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Reuse and Recycling on the London 2012 Olympic Park

Lessons for demolition, construction and regeneration

October 2011

Disclaimer: This report was produced by BioRegional, Atkins and CLM. All of the factual details have been agreed by all parties. However, the opinions stated do not necessarily reflect the views of all parties in all cases.

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1 Executive Summary

The environmental benefits of reclamation and reuse are considerable. Overall the Construction and Demolition (C&D) sector contributes at least 15% of the UK's national CO_2 emissions[1] and generates 120 million tonnes of waste per year, making it the single largest producer of waste in England[2].

The Olympic Delivery Authority (ODA) set demanding sustainability targets for the Olympic Park demolition, including an overall target of at least 90% by weight of demolition material to be reused or recycled. The ODA's overall target was achieved on a project of significant scale, with challenging and inflexible deadlines.

The focus of this report is reuse of C&D materials. It describes the processes used throughout demolition highlighting project management, contracting, communication, documentation, demolition processes, product storage and design.

The successes, lessons and recommendations will be of interest to local and national government departments responsible for large scale events such as the Commonwealth Games and regeneration projects similar to the Kings Cross redevelopment. This report should further be of interest to senior executives and project managers in the construction and demolition industries and the case studies and key lessons may be beneficial to demolition contractors looking to expand income streams.

This report is designed to highlight lessons for future projects; learning from the positives and being in a position not to replicate the areas of missed opportunity. In particular there are lessons to be learnt from the missed opportunity to maximise the reuse of products on a project of this size. In this report learning is clearly set out in pull-out boxes to assist the planning of future projects.

The ODA exceeded the demolition reuse or recycling target of 90% by 8.5%, with less than 7,000 tonnes landfilled. This is an improvement on industry standards and significant progress towards an overall industry goal of halving waste to landfill by 2012[3]. Reclaimed and reused materials are a drop in the ocean in the total context at only 0.5%. There was no overall target for reuse and it is almost impossible at this stage to determine what would have been appropriate. All figures contained in this report are accurate up to December 2009.

It is possible to conclude that more products could have been reused, and recommendations in this report should help to show how future projects can set similar targets and in doing so work towards achieving improvements in sustainability.

Much of this learning can be employed in the transformation phase of the Park between Games and Legacy and there are steps that can be taken during construction which will help to ensure reuse and recycling is maximised. Managers throughout the process will need to be aware of the potential for reuse as well as recycling, and ready to take effective action at an early stage.

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1 What Makes an Eco-Town? Published by BioRegional and CABE, 2008.

2 WRAP 2007

3 WRAP, (2009). *Halving Waste to Landfill* [online]. Available: http://www.wrap.org.uk/construction/halving_waste_to_landfill/index.html [accessed 1st December 2009]

2 Context

2.1 The London 2012 Olympic Park Site

Demolition underway on the Olympic Park

On 6 July 2005 the International Olympic Committee announced that London would host the 2012 Olympic and Paralympic Games. The London 2012 bid identified a 2.5 square kilometre site in the Lower Lea Valley, East London, as the site for the 2012 Olympic Park redevelopment. The site has historically had a strong industrial focus based around the important transport links provided by the River Lea and the extensive canal network.

For the demolition phase over 220 buildings had to be demolished alongside a number of walls, bridges and roads. A consortium consisting of CH2M Hill International, Laing O'Rourke and Mace (CLM) was the delivery partner to the Olympic Delivery Authority (ODA) with Atkins as project manager. The Park itself was divided into a North and a South side with Morrison Construction and BAM Nuttall acting as the respective Tier 1 contractors for the Enabling Works.

At the peak of construction as many as 11,000 workers will be employed simultaneously at the London 2012 Olympic Park site and Athletes Village[4]. The fixed delivery date of July 2011 for completion of Olympic Park infrastructure and venues is obviously inflexible. The significance of deadlines along with the tight timescale and size of the site all presented challenges for the partners involved in demolition, in particular for reclamation and reuse, which can take longer than traditional demolition.

2.2 Environmental Impacts of Construction

Construction of the built environment has a significant impact on UK sustainability. The Construction and Demolition (C&D) sector contributes at least 15% of the UK's national CO_2 emissions[5] and generates 120 million tonnes of waste per year, making it the single largest producer of waste in England[6].

> Reclaimed and reused steel sections typically have a 25 times lower environmental impact than new, even though new sections typically have a 60% recycled content.

[4] ODA press release of 29th April 2009
[5] What Makes an Eco-Town? Published by BioRegional and CABE, 2008.
[6] WRAP 2007

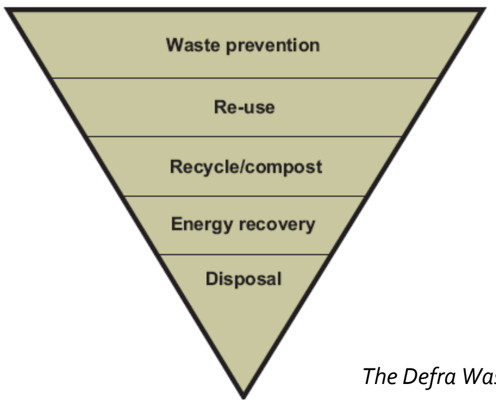
In 2005, 52% of England's C&D waste was recycled[7]. Several EU member states recycle over 80% of C&D waste generated, including Denmark and Germany[8]. This is mainly achieved through recycling into a product of lower value or "downcycling", such as crushing materials for aggregate use onsite or incineration for energy recovery. See Table 1 below for a definition of reuse and recycling terms.

The challenge of reducing global greenhouse gas emissions by 80% below 1990 levels to avoid irrevocable climate change[9] should impact the way in which we deal with waste. One of the ways the construction sector can take on their share of this climate challenge is to maximise waste reduction and reuse as it moves towards zero waste.

Table 1: Definition of Terms

Term	Definition	Examples
Reclaim	To recover a product, for reuse purposes, that was originally destined for waste or recycling.	Dismantle a steel frame building. Collect bricks/blocks from a demolition site.
Reuse	The use of a product, in its original form with minimal reprocessing, that was originally destined for waste or recycling.	Making a table from reclaimed floorboards. Building a wall from reclaimed bricks.
Recycle	To recover the constituent materials of a product for remanufacture or re-processing into a something of equivalent value.	New plasterboards reformed from plasterboard off cuts.
Downcycle	To recycle an original product into something of lower grade; in terms of either material or economic value.	Graded aggregate from crushed bricks. Panel products from chipped timber.

Reuse retains the embodied energy in the original material, reduces the need for more energy and materials to be expended, can reduce transport emissions and congestion and preserves historic, rare, irreplaceable and sought after materials. In contrast, downcycling wastes carbon, as the new product has a lower embedded carbon when made from virgin sources than the product



The Defra Waste Hierarchy

[7] Department for Communities and Local Government: http://www.defra.gov.uk/evidence/statistics/environment/waste/kf/wrkf09.htm [accessed 12th April 2010]

[8] Eurostat and ETC/RWM, 2008 based on national reports and Statistics; cited in *EU as a Recycling Society: Present recycling levels of Municipal Waste and Construction & Demolition Waste in the EU*; Christian Fischer and Mads Werge, Danish Topic Centre on Waste; April 2009): http://scp.eionet.europa.eu/publications/wp2009_2/wp/wp2009_2 [accessed 12th April 2010]

(The EU Waste Framework Directive (2008/98/EC) set a target for member states that by 2020, "the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 170504 in the European Waste Catalogue (EWC) shall be increased to a minimum of 70% by weight."

EU Waste Framework Directive (2008/98/EC)

[9] What Makes an Eco-town? Report of BioRegional and CABE, 2008

which is recycled. An example of this is crushing bricks to create recycled aggregate. Recycling can still consume significant energy for reprocessing or remanufacturing, around 70% of the environmental impact of new construction arises from the 'embodied' energy due to the manufacture of the product[10]. Whilst recognising that some materials (notably concrete) cannot be reused it is important to keep reuse above recycling and energy recovery for the reasons outlined above.

The potential contribution of the reuse of building materials to the UK's waste and greenhouse gas emission targets is considerable. For example, reclaimed and reused steel sections typically have a 25 times lower environmental impact than new, even though new steel sections commonly have a 60% recycled content[11]. In addition to these environmental impacts, 1 tonne of embodied CO_2 may be saved through the reuse of around ½ a tonne of structural steel or 400 bricks.

3 Reclamation, Reuse and Recycling Best Practice

Reclamation and re-use of construction products is not a new idea, salvage has always formed an integral part of the demolition process[12]. However, reuse declined with the advent of modern construction methods and the land filling of building materials increased[13]. Recent technical developments in recycling have tended to both reduce total waste to landfill and reduce the amount of construction products reused in their original form[14].

Just as demolition companies can realise profits by investing in the capital machinery required for recycling, profits could also be increased by investing in the skills and knowledge to reclaim materials. If this trend took off in the demolition industry, it could enable those most skilled at reclaiming to out-bid others on lower price and increased sustainability, unleashing a chain reaction of market forces benefiting the environment and the supply chain.

> Sustainability objectives are best achieved when the client organisation is committed and takes the lead. – *Recommendation of the Joint Contracts Tribunal*

Current best practice on construction waste tends to follow the UK Governments *Strategy for Sustainable Construction*[15] which includes the Construction Waste Commitment, a government and industry target to halve waste to landfill by 2012. The campaign is delivered by WRAP[16].

3.1 Institute of Civil Engineers Demolition Protocol

The revised Demolition Protocol, produced by the Institution of Civil Engineers (ICE) and endorsed by WRAP provides a framework for using the waste hierarchy to maximise materials resource

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[10] Pushing Reuse, Thornton Kay, published by BioRegional, 2009
[11] Building Research Establishment (BRE) lifecycle analysis, cited in Reclaimed Building Materials in the Development of the Thames Gateway, BioRegional Reclaimed, 2006
[12] History of Waste published by the Chartered Institute of Waste Managers
13 Ibid
[14] For example, the Big Rec survey in 2008 notes the reduction in the overall volume in reuse of construction timber in the previous 10 years. See. www.reuse.it/salvo/bigrec.html
[15] Strategy for Sustainable Construction, June 2008
[16] WRAP commitment as agreed by the Strategic Forum for Construction *(see* www.strategicforum.org.uk/PR-ForumandWRAPpledgeNov06.doc.)

efficiency[17]. The waste hierarchy is related to the demolition process as indicated in Figure 1, below.

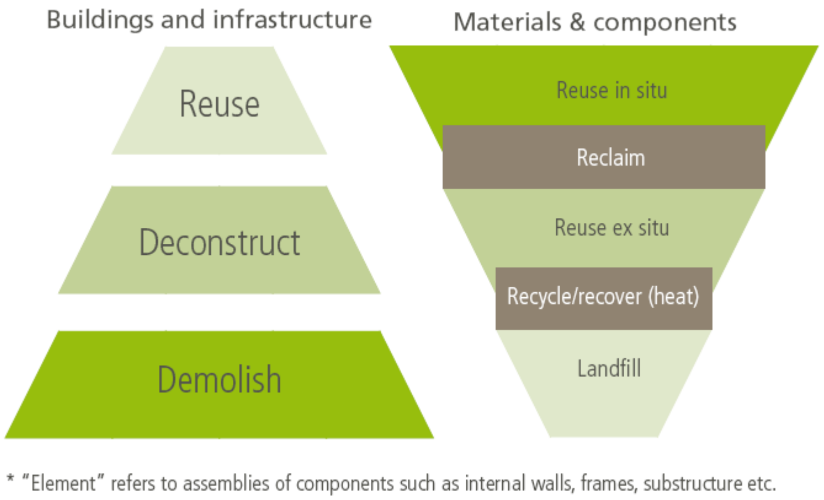

Figure 1. Relating the Waste Hierarchy to Demolition (ICE, 2008)

The Demolition Protocol proposes that before demolition starts a full pre-demolition audit and reclamation survey are undertaken to identify the specific opportunities for reuse (see Figure 2 below). Completing a reclamation survey alongside a full pre-demolition audit enables a target to be set for the amount of reclamation from different parts of a site to be deconstructed and demolished and creates a benchmark for site wide reuse, recycling targets and performance monitoring.

[17] This is located at http://www.ice.org.uk/downloads//Demolition%20Protocol%202008.pdf.

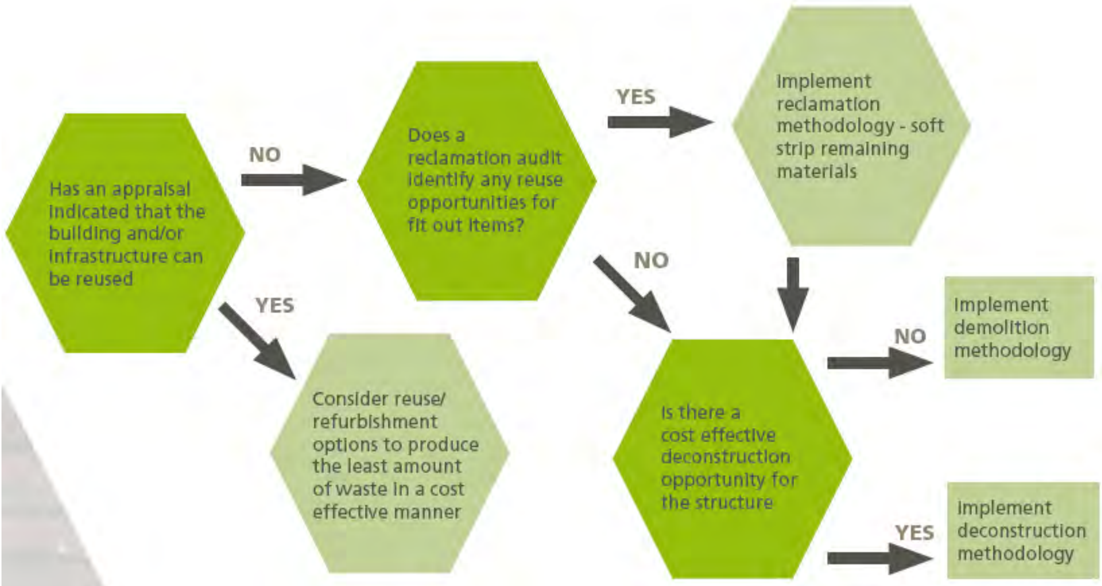

Figure 2. Maximising Reclamation through the Decision Making Process

3.2 Carbon Accounting

All projects that undertake complete carbon accounting (during the construction stage as well as demolition stage) should conduct an analysis of the embodied carbon of recovered materials. This could be included as part of the pre-demolition audit. The Environment Agency has integrated carbon emissions into its procurement process to reduce carbon costs from concept through outline and detailed design to final as-built carbon costs. This approach could have been taken further for the (far more complex) 2012 Olympic Park project by integrating carbon into the cost estimating system, to ensure that 'value engineering' reduces costs and carbon together. However, carbon targets were not set as the process was relatively new when targets for the project were being agreed.

3.3 Sustainability Clauses in Contracts

The Joint Contracts Tribunal, in a recent briefing note on sustainability comments that:

> "Sustainability in design and construction is an issue of major importance and should be provided for in the contract documents. Its incorporation can be in the printed contract conditions, a specifically drafted schedule to the conditions or in the specification or other contract documentation. Whatever means are used it is important that the sustainability requirements are contractually enforceable or at the very least provide objective measures for exercising sanctions where there is non-compliance." [18]

For further information on incorporating sustainability clauses and reclamation, in particular into contracts, The Northern Ireland Executive Central Procurement Directorate has published a useful guidance note aimed at project managers on demolition projects[19]. The recommendations echo

[18] Building a Sustainable Future Together, available from www.jtcltd.co.uk

[19] Available from the Northern Ireland Executive at www.cpdni.gov.uk/scg_guidance_note_6.pdf

some of the learning highlighted in this report including the importance of contracts and good target setting.

3.4 Incentives and Markets

The standard rate of landfill tax was £24 per tonne on 1st April 2007 and increased by £8 per tonne each year after that. This represents a considerable economic incentive for landfill avoidance though there is no economic incentive for contractors to choose off site reuse over recycling, except for architectural salvage and other higher value items.

Salvo, the directory of UK suppliers of architectural salvage and publishers of the BigREC report, estimate that around 10 million tonnes per year of materials could be salvaged[20] which equates to around 8% overall across the UK[21]. Also, industry research shows that around 13% of construction waste is new, unused material[22], this suggests that 10% by weight may be a good guide for future reuse levels for the construction stage.

Not all sites contain large amounts of easy wins and heritage products. For demolition, the reuse target should be set following a reclamation audit[23] as the reuse opportunities will depend on structure (e.g. this is much higher for Victorian houses where the bricks are held together with lime mortar, and for portal steel frames where most of the building can be reclaimed). The 2007 BigREc Survey[24] findings report that the amount of bricks reclaimed in the UK have doubled since 1998 to over 845,000 tonnes, suggesting that there is an established market for reclaimed bricks.

3.5 Health and Safety

The health and safety of the workforce is obviously of vital importance. Construction and demolition can be dangerous and in 2008/09 53 construction workers died in accidents on building sites. In 2007/08 there were 72 fatal injuries[25]. Most reclamation techniques involve a greater number of operatives working closer to the structure for a longer period of time. In light of this, reclamation does require increased health and safety processes to be put in place, so time or resources need to be allocated to ensure that this happens.

[20] Ibid.

[21] Construction, demolition, refurbishment and excavation produce around 120 million tonnes of waste each year in the UK. See Halving Construction Waste to Landfill by 2012: Construction Briefing Note – www.wrap.org.uk/construction.

[22] See www.bre.co.uk/.../sustainable_construction_simpleways_to_make_it_happen.pdf

[23] See Demolition Protocol 2008 (Institution of Civil Engineers)

[24] BigREc survey 2007 available at: http://www.crwplatform.co.uk/conwaste/assets/Publications/BigREcfullreport.pdf [Accessed 12th April 2010]

[25] Chartered Institute of Environmental Health

4 The Olympic Park Strategy

In this section we describe the processes adopted on the Olympic Park under the headings of Contractual Relationships, Specialist Subcontractors, Demolition and Reclamation Audits, Decision Making Process, Monitoring and Data Collection, Working with Designers and Materials Storage. We draw out comparisons with best practice and highlight the lessons learned from each stage of the process.

90% of material by weight arising through demolition works to be reused or recycled following the ODA's waste hierarchy of eliminate, reduce, reuse, recycle, recover, dispose. – London 2012 Target

Central to the Olympic Park approach was London 2012's commitment to sustainability. This commitment was encapsulated in the Towards a One Planet Olympics bid document[26] The Sustainable Development Strategy, produced by the ODA, set out the approach in more detail and twelve key themes were identified each with specific targets. With regard to waste the target was 90% of material, by weight, arising through demolition works to be reused or recycled and to follow the ODA's waste hierarchy of eliminate, reduce, reuse, recycle, recover, dispose[27]. This was refined to give a detailed waste hierarchy which also prioritized onsite and local solutions in the Demolition and Site Clearance Material Management Plan "where feasible and cost effective to do so".

Prior to demolition, the Tier 1 contractors completed both a pre-demolition audit[28] and a reclamation survey[29]. Neither document agreed a target for reclamation and reuse but the waste hierarchy was adopted. The 90% target for combined reuse and recycling during demolition was included in contracts between the ODA and demolition contractors. A combined target does not encourage the waste hierarchy to be followed as recycling is currently cheaper than reclamation., , Consequently neither demolition contractors nor designers were incentivised to seek innovative reuse solutions. The combined target encouraged more recycling than reuse and this is an inversion of the best outcome as demonstrated by the waste pyramid.

These contracts led directly to the achievement of high recycling rates, well above industry standard for recycling. Reuse is more complicated and time consuming and there is no one size fits all approach, therefore, the contract process would likely have led to contractors achieving the 90% recycling target with close to zero reuse without an intervention to pursue reuse.

As a result, the opportunities identified for reuse were not integrated into the main tender and contract clauses and there were no overall measures to maximise reuse opportunities such as provision for offsite storage and reuse.

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[26] *Towards a One Planet Olympics* available at: http://www.london2012.com/documents/bid-publications/towards-a-one-planet-olympics.pdf

[27] ODA Sustainable Development Strategy, January 2007

[28] Completed by Hyder on behalf of Morrison Construction. It is not clear if this was for part or all of the demolition works.

[29] The Reclamation Surveys were completed by BioRegional, working in consultation with Tier 1 contractors.

4.1 Contractual Relationships

As can be seen above, contracts are a crucial factor affecting the success of reclamation. Well-written contracts should lead to transparent, efficient and cost-effective projects where reclamation works are required to meet reuse targets and are not disadvantaged (such as through insufficient time or flexibility in the project programme).

Table 2: Contractor Responsibilities and Benefits Relating to Reclamation and Reuse

Agency	Project	Responsibilities	Related Financial Incentives and Benefits
Client	Recycling Focused	n/a	Incurred additional costs through compensation events where reuse occurred.
	Reuse Focused	n/a	Competitive tenders challenge contractors to meet reuse targets, ensuring best value to the client.
Tier 1 Contractors	Recycling Focused	Soft strip and site clearance. Consideration of reuse and reclamation as part of a waste management strategy.	Own items cleared as part of the soft strip (minimal value or present a disposal cost).
	Reuse Focused	Soft strip and site clearance. Contracted to consider reuse and reclamation in the soft strip and given time and contacts in the reuse and reclamation sectors. Contracted to deliver reuse and recycling targets which are passed on to Tier 2s.	Tier 1 reduces their disposal costs by facilitating reclamation and furniture reuse specialists to remove any remaining saleable furniture, white goods, lighting etc before the soft strip.
Tier 2 Contractors	Recycling Focused	Demolition of buildings to the floor slab. Obligation to contribute to 90% recycling target. No obligation to undertake reclamation.	Own building fabric and related arisings. Materials present a low cost when sent for recycling or an asset if contractor can recycle and sell materials themselves.
	Reuse Focused	Demolition of buildings to the floor slab. Obligation to deliver % by weight recycling target. Obligation to deliver % by value reuse target.	Own building fabric and related arisings. Financial penalties, bonuses or gain share in contracts ensure delivering on reuse is as profitable as recycling.
Specialist Subcontractors	Reuse Focused	Undertake initial reclamation audit following the pre-demolition audit. Subcontracted to undertake reclamation of specific structures.	Where subcontractors are employed, ownership of the structure passes to them. Charge for work can vary between the specialist paying for the building, to no charge or a charge for deconstruction and removal. On the Olympic Park the specialist subcontractors involved effectively paid to take down and reuse the building[30].

[30] Based on an interview with John Rose of Portal Power August 11, 2009

Table 2 compares common practise, "Recycling Focused" projects to an idealised "Reuse Focused" project and suggests how with good use of contracts and incentives, reuse can be financially incentivised.

The Institute of Civil Engineers Demolition Protocol highlights the effects of the arrangement of ownership in demolition contracts[31]. Salvo also stresses the importance of the client's role stating that it is "best if the client makes the decision to reuse"[32].

On the London 2012 Olympic Park, the Tier 1's were responsible for buildings handed over to them during the demolition phase, but the ODA retained ownership of all buildings and materials, this may have adversely affected financial incentives for reuse compared to common reclamation practice where ownership passes to the reclamation specialists and demolition contractors. In a case where the client retains ownership of buildings, there is less incentive for contractors to maximise the sales revenue from materials by selling those for which there is a ready market as reclaimed products. However, if ownership had passed to the specialists then the materials may have been immediately processed for recycling rather than considered for reclamation or reuse. Experience on the Olympic Park suggests that the market was not necessarily prepared to accept all of the potentially reclaimable materials available in the limited project timeframe.

Key Lessons on Incorporation of Reuse into Construction Contracts

Make distinct reclamation, reuse *and* recycling targets. State targets clearly in the tendering process. Base the reclamation targets on reclamation audits to identify what is achievable onsite. Consider specifying the reclamation of key items or materials. If unsure consult with specialist reclaimers before drafting tenders.

Make explicit in the Contract, which party has responsibility for demolition and removal of materials and final ownership of arisings. Make clear the business benefits of ownership of site arisings.

Ensure the reclamation targets specified in the Contract are achieved; do not allow them to be overlooked once the tendering process is completed.

Incentivise use of specialist contractors especially where expertise is available (e.g. for structural steel and regional bricks). Create specific tenders and contracts where feasible and refer to specific items and materials identified onsite.

Include use of site won reused materials in the design and construction contracts, setting a separate target for reuse and recycling.

Require reuse to be entered into a material tracking system and include in Site Waste Management Plans. Adherence should be verified by an individual responsible for monitoring environmental targets, through spot checks of data on existing and reclaimed tonnages.

Create financial incentives for achieving reuse targets, these should be informed by an awareness of the relative prices for the reused or recycled product. Set bonuses and penalties to ensure that reuse of the key items and materials are financially incentivised.

The Defra waste hierarchy is a useful tool for reference, strategy, education and awareness. However, without specific targets, referring to the waste hierarchy will not yield specific results.

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[31] Available from the Institute of Civil Engineers: www.ice.org.uk

[32] Pushing Reuse, published by BioRegional

Elsewhere, higher levels of reclamation have been achieved through specific requirements and targets in planning and contractual requirements. For example, the Kings Cross redevelopment included a requirement to reclaim some structures in its Section 106 planning agreement. The Cane Hill hospital in Croydon included minimum targets for brick reclamation in the tender and contract documents, which led to a higher level of reclamation to that achieved on the 2012 site.

4.2 Specialist Subcontractors

Three steel portal frame buildings were removed before compulsory purchase orders on the Olympic Park were put in place. Once the ODA took control of the site, specialist subcontractors were employed by London 2012 Olympic Park contractors for elements of demolition works on another three steel portal frame buildings, and one Tier 1 contractor successfully carried out reclamation of a portal frame building themselves (a full list of reclaimed portal frame buildings can be found in section 6). Use of a Project Managers Instruction meant several demolition firms undertook the deconstruction of brick structures and the recovery of the bricks with no specialist subcontractors.

Specialist reclamation subcontractors have the knowledge and technique to achieve higher levels of reclamation than most generalist demolition firms. More detail on these processes is included in the steel portal frame and brick reclamation case studies in sections 5 and 6 and in the data tables from section 8 below.

Knowledge of resale markets is as important as skill in deconstruction. Heritage and antique products, and good quality stone are resold relatively easily and there are good markets for steel portal frame buildings, whereas concrete block, generic brick and fencing can be relatively easy to reclaim but markets may be hard to find. Advising on the market or even offering to purchase is a key role for the reclamation specialist. A significant proportion of demolition operational costs may be recovered from product resale. In August of 2009 an interview with one of the reclamation contractors operating on the Park revealed that contractors are willing to pay between 40 pence and one pound per square foot of building footprint for steel portal frames.[33]

Because of the scale of the project and time constraints, in some cases there may have been a lack of capacity in the reclamation sector to dismantle buildings in the required time. Reclamation specialists would have had more opportunity to find end users given more time or resources[34].

Benefits of Using Specialist Reclamation Contractors[35]

Can achieve higher levels of reclamation.

Experienced in finding markets and end users, ensuring materials are reused.

Can offer good prices for deconstruction as the ownership of the building passes to the contractor and its value makes up a part of their payment and is included in the overall price.

The demolition phase of a build can be perceived as a costly delay before the 'value adding' elements of a build begin. By clearly separating demolition from build the right time and focus can be given to this phase allowing for improved reclamation and reuse.

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33 Based on dialogue with Portal Power, specialist steel portal frame building reclamation company (August 2009)
34 Ibid.
35 Specialists can be found through www.salvo.co.uk and www.frn.org.uk.

4.3 Pre-Demolition and Reclamation Audits

The ODA worked with BioRegional and others, trialling more than one audit process to scope the potential to develop robust procedures and generate auditable document trails. Experimental processes were trialled to raise the profile of reuse and its sustainability context through the supply chain. The ODA used four sets of audit data, these are described below and evaluated.

Pre-demolition Audit: Pre-demolition audits are recommended by WRAP and the Institute of Civil Engineers as best practise in demolition. Pre-demolition and Site Clearance Materials Surveys were carried out by specialist engineering consultants for the north of the Olympic Park, however the Tier 1 contractor carried out the surveys in the south of the Park. This is a positive message and demonstrates that it is not only the realm of specialist consultants to complete surveys and that contractors have the capacity to complete them, albeit with appropriate training.

Items of historic and cultural significance, such as this war memorial , help to retain sense of place and should be identified in reclamation audits. This stonework remained in-situ.

Embodied Carbon and Recovery Potential Report: In November 2006, BioRegional submitted an assessment of the embodied carbon and recovery potential of just four work packages to the contractors. This gave a detailed picture of the reclamation potential from a limited number of structures, including the potential embodied carbon savings calculated by engineering consultants, Hyder Consulting.

Key Opportunities Reports, Proposals for Reclaiming Steel Frames and Bricks: In January 2007 BioRegional submitted two short reports to the ODA, highlighting the potential for reclamation of specific steel portal frame and brick structures. The report aimed to highlight quick wins and included recommendations to achieve high levels of reclamation and lists of available specialist contractors. This document was made possible as a result of a grant provided to BioRegional from Defra to support and encourage reuse[36]. In an ideal situation, where contractors have both reuse and recycling targets in their contracts, this step would not have been necessary. However, a similar document highlighting the quick wins for reclamation, potential subcontractors and end users would assist contractors to meet targets. Ease of reuse and potential carbon savings could form part of a pre-demolition audit, removing the need for this additional step.

Detailed Reclamation Surveys: BioRegional carried out detailed reclamation surveys alongside Tier 1 contractors following vacant possession of structures. These surveys covered the entire Park and included most of the buildings, structures and materials including street furniture. They

[36] BioRegional received funding from Defra's Business Reuse Fund to increase reuse of building materials.

were carried out through non-invasive visual inspection of the building interior, exterior and surrounding area. Qualitative and quantitative (approximate) data of reclaimable materials were recorded on survey sheets. Information was then summarised in a digital format linked to a photographic summary of items. These reports were mainly used as a communication tool for designers to generate interest in incorporating site won materials in the Olympic Park designs. Reclamation surveys were time consuming. In the future, other processes would need to be used. A similar effect could perhaps be created by allowing specialist reclamation contractors access to the pre demolition audit data and arranging site visits.

Key Lessons on Reclamation Surveys and Data Gathering

Ideally, gather data before issuing tenders and contracts.

Start early by completing a pre-demolition audit.

Ensure the pre-demolition audit includes a reclamation survey that identifies the range of reclamation possibilities and major reuse opportunities, and sets out the carbon and potential financial benefits. This could involve taking reclamation specialists on a "shopping trip" of your site. Record all buildings, building elements and products with reclamation potential.

Particular structures likely to be of interest to reclamation professionals are identified and their reclamation specified in the tender documents, thereby allowing demolition firms to form alliances with specialists. Provide contact details of recommended specialists if necessary.

Identify opportunities for reclamation, including savings to disposal costs on the soft strip. These items can be saved by inviting a furniture reuse or salvage specialist to identify items to remove.

In practise it takes knowledge and experience to identify reclamation potential and weigh the costs and benefits. As the industry reduces waste and increases reuse, expertise in cost effectively maximising resource efficiency will grow. Tier 1 contractors will require continued support and training.

4.4 Decision Making Process

The survey documents described above were reviewed by representatives of the project management team, Tier 1 contractors and BioRegional. The review discussed individual items on the survey list and considered: health and safety, program, cost and access to a reuse market. The survey review meetings led to an agreed list of actions for the Tier 1 contractor to carry out to achieve reclamation.

"…there is evidence that some contractors are embarking upon projects without properly checking whether they can actually achieve the sustainability requirements set out in the specification. Those that do are often failing to price these requirements properly." – Building Sustainability Together, briefing from the Joint Contracts Tribunal

It was not until the reclamation surveys were complete and the design teams engaged that the client identified particular materials and outline quantities for reclamation. For the majority of buildings this was from July 2007 onwards, after demolition contracts had been agreed.

The ODA required the Tier 1 contractors to submit quotes for the reclamation of some items identified in the pre-demolition surveys. Based on the four key considerations in the survey document reviews mentioned above, the ODA understandably rejected many (if not most) of the inflated prices and schedules for reclamation submitted by demolition firms who were inexperienced in reclamation and uncertain of the market for reused materials[37]. Most buildings that went through this process were demolished and recycled generally due to programme constraints combined with no immediate end user.

Where there was a clear demand from the Olympic Park design teams for site won reusable materials, the Project Manager issued a Project Manager Instruction (PMI[38]). For example, a PMI was issued for the reclamation and storage of all:

- Yellow Stock and Staffordshire Blue bricks;
- Granite Kerbs and setts / cobbles;
- Roof tiles;
- Street furniture including bollards, manhole covers, drainage gratings, and signage;
- Heritage items; and
- Concrete kerbs and paving to 600mm^2.

Some but not all of these were reclaimed, and some were reused. Some items which were the subject of PMIs for onsite reuse did not appear in the storage area inventory as they were inadvertently sent off site for recycling, so although the intention for reclamation and reuse was there, the intermediate storage of materials must be properly managed.

The quantity of earthworks to be handled complicated monitoring of materials recovery. This image shows soil awaiting processing.

4.5 Monitoring and Data Collection

A Site Arisings Steering Group was created and chaired by a representative of Atkins, the project manager. The Steering Group included the demolition project manager, Tier 1 contractors, designers, and third parties including WRAP and BioRegional.

The ODA used SMARTWaste, a suite of tools and

[37] For example, one contractor provided quotes for the deconstruction of the steel portal frame buildings of over £150,000. This contrasted with the guide prices provided by specialist steel portal frame reclaimers of under £50,000 in one case. These buildings were subsequently demolished as a result of programme constraints.
[38] A PMI is [BioRegional suggests ODA provide a definition of this internal role.]

consultancy services developed by the Building Resource Establishment (BRE) to benchmark, survey and audit waste arising from the construction and demolition industries, (the tool was also used for tracking the large quantity of earthworks handled onsite which was SMARTWaste's main focus). The source of material was identified by its building reference and its destination was then recorded as off-site or given an on-site GPS co-ordinate, and the specification and quantity (in tonnes) of material was also recorded. This level of data collection amounted to over 160,000 data entries (including earthworks data) inputted to SMARTWaste by Tier 1 contractor BAM Nuttall alone. However, despite its shortcomings, many contractors felt SMARTWaste captured the information needed. A manual[39] has since been developed and been issued to all contractors responsible for inputting data into SMARTWaste. Issues with monitoring identified through interviews with contractors included:

- The complexity of collating information from multiple sources without a clear Bill of Quantities produced for the demolition stage
- The backlog of data resulting from the delay in issuing the adapted tool and the time taken to collect and input data
- As with all databases it was sensitive to data quality; additional training, a central data entry team, more involvement of users in setting up the database, creation of a manual and standardisation of input systems and waste codes would have improved data quality
- Tier two contractors and the waste transfer stations were not contractually obliged to provide information
- Although weighbridges were used, data collection could have been improved if a comprehensive system of weighbridges had been employed
- BioRegional could have been given the opportunity to have more influence and more responsibility for distribution and securing of end points and Tier 2's should have had an obligation or been contracted to comply. Tier 1's believed that BioRegional had the ability to influence end users and that Tier 1's required additional support.
- The inclusion of all earthworks data into SMARTWaste made elements of the system complicated to manage and it became difficult to make changes.

Key Lessons on Monitoring

Material tracking systems are a useful tool for managing and monitoring waste arisings onsite.

Ensure those responsible for inputting data have adequate training in its use and are suitably incentivised to ensure data quality.

Creating a site arisings steering group is a good idea for large projects that aim to exceed industry best practise.

On large projects and particularly if large earthworks movements are to be recorded, separate systems may be needed for recording smaller quantities of reclaimed materials.

Produce a 'How to' manual to ensure the method for inputting data is standardised across all users.

[39] A Guide to Materials Movement

On large projects ensure an extensive system of weighbridges are employed as waste carriers leave site and that they are suited to the volume of material onsite.

4.6 Working with Designers

End users are essential to ensure eventual reuse. These can either be direct contacts (e.g. designers within the project team) or indirect (delivery to a reclamation yard allows end-users to be identified separately, after reclamation has taken place).

Designers are often inspired by the opportunity to capture the texture and "memory" of previous site use into modern designs and images such as these can be captured in Character Appraisals of the local area. The techniques used to create an onsite market for materials were:

Site visits and workshops were attended by Design Teams throughout the demolition phase

Designer Workshops: A number of 'Designing with Reclaimed Materials' workshops were run for design teams.

Design Team Site Visits: Delivery partners arranged site visits. Design teams were also shown the types and quantities of construction products available. Where items were identified, design teams submitted Design Request Forms identifying the type, quantity and location of desirable products.

Materials Database: Data was downloaded from SMARTWaste and issued to design teams.

Design teams submitted requests for a variety of materials, which resulted directly in PMIs being issued to the Tier 1's to ensure these items were reclaimed. For many items it was difficult to find onsite end users and in some cases items were available too early for the Park design teams to specify them. Some materials may have been unsuitable for onsite reuse in the designers' vision. Some designers require guidance on how materials can be reused, and they need to be inventive. It would have been helpful if designers were required to incorporate site-won reusable materials into their designs.

Key Lessons on Working with Designers

Design team workshops are recommended and should be backed up by site visits. These site visits should be completed before demolition begins.

Use a simple but effective product procurement or allocation process.

Invite designers and potential end users from other local regeneration projects to reduce delays if your own designers are not at a stage to specify materials. However, this alternative should only be used if materials cannot be reused onsite.

Educate designers on how materials can be reused.

Images and Character Appraisals may be adequate to generate design team interest at early stages.

For onsite reuse, supply will not coincide with demand. Ensure adequate storage (See Materials Storage section below).

Export of available reusable materials into a summary for design teams was not sufficient as a stand alone tool to facilitate reuse, feedback from design teams suggested getting onsite to see materials was the most useful element for them. Less detailed information, such as the Character Appraisal documents used by planning teams in conservation areas may be more appropriate at an early stage.

4.7 Materials Storage

Suitable storage secured from the very beginning of demolition is vital for maximising rates of reclamation and reuse by:

- Providing a holding place for materials/items until such time as they are required or purchased;
- allowing time for the identification of end users;
- allowing aggregation of materials so that sufficient quantity exists as to be economical for an end user to collect;
- making it easier to market product;
- minimising double handling and any resultant damage; and
- allowing time to source sufficient quantities of reclaimed materials/items in advance of construction activities.

Reclaimed granite setts in storage on the Greenway

Reclaimed yellow stock bricks in storage on the Olympic Park

Suitable storage is determined by considering a number of factors, including:

- Quantity of material and the area required to store them;
- duration of time they need to be stored;
- whether the materials can be stored exposed to the elements or require packaging and/or covering;
- security measures necessary to ensure that materials are not stolen;
- logistics measures necessary to minimise double handling; and
- management measures necessary to make the materials and their specifications accessible to the end users.

Storage may be onsite or offsite and may be provided through the project (project site or contracted through the project) or via a third party (e.g. reclamation yard).

A temporary onsite Reclamation Yard was created at the Olympic Park in November 2007. Prior to this, materials to be reclaimed were stored onsite but in some cases needed to be moved to allow works to take place. The Yard had a secure perimeter, a part-time Yard Manager, and was inventoried quarterly; however, materials were eventually relocated from this site to allow works in the area to be completed.

Onsite storage minimises transportation of materials and risk of damage. Due to the large volumes of soil and aggregates stored for recycling at the Olympic Park, storage space was at a premium. This led to the programme team deciding that storage could only be justified for products that would be reused onsite. This may have limited the viability of reuse by reducing the range of end users (see Working with Designers).

Key Lessons on Planning Reclaimed Materials Storage

Sufficient storage area is vital to enable reuse along with ample viewing time for designers.

Aim for onsite storage for onsite reuse according to the waste hierarchy. Off site storage and off site reuse is preferable to recycling, even where an end user is not identified at the time of demolition.

Double handling of reclaimed products increases cost, increases breakages and can result in valuable materials being sent off site for recycling due to miscommunication.

Storage should be secure, managed and staffed. If a logistics compound is planned, it should be opened before demolition and should incorporate space for reusable materials.

Where there is a lack of local capacity to reuse construction materials or products, a large project can help facilitate start up of such an initiative and create a new sustainable waste infrastructure in the area of the project.

5 Case Study 1 - Bricks

On the London 2012 Olympic Park there were a number of buildings and structures built with bricks that were easy to reclaim especially Yellow Stock, Red Rubber and Staffordshire Blue bricks. A survey of the entire site was completed to identify brick buildings with the potential for reclamation and provided a list of potential reclamation contractors who could carry out reclamation work[40]. This survey identified 3.6 million bricks onsite. Taking into account barriers to their reclamation, a figure of 1.35 million bricks was estimated as feasible to reclaim. BioRegional were asked to assist in creating a target for site wide brick reclamation. Through consultation with the reclamation industry a target of 60% of bricks site wide or 80% on specific buildings was recommended.

Reclaimed yellow stock bricks used to create seating areas on the Greenway

Yellow Stock and Staffordshire Blue bricks were the subject of a PMI and all should have been reclaimed and stored. Although approximately 20,000 Yellow Stocks have been reused onsite to date, not all of the bricks reclaimed were eventually reused, 130,000 Yellow Stocks were sold on to a specialist demolition contractor, some were damaged during demolition and others were inadvertently sent offsite for recycling. These included the Staffordshire blues and the Red Rubber bricks from Old Ford Cottage, a two-storey building with a 60m^2 footprint where there were estimated to be 35 tonnes of Red Rubbers of which 3 tonnes were reclaimed for reuse. This case study describes the process used to demolish Old Ford Cottage and reclaim 6% of the bricks in the building.

Red and Blue bricks being reclaimed at Construction Zone 8

Soft Strip of Internal Items

The Tier 1 contractor carried out the majority of the soft stripping of Old Ford Cottage. It was thought that the building contained a total of 10 tonnes (15 tonnes of embodied CO_2) of heritage items and materials with a value of over £2,000[41]. However, during the soft-strip the Tier 1 deemed the building to be structurally unsafe and no further internal items could be reclaimed.

Example items lost from the interior of Old Ford Cottage

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40 Olympic Park Steel Frame and Brick Reclamation Proposal, January 2007.

41 Based on quotes provided by Jason Davies of Architectural Forum

Steps to Reclamation of Bricks

In this demolition and reclamation project the reclamation of elements of the building was undertaken by the demolition contractors themselves at the request of the client.

1. An exclusion zone was erected consisting of Heras fencing around the building.
2. Removal of the roof.

A combination of machinery and manual work was employed in the demolition and reclamation of bricks

3. Demolition of the main building using high reach excavator. The excavator worked from the top down breaking away all the facing brick at this elevation so as to expose all the interior mezzanine timber floor and first floor internal walls.
4. Internal walls at first floor were demolished.
5. Progressive sequential demolition of the walls on a bay-by-bay basis ensured that all portions collapsed in a controlled manner into the building footprint.
6. Removal of timber mezzanine floor.

7. Segregation of all brick and block work and concrete rubble into stock piles at ground level using a skid steer loading shovel.
8. Segregation of timber arisings into a waste skip beyond the building footprint.
9. An additional stock pile of 'mixed arisings' was maintained for portions of demolition debris where the above two components were not easily separated.
10. Clearance of brick to safe distance. Manual removal of mortar and palletising of bricks by operatives.

Table 3: Outline Comparison of Deconstruction Methods[42].

Method	Reclamation rate	Time onsite	Minimum access	Labour	Plant	Potential earned income from Sale of Product
1. Standard mechanised demolition: - plant demolish the building; - materials separated on the ground using machinery; - masonry crushed and used as fill.	0%	3 weeks	Good	4 workers 2 machine operatives	1 long reach and 1 standard excavator	£35.00
2. Collapsing building into/out of footprint: - building dismantled panel by panel by pulling/pushing wall with excavator; - use excavator to carefully move bricks to one side for cleaning; - clearing as you go increases rates; - where backed up with undesirable bricks, reclamation of facing skin can reach 70%.	30-40%	3-4 weeks	Good	6 workers 2 machine operatives	1 long reach and 1 standard excavator	£5,238
3. Padded grab: - peel sections of brickwork off; - swing away from building to a cleaning station approximately 30 metres away where a cleaning gang separate, clean and pallet them.	80%	3 weeks	Good	4 workers 2 machine operatives	1 long reach and 1 standard excavator	£11,927.00
4. Scaffold: - long reach used to demolish roof; - scaffolding erected around building; - manual removal and cleaning onsite; - bricks placed on forklift and removed; - often used where access is an issue e.g. adjacent to main road.	90%	6 weeks	Poor	8 workers 2 machine operatives	1 forklift and 1 long reach excavator	£13,414.00

[42] A result of conversations with Lee Demolition and other leading brick reclamation contractors

Key Learning – Bricks

- Through consultation with the reclamation industry a target of 60% of bricks site wide or 80% on specific buildings was recommended which would have resulted in the reclamation of over 800,000 bricks. Overall the reclamation of bricks was far below this figure.
- Yellow stock bricks were reused around the Olympic Park, but other types of bricks were inadvertently recycled. This emphasises the need for constantly controlled storage areas that are well managed.
- The process adopted was as quick as conventional demolition. The approach required two more operatives than purely mechanical demolition but can be carried out by demolition contractors and workers without specialist reclamation experience.
- Unfortunately mechanisation causes damage to materials when falling onto the ground and when moving away from the building footprint for cleaning, reducing the quantities which can be reused, this explained some losses of bricks. However, although 1,000 bricks can be manually stacked and cleaned by one worker in a day, this is still a slower process than mechanisation and a balance between cost and programme is necessary. Health and Safety considerations also need to be taken into account.
- Some losses of bricks can be attributable to process issues. The recommendations on processes are described throughout this document.

6 Case Study 2 - Steel Portal Frame

Steel portal frame buildings are a potential quick win in terms of reclamation. The structures are relatively easy to dismantle; several operators will dismantle and resell portal frames, and the market for pre-used buildings is strong. BioRegional carried out surveys on the Olympic Park and identified a total of 34 buildings containing reclaimable steel; 26 steel portal frame buildings and 8 buildings containing elements of structural steel[43]; of these, seven were reclaimed for reuse including three by specialists, one by a demolition contractor and 3 by the owners. Table 4 below summarises the steel framed buildings which were not demolished but were either removed prior to compulsory purchase, totally reclaimed for reuse or partially reclaimed for reuse.

Reclamation of a steel portal frame building on the Olympic Park

Table 4: Reclaimed Steel Frame Buildings

Blg Ref.	Name	Footprint	Process	End Use and Destination
CZ4/1/1	Boots	6,750m^2	Reclaimed by specialist contractor	Transportation company in Ireland
CZ4/1/2	Fedex	3,150m^2	Reclaimed by specialist contractor	Agricultural Plant Store in Lincolnshire
CZ8a/3/1	Sortex	7,150m^2	Reclaimed by specialist contractor	Currently unknown use in Sussex
CZ4/1/3*	Newsfax	Unknown	Reclaimed by demolition contractor	Elements reclaimed by transportation company in Ireland
CZ3a/8/2	Angel House Site	261m^2	Reclaimed prior to CPO	Reclaimed by owner to unknown destination
CZ2b/1/1-3	Clearun	724m^2	Reclaimed prior to CPO	Reclaimed by owner to unknown destination
CZ1b/3/4	Hanson Premix Depot	91 m^2	Reclaimed prior to CPO	Reclaimed by owner to unknown destination
CZ8c/6/1*	Bridgewater Distribution	3,855m^2	Unknown	Currently unknown
CZ5a/4/2*	First Bus Depot (Fuelcell)	216m^2	Unknown	Currently unknown

* Some documentation evidencing the reclamation and reuse process was incomplete or unavailable

Barriers to the reclamation of the remaining buildings included lack of time, age of the building giving it a low resale value, and in one case proximity to a live railway track. This case study outlines the steps, advantages and disadvantages of the process used on one reclaimed building.

[43] Listed in Olympic Park Steel Frame and Brick Reclamation Proposal, January 2007

Steel Portal Frame - An Example

The steel portal building was used as a parcel distribution warehouse. It was approximately eight years old with dimensions of 100m x 32m x 7m and had a footprint of 3,200 m^2. The building was in excellent condition and included insulated metal cladding, roller shutter door access, a two storey internal office area of steel and concrete, a conveyer belt system and assorted building services. The process described herein is similar to that used on two other reclaimed buildings on the Olympic Park and is recommended as good practice.

Table 5: Summary of Reclamation of One Steel Frame Building

Total material within the structure: Of which structural steel and steel cladding:	190 tonnes 163 tonnes
Total embodied carbon within the structure: Of which structural steel and cladding:	346 tonnes 297 tonnes
Total embodied carbon saving compared with recycling:	84 tonnes
Labour:	3,000 person hours (based on discussions with reclamation contractor)

To put the environmental benefits into context, 84 tonnes of CO_2 is more than the total CO_2 emissions saved over a year by insulating and installing energy efficiency measures in 16 households[44]. This figure is based on comparison of reusing or recycling the steel elements only.

Process

In this project the reclamation of the entire building was undertaken by a reclamation specialist under contract to the demolition contractor. The reclamation contractor was Portal Power, their approach aimed to maximize the recovery of the complete building and accessories. Their Tier 2 contractor carried out the majority of the soft stripping prior to handover. Following handover, external and internal elements were removed for reuse using the following process:

1. Extensive labeling of each building element.

2. Removal of roofing and cladding one bay at a time stacked onto a telescopic handler and lowered to the ground for storage.

3. Unbolting and removal of purlins and roofing and cladding rails using powered access, scissor lifts and telehandlers. A single line of purlins were left at the apex of each roof to maintain structural stability until a crane was used for support prior to final unbolting.

4. Crane positioned to support the weight of each rafter.

[44] Energy Saving Trust

5. Unbolting of rafters from supporting columns. Cherry picker platforms and scissor lifts employed to allow operatives access.

6. Rafters lowered to the ground by crane and unbolted by operatives on the ground.

7. Vertical columns supported by crane whilst anchor bolts fixing the columns to concrete anchors were cut. Once each bolt was cut the column was lowered to the ground by crane.

8. Columns moved to storage by telehandler.

Two months onsite, or approximately 3,000 person hours, were required. Portal Power believe that additional time was required due to the logistical complexity of operating as part of a large project and that a similar building could be reclaimed in under 2,000 person hours.

Key Learning - Steel Portal Frame

- The reclamation of this building and other steel portal frames on the Olympic Park was a success and can be considered best practice suitable for replication on other projects. Steel portal frame buildings are readily reusable. On a project with less pressing time constraints, a greater number of steel portal frames could have been reclaimed and reused.
- Conventional demolition would have resulted in recycling of at least 90% of demolition wastes[45]. Approximately 190 tonnes of steel with an embodied CO_2 of 345 tonnes was reclaimed in this example, resulting in an embodied CO_2 saving of 84 tonnes compared with recycling[46].
- There are considerable financial advantages to the reclamation contractor. Portal Power were able to sell the building for £170,000, and made a profit after cost of the work and price paid to the demolition contractor were included[47].
- There are considerable financial advantages to the demolition contractor. Reclamation contractors will pay around £5 per m^2 or £0.05 per ft^2 to deconstruct salable buildings[48]. Financial benefits will depend on prices available for scrap steel compared with the price for pre-used portal frame buildings. When the project took place the scrap value of steel reached a peak from which it has recently declined considerably[49]. As these markets will vary, financial incentives cannot be relied on to drive reclamation and reuse in the demolition industry. Regeneration projects aiming to reduce their carbon impacts need to require reclamation through tenders and contracts to ensure reuse is maximised.
- The opportunity to reuse steel portal frame buildings is under exploited and the capacity of the reclamation sector has scope for expansion. With increased demand and investment this sector could grow and lead to mainstream reclamation for these buildings.

[45] Based on Olympic Development Authority targets
[46] Based on new steel with 60% recycled content contains embodied CO^2 of 1.82 tonnes per tonne (University of Bath, Inventory of Carbon and Energy, 2006)
[47] Based on correspondence with Portal Power
[48] BioRegional
[49] www.eurofer.org

7 Case Studies of Other Materials

A wide variety of materials were stored in the reclaimed materials storage area onsite for reuse.

Table 6: Detailed Breakdown of Items Stored onsite for Reuse (This table includes the total bricks in the storage area, including Yellow Stock Bricks)

Material	Tonnes	Tonnes CO_2
Bricks	995.0	517.4
Stone and Paving	507.5	113.4
Tiles, Clay Product, Slate	86.1	91.9
Timber	9.8	4.5
Metal	63.8	154.8
Misc	4.0	26.1
Total	1,666	908

Stone and Paving: Granite Kerbs

Granite kerbs are being reused as drainage runs and for detailing on road sides in the Landscape and Public Realm area at the North of the Olympic Park. The granite kerbs are a hard wearing and long lasting material and these examples are still in a very good condition.

The reuse of granite kerbs creates a link to the industrial past of the area, allowing the character and warmth of the Stratford site to be preserved. Granite is a very popular choice of natural stone and the kerbs should be seen as an asset.

Table 7: Summary of Reclaimed Granite Kerbs

The CO_2 savings from substituting reclaimed granite kerbs for imported granite	0.7 kg CO_2/kg
Volume of granite kerbs stored in Reclamation Yard	298 tonnes
Embodied carbon of granite kerbs stored in Reclamation Yard	93 tonnes
Quantity of reclaimed granite kerbs used onsite	298 tonnes currently specified in designs
Estimated CO_2 saving from use of granite kerbs onsite	93 tonnes CO_2

Granite kerbs wrapped and ready for reuse

Stone and Paving: Granite Setts

The reuse of materials has enabled the Olympic Park to utilise the high quality material traditionally used in the area and to provide a unique finish to architectural features across the Park.

Granite setts being installed on the Greenway

The distinctive granite setts from the Olympic Park area have been retained for use on The Greenway as a feature around utility access and drainage areas, the setts will help to break up the continuous strips of re-laid tarmac and will provide an attractive feature and regeneration value to The Greenway.

Table 8: Summary of Reclaimed Granite Setts

The CO_2 savings from substituting reclaimed granite setts for imported granite	0.7 kg CO_2/kg
Volume of granite setts stored in Reclamation Yard	38 tonnes
Embodied carbon of granite setts stored in Reclamation Yard	2 tonnes
Quantity of reclaimed granite kerb used onsite	38 tonnes specified in designs
Estimated CO_2 saving from use of granite kerbs onsite	12 tonnes CO_2

The contractor involved in regeneration of The Greenway initially estimated that they would only be able to use 60% of the available stock but after realising the setts were in such good condition around 95% were reused.

Granite setts in storage prior to use

Granite setts in place on the Greenway

Stone and Paving: Sandstone

Reclaimed sandstone paving blocks are being reused on The Greenway as a decorative pathway and in some temporary areas on the Olympic Park. The blocks are of similar proportion which is fortunate as reused examples can often be of variable size and dimension.

Sandstone paving forming a path through a temporary garden in the Olympic Park.

Sandstone is one of the most widely used stones available due to its rustic colouring and beauty and this particular application lends an appealing and natural appearance to the surroundings and will provide a hardwearing base for this lightly trafficked footpath.

Table 9: Summary of Reclaimed Sandstone

The CO2 savings from substituting reclaimed sandstone paving	0.05 kg CO2/kg
Volume of sandstone paving stored in Reclamation Yard	117 tonnes
Embodied carbon sandstone paving stored in Reclamation Yard	6.55 tonnes CO2
Quantity of sandstone paving used onsite	117 tonnes specified in designs
Estimated CO2 saving from use of sandstone paving onsite	6.55 tonnes CO2

Reused sandstone paving

Regeneration of the Greenway with sandstone pathway

Concrete Product: Blockwork

Concrete blockwork has been laid at the North Plaza in the 'Dog Pound' area. This small section of the Park is being used as a temporary exercise yard for the large number of security dogs working on the Park.

The blockwork has been used instead of standard tarmac and provides a more attractive vision of the Park for passing cars as they pass along the busy A12.

Concrete blockwork in situ in the North Plaza

Table 10: Summary of Reclaimed Concrete Blockwork

Embodied CO_2 savings for reusing blockwork instead of using tarmac	0.14 kg CO_2/kg
Volume of concrete blockwork stored onsite (not stored in Reclamation Yard)	485 tonnes
Quantity of concrete blockwork used onsite	485 tonnes (approx)
Estimated CO_2 saving from use of concrete blockwork onsite	67.9 tonnes CO_2

Because the use or the blockwork shown here is temporary the carbon saving must be discounted unless the blocks are reclaimed a second time and used on or off site as part of a permanent feature.

Over 30 pallets of the concrete setts reclaimed have not yet found end uses and may be sent for recycling.

Improved aesthetic compared with tarmac

Concrete blockwork

Timber: Belfast Truss

The roof truss in its original location

The Kings Yard area contained a pre-World War Two factory where 3,000 employees made sweets, chocolates and lozenges for national and world markets. It was one of London's few surviving Edwardian works. Among many interesting and unusual architectural features was the Belfast truss roof, once a popular structure to support wide span roofs without columns in factories and hangars before steel frames were widely available. The trusses provide evidence of the industrial history of the area.

The wooded truss structure and accompanying steel pillars were carefully removed by operatives and moved to a local storage area in the Lea Valley. No end user has yet been found and the trusses are awaiting a new home. The weight and embodied carbon of the trusses were not quantified.

Local heritage campaigner, Tom Ridge and local councilor Stephanie Eaton visit the site

The truss is now stored in the Lea Valley awaiting a home

8 Materials Recycling with Data Tables

The demolition of buildings and recycling of materials across the Park was carried out by six demolition contractors and was ongoing for around six months. Guidance[50] on materials management was issued to demolition contractors. The guidance set out the recommended reuse and recycling processes available for materials expected to be recovered and provided a strategy for the demolition process.

Tier 1 contractors were required to set reclamation and recycling targets for each demolition site and a demolition and site clearance management implementation plan was produced describing how the targets would be met. A log of the quantities and movement of demolition material was kept using material transfer notes. Material was processed locally at the demolition site or at the central processing area. Tier 1 contractors were required to provide monthly reports showing performance against the waste recovery targets.

Prior to demolition, contractors carried out a Type 3 asbestos survey to confirm the presence of all areas of asbestos, these involved demolition inspections to gain access to difficult areas. All asbestos was removed using controlled methods and under HSE guidelines.

Demolition contractors issued Section 80 notices to the Local Authority for all buildings intended to be demolished. A six week notice period followed within which the Local Authority would issue a Section 81 response giving the go ahead for removal subject to specific conditions.

The initial soft strip stage involved the removal of furniture, lighting and electrics. Any segregation of materials that could be carried out prior to demolition was completed.

Modern construction methods tend to favour a swift approach to demolition and will utilise heavy machinery to level the structures as they move through. This leaves a mass of waste mixed in with recyclable material that will be destined for landfill. The methods employed on the Park utilised a process designed specifically to try and maximise material recovery and minimise landfill through reuse and recycling.

At this point, the building could be demolished to ground level and the teams were able to move in and separate the remainder of the concrete, hardcore (brick and blockwork), steel and timber. Most buildings had one crusher locally onsite, concrete and hardcore was screened down to 75mm and stored on segregated piles until required for use on the Park. All material crushed onsite was used onsite.

The ODA exceeded the demolition reuse or recycling target of 90% by 8.5%, with less than 7,000 tonnes land filled. This is an improvement on industry standards and progress towards an overall goal of zero waste. However, a relatively low percentage of material was reclaimed and reused constituting only 0.5% of total materials available for reuse.

[50] ODA Demolition and Site Clearance Materials Management Plan

Table 11: Breakdown of Recycled Materials

Material	Total
Concrete	249,131
Brick/Hardcore	164,133
Metal	7,842
Bitumen	7,812
Timber	2,267
Other	3,018
Total	**434,203**

The breakdown of recycled materials indicates the large scale demolition carried out on the Park. All concrete, brick and hardcore was recycled and used onsite with none going off for further off site processing or disposal. This is a very impressive achievement considering the limited storage space available on the Park with a large number of contractors taking control of different areas of the Park. Processing and use of recycled materials onsite also saved over 20,000 lorry movements, which significantly reduced traffic loading on local roads. The success of the recycling process is a testament to the dedication of the teams involved to meeting the Park's recycling targets and having a strong and committed project management team in place.

Recycled materials were utilised primarily onsite. Thousands of tonnes of material was screened and sorted for a wide variety of engineering uses.

Table 12: Example of End Uses for Recycled Materials

End Use	Tonnes
Stadium Base	14,716
Temp Roads	7,124
Haul Roads	6,885
Structural Fill	5,481
7AI Travellers site*	5,291
Piling Matts	5,238
Velodrome Retaining Wall	779

**3,047 tonnes was subsequently reused as sub-base for the Media Centre*

Gabion baskets installed at the LO3 Bridge

Recycled material was used as a sub-base for the Olympic Stadium

9 Materials Reuse and Recycling – Data Tables

The ODA achieved a 98% recycling rate and 0.5% reuse rate during the demolition of the Olympic Park. Combined, this well exceeded the ODA's 90% target. Less than 7,000 tonnes were landfilled, the majority being hazardous and general waste.

No target was set for overall reuse and this has been highlighted as an issue throughout this report. BioRegional had estimated through site surveys that around 9,000 tonnes of materials (2.8% of the total materials) could have been reclaimed and reused. Fourteen per cent (14%) of potentially reusable material was actually reused, the rest was recycled. The carbon saved through reuse can be estimated at around 1,300 tonnes. The carbon lost through recycling reusable materials can be estimated at around 7,900 tonnes.

Table 13 shows the estimated quantities of reused materials logged in SMARTWaste. The value for materials stored for reuse is taken from Table 16: Detailed Breakdown of Items Stored onsite for Reuse, and is a reasonably accurate estimate of these quantities. The total reused is more difficult to ascertain; the figure here is taken from Table 15 below, and is a total of every line for which there is a quantity available.

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Table 13: Summarising Quantities Reused Onsite

	Tonnes	% of Total Demolition Materials logged in SMARTwaste
Materials onsite (excluding soils)	434,203	100
Materials stored for reuse	1,666	0.38
Total materials reused	2,171	0.49
Reused onsite	1,305	0.3

Table 14 below provides a summary of Olympic Park demolition material quantities logged in SMARTWaste that were reused or recycled.

Table 14: Summarising Quantities Reused or Recycled

	Tonnes	% of Total Demolition Materials logged in SMARTwaste
Materials onsite (excluding soils)	434,203	100%
Materials reused or recycled	427,531	98.5%
Reused or recycled onsite	417,359	97.6%
Recycled off site	10,172	2.4%
Total materials reused	2,171	0.49
Landfill	6,672	1.5%

Table 15: Total items Reclaimed and Reused On or Off Site

Structure or Material	Tonnes	Destination
Metals		
Steel Portal Frame Building 1 (Fed Ex)	190*	Sold by reclamation specialist
Steel Portal Frame Building 2	unknown	Sold by reclamation specialist
Steel Portal Frame Building 3	unknown	Reclaimed by demolition contractor
Steel Portal Frame Buildings 4 - 9	unknown	Various
Bricks and Concrete Block		
Yellow Stock Bricks	674**	Given to construction Training Centre. **
Yellow Stock Bricks	310	130,000 bricks bought from ODA by Oakwood
Red Rubber Bricks	3*	Unknown, possibly sent for recycling
Concrete Block	485*	Onsite paving
Concrete Slabs and Kerbs	71*	Onsite paving
Timber		
1 Timber Bridge	2**	Sold to Kent County Council**
67 Timber sleepers	unknown	Used onsite**
1 Belfast Truss (timber and steel)	unknown	Stored in the Lea Valley, no end user found
Ceramics	12***	Destination unknown
Stone		
Granite Setts	319**	Decorative pathway onsite (note only 38 tonnes appear in the onsite store inventory)
Granite Kerbs	298***	Onsite decorative edging
Sandstone Paving	117***	Decorative pathway onsite
Furniture		
Home Furnishings	0.25**	Given to local housing association**

Notes to Table 15:

*Calculations carried out by BioRegional April 2008

**Correspondence with Atkins

***Based on quantities stored onsite

All other data in Table 15 has been verified by more than one source.

Table 16: Detailed Breakdown of Items Stored onsite for Reuse (At July 2008[51])

Material	Tonnes	Material	Carbon Value[52]	Total Carbon
Sandstone Edging Stones	117	Stone	0.1	6.55
Granite Kerb Stones	20	Local Granite	0.3	6.34
Granite Kerb Stones	155	Local Granite	0.3	49.14
Red Bricks	2	Facing Bricks	0.5	1.04
Yellow Stock Bricks	504	Facing Bricks	0.5	262.08
Curved Red Roofing Tiles	9	Tile	0.5	4.14
Dark Bricks	173	Facing Bricks	0.5	89.96
Tactile Paving	2.5	Concrete Paving/ General Clay Product	0.2	0.55
Large Paving Slabs	30	Concrete Paving/ General Clay Product	0.2	6.60
Small Paving Slabs	4.7	Concrete Paving/ General Clay Product	0.2	1.03
Building Sand	0.1	Sand	0	0.00
Rock Salt	0.4	Take Sand Value	0	0.00
Flat Red Roofing Tiles	9	Tile	0.5	4.14
Large Granite Kerb Stones	65	Local Granite	0.3	20.61
Large Concrete Kerb Stone	18	Precast Concrete	0.2	3.84
Fire Extinguishers	0.1	Estimate	5	0.50
Fire Point Sign and Bell	0	Estimate	5	0.05
Heavy Duty Batteries	0.3	Estimate	2	0.50
Timber (2)	1.84	Softwood	0.5	0.83
Timber (2)	1.38	Softwood	0.5	0.62
Timber (2)	0.23	Softwood	0.5	0.10
Sleepers (3)	4.36	Hardwood	0.5	2.05
Pipework	0.25	Steel Pipe	2.7	0.68
Bollards	18	PVC Pipe	2.5	45.00
Chimney Stacks	0.1	Concrete Paving/ General Clay Product	0.2	0.02
Drain Pipes	0.2	Concrete Paving/ General Clay Product	0.2	0.03
Cast Iron Fire Escape Stairs	8	Iron	1.9	15.28
Single Lamp Post	2.6	Aluminium	8.2	21.42
Double Lamp Post	0.3	Aluminium	8.2	2.47
Speed Bump	0.1	Injection Moulded Polypropylene	3.9	0.20
Large Security Fencing	0.2	Steel Sheet - Galvanised	2.8	0.42
Spiral staircase	2.5	Iron	1.9	4.78
Concrete chairs	0.4	Precast Concrete	0.2	0.09
Stainless steel mesh	0.2	Stainless Steel	6.2	1.23
Metal electrical conduits	0.1	Estimate as product	10	0.50
Cast Iron Fire Place	1	Iron	1.9	1.91
Flat Roofing Tiles	39	Tile	0.5	17.94
Blue Pillars	8	PVC Pipe	2.5	20.00
White Pillars	18	PVC Pipe	2.5	45.00
Weighbridge	10	Iron	1.9	19.10
Small Security Fencing	1	Steel Sheet - Galvanised	2.8	2.82
Desk	0	FRN value	3	0.03
Chairs	0.2	FRN value	3	0.45
Telegraph Pole	2	Timber	0.5	0.92
Dark Bricks	312	Facing Bricks	0.5	162.24
Dark Triangular Bricks	4	Facing Bricks	0.5	2.08
Small Paving Slabs	19	Concrete Paving/ General Clay Product	0.2	4.18
Palisade Security Fencing	22	Steel Sheet - Galvanised	2.8	62.89
Manhole Covers	0.4	Iron	1.9	0.76
Granite Kerb Stones	21	Local Granite	0.3	6.66
Street Cobbles	2	Stone	0.1	0.11
Street Cobbles	36	Stone	0.1	2.02
Extra Large Granite Kerb Stones	20	Local Granite	0.3	6.34
Totals	1,666			908

[51] July 2008 - time of the last documented inventory made of the site-wide reclamation yard. Materials still stored onsite at various locations
[52] Carbon values were obtained from the "Inventory of Carbon and Energy" published by the University of Bath

10 Conclusions - Items Reused and Recycled

The overall level of reclamation of buildings on the Olympic Park is not known as there was not a full pre-demolition audit completed setting out the quantities to be demolished in the different structures and external works. It is regrettable that we are unable to express the reuse and recycling as a percentage of the total materials onsite, but rather only based on materials logged in SMARTWaste.

Over one and a half thousand tonnes of items and materials were identified for reuse and stored in the onsite store with unquantified others including the Belfast truss being stored off site. Given the detailed processes involved in identifying, assessing, moving and monitoring these materials as described above in this report, it is unfortunate that we are unable to identify the end use which many were put to either because an accurate record was not kept or because a significant quantity of material was sent off-site for recycling.

It is further unfortunate that heritage items like the Belfast truss have not yet found a use, and that some items such as the concrete blockwork may yet be recycled before the Games are staged.

There was limited reuse of a number of items which were requested by design teams and may have been the subject of PMIs, including cast iron columns, company and street signs, street furniture and an iron weighbridge due to items being inadvertently sent off-site for recycling. We cannot therefore conclude that those items were reused (although we can claim significant success in the reuse of other items including granite kerbs and cobbles and sandstone pavers). This emphasises the need for tight controls on materials management with a dedicated storage area and responsible persons in charge of managing stock.

The level of reclamation achieved was mainly due to the hard work and dedication of those involved from the project team and the contractors engaged. Elsewhere, higher levels of reclamation have been achieved through specific requirements and targets in planning and contractual requirements (e.g. Kings Cross and Cane Hill in Croydon). Although the Olympic Park was subject to planning and contractual requirements to some degree, the majority of reclamation was achieved following cost-benefit analysis. Environmentally, maximising reuse and recycling is vital. For most businesses, it now makes economic sense to recycle, but not always to reuse. Currently there is a limited financial case for reclamation over recycling, and reuse requirements must be included in contracts and at the tender stage in order to encourage successful achievement.

The London 2012 Olympic Park generated large quantities of demolition material in a very short period of time. The local reclamation and reuse sector was challenged to cope with these volumes because separate reclamation and reuse targets were not established in contracts and therefore did not prioritise and provide incentives for reclamation and reuse. The uniqueness of the project meant that onsite storage space was very limited, and the project timeline was rapid. Ideally, workers would have been mobilised with enough time and space to achieve greater reclamation rates. Demolition projects on the scale of the Olympic Park require upfront client and contractual targets and arrangements, investment in the reclamation/reuse sector, and enough time to employ large scale reclamation techniques in a safe and secure manner in order to achieve greater levels of reuse.

One of the easiest measurable benefits of reuse over recycling is the saving of embodied carbon. London 2012 completed a carbon footprint calculation for the construction works but this approach was not employed on the demolition phase. Greater estimation of the carbon costs of demolition and construction (such as by 'carbonising' the pre-demolition audit), would have been useful. This would have integrated carbon reduction into the procurement process in a quantitative way (focusing on a few headline initiatives does not necessarily minimise overall impacts, if overall targets are not enforced and linked into the contract). This reduction of embodied carbon, through reclamation and reuse at the demolition stage and elimination of surplus un-used product and waste during the construction stage, is key to reducing not just the climate impact but the overall environmental impact of construction.

Thanks to those individuals involved at the time, the London 2012 Olympic Park achieved truly outstanding recycling rates and great effort was put into reusing and reclaiming buildings and materials. Using the lessons learnt from this unique project and the recommendations generated in this report, it is hoped that the bar can be raised for future projects and higher rates for reclamation and reuse achieved.

11 Overall Recommendations

The key lessons, highlighted in pull out boxes throughout this report are intended as an easy reference for project managers at different stages of the process. The ten most important are included below. Much of this could be applied to the transformation phase of the Park.

Much of this learning can be employed in the transformation phase of the PPark and there are steps that can be taken now which will help to ensure reuse and recycling is maximised at that stage. Managers throughout the process will need to be aware of the potential for reuse and recycling, and ready to take effective action at an early stage. This report has highlighted the significance of practical audits and targets. The transformation phase will need these, as well as persons with responsibilities for recycling and reuse.

Ten Key Lessons for Enabling Reuse

1. Undertake a pre-demolition audit and include a reclamation survey.

2. Use this data, and consultations with reclamation specialists, to set headline targets for reuse and reclamation for key materials before issuing tenders, ideally linked to carbon targets. Thoroughly investigate the end user market and look out for building elements/products with a clear market and those which present a particularly high carbon saving opportunity.

3. Include clear reclamation and reuse targets as separate and additional to the overall recycling target and state them clearly in the tendering process and in contracts. Make explicit the responsibility for demolition and removal of products with regard to reclamation and the final ownership of arisings.

4. Incentivise use of specialist contractors especially where expertise is available (e.g. for structural steel and regional bricks, removal of fixtures and fittings).

5. Incentives for achieving reuse targets, as well as recycling should be informed by an awareness of the relative prices for the reused or recycled product (i.e. whole building compared to steel or reclaimed brick compared to aggregate).

6. Require the project to measure the total carbon impact of the demolition process and the new construction on the site. This should inform design and planning, be included in the tender and contract and recorded once the works are completed. For the demolition stage this should include the embodied carbon of existing works, the carbon involved in transport of product from site and the on-site energy use.

7. Require reuse to be entered into a materials database and included in Site Waste Management Plans. Adherence should be verified by an individual with responsibility for monitoring environmental targets, through spot checks of data on existing and reclaimed tonnages.

8. Design team workshops are recommended; regular site visits are vital; as early in the design process as possible, but don't neglect to communicate with other local regeneration projects.

9. Include use of site won reused materials in the design and construction contracts for the new build.

10. Sufficient storage space is vital to enable reuse of construction products. Make sure it is secure, staffed and communicated. If on-site storage is unavailable, engage, or sell direct to a reclamation specialist with sufficient off-site storage and market presence.

About BioRegional

BioRegional is an entrepreneurial charity, which initiates practical sustainability solutions, and then delivers them by setting up new enterprises and partnerships around the world. We assist and encourage others to achieve sustainability through consultancy, education and informing policy.

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