The objective of the WRAP Aggregates Programme is to reduce the environmental impact of mineral extraction by minimizing the demand for primary aggregates. This is to be achieved through facilitating the increased availability and use of aggregates from recycled and secondary resources in England.

To develop the programme to achieve this objective it is necessary to analyse the present resources used for construction aggregates, their availability, and their utilization in the marketplace. From this information it is possible to identify and overcome the barriers to the more sustainable resourcing of these aggregates.

**SOURCES AND END USES OF AGGREGATES**

**Primary**
The figures used for primary aggregates in DTI construction statistics are production figures and not for the location of use, but in considering total market demand they give a reliable picture (table 1).

The distribution of the end uses of sand and gravel and crushed rock is different, illustrating the characteristics of the resources (figs 1 & 2).

**Secondary and recycled resources**
The use of secondary* and recycled** aggregates in construction is well established and statistics on their production are finally becoming more reliable with the recently published surveys from the Office of the

---

**TABLE 1 Primary aggregate production**

<table>
<thead>
<tr>
<th>Region</th>
<th>Total primary production (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>North-West</td>
<td>4</td>
</tr>
<tr>
<td>North-East</td>
<td>3</td>
</tr>
<tr>
<td>Yorkshire &amp; Humber</td>
<td>5</td>
</tr>
<tr>
<td>West Midlands</td>
<td>10</td>
</tr>
<tr>
<td>East Midlands</td>
<td>10</td>
</tr>
<tr>
<td>East of England</td>
<td>6</td>
</tr>
<tr>
<td>London</td>
<td>10</td>
</tr>
<tr>
<td>South-East</td>
<td>21</td>
</tr>
<tr>
<td>South-West</td>
<td>6</td>
</tr>
<tr>
<td>England</td>
<td>75</td>
</tr>
</tbody>
</table>

---

* Secondary aggregates: Aggregates produced from the by-products of other industrial processes and not previously used in construction.

** Recycled aggregates: Aggregates derived from reprocessing materials previously used in construction.
Deputy Prime Minister (ODPM). The major resources are shown in table 2. The use of recycled construction and demolition waste (C&DW) is reasonably uniform nationally whereas secondary materials are more regionally based.

The ODPM’s survey on secondary resources determined the total potential amount of secondary aggregates produced, the aggregate usage, and non-aggregate use, making it possible to calculate the annual surplus going to stock. A figure for useable stock was also given. The ODPM considered spent rail ballast as a secondary material, therefore, for reconciliation purposes, it is included in this analysis (table 3).

The two regions showing the highest output are Yorkshire and Humber and the South-West; the former results from slag from the Redcar and Scunthorpe steelworks plus some colliery spoil and PFA, whereas the latter is predominantly china clay with some slate.

The potential of surplus production and stocks will be addressed later.

The ODPM’s construction, demolition and excavation waste survey provided data on various categories of waste still going to landfill, covering sites with waste-management licences (WML) and those with formal WML exemptions.

It is difficult to determine the amount of recoverable aggregates lost to landfill, especially excavation waste as this can vary according to local ground conditions, but an experienced estimation has been made on the following assumptions:
- 75% of hard C&DW is recoverable
- 35% of excavation waste used on exempt sites is recoverable
- 25% of mixed/C&DW landfilled on licensed/exempt sites is recoverable
- 15% of excavation waste used for engineering/restoration/fill on licensed landfills is recoverable.

The recycled aggregates analysis in table 4 shows the regional breakdown of use and preference for useable stock.
the estimated total of potential aggregates recoverable from the construction, demolition and excavation waste stream. The usage figure also includes an assumed 5 million tonnes of recycled asphalt planings, distributed by population.

**End use of secondary and recycled aggregates**

No statistics have been gathered on the end use of secondary and recycled aggregates, but WRAP has asked some 260 suppliers of recycled aggregates what products they supply and has made an assessment of end use across all resources (fig. 3).

**All aggregates**

Combining all aggregates, construction aggregates produced in England are considered as shown in table 5.

The combined end use is an indication of the total range of aggregate end use (fig. 4).

**Potential for increased and improved use of secondary/recycled aggregates**

Determining the potential for the greater use of non-primary resources is not a simple matter of totalling up the surplus annual production, the potential recycled aggregates landfilled and the useable stockpiles.

The sustainable use of resources should initially use the most appropriate locally available resource for an end use, allowing materials to be used to their full potential. In most cases materials should only be imported into a region when suitable alternatives are not available. Using this principle, a policy for sustainable aggregates must also consider and include primary resources, optimizing their potential and minimizing waste.

More aggregates will be sourced from secondary and recycled materials that are fit for purpose for a wide range of applications, consistent, and competitive on price.

---

**TABLE 5 Aggregate resource market share in 2001**

<table>
<thead>
<tr>
<th>Resources</th>
<th>Million tonnes/year</th>
<th>Market share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand and gravel</td>
<td>75</td>
<td>35%</td>
</tr>
<tr>
<td>Crushed rock</td>
<td>89</td>
<td>42%</td>
</tr>
<tr>
<td>Recycled</td>
<td>41</td>
<td>19%</td>
</tr>
<tr>
<td>Secondary</td>
<td>9</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>214</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**TABLE 6 Potential additional annual output of secondary/recycled aggregates in 2011**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Million tonnes/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction, demolition and excavation waste</td>
<td>12.2</td>
</tr>
<tr>
<td>Slag</td>
<td>0.7</td>
</tr>
<tr>
<td>China clay waste</td>
<td>4.8</td>
</tr>
<tr>
<td>Used foundry sand</td>
<td>0.5</td>
</tr>
<tr>
<td>Incinerator bottom ash</td>
<td>1.3</td>
</tr>
<tr>
<td>Asphalt planings and waste</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20.2</strong></td>
</tr>
</tbody>
</table>

---

**FIG. 3 End use of secondary and recycled aggregates**

**FIG. 4 End use of construction aggregates**

---

**Major resources**

There is a wide range of resources with the potential to be used as aggregates but only larger-scale resources will have any significant impact on a market demand of around 220 million tonnes a year. Therefore, although there will be an important and increased use of plastic, tyres and, in the short term, glass, these combined materials are unlikely to have an impact of 0.5% on the market.

Slate is excluded as WRAP’s brief excludes Wales, although the Arup Report for the Welsh...
Assembly on slate as a secondary aggregate considered that infrastructure problems and market economics would prevent slate aggregates increasing their market share in the medium term.

The potential growth of major resources available to the aggregates market over the next 10 years is shown in Table 6.

**Construction, demolition and excavation waste**
The figure used in Table 6 is taken from the ‘available balance’ total in Table 4. There is considerable debate on the quantity recoverable from this waste stream but, even so, the criteria used for calculating this figure are reasonable. The potential from the broad range of arisings classified as ‘excavation waste’ is significant, as time will tell.

The key barriers to growth are:

— the availability of WML-exempt landfill sites that divert resources away from recycling
— the lack of segregation of materials
— the lack of suitable reprocessing infrastructure
— difficulties in securing planning permission
— end-user confidence
— inconsistent application of waste-management licensing rules.

**Slag**
Blast-furnace slag from all major steelworks is fully utilized, be it air cooled, granulated or pelletized.

Steel slag has more limited uses and consequently is not fully utilized. There are problems with sulfates that require stocks to be left to oxidize, and, after processing, steel slag aggregate is usually only used as a filler material to meet the demand of local markets.

Old stocks of steel slag, as well as new production, are available for processing however; and there is the potential to research wider uses of steel slag and to consider distribution networks to move it to more distant markets.

Non-ferrous metal slag, such as that from ISF zinc production, does have potential as a construction aggregate.

The barriers to increasing the use of slag as an aggregate include:

— the need for a wider range of end uses
— cost-effective distribution systems
— inconsistent application of waste-management licensing rules.

**China clay waste**
China clay waste is an aggregate looking for a market, with increased use dependant on improved and economic distribution, predominantly by sea.

Imerys, the main producers, are hoping to increase sales by 250,000 tonnes in 2003 and by 500,000 tonnes in 2004, with the aspiration of reaching 5 million tonnes between 2010 and 2015. Their target geographic market is the UK and mainland Europe.

An initial increase in capacity is underway at the port of Par, supported by a Government freight-facilities grant, but the major works required for the aspired 5 million tonnes are several years distant.

The barriers to greater use of this material include:

— lack of reprocessing infrastructure
— lack of deep-water loading facilities in Cornwall.

**Used foundry sand**
There are different types of used foundry sand depending on the foundry process. Modern foundries reuse the sand several times before discarding it as waste. It can be processed reasonably easily to produce a sand suitable for use in asphalt, foamed concrete or cement manufacture.

The barriers to the use of foundry sands include:

— lack of sand-reprocessing facilities
— dispersed production of materials
— inconsistent application of waste-management licensing rules.

**Incinerator bottom ash**
Incinerator bottom ash (IBA) is the main by-product of the incineration of municipal waste in energy-from-waste (EFW) plants. Typically, 25% of the input to an EFW plant becomes IBA. The unprocessed IBA contains small proportions of both ferrous and non-ferrous metals as well as unburnt waste. In order to produce a clean and usable aggregate it is necessary to remove these fractions using magnetic separation equipment and conventional screening.

IBA can be used in precast block production, hot- and cold-process asphalt, and cement-bound macadam and fills.

IBA is an ideal resource for a secondary aggregate as it is consistent in quality and quantity, usually occurring in urban areas close to a point of end use, and can be used in higher-value applications.

If additional EfW plants are constructed over the next 10 years to handle 5 million tonnes of MSW, the potential for aggregates production would be 1.25 million tonnes a year in year 10.

The barriers to the use of IBA include:

— concerns over the chemical nature of the material
— lack of awareness and knowledge in local markets for the materials
— inconsistent application of waste-management licensing rules.

**Asphalt planings and waste**
The quantity of asphalt planings removed from England’s roads is estimated at 5 million tonnes a year and it is assumed that around 95% is used as low-grade fill, although a growing proportion is being recycled into asphalt.

Asphalt waste is that generated at the point of manufacture, ie the asphalt plant. English production of asphalt is around 20 million tonnes and it could be assumed that there is 2% waste generated by process wastes and returned loads; this equates to 400,000 tonnes a year of asphalt waste.

Asphalt should be recycled back into hot asphalt to gain the benefit of the bitumen and quality aggregate, or into cold-lay foamed bitumen where the aggregate quality is optimized and its use replaces more environmentally and financially expensive hot asphalt.

From these figures there is the potential for 20% of all asphalt
Recycling to be recycled. The environmental and economic benefits of this would be high; the annual saving in bitumen alone would be in the region of £19 million.

Even if it is assumed that 95% of asphalt planings are currently used as low-grade aggregates, the provision of higher-value recycling could recover the lost 5% and recover the asphalt waste stream, releasing an additional 650,000 tonnes a year.

The barriers to the recovery of high-grade aggregate from asphalt planings include:
— lack of reprocessing infrastructure at hot-process asphalt plants
— lack of cold-process foamed-bitumen asphalt plants
— lack of awareness and knowledge in local markets for the materials
— inconsistent application of waste-management licensing rules.

Sustainable utilization of resources
The present end use of secondary and recycled aggregates (fig. 3) shows a high proportion of use as low-performance fills. This is a waste of resources. Materials should be used more effectively, optimizing their potential. This does not mean that these resources should be used to the highest performance that they can achieve technically, as this will often not be the best environmental and economic option.

An analysis of the potential use of secondary and recycled aggregates, assuming the growth projected in the earlier ‘Major resource’ section of this article, for the next 10 years gives the end-use analysis shown in figure 5.

The changes in tonnage are shown in table 7 (rounding causes minor changes).

This analysis shows that there will be an increase of use of secondary or recycled aggregates in concrete; this will be predominantly in ready-mixed concrete and through blending with primary aggregates in lower-strength concretes, but also through the closed-loop recycling of precast concrete waste and the wider availability of china clay sand for precast concrete.

However, impact is unlikely to reach 15% of concrete aggregate demand.

The impact on aggregates for asphalt has the potential to be more significant. Aggregates from C&DW and planings will be more widely used in cold-lay foamed-bitumen asphalts; planings will be widely recycled into hot asphalt to gain the added benefit of recovered bitumen; and IBA, spent rail ballast and many lower-volume resources are best suited for use in asphalt. Secondary and recycled aggregates could amount to 40% of asphalt aggregates.

Secondary resources of PFA and colliery spoil have not featured in this analysis because their aggregate use is invariably as a fill. However, as can be seen from table 7, better use of the other resources creates a demand for more low-price fills, and these should be supplied from appropriate resources most closely located to the point of use, be they low-grade primary aggregates or secondary fills.

Impact on primary resources
These changes in the resourcing of aggregates should occur regardless of the total demand for aggregates, but demand is forecast to increase over coming years and the impact on the supply chain should be considered.

A middle-of-the-road forecast would project aggregate demand to increase by 1% a year over the 10 years from an assumed 2001 base of 214 million tonnes. This would make total aggregate demand in 2011 (for England) 234 million tonnes.

The distribution of resource use would change as shown in table 8.

This change in share assumes that the demand for fill materials is sourced from primary materials, leaving the total demand for primary aggregates at the same level as 2001 but higher.

### TABLE 7 Changes in end use of secondary/recycled aggregates

<table>
<thead>
<tr>
<th>Aggregate grade</th>
<th>2001 secondary/recycled aggregates (million tonnes)</th>
<th>2011 secondary/recycled aggregates (million tonnes)</th>
<th>Change in use (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete sand</td>
<td>3.3</td>
<td>12.1</td>
<td>+8.8</td>
</tr>
<tr>
<td>Concrete/graded coarse aggregate</td>
<td>2.7</td>
<td>10.2</td>
<td>+7.5</td>
</tr>
<tr>
<td>Asphalt aggregates</td>
<td>9.3</td>
<td>25.2</td>
<td>+15.9</td>
</tr>
<tr>
<td>Fills</td>
<td>35.3</td>
<td>23.5</td>
<td>-11.8</td>
</tr>
<tr>
<td>Building sand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50.6</td>
<td>71.0</td>
<td>+20.4</td>
</tr>
</tbody>
</table>

### TABLE 8 Change in aggregate resource market share

<table>
<thead>
<tr>
<th>Resource</th>
<th>2001</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>77%</td>
<td>70%</td>
</tr>
<tr>
<td>Secondary and recycled</td>
<td>23%</td>
<td>30%</td>
</tr>
</tbody>
</table>
The figures clearly illustrate that a comprehensive evolution of all resources within one overall strategy is required to achieve the more sustainable resourcing of aggregates.

**DRIVERS OF CHANGE IN MARKET SUPPLY**

The last six years have seen a sharp growth in the use of non-primary aggregates. In considering the measures required to continue this growth an assessment of the drivers behind the change is required.

**Government intervention**

**Landfill tax**

The economics of recycling took a step change in 1996. The introduction of the landfill tax dramatically increased the number of recycling activities both at construction/demolition sites and at fixed recycling operations. Without doubt, the landfill tax has been, to date, the most influential driver for increased availability and use of recycled aggregates.

**Aggregates levy**

The aggregates levy increased the market price of aggregates, bringing more revenue into recycling/secondary activities, and broadened awareness of the availability of alternatives to primary materials. This levy is allowing the most proactive members of the construction community to more readily pursue the use of recycled and secondary aggregates.

Local Agenda 21 impact on local authority procurement

Local authorities following Local Agenda 21 policies are specifying recycled aggregates in annual tenders. However, the use of procurement initiatives to increase the use of recycled and secondary aggregates is patchy, with some local authorities being more proactive than others.

**Highways Agency Specification for Highway Works**

In May 2001 the Highways Agency issued modifications to the Specification for Highway Works, based on the work carried out for the European Aggregate Standards, permitting the use of recycled and secondary materials as aggregates for most construction applications.

**Mineral planning policy**

The new edition of Mineral Planning Guidance Note 6 (MPG 6) being produced by the ODPM has been going through a lengthy consultation process for the last three years. This document’s purpose is to ensure that there are sufficient construction aggregates available to meet the projected demand of the construction market for the next 15 years. Government policy is that this demand will be met from secondary and recycled resources in the first instance, with the balance provided from primary resources.

The major suppliers in the aggregates market realized that the planning consents on the primary mineral reserves from which they sourced their products would be constrained and, as a consequence, took action to balance their resources with secondary and recycled materials.

**OVERCOMING BARRIERS TO INCREASED AND IMPROVED USE OF SECONDARY/RECYCLED AGGREGATES**

Barriers preventing the increased use of key non-primary resources were listed earlier. There are certain common issues across these material streams, and WRAP’s Aggregates Programme is addressing those that can facilitate further change.

**Availability of resources and reprocessing infrastructure**

The WRAP Capital Programme has targeted those secondary/recycled resources capable of having the most significant impact on supply.

Grant funding will facilitate the processing of construction, demolition and excavation wastes being lost to landfill by assisting in the provision of appropriate plant, allowing processing to quality aggregates capable of being used to their optimum potential.

Grant funding will also facilitate higher-quality recycling, increasing the value of products, improving the viability of the recycling process, and thereby improving competitiveness in securing recyclable resources away from landfill. This support will assist in broadening the range of products to match market demand.

Secondary resources will also benefit from grants for the establishment of processing facilities, allowing the use of smaller resources adjacent to local markets and the sustainable exploitation of larger resources to wider markets.

This programme will be used to expand the range and quality of facilities in urban and more rural locations. To expand good practice these projects will be publicised and developed as case studies.

---

**TABLE 9 Changes in end use of primary aggregates**

<table>
<thead>
<tr>
<th>Aggregate grade</th>
<th>2001 primary aggregates (million tonnes)</th>
<th>2011 primary aggregates (million tonnes)</th>
<th>Change in use (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete sand</td>
<td>27</td>
<td>31</td>
<td>+3</td>
</tr>
<tr>
<td>Concrete/graded course aggregate</td>
<td>43</td>
<td>39</td>
<td>-3</td>
</tr>
<tr>
<td>Asphalt aggregates</td>
<td>18</td>
<td>12</td>
<td>-5</td>
</tr>
<tr>
<td>Sub-base</td>
<td>24</td>
<td>10</td>
<td>-14</td>
</tr>
<tr>
<td>Fills</td>
<td>43</td>
<td>60</td>
<td>+17</td>
</tr>
<tr>
<td>Building sand</td>
<td>9</td>
<td>11</td>
<td>+1</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>163</td>
<td>-1</td>
</tr>
</tbody>
</table>
Availability of information
Recycled/secondary aggregates have been widely used and tested. Standards for their use have been published and research into potential technical problems has been undertaken. However, a lack of awareness of this wealth of information is preventing the wider use of these materials. The distribution of information on good practice, technical aspects and established standards is required to strengthen confidence and facilitate change.

AggRegain
This need for the dissemination of information will be facilitated through AggRegain, the sustainable Internet-based aggregate information service from WRAP. This is the conduit through which research, experience, standards and good practice will be distributed. It is in a format that is easily interrogated and practical, and it serves the needs of the specifier, purchaser and supplier. The website is also supported by a free telephone helpline to provide a more specific service when required.

As the Aggregates Programme evolves the AggRegain database will grow, providing information on a wider range of products, end uses and research projects. It will also be a means of distributing case studies and experience gained from the Capital Programme. The helpline will also be a source for identifying areas requiring support and development.

Aggregates Forum
To ensure direct contact with key players and influencers across the aggregates supply chain WRAP has brought together the Aggregates Forum. Members of the forum, who total around 50, are representatives of the various stakeholder groups involved in the production, procurement, application and specification of construction aggregates.

The purpose of the forum is to secure the active involvement of these stakeholders in the direction and implementation of the WRAP Aggregates Programme.

The forum meets at six-month intervals; the first meeting was on the 6 November 2002.

Research
A directed research call which generated nine reports by the end of March 2003 was commissioned jointly by the DTI and WRAP. Co-operation with the DTI is important to ensure no duplication with the Construction Directorate’s existing programmes. The reports address real issues, rather than academic research, on subjects such as ‘whole-life costing’ and ‘application of the new European standards’.

A further call for 2003/4 was made through the focus section in the DTI’s Partners in Innovation. Again the emphasis is on gathering knowledge and compiling it in a concise form to assist and inform the market.

All projects will have outputs that can be disseminated through AggRegain, allowing WRAP to link specifiers, buyers and suppliers with the best information relative to their needs.

Procurement
The biggest commercial driver of change is when ‘your’ customer goes to a competitor because you cannot meet their needs. Local authorities and commercial clients specifying recycled/secondary aggregates force the most reluctant suppliers to reassess the resources they use for their aggregates.

It is considered that 40% of construction aggregates are purchased for Government-sponsored contracts, therefore even a modest 10% recycled/secondary aggregate procurement policy would create an additional demand of around 8 million tonnes a year.

Procurement will be addressed in the Aggregates Programme through the broader WRAP procurement initiative.

Legislation/regulation
At the Aggregates Forum meeting last November members were split into small groups for facilitated breakout sessions. They were asked to list the major barriers to the greater use of secondary and recycled aggregates. The output was generally in line with the barriers listed elsewhere in this article, but every group put legislation and regulation at the top of their list.

There are three key areas of concern.

Planning
Inconsistency in planning policy and the implementation of policy prevents the investment in, and development of, quality recycling facilities especially in urban locations. This subject is being researched under the 2002/3 DTI/WRAP research call.

There is a need for the results from this research to be developed to produce guidance for both planners and applicants to assist in establishing a consistent infrastructure of strategically located recycling facilities.

Waste-management licences
There is inconsistency and confusion on the issue of waste-management licences and exemptions from waste-management licences for recycling activities. The Environment Agency has no standard approach to the control of different types of recycling activity and this prevents the establishment and operation of facilities, resulting in the loss or inefficient use of resources.

There is a need to address the development of standard guidance documents for both the establishment of recycling facilities and the application of waste-management licensing regulations to ensure good practice and the sustainable use of resources.

Waste/product
The present policy of the Environment Agency is to interpret the definition of waste in such a way that all recycled aggregates and secondary aggregates from industrial resources (ie excluding china clay and slate wastes) continue to be wastes until ‘fully recovered’. This policy has not been implemented in practice but will be if no action is taken, resulting in a significant commercial and operational deterrent to the use of secondary and recycled aggregates (see appendix 1).

A collective approach by stakeholders is urgently
Recycling

needed to develop a protocol that will define an acceptable procedure for processing and testing secondary and recycled aggregates, such that the point of ‘full recovery’ is at the aggregate-processing facility.

CONCLUSION

The use of recycled and secondary aggregates has been through its greatest period of growth. The future is about doing it better.

The marketplace should understand that aggregates are aggregates regardless of the resource used. It is using the most appropriate resource in each geographic area for its most appropriate use that will result in a more sustainable supply of aggregates.

Economics are important and products must be competitive, but minimizing waste and optimizing the potential of resources can be the lowest-cost option. Undoubtedly, economics will improve with further fiscal measures on landfill costs and primary extraction, but a proactive approach will give forward-thinking companies a competitive edge now, and even higher returns in the future.

REFERENCES

2. Survey of Arisings and Use of Secondary Materials as Aggregates in England and Wales in 2001, planning research by ODPM.