual process of cement-making.

Used glass can be used with concrete, however, research has shown some chemical reactions do occur and the batching process is critical to the outcome. Boral and Blue Circle in New South Wales, in conjunction with The Roads and Traffic Authority and the DEC, has completed a significant amount of current development work.

The Alex Fraser Group in Victoria pioneered glass into concrete and in Western Australia, the Hanson Group has also used it successfully. Particle size and shape is critical for concrete use and a preferred size of sub-7 mm is required for it to be ideal.

Larger sized particles can be used in decorative applications and market opportunities do exist, however, substantial market development will be required to gain market acceptance and establish a market.

With regard to cement-making, Blue Circle has concluded that used glass powder can be used in the kilns as a substitute to fly ash, however, as Australia uses in excess of 6.0 million tonnes of cheap fly ash, the economic considerations as well as the environmental impacts of disposing of the vast quantities of ash must be considered.
Limiting Factors and Challenges

Economics and market development work remain issues that require resolving. If glass were crushed and cleaned ready for use, gaining commitment from concrete manufacturers and batching plants would be a key driver for change.

Local or state government can play a vital role by modifying purchasing specifications and specifying preference for used glass in concrete applications to create a market demand and market pull.

Recommendation

4. **That the WMB hold a forum for the concrete and cement industries, together with procurement managers and engineers from local and state government departments and agencies, to showcase the available research and applicability of using glass as a component in concrete and cement. Each department or agency is then to be set a time-frame within which it is required to modify specifications to incorporate the use of recycled glass in suitable applications.**

7.2 Longer Term Opportunities

The following applications, including brick-making, roof tile additives, filler compounds in glass block-making moulds and water filtration, require further research and/or market development.

7.2.1 Brick-making and Roof Tile Additives

Significant work on the use of glass in the brick industry has already been undertaken, and Midland Brick has expressed a willingness to develop this alternative market. If the technical challenges can be overcome, Midland Brick has the capability and capacity to consume most of the cullet material.

Midland Brick is committed as an organisation to replacing fill and other brick structures with recycled content, and has a specific technical goal of finding alternatives to the quarry dust it currently uses, as part of its environmental stewardship responsibility.

Being part of the Boral group, it is heavily engaged in looking at ways to increase the waterproofing of bricks, increase the light-weighting and developing new markets. Midland identified glass as a product that could possibly assist it to achieve these outcomes. Trials have been conducted locally, but with less than desirable results, compared to the outcomes in New South Wales.

Limiting Factors and Challenges

Compared to the Eastern States, the use of glass in brick-making production in Western Australia is more complicated. Technically, the Eastern States’ clays are more finely structured and thus more readily conducive to technical alteration, being more pliable, whereas the Western Australian base clay material used by Midland Brick is fundamentally different in its core structure.
The trials to date have shown that glass additives to the Perth clays, at a 5% addition rate, actually changed the brick colour by darkening it. The Hong Kong and Asian markets require bricks to have an absorption rate of no more than 5%, whereas the current composition of bricks in WA has a rate of between 9.5–11%. When glass was added, the water absorption dropped by 1.5%, which was still not sufficient to provide any export benefit.

The economic impacts are a concern, as competitor products are available at less than $8.00 tonne for clay and at less than $4.50 tonne delivered for dust or filler compounds. Glass would be required to be around 250 microns, thus the cost of processing it to this size is a matter for further consideration.

7.2.2 Glass Block-Moulding Additives.

Glass Block Technologies is a locally based export-oriented company which has developed glass block-building systems for use in walls and floors.

The Managing Director expressed interest in using processed glass as an alternative to the aggregates in the compound, but before this could be established technical specifications will be required to be developed and approved to ensure it is compliant with relevant building codes.

The block systems, inclusive of their compounds, are currently exported and the decorative elements within the compounds are based on aggregates. If used glass can be substituted in place of the aggregates and meet with technical building codes, export market opportunities exist for the product.

7.2.3 Water Filtration Replacement Applications

This market is significant in size, however, used glass would be required to compete directly with what is regarded as a high-quality sand medium. As other alternatives are established, residual streams of high-quality used glass can be sold into this sector, but it is very much a longer term solution.

Currently, PoolRite distributorships incorporate processed glass from the eastern seaboard at their manufacturing facility in Victoria, and product is sold into the Western Australian market, particularly for water and sewerage treatment plants.
8.0 QUANTIFICATION AND IMPEDIMENTS TO MARKET OPPORTUNITIES

8.1 Market Quantification

It is estimated that if 100% of all bottles sold in the state were recovered for reuse the quantity is calculated at between 80,000–90,000 tonnes of glass. Based on the landfill diversion targets set and agreed to between industry and governments in the National Packaging Covenant, the recycling and reuse figure for glass is between 50 and 60%, compared to sales by the year 2010. Based on state-estimated sales, this therefore equates to between 40,000 and 48,000 tonnes of material that must be diverted for recycling and reuse if the covenant target is to be met.

The OI PAS for glass cullet specifies a minimum particle size of 60 mm\(^45\), thus all glass below this size currently collected and processed by MRF’s is outside the PAS and is not currently recovered for recycling but disposed of to landfill.\(^46\)

The real estimates of glass returns and available product for use in alternate applications could, in fact, be severely underestimated as reported in the Glass Compaction Study of losses that occur in the collection vehicle only, and in fact is probably closer to 45 % when total system losses including MRF’s are taken into account.\(^47\)

If these glass fines losses are factored in and added to the reported statistics by Rail Road Transport and OI, then it can reasonably be estimated that the real recovery rate for used glass bottles in Western Australia is at least 25,000 tonnes and in fact could be as high as 30,000 tonnes.

On the basis of these calculations, the used glass bottle market size capable of servicing alternate markets is therefore estimated at a minimum of 25,000 and as high as 30,000 tonnes.

With a continued drive for diversion and recovery to reach the NPC target of 55% for all glass containers, alternate markets must have the capacity to consume a minimum of 55,000 tonnes.

Any change to the economic equation for glass recovery, such as a reduction in the value for glass paid to recyclers or future changes to material specifications, could seriously impact on the ability to reach the targets, as it may be perceived to be economically unviable to handle the material. Managing the transition from the current to future markets will need to be undertaken carefully.

The following secondary applications for crushed glass were identified in 2002:

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45 See appendices attached: PAS OI.
46 Confirmed by Stakeholder interviews and inspections of 3 major Perth MRFs.
47 Confirmed from stakeholder and other industry data in from Queensland MRFs.
Table 9 Potential Australian Secondary Markets for Waste Glass

<table>
<thead>
<tr>
<th>Market</th>
<th>Market Size (kt/year)</th>
<th>Production Cost (A$)</th>
<th>Sales Price (A$/t)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasive Wheel</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Speculative</td>
</tr>
<tr>
<td>Absorbent Small</td>
<td>120 - 180</td>
<td>300</td>
<td>For oil clean-up; &lt;500 μm particle size</td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>Very high potential for $20/ton material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bead</td>
<td>18</td>
<td>--</td>
<td>For road markings; current product &gt;A$650/ton</td>
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<tr>
<td>Blasting Abrasive</td>
<td>80</td>
<td>120 - 180</td>
<td>Could take 25% of Australia/New Zealand market</td>
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</tr>
<tr>
<td>Braking Media</td>
<td>2</td>
<td>60</td>
<td>For locomotives and trams; speculative</td>
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</tr>
<tr>
<td>Brick Flux</td>
<td>200</td>
<td>&lt;500 μm particle size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crushing Media</td>
<td>--</td>
<td>--</td>
<td>For mining operations; speculative</td>
<td></td>
</tr>
<tr>
<td>Domestic Filter</td>
<td>--</td>
<td>150</td>
<td>Speculative</td>
<td></td>
</tr>
<tr>
<td>Filler</td>
<td>--</td>
<td>--</td>
<td>For plastics and paints (&lt;75 μm); speculative</td>
<td></td>
</tr>
<tr>
<td>Fire Extinguisher</td>
<td>--</td>
<td>--</td>
<td>Speculative</td>
<td></td>
</tr>
<tr>
<td>Fire-Resistant Board</td>
<td>--</td>
<td>--</td>
<td>Speculative</td>
<td></td>
</tr>
<tr>
<td>Landscaping</td>
<td>--</td>
<td>--</td>
<td>Small market; large size and colour important</td>
<td></td>
</tr>
<tr>
<td>Sandpaper</td>
<td>2</td>
<td>120-130</td>
<td>300</td>
<td>Weak and shrinking market</td>
</tr>
<tr>
<td>Stained Glass</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>No market potential</td>
</tr>
<tr>
<td>Stucco Component</td>
<td>5</td>
<td>60</td>
<td>Garnet and slags $110–$135 tonne (Distributors retail for $168–$210/T)</td>
<td></td>
</tr>
<tr>
<td>Termite Barrier</td>
<td>--</td>
<td>--</td>
<td>Speculative</td>
<td></td>
</tr>
<tr>
<td>Thermal Insulation</td>
<td>--</td>
<td>--</td>
<td>80 - 120</td>
<td>500 μm to 10 mm particle size; clear only</td>
</tr>
<tr>
<td>Tile</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Technology unlikely to succeed</td>
</tr>
<tr>
<td>Traction Surface</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Small market</td>
</tr>
<tr>
<td>Waterjet Cutter</td>
<td>0.2</td>
<td>--</td>
<td>--</td>
<td>Product trialed successfully</td>
</tr>
</tbody>
</table>


Based on our discussions with potential end-users, we have ascertained the following short-term market situation.

Table 10 Short-term Market Quantification

<table>
<thead>
<tr>
<th>Market Opportunity</th>
<th>Market Size Tonnes</th>
<th>Competitive Material</th>
<th>Estimated Price of Competition</th>
<th>End-user</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass cullet</td>
<td>20,000</td>
<td>Sand, soda ash and limestone</td>
<td>$91.00 furnace-ready</td>
<td>OI</td>
</tr>
<tr>
<td>Asphalt plants</td>
<td>&gt; 5,000</td>
<td>sand and aggregates</td>
<td>$5–$12.00/T</td>
<td>Pioneer Road Surfaces</td>
</tr>
<tr>
<td>Abrasives</td>
<td>5,000–9,000 over 3 years</td>
<td>Garnet and slags</td>
<td>$110–$135 tonne (Distributors retail for $168–$210/T)</td>
<td>Total Corrosion Control</td>
</tr>
<tr>
<td>Construction areas</td>
<td>Unlimited</td>
<td>Aggregates</td>
<td>$2–$8.00 / T</td>
<td>Road base, paths drainage</td>
</tr>
<tr>
<td>Concrete</td>
<td>Unlimited</td>
<td>Aggregates</td>
<td>$2–$8.00/T</td>
<td>Concrete applications</td>
</tr>
</tbody>
</table>

Markets identified as probable, but requiring considerable development work to overcome technical knowledge gaps, market acceptance, market demand and economic realities, are detailed below:


### Table 11 Long-term Market Quantification

<table>
<thead>
<tr>
<th>Market Opportunity</th>
<th>Market Size Tonnes</th>
<th>Competitive Material</th>
<th>Estimated Price of Competition</th>
<th>End-user</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement applications</td>
<td>Estimated at 50,000 T+</td>
<td>Fly Ash</td>
<td>$5.00 / T</td>
<td>Blue Circle</td>
</tr>
<tr>
<td>Brick-making and Fluxing</td>
<td>Estimated at 28,000 T+</td>
<td>Diorite dust, Quarry dust, slag.</td>
<td>$2 – 8.00 / T</td>
<td>Austral and Midland Brick</td>
</tr>
<tr>
<td>Clay pavers/roof tiles</td>
<td>5,000–8,000 T</td>
<td>Fluxing agents</td>
<td>Unknown</td>
<td>Austral and Midland Brick</td>
</tr>
<tr>
<td>Water filtration systems</td>
<td>20,000 T</td>
<td>Processed sand</td>
<td>$80.00 – 120.00 / T</td>
<td>Water/Sewerage Treatment Plants, Pulp and Paper Plants Swimming pool replacement</td>
</tr>
<tr>
<td></td>
<td>3,000 T over 5 yrs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block-making Systems</td>
<td>Undetermined</td>
<td>Fine aggregates</td>
<td>&lt;$ 10.00 / T</td>
<td>Glass Block Technologies</td>
</tr>
</tbody>
</table>

### 8.2 Impediments To The Identified Opportunities.

The greatest impediments and issues in commercialising alternatives for reusing glass within the state have been assessed as economic and cultural rather than technical. Technically, used glass has been proven to be equal to or in some applications superior to the material it is replacing and a significant amount of documented research is available that reinforces this statement.

Cultural factors relating to reusing glass seem to be driven by society’s lack of valuation of the finite virgin materials and the focus on economic considerations, rather than environmental stewardship and sustainability.

Ironically, the brick-making industry in Western Australia now faces some unforeseen technical challenges in relation to the use of the substantial clay reserves available, due to the clay’s poor molecular structure which requires constant modification in the industry’s batching process to make the same or similar brick item. Brick-making companies are now looking at all alternatives, including paper and quarry dust, to blend with the clay to act as fillers in overcoming these increasing technical issues.  

Every potential user of used glass interviewed identified that until real environmental values are placed on finite virgin materials, that is, sand and aggregates, the excuse for not using processed glass alternates will be “we only pay X$ per tonne for its competitor material”.

Further, when government stakeholders were asked if they would use glass in alternate long-life applications, the priority was to use low-cost finite raw materials. Clearly, sustainability and environmental considerations were not part of their considerations.

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48 Midland Brick, April 2006.
This view is reinforced in state legislation, whereby the state specifically prohibits the use of silica-based alternates in the abrasive and sand-blasting areas, whereas worldwide, used glass is used extensively as an alternate abrasive medium.

We have identified that market opportunities do exist to consume more than 100% of all the available product, but that due to the historical low value placed on finite virgin reserves by government and the community glass, cannot compete in Western Australia against its low-value virgin aggregate counterparts, therefore new markets to displace high-value products must be pursued.

To assist in the development of markets for secondary use of glass, the state government may wish to consider introducing some type of disincentive for society’s continued use of virgin products, whereby secondary materials can meet or exceed the technical and operational requirements when compared to virgin materials.

As part of sweeping reforms in waste management practices, in 2004 the UK government introduced an Aggregates Tax to reduce the environmental impact from quarrying and to stimulate the rate of recycling of construction materials. All excavated materials, for example, sand, gravel and crushed rock, but with the exception of shale, are taxed at £1.60/T. Ten per cent, or £29.3M of the funds raised through the application of the levy are directed to the Aggregates Levy Sustainability Fund to fund rehabilitation projects, while 90% of the funds provide a small reduction in National Insurance Contributions.

The Government may consider introducing a similar virgin aggregates tax on the use of virgin aggregates in specific applications, to assist in stimulating the use of secondary materials and to create a fund to assist in undertaking trials and market development.

Extensive community education regarding the real value of re-using secondary materials instead of mining virgin materials may assist in moving the community’s attitude forward to assist people in making informed decisions on future product purchases, particularly if a premium is required to be paid.

The structural and physical differences between glass and sand or similar raw materials underpin many of the economic challenges impacting on its alternate reuse, as before it can substituted, it must be reshaped and reformed for it to compete technically in any alternate market other than bottle-to-bottle applications. The technical challenge for reusing bottle glass is therefore to turn the material from a flat structure to a more cubic form or spherical shape to enable it to have abrasive properties or compacting and binding characteristics. Glass uncrushed or unshaped and containing paper, plastics and other organic materials has extremely limited applications.

From an economic perspective two specific sectors are impacted upon in the process of transforming the glass into a form for reuse. These sectors are the actual re-processor of the material and the commercial collectors and/or MRF operator.

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49 Interview with Jamie Mc Keller and Alex Fraser, April 2006; Jim McLeod, May 2006.
## Alternate Used Glass Applications Compared with Primary Material Types

<table>
<thead>
<tr>
<th>Application</th>
<th>Process type</th>
<th>Competitor Material</th>
<th>Price $ Tonne (Virgin)</th>
<th>Recycled Glass Cost *</th>
<th>Likely Market Size Tonnes</th>
<th>Identified Local End-user</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass cullet</td>
<td>Beneficiation</td>
<td>Sand, Soda, Lime</td>
<td>$91</td>
<td>+ $125</td>
<td>40,000</td>
<td>OI</td>
<td>OI compares recycled batch cost to virgin batch price.</td>
</tr>
<tr>
<td>Asphalt plants</td>
<td>Crushing /</td>
<td>sand and aggregates</td>
<td>5–12</td>
<td>+ $33</td>
<td>&gt; 5,000</td>
<td>Pioneer Road Surfaces</td>
<td>Will use as much as it can get, provided the cost is comparable to virgin.</td>
</tr>
<tr>
<td>Abrasives</td>
<td>Crushing and pulverising</td>
<td>Garnet and slags</td>
<td>$110–$135 tonne (Distributors retail for $168–$210/T)</td>
<td>$120–150</td>
<td>&gt; 5,000</td>
<td>Total Corrosion Control and others</td>
<td>The market can be developed, but initially it will compete with locally produced cheap garnets. Market size significant and accessible now.</td>
</tr>
<tr>
<td>Construction areas</td>
<td>Crushing</td>
<td>Aggregates</td>
<td>$2–8</td>
<td>+ $33</td>
<td>Unlimited</td>
<td>Road base, paths drainage</td>
<td>Can use all glass collected but cost of clean-up and shaping pushes the cost up.</td>
</tr>
<tr>
<td>Cement Applications</td>
<td>Residual</td>
<td>Fly Ash</td>
<td>$5</td>
<td>+ $68</td>
<td>50,000 +</td>
<td>Blue Circle</td>
<td>Glass needs to be ground to a powder and against fly ash this is prohibitive in cost.</td>
</tr>
<tr>
<td>Concrete</td>
<td>Crushing and Batching</td>
<td>Aggregates</td>
<td>$2–8</td>
<td>+ $33</td>
<td>Unlimited</td>
<td>All concrete batching plants</td>
<td>Glass needs to be shaped, but the use in concrete applications is substantial if the cost barrier can be overcome</td>
</tr>
<tr>
<td>Brick-making and Fluxing</td>
<td>Grinding and Pulverising</td>
<td>Diorite dust, Quarry dust, slag</td>
<td>$2–8</td>
<td>+ $38</td>
<td>28,000 +</td>
<td>Austral and Midland Brick</td>
<td>Need to overcome technical issues, whereby the use of glass changes brick colours in the kiln process.</td>
</tr>
<tr>
<td>Clay pavers/roof tiles</td>
<td>Grinding and Pulverising</td>
<td>Fluxing agents</td>
<td>Unknown</td>
<td>+ $38</td>
<td>5,000 +</td>
<td>Austral and Midland Brick</td>
<td>Need to overcome technical issues of tiles sticking together in kilns.</td>
</tr>
<tr>
<td>Water filtration systems</td>
<td>Grinding and Pulverising</td>
<td>Processed sand</td>
<td>Estimated at $80 -120</td>
<td>Cost of using glass is estimated at about the same, possibly higher.</td>
<td>20,000 T</td>
<td>Water/sewerage treatment plants, pulp and paper plants swimming pool filter replacement</td>
<td>Significant market end-use but will need to be developed locally. This application is growing rapidly due to recent health issues surrounding the use of sand and the fact it’s been proven now to hold and distribute bacteria whereas glass doesn’t.</td>
</tr>
<tr>
<td>Block-making Systems</td>
<td>Grinding and Pulverising</td>
<td>Fine aggregates</td>
<td>&lt;10</td>
<td>+ $33</td>
<td>Not known</td>
<td>Glass Block Technology</td>
<td>Unlikely major user, market will need to be developed.</td>
</tr>
</tbody>
</table>

* The sales price estimated assumes a gate fee of $12.00 per tonne has been paid to the processor to take the material (not shown in this price) and allows for an estimated production cost only and marginal profit. Real pricing will vary, depending on the commercial arrangements in place and competitive nature of other materials protecting their market dominance.
9. COST–BENEFIT ANALYSIS

9.1 Glass Re-processors

The cost of processing used glass is totally dependent on and directly impacted upon by many local market factors, including the market value of competitive products, landfill disposal costs and transport logistics. The table below shows the value for some applications effective in 2002.

Table 12 Purchase Price of Recycled Glass Types

<table>
<thead>
<tr>
<th>Type of Glass</th>
<th>Description</th>
<th>Sales Price ($/t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRF Reject</td>
<td>Mixed colour; manually sorted; small debris remaining; 20-50% of all glass collected</td>
<td>0</td>
</tr>
<tr>
<td>Beneficiated Quality</td>
<td>Colour sorted container glass; &gt;10 mm particle size</td>
<td>80</td>
</tr>
<tr>
<td>Insulation</td>
<td>≥95 wt% clear glass; &lt;10 mm particle size; no ceramics/stones; usually flat glass</td>
<td>95</td>
</tr>
<tr>
<td>Beneficiated</td>
<td>ROA quality but with additional crushing and cleaning; for glass manufacture</td>
<td>120</td>
</tr>
<tr>
<td>Abrasive</td>
<td>MRF reject quality</td>
<td>200</td>
</tr>
<tr>
<td>Fibreglass</td>
<td>Domestic insulation</td>
<td>3,000</td>
</tr>
</tbody>
</table>


AGT has estimated that for glass fines to be processed for value-adding into other products, a gate fee of at least $15.00 per tonne must be applied to accept the product from a collector. This is driven by the fact that a significant amount of foreign material must be screened and cleaned from the glass before it can be reprocessed or value-added. Once this material is separated, it must then be transported and disposed of to landfill. The quality and quantity of the feedstock will determine the quantity to be disposed of to landfill, however, it could be as high as 20% of the delivered product.

In the case of glass over 50–60 mm, this product is largely free of contaminants and a small financial payment for the material may be viable. However, it is estimated that the material would only have at best a value of about $10.00 per tonne, compared to the current price paid by OI of $40.00 per tonne for the same material.

The gate price to be charged will be a reflection of the markets secured. If the processed glass were to be used in an aggregate application, the gate price will need to be higher as the selling price is substantially lower than that which can be achieved as an abrasive medium.

As already stated, in the production of abrasive media, glass powders and other sized products will also be generated during the production cycle. These can either be recovered for resale in the longer term and will incur additional costs associated with bagging and transport, but will produce an income stream or will need to be disposed of to landfill, in the short term requiring transport and disposal costs which must be factored into any gate fees charged.50

50 Interviews with AGT, Blue Circle Cement and Alex Fraser.
Market Development Study – Used Glass

Market acceptance takes time and in Queensland, for comparative purposes it has taken AGT two years to establish reliable markets for all of its outputs. However, a reality is that in the interim, these by-products may require landfilling until such time as the markets are developed or sold into lower grade applications.

Glass powders have a higher selling price than larger particle materials but as a percentage of input streams they produce less material and require significantly higher energy consumption to produce, compared to the production of aggregates and sand replacement materials. Powders, whilst initially appearing financially more attractive, have significant limitations in their economic ability to use all of the generated glass in the state at this stage.

The consultants benchmarked AGT’s estimates for the reprocessing of used glass and found that glass reprocessing costs in the USA were similar to those estimated by AGT.\(^51\) According to information reviewed and sourced from the company Glass Recycling Inc of Georgia, a four-tonne-per-hour processing plant that is used to produce a range of glass products from used container bottles, in sizes of 1.68 mm – 600 um, including their abrasive media, marketed as “GlassBlast”, incurs an operating cost of about US $32.00 (A$42) per tonne, excluding the costs of marketing, internal cost recovery, equipment purchase, depreciation and other capital costs to establish a plant. For a 10-tonne-per-hour-plant, the operating costs are estimated to drop to about US$25.00 (A$33) per tonne and a plant of this size would be capable of producing about 1,600 tonnes of product per month. This production capability is equivalent to the current tonnes being purchased by OI and shipped from WA to Adelaide.

The costs identified above included labour (hourly labour rate of US$18.00) to operate the equipment and pack the processed glass into bags, and were inclusive of electricity, gas, some maintenance of equipment (crushing blades) and the labour cost of replacing these blades. The estimates exclude other operating, costs but they do support the information provided by other stakeholders that, regardless of the application, any solution for reprocessing glass must be supported to some degree by the payment of a gate fee to assist and secure the economic model’s viability.

An alternative view by an industry practitioner that product-sizing should not be adapted to the specific markets, but rather markets should be found for the spectrum of sizes that the processing plant produces. This may mean that 80% of product produced is sold at $20 per tonne or less while the other 20% is sold at a premium of perhaps $200 per tonne. This is likely to be far more cost-effective than attempting a smaller throughput for an exact size range and selling 100% of the output at $200 per tonne.

An additional consideration for any glass re-processor will be the cost of developing a market to take all of her/his product range and outputs. It cannot be assumed that by simply providing infrastructure such as a building and power connections for a new operator as well as nominal or no rent for a period, that these measures in themselves will provide the stability for establishing a new business in the state.

\(^{51}\) Glass Recycling Inc – Georgia memo to Visy Abrasives.
It is estimated that a minimum of 7,000 tonnes of glass inputs would be required to establish a viable plant in Western Australia, subject to the immediate and short-term market opportunities for the processed product. The most likely viable end use is as abrasive media, however, government regulations currently preclude this avenue.

The cost of setting up the Gold Coast facility is estimated to have cost AGT Directors more than $600,000 excluding the building and lease arrangements. These figures are confirmed by our discussions with other re-processors in the eastern states including Peter Harkins who estimated the cost to establish and operate a glass recycling plant to manufacture glass to be used in the top-end market of blasting abrasive would be in the range of $500,000–$1,000,000, depending on cullet quality. Whereas to construct a basic plant with a 4 – 5 tonne per hour throughput (operating 1 day per week) would cost around $200,000. A mobile plant capable of being transported from site to site for processing of stockpiles of material would be approximately $500,000 with higher operating costs then a stand alone unit.

AGT is housed as part of the operating MRF facility. Visy,\(^{52}\) as the operator of the MRF, contracts directly with AGT to take its reject material or fines and AGT is responsible for all costs associated with material unused or contaminants removed. Cleanaway and now Visy confirmed that this charge is comparable to the combined transport and disposal costs if the product were to be landfilled. Queensland does not have a landfill levy and the cost of landfilling has been confirmed at between $5.00 and $6.90 per tonne plus transport of the glass fines, thus the avoided disposal cost is in the range of $15 -18.00 per tonne.

In addition, it is expected that between 18–24 months will required before any real return on investment occurs, subject to market acceptance of the processed product and the time lag for sales to be fully established. The core business around which the business model would be developed is the abrasives sector. Assuming the current legislative impediment can be removed, it is envisaged that sales could be around 1,250 tonnes for the first year of operations, increasing to around 2,000 tonnes in the second year and continuing to increase to between 5,000 – 9,000 over three years.

It must be remembered that one of the world’s largest garnet mines is located just four hours north of Perth in Geraldton and, subject to the position the local competitor takes to protect its current market sales, estimates could, in fact, start lower and be expected to increase in a more conservative manner.

With abrasive media the wholesale market value is around $110–$135 per tonne. Even with production costs of around $33.00 tonne excluding significant other internal costs, our investigations conclude that a gate fee will be required for glass fines for the operation to remain viable and meet the disposal costs for waste materials.

Mr Damien Cole identified landfill as the direct competitor to the commercial collection of glass and considers that the operation should be profit-driven, not supported by government subsidies. However, initially funding from the landfill levy could be diverted to establish alternative markets and offset establishment costs. Based on a $10 per tonne processing subsidy and assuming 20,000 tonnes per annum, seed funding of $200,000 could be provided.

\(^{52}\) Previously owned and operated by Cleanaway and sold to Visy 1st July 2006
Australian Glass Technologies agrees with the comments above that the cost of processing used glass for all applications including the abrasives sector, aggregate replacement or cement applications will require some financial incentive at the front end to offset the production and operating costs to enable the establishment of a commercially sustainable business.

**Recommendations**

5. That the state government issue an “Expression of Interest” nationally and internationally, seeking interest from potential operators to set up a reprocessing operation in the state to process used glass and to identify the terms, conditions and support required to make such an investment decision.

6. That the state government consider what support it may be able to offer in the form of grants, direct or indirect funding for the purchase or lease of land, buildings, plant and equipment, the conduct of feasibility studies, trials to demonstrate alternate local uses, publication and promotion of results to assist in market development and market acceptance.

9.2 MRF Operator

Used glass products represent approximately 27% of the total product mix that is collected in a typical commingled recycling service. Therefore, for every tonne of commingled product delivered to a MRF, it can be assumed that glass represents 270 kilograms of the total collection. The current WA value of mixed colour glass (excluding flint) that meets the OI PAS is $40.00 tonne. Therefore, for every one tonne of commingled product delivered to the MRF, the glass value is $10.80.

As previously reported, the traditional market of bottle to bottle, supported by O-I, is the only immediate market for used glass that generates a financial return in its semi-sorted raw form. This value, although it has been substantially reduced in recent years, along with an increase in quality specifications, does provide a reward or revenue stream in return for collecting, colour sorting and handling the material.

Councils traditionally pay for the service of collecting the recyclables to a collection contractor, although some councils do operate day labour services using their own collection fleet. Also, typically councils or the collection company deliver the collected recyclables and pay a third party to sort the recyclables at a MRF. The MRF charges a gate fee for the service, which is a reflection of the operating costs less revenues generated from the sale of commodity. The processing cost or gate fee applied may vary from operator to operator, depending on the structure of the contracts, quantity delivered and quality of the product.

A commercial collector who undertakes a service to the hospitality sector, where significant quantities of glass are generated, will usually charge a fee per bin collected, similar to waste collection. The fee for service will be a balance between the cost of collection and treatment or processing fee, however, if the fee is close or higher than the

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53 Visy Recycling, April 2006.
garbage cost it will not be attractive for the business and it will be cheaper to dump everything in just one bin which is then transported to landfill.

MRF operators require specific plant, equipment and labour to separate and recover glass from other commingled recyclables. Typically the plant and equipment associated with glass recovery include:

- Equipment to separate glass fines from other recyclables, that is, trommels and screens, air blowers and classifiers
- Specific conveyor lines
- Labour cost to positively sort glass by colour from other materials, typically up to three staff
- Bulk storage of colour-sorted glass and fines
- Loading, transport and unloading of glass at destination, that is, the Road Rail Transport depot at Kewdale, or landfill
- Landfill fees for disposal of fines and residuals

Commercial operators usually recover the entire product collected by them, as they may require their customers to colour-sort the glass or provide glass-only bins to prevent commingled collections.

GHD\textsuperscript{54} determined in its report that the cost of processing glass in the Perth metropolitan area for MRF operators was estimated at $70.00 per tonne, with a glass value of $50.00 tonne. With its current value set at $40.00 tonne\textsuperscript{55}, the GHD estimates of processing costs have now gone up by $10.00 tonne since this report was published. Further, GHD identified that the cost of disposing of glass to landfill was estimated to be $10.00 per tonne in Perth. This figure has been confirmed as being correct and, in fact, in some regional areas is actually less.

Based on the findings of the NSW JPG Glass Compaction Report, and confirmed by local stakeholder interviews, the current loss of glass fines and undersized glass is estimated to be between 34% and 45% of the input streams as a minimum.

On the basis that a MRF is currently receiving, in the metropolitan area, $40.00 per tonne for glass delivered into the Rail Road Transport Kewdale depot, if 100% of all glass delivered were recovered it would receive $10.80 revenue from glass alone, for every 1 tonne of commingled product received in the plant. With an expected loss due to breakage and compaction of between 34% and 45%, the current real return from glass is therefore estimated at between $7.12 and $5.94 for every tonne of fully commingled product delivered to a MRF. The potential revenue loss for undersized material not recovered can be estimated at between $3.67 and $4.86 per tonne of fully commingled material. The operator, whilst losing the revenue stream, also incurs the additional cost of handling, maintenance, transport and landfill disposal.

On the basis of these figures, the following estimates can be assumed for handling glass at a MRF in Perth, based on a current market price of $40.00 tonne and 270 kg potentially available material per tonne of commingled product delivered.

\begin{flushright}
\textsuperscript{54} Glass Recycling Review 2005, Section 3.2.2. \\
\textsuperscript{55} Confirmation by Ol, April 2006. \\
\textsuperscript{*} Concludes a loss of only 34% for compaction. The higher the compaction and glass loss, the higher the business cost.
\end{flushright}
Table 12 Current MRF Costs to Process Glass

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Cost or revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass recovered – 178 kg</td>
<td>Value $40/tonne</td>
<td>+$7.12</td>
</tr>
<tr>
<td>Glass lost – 92 kg</td>
<td></td>
<td>-$3.67</td>
</tr>
<tr>
<td>Landfill cost</td>
<td>$10.00 tonne</td>
<td>-$0.92</td>
</tr>
<tr>
<td>Transport</td>
<td>@: $50.00 tonne</td>
<td>+$4.50</td>
</tr>
<tr>
<td>Total cost</td>
<td></td>
<td>-$9.09</td>
</tr>
<tr>
<td>Loss of real revenue</td>
<td></td>
<td>-$1.97</td>
</tr>
</tbody>
</table>

The real loss in revenue for handling glass delivered on the assumption that 270 kg are delivered is estimated to cost the operator $1.71 for every tonne of commingled product s/he handles. These estimates exclude real labour costs, operation costs and transporting of the recovered glass to Kewdale. The estimates exclude the costs charged by a MRF to councils or contractors for processing. On a pure revenue contribution basis, glass is actually a cost to MRFs for recovery. The actual cost would need to be assessed on a case-by-case basis with all inputs accounted a greater economic rigour.

Depending on individual operations and their business structures, it can be concluded, but not fully substantiated without a more detailed economic analysis, that glass separation, recovery and delivery for transport to Adelaide is potentially currently costing MRF operators. It appears that other higher value commodities and gate fees for processing are subsidising the real cost of separation and disposal of glass collected via kerbside systems.

It can therefore be concluded, but not verified until a more definitive study is concluded, that MRF operators may already be losing money handling glass. In fact, they may be better off financially by changing their processes of glass recovery, reducing their labour component and producing two mixed streams in two sizes – glass fines and oversized > 50 mm.

This broad analysis concludes that an opportunity exists for all MRF operators to review their current separation and processing operations. We understand since our site inspections and discussions with MRF operators in April 2006 that changes have been made at all metropolitan MRF’s to minimise the amount of colour sorting seperation and to significantly reduce the labour content.

The future of delivering all glass to a single processor may provide a more viable financial model than it at first appears. Currently, MRFs all lose product as glass fines with the costs of landfill disposal and a payment of $40/tonne for colour-sorted recovered glass > 60 mm which can only be achieved with high input costs.

Glass provides a MRF operator with an added source of business revenue, but clearly does not financially support itself, thus it only assists with overall cash flow inputs and it is not a genuine profitable commodity to be handled.

The overall loss of contributing revenue to a MRF’s operations, based on the GHD’s estimates of recovery for the Metropolitan and Kwinana/Pee regions alone can be estimated at:
The loss of revenue forgone for the glass currently sent to OI currently estimated to be $429,160 for the 10,998 tonnes captured, based on its purchase price of $40.00 tonne.

Plus

- The cost for disposal based on an average of $10 per tonne or paying a gate fee to an alternate glass reprocessor of $15.00 per tonne will result in additional costs of between $109,998 and $164,970, depending on the actual gate fee charged.

MRFs or their operators in the Perth and Kwinana/Peel regions can expect to lose a total of between $539,158 and $594,130 per annum if they recover only 55% to 66% of all glass currently delivered to their facilities. The financial loss for this region in real terms moves from an estimated $429,160 current revenue contribution for glass to a loss of revenue of as much as $594,130 or a total turnaround or more than $1,023,290, based on GHD’s estimates.

If and when OI withdraws from the Western Australia market, the cost structures for glass recovery will be changed forever. MRF operators and councils will be faced with potentially paying to process the recovered glass, receiving a small fee or paying to dispose of the glass to landfill. A financial analysis would need to be undertaken by each MRF owner and operator to determine the impact of changing the specifications and end markets for recovered glass. It is hoped such an analysis can reveal a cost neutral position.

9.3 Council and Commercial Operators

Depending upon the financial impact of any changes in the market place on the MRF operators, flow-on effects to member councils or councils that are MRF clients will also need to be considered on a case-by-case basis. Again the contractual position and the financial impost – positive or negative – will need to be considered.

If the glass fines are recovered and sent for re-processing rather than landfilled as they are currently, the cost impact on MRF operators will be the difference between transport and gate fees at a re-processor versus transport and gate fees at a landfill plus the landfill levy.

From a commercial operator’s view, in the case of the company Perth Recycling, which collects glass from commercial premises, that is, hotels, cafes, pubs etc., any change to the current revenue base will significantly impact on the business. The company recoups their costs from a combination of revenue from businesses for services and the sale of the commodity. Businesses such as this may withdraw from offering such a service or may change the product mix collected by them, if they are faced with the prospect of paying for disposal of glass.

It can be expected that the current volume collected by this sector, if the revenue returns are removed, will not be recovered and would be lost directly to landfill, thus the overall state recycling rate can be expected to fall dramatically.
Actual estimates of glass recovery were deemed by the operator as being “commercial in confidence” and were not provided by either the operator, Rail Road Transport or OI, despite repeated requests.

Some Councils and contractors close to Perth may consider continuing to send product to Perth based on social and environmental considerations. However, rural, regional and remote areas, where landfill is cheaper, will potentially be faced with tougher economic decisions unless the state will assist by offering transport subsidies or other mechanisms to assist in offsetting the likely decrease in revenues.

Recommendations

7. That a cost model be developed and made available to all commercial, council collection contractors and council officers to enable each operator to assess the financial impact of changing from the current revenue stream to an alternate approach for the organisation.

8. In collaboration with the commercial collectors the Government and collectors determine if there is a method of recovering glass from sectors not serviced with kerbside collections and what if any support or mechanisms are necessary to support this service provision.

9.4 Regional Considerations

The recycling of glass from the country regions of the state has been in decline since the economic value paid by OI has fallen and the transport subsidies removed. Regional collectors other than Council contractors are finding it uneconomical to continue to collect glass, even at a rate of $40.00 per tonne. Based on stakeholder discussions, several collectors have already indicated they have stopped glass collections due to the lack of revenue and commercial return for their efforts.

GHD confirmed, in its Glass Recycling Review Assessment Report in 2005, that the total quantity of glass recycled by Local Government in 2004–05 was estimated at 12,998 tonnes. However, only 2,269 tonnes, or 17% of the total, were generated from the regional and rural areas (excluding the Kwinana/Peel region). This equates to just 190 tonnes of material per month from across the state.

Clearly, the economics to collect and transport glass long distances, compared to cheap local landfill for an inert material, is a key consideration for local authorities. Given the individual complexity of regions, transport distances and other factors, no one single solution can be drawn for the regional and rural areas.

However, from the list of uses identified in the report, an obvious outcome could be that glass could be processed locally and used as a substitute in non-engineered applications. In such cases the glass will only require a simple crush and clean and this may be able to occur using existing equipment within the area.
Where more technical solutions are desired the identified cost of a mobile plant affixed to a semi-trailer for transport around the state has been identified at around $500,000. However, the costs of transport, operation, maintenance and repair and finding an operator versed in the use of the equipment and ongoing ownership could be problematical.

Where communities want to recycle and back-loading rates are favourable to transport the collected tonnage to the market in the metropolitan area, consideration should be given to providing relief through re-introducing transport subsidies based on distance and anticipated cost.

Whether we promote local reuse or transport to the metropolitan area for processing, it is important to continue to promote social equity between the urban and rural areas where communities equally want to recycle and provide a positive contribution to a more sustainable society.

Recommendation

9. Regional and rural communities will need to address the use of glass locally where possible. The WMB should provide support and skills to transfer knowledge to councils and interested parties in these regional and rural areas for glass reuse.

10. Where local reuse is not achievable, consideration should be given to providing transport subsidies to offset the cost of moving glass to the metropolitan area for processing.
10. CONCLUSIONS

Significant immediate and long-term opportunities have been identified within this report that have the capacity of consuming all of Western Australia’s used container glass.

The most immediate and economically viable option identified which will be sustainable over the long term is to use container glass as an abrasive medium in the engineering and construction industries. Whilst this market has been identified as being substantial it will, however, take time to position the product against its competitors. This challenge should not be underestimated, particularly as one of the world’s largest garnet mines, a direct material competitor to used glass, is situated only four hours north of Perth.

However, we have identified that, according to the Western Australian Department of Consumer Protection Worksafe Regulations, Code of Practice, Abrasive Blasting, section 2.2.2 and 2.2.3\textsuperscript{56} referencing Silica Dust, the current code specifically precludes the following materials for use in the Western Australian abrasives sector.

- A substance that consists of or contains crystalline silicon dioxide as an abrasive material in abrasive blasting except where less than 2% dry weight of crystalline silicon dioxide is present as a contaminant and
- A recycled material that has not been treated to remove respirable dust.

Whilst glass is widely used around the world in the abrasives sector, a statement such as this could be misinterpreted either deliberately or mischievously by competitors in the market place and is ambiguous in its meaning. Given that container glass is made from silica-based raw materials, clarity regarding this exclusion clause is required prior to the government promoting or assisting any new business being established.

To our knowledge, this exclusion does not appear in any other state-based occupational health and safety code to protect employee health. It is strongly suggested that the Department of Environment commence discussions with Department of Health and Worksafe Authorities to gain a full understanding and appreciation of the issues of concern. The Department may need to consider contributing to a detailed review of national and overseas experiences and literature to address the concerns of Worksafe in respect of this matter.

Based on this information, a commercial operation establishing itself in this market would be breaking the law if it were to use glass as an abrasive agent. Without clarification of this matter, it is unlikely that any new operator would invest in a reprocessing operation, given that Worksafe could deem the use of used container glass as an abrasive as potentially dangerous and unlawful for use in Western Australia.

Glass is both chemically and physically classed and formed as a liquid and in all its alternate applications it must compete with solid-based forms. For glass to compete in these areas requires it to be reshaped to a spherical or cubic form, with some cleaning, as a minimum. For several of its possible uses, sugars contained in the residues in and

on the glass container, must be removed from the glass surface. The sugars can react with certain other ingredients in some applications and cause concrete cancer and thus have devastating structural implications if the material is not processed correctly.

Given that all used container glass will require some degree of beneficiation if it is to be economically value-added in a sustained way, a reprocessing facility will need to be established that is capable of undertaking this task. This facility will at the least require an area of approximately 1,000 square metres, as a minimum, with adequate internal and external storage facilities for receiving material and an adequate undercover area for processing and storage. In addition a weighbridge would be required for receipt and selling of product and access to three-phase power. It is envisaged that an investment, excluding land and buildings, of between $500,000 and $1 million could be required. A smaller plant suitable for rural areas would cost in the order of $200,000 with a $10 per tonne operational cost plus power. A mobile unit to travel the state would be available but the cost at an anticipated $500,000 may preclude its acquisition.

Given the uniqueness and remoteness of the market place from other capital cities and the associated high cost of transport to the eastern states, the WMB, together with the glass manufacturers, fillers and brand owners selling glass into Western Australia, may jointly consider assisting in the establishment of a beneficiation and re-processing plant in or near the Perth metropolitan area. This assistance could be in the form of grants or direct funding for the purchase or lease of land, buildings, plant and equipment, the conduct of feasibility studies, trials to demonstrate alternate local uses, publication and promotion of results to assist in market development and market acceptance.

Any transition will take time and cannot occur quickly, thus it will be important for OI and the beverage industry to maintain a presence in the market during this transitional period. Support for the transition to alternate uses should be considered by all as a long-term commitment.

Any new venture is not without risk; however, critical to any business is raw material supply. Of concern to any new operator will be reliance on the continuity of supply of glass to underpin the production and sales capacity.

With the legislative and processing issues resolved the key fundamental issue of economics needs to investigated and addressed. Currently, used glass has a value of $40.00 per tonne delivered into Kewdale for transport to Adelaide for reprocessing into new container glass. Whilst the recycling collection contractors and material recovery facility operators consider this price makes recovering used container glass for recycling a marginal business, it does provide a positive cash flow benefit to these operations.

In changing markets from high-use (bottle to bottle) to lower grade applications, the revenue stream for MRFs and commercial operators from this commodity will fundamentally change. This may impact, perceived or in reality, on the economic modelling and viability of current businesses. Glass will no longer produce the same revenue stream to a MRF operator and the costs to collect glass from commercial properties may not be recovered from the sale of the product by commercial operators.
The project identified that glass recovery, on a pure revenue contribution basis, currently falls well short of supporting itself at a value of $40.00 per tonne and appears to be supported by other commodity prices and charges applied to contract processing. It was identified, however, that MRF operators, by changing internal processes and operations, whereby glass will no longer need to be colour sorted could create some productivity gains which may actually offset the potential decrease in revenue. We understand through discussions with the MRF operators and OI in recent months operational modifications have been made.

In addition, all glass fines could be recovered instead of currently being landfilled, thus delivering the Government and Waste Managements Board’s vision of zero waste to landfill.

This possible future scenario warrants a more detailed economic evaluation to identify the actual costs of currently recovering glass through a typical MRF and kerbside collection system, compared to the future option of modifying MRF flows and labour inputs to the sorting process and, as a result, capturing all glass including fines. Contamination would still need to be removed and the glass fines and material greater than 60 mm may still be required to be kept as two separate streams and not mixed, depending on the reprocessor’s options.

It is only by undertaking a detailed analysis of MRF and kerbside /operations that the financial impact can be assessed on a case-by-case and contract-by-contract basis. Local government, collection contractors, MRF operators and regional councils will need to consider how best to manage this transition and determine whether a change results in a positive or negative cash flow and its order of magnitude.

If container glass is deemed by collectors, councils and MRF operators to have a lower or negative value and if all glass is to be redirected to a reprocessing operator for beneficiation, stakeholders will balance cheap landfill disposal (glass is inert and attracts the lowest landfill levy fee) with the cost of transporting to an alternate processing facility.

A financial model needs to be developed and used, and case studies promoted throughout the industry to demonstrate the actual versus the perceived impacts. Government may also need to consider mechanisms to secure the supply of used container glass for any future operator, to prevent a possible collapse of the system as a result of possible cheap alternate disposal methods.

The future of collections from the “away-from-home” sector is most vulnerable and at risk.

The tyranny of distance and transport logistics directly impact on the ongoing recovery efforts from rural and regional areas throughout the state. The greatest challenge of moving materials intrastate will be the increasing cost of fuel, resulting in increased freight costs, while the movement of glass interstate will be impacted upon by rail prices.
The issue is always about who pays – a forum of all interested parties to detail the issues, challenges, constraints and full cost implications would go a long way towards dispelling the myths and dealing with the realities of the road ahead. It is recommended that such a forum should specifically involve all major fillers of container glass, OI, commercial and council collectors and contractors, MRF operators, as well as local, regional and state government stakeholders.

Similar forums were held in NSW over a decade ago to discuss in a rational manner ways of managing a downturn in the price to be paid for glass. In NSW participants included contractors, local and state government, equipment manufacturers, industry groups and processors. A number of specific actions and outcomes were defined for each of the participant groups and provided a framework for many of the future studies, trials and projects undertaken with government leadership and support.

Recommendations

11. *The WMB should seek to conduct a forum to disseminate information contained in the GHD Glass Recycling Review Assessment Report 2005 and this study to participants. It is suggested that such a forum should specifically involve O-I, fillers and users of glass packaging, commercial and council collectors, recycling contractors, MRF operators, local, regional and state government stakeholders and potential end-users identified in this report.*

12. *It is strongly suggested that the WMB continues to take the leadership position it has to date on this critical issue and facilitates a dialogue with all parties in an open and transparent manner.*
11. **RECOMMENDATIONS**

1. That a broad, common-themed community educational recycling awareness program be developed and implemented State-wide immediately, communicating the key message of “bottle and jar recycling”. The program must identify that household cookware, glassware and light globes are non-recyclable.

2. The WMB should enter into discussions with the appropriate staff at the Department of Consumer Protection in relation to the exclusion of “products made from used container glass” in the Worksafe Regulations, Code of Practice, Abrasive Blasting. This prohibition is not present in other state legislation where used glass is part of these applications. Its presence will severely impact on the future business viability as it removes a vital high-value market for processed used container glass.

3. That the WMB hold a forum for procurement managers and engineers from local and state government departments and agencies to showcase the available research and applicability of using glass as a substitute for virgin excavated materials. Each department or agency is then to be set a time-frame within which it is to modify specifications to incorporate the use of recycled glass in suitable applications.

4. That the WMB hold a forum for the concrete and cement industries together with procurement managers and engineers from local and state government departments and agencies, to showcase the available research and applicability of using glass as a component in concrete and cement. Each department or agency is then to be set a time-frame within which it is required to modify specifications to incorporate the use of recycled glass in suitable applications.

5. That the state government issue an “Expression of Interest” nationally and internationally, seeking interest from potential operators to set up a reprocessing operation in the state to process used glass and to identify the terms, conditions and support required to make such an investment decision.

6. That the state government consider what support it may be able to offer in the form of grants, direct or indirect funding for the purchase or lease of land, buildings, plant and equipment, the conduct of feasibility studies, trials to demonstrate alternate local uses, publication and promotion of results to assist in market development and market acceptance.

7. That a cost model be developed and made available to all commercial, council collection contractors and council officers to enable each operator to assess what the likely financial impact of changing from the current revenue stream to an alternate approach will have on the organisation.
8. In collaboration with the commercial collectors the Government and collectors determine if there is a method of recovering glass from sectors not serviced with kerbside collections and what if any support or mechanisms are necessary to support this service provision.

9. Regional and rural communities will need to address the use of glass locally where possible. Government should provide support and skills to transfer knowledge to councils and interested parties in these regional and rural areas.

10. Where local reuse in regional and rural areas is not achievable, consideration should be given to providing transport subsidies to offset the cost of moving glass to the metropolitan area for processing as costs may become prohibitive relative to the revenue stream which will be generated.

11. The WMB should seek to conduct a forum to disseminate information contained in the GHD Glass Recycling Review Assessment Report 2005 and this study to participants. It is suggested that such a forum should specifically involve O-I, fillers and users of glass packaging, commercial and council collectors, recycling contractors, MRF operators, local, regional and state government stakeholders and potential end-users identified in this report.

12. It is strongly suggested that the WMB continues to take the leadership position on this critical issue and facilitates a dialogue with all parties in an open and transparent manner.
BIBLIOGRAPHY

International Review

http://www.wrap.org.uk/materials/glass/


**Australian / New Zealand Review**

Sorrell, Charles.C. May 2004 ,School of Materials Science and Engineering, University of New South Wales, Feasibility Assessment of Generating Crushed Glass Fines for Markets Report for the NSW Department of Environment and Conservation


Fisher and Associates, PMJ. 1997 Final Report, Value adding to recycled waste streams from MSW: Glass and Plastic; Energy Developments Pty Ltd


Appendix 1

Table of Equipment

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<th>Equipment</th>
<th>Manufacturer</th>
<th>Contact</th>
<th>Specifications</th>
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<td>Storage shed</td>
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<td><strong>Closed Bulk Storage Shed</strong></td>
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|                         |                                       | Email: webenquiry@sheds.com.au                                          | • BHP high-tensile-strength steel height 3.6 m  
  • Cost: $6/100 m² + $30 per m² for labour                                                                                          |
| Front-end loader        | Case                                  | Tel: +61 2 9833 6000  
  Fax: +61 2 9833 9777  
  Email: mail@caseequip.com.au  
  Web: www.caseequip.com.au  | **Case 721MXT Front End Loader**  
  • Operation load: 6 t per load Cost: $200,000  
  **Case 570MXT Front End Loader**  
  • Operation load: 2 t per load Cost: $90,000                                                                                   |
| Forklift                | Toyota                                | Tel: +61 2 9644 3433  
  Fax: +61 2 9644 2416  
  Web: industrial.toyota.com.au  | **Toyota Forklift 7FB20**  
  • Battery Electric, Capacity: 2 t and 3 m lift  
  • Cost: $25,000                                                                                                                     |
| Magnetic separator      | Eriez Magnetic Australia Ltd          | Tel: +61 3 9305 4099  
  Fax: +61 3 9305 4042  
  Email: sale@eriez.com.au  
  Web: www.eriez.com         | **HI Magnetic Separator**  
  Capacity: 25 t/h, Footprint: 1.00 x 0.85, Cost: $55,000                                                                        |
| Pulverizer system       | Andela Products Ltd  
  Agent Controlled Environment Pty Ltd  
  (agent in Australia) | Australia  
  Contact: Peter Harkins  
  Tel: +61 2 4566 8174  
  Fax: +61 2 4566 8115  
  E-mail: hsol@tpg.com.au | **GP-1 Model System**  
  1. Surge hopper (AMSH-86) ($10,320)  
  2. Glass pulveriser (GP-1) ($31,620)  
  3. Trommel separator (ATROM-104) ($20,630)  
  4. Pulveriser infeed conveyor ($7,630)  
  5. Trommel infeed conveyor ($7,660)  
  • Capacity: 2 - 10 t/h  
  • Particle size: d₉₇.₇ = 2.36 mm, d₁₂ = 75 μm  
  • Footprint: 1.68 x 1.7 x 2.92 m  
  • Cost: $77,860  
  **GP-1LG Model System**  
  1. Surge hopper (AMSH-86) ($10,320)  
  2. Glass pulveriser (GP-1 long) ($34,650)  
  3. Trommel separator (ATROM-104) ($26,530)  
  4. Pulveriser infeed conveyor ($7,630)  
  5. Trommel infeed conveyor ($7,660)  
  • Capacity: 2 - 10 t/h  
  • Particle size: d₉₇,₁ = 4.75 mm, d₉₈ = 75 μm  
  • Footprint: 2.04 x 1.7 x 2.92 m  
  • Cost: $86,790  
  **GP-2 Model System**  
  1. Surge hopper (AMSH-86) ($10,320)  
  2. Glass pulveriser (GP-2) ($44,800)  
  3. Trommel separator (ATROM-104) ($26,530)  
  4. Pulveriser infeed conveyor ($7,630)  
  5. Trommel infeed conveyor ($7,660)  
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  • Particle size: d₉₇,₁ = 4.75 mm, d₉₈ = 75 μm  
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**GP-07 Model System**

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**GP-07L Model System**

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<td>3. Trommel separator (ATROM-101) ($20,630)</td>
<td></td>
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<tr>
<td>4. Pulveriser infeed conveyor ($7,000)</td>
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<td>5. Trommel infeed conveyor ($7,660)</td>
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<tr>
<td>• Capacity: 1 - 3 t/h</td>
<td></td>
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<tr>
<td>• Particle size: $d = 9.5$ mm minus (after 1 pass)</td>
<td></td>
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<tr>
<td>• Footprint: $1.60 \times 1.35 \times 2.64$ m</td>
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<tr>
<td>• Cost: $66,460$</td>
<td></td>
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</tr>
<tr>
<td>Equipment</td>
<td>Manufacturer</td>
<td>Contact</td>
</tr>
<tr>
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<td>----------------------------------------------</td>
</tr>
</tbody>
</table>
| Screening  | Andela Products Ltd               | Australia                                    | **Trommel Separator ATROM-101 Model**  
Separation: d = 0.125 mm minus  
Footprint: 3.67 × 1.53 m × adjustable  
Cost: $14,850  
**Trommel Separator ATROM-102 Model**  
Separation: d = 0.125 mm minus  
Footprint: 4.28 × 1.53 m × adjustable  
Cost: $20,630  
**Trommel Separator ATROM-104 Model**  
Separation: d = 0.125 mm minus  
Footprint: 4.89 × 1.83 m × adjustable  
Cost: $26,530  
**Trommel Separator ATROM-104L Model**  
Separation: d = 0.125 mm minus  
Footprint: unavailable  
Cost: unavailable  
| Agent      | Controlled Environment Pty Ltd    | Contact Peter Harkins                         | **Trommel Separator ATROM-101 Model**  
Separation: d = 0.125 mm minus  
Footprint: 3.67 × 1.53 m × adjustable  
Cost: $14,850  
**Trommel Separator ATROM-102 Model**  
Separation: d = 0.125 mm minus  
Footprint: 4.28 × 1.53 m × adjustable  
Cost: $20,630  
**Trommel Separator ATROM-104 Model**  
Separation: d = 0.125 mm minus  
Footprint: 4.89 × 1.83 m × adjustable  
Cost: $26,530  
**Trommel Separator ATROM-104L Model**  
Separation: d = 0.125 mm minus  
Footprint: unavailable  
Cost: unavailable  
|            | [Telephone], Fax, Email, Web      |                                              | **VS 136 Vibrating Screen**  
Separation: unavailable  
Footprint: 2.55 × 1.60 m × adjustable  
Cost: $34,000  
|            |                                   |                                              | **Axle (10 t)**  
Footprint: 3 × 3 m, Cost:$8,800  
|            |                                   |                                              | **Weightbridge**  
For weighing heavy road vehicles  
Footprint: 18 × 3.5 m Cost: $55,000  

| Screening  | TPE Kintech Pty Ltd               | Australia                                    | **VS 136 Vibrating Screen**  
Separation: unavailable  
Footprint: 2.55 × 1.60 m × adjustable  
Cost: $34,000  
|            |                                   | Tel: +61 2 9838 8800 Fax: +61 2 9838 8833 Email: sales@tpe-kintech.com Web: www.tpe-kintech.com | **Axle (10 t)**  
Footprint: 3 × 3 m, Cost:$8,800  
|            |                                   |                                              | **Weightbridge**  
For weighing heavy road vehicles  
Footprint: 18 × 3.5 m Cost: $55,000  
|            |                                   |                                              |  

| Scales     | Wedderburn                        | Australia                                    | **Axle (10 t)**  
Footprint: 3 × 3 m, Cost:$8,800  
|            |                                   | Tel: +61 2 9797 0111 Fax: +61 2 9799 2013 Web:www.wedderburn.co.nz | **Weightbridge**  
For weighing heavy road vehicles  
Footprint: 18 × 3.5 m Cost: $55,000  
|            |                                   |                                              |  

| Truck scales | QWC (Queensland Weighing Machines Pty Ltd) | See above QWC (Queensland Weighing Machines Pty Ltd) | **Weightbridge**  
For weighing heavy road vehicles  
Footprint: 18 × 3.5 m Cost: $55,000  
|            |                                   |                                              |