Construction Consolidation Centres

An Assessment of the Potential for London wide use

Project Ref: 17321/004

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Final Report

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1.1 Introduction

This report documents the findings of a study which has examined whether London would benefit from greater use of Construction Consolidation Centres (CCCs) by the building sector. The work was commissioned by Transport for London (TfL) and completed by Peter Brett Associates (PBA) between February and December 2006.

The concept of using CCCs is highly relevant to the challenges of delivering building materials into congested urban areas. London is planning a series of large-scale developments over the coming years and these will bring them the inherent problems of delivering materials to the sites while construction takes place. These projects will put tremendous pressure on the local road systems and it is timely, therefore, to consider the advantages of establishing CCCs to serve these and other developments. In addition, some projects will have staggered construction phases, with areas being developed as part of “legacy” programmes.

1.2 Study scope and objectives

Within London there are two CCCs currently being used by the construction industry. These are:

- BAA has a centre which serves Heathrow Airport’s Terminals 1 to 4;
- A CCC set up in Bermondsey to serve four construction sites within the City of London.

A further example of a facility which operates to some extent as a consolidation centre, although this is not its primary role, is the Colnbrook Logistics Centre (CLC) which serves the Heathrow Terminal 5 construction. No construction materials are allowed on site without first registering with the CLC. An important feature of this facility is the railway link and sidings, permitting the delivery of materials to the CLC by train.

The study presented in this report examined the benefits that could be gained from creating CCCs to serve major construction projects across the capital. It has considered how CCCs might influence the transport requirements of materials moving to individual construction sites, and examined how the presence of a network of such centres might impact upon overall levels of construction freight traffic.

Thus the main objectives of the study were:

- To assess the potential benefits of implementing a number of CCCs across London in order to supply large scale construction projects with their building materials.
- To assess whether using dedicated CCCs for large individual construction projects would improve materials management and reduce related freight traffic.

1.3 Structure of this report

The remainder of this report is structured such that Section 2 explains the approach and methodology used in the study. Section 3 discusses the operations of, and options for, consolidation centres, while Section 4 outlines the model and data used. Section 5 discusses how the model is used, and the results of the modelling exercise are presented in Section 6. The conclusions and recommendations are set out in Section 7.

2 Approach and methodology

2.1 Approach

The approach to this study required a practical evaluation methodology to be developed. The evaluation needed to be completed on a number of levels in order to assess impacts at an aggregated level for London and to compare locating CCCs remote from building sites to locating CCCs within or close to building sites.

In this study the two principle CCC schemes evaluated are:

- A London wide network in which an optimal number of CCCs are proposed to service major developments coming on stream in the foreseeable future.
- Dedicated CCCs for specific developments, where the CCC is either on-site or remotely located.

2.2 Methodology

In order to assess what impact a CCC will have on construction site delivery vehicle activity, a range of indicators can be developed and used. For example, indicators that could be used include changes in the number of trips made, changes in the number of vehicle kilometres and changes in vehicle load factors.

An important aspect of the evaluation is the different costs associated with CCC implementation and operation, delivery activity and the potential available savings. These elements need to be modelled and developed individually and in an aggregated form. It is important to understand which costs are the main drivers and how they influence each other. Making the costs transparent is a key feature of this part of the evaluation.

For the two principle options the evaluation has had to consider the role intermodal linkages would play and the types of materials that could be delivered by non-road modes. However, it must be accepted that road-based deliveries will be the dominant means by which materials will arrive at a CCC, since materials are sourced from many different suppliers.

The research and analysis has been carried out addressing a number of inter-related topics which are integral to the construction industry. These comprised:

- Sites
- Materials required by sites,
- Material sources, transport routes,
- Define construction consolidation centre options,
- Cost modelling,
- Costs & benefits,

Each of these is considered below.

2.2.1 Potential CCC Sites

Within London certain areas are recognised as primarily industrial zones (i.e. the GLA have identified 49 Preferred Industrial Locations (PILs) across London). Such PILs would make suitable locations in which to site CCCs because a noticeable amount of goods vehicle traffic will be generated and therefore need to be within an area that could absorb this traffic. Thus the key aim of this task was:

- To identify site locations that would be suitable for accommodating permanent CCCs to serve London.
- To identify site locations that would be suitable for accommodating dedicated CCCs to serve specific projects in London.

2.2.2 Location of Major Planned Construction Sites

The information for this task was drawn from planning applications made for developments currently in the system and which are in the public domain. The time horizon for new development was 2012.

Using this data made it possible to first model the suitability of the CCC sites and then assess catchment areas using a geographical information system (GIS). In addition this approach permitted the identification of road access points and routes, and the consideration of relationships between each site and the different modal transport networks.

2.2.3 Materials required by site

The aim of this task was to develop forecasts for construction materials by site and for the duration of the construction period. Data on materials flows has been obtained from Constructing Excellence pertaining to the Bermondsey CCC and used to generate estimates for the greater use of CCCs.

Material sources

Identifying sources of materials is a complicated task and relied mainly on broad assumptions concerning the starting point of the individual journeys and information obtained from the Bermondsey CCC.

Key suppliers of materials

The study sought to identify the major suppliers of key commodity groups for the London market and these are provided further in the report.

Supply locations details

While many materials are sourced relatively locally (for instance aggregates or concrete from sources along the Thames estuary), more specialist materials come from further afield, particularly fit-out materials such as internal walling, electrical installations.

2.2.4 Transport Routes

For the CCC locations identified, the potential for each location to use rail or waterways freight was assessed - for instance whether the location had a rail freight siding or was alongside a navigable waterway.

Road

Road routes were assessed using a basic routeing programme, calibrated for goods vehicle speeds and taking into account any specific restrictions on construction site traffic.

Rail and waterways

Where rail or waterways access was available to the source, the study considered whether the configuration of CCC would allow direct deliveries by rail or waterway to be made.

2.2.5 Define construction consolidation centre options

The objectives for this part of the study were to consider how consolidation centres might operate in support of large developments. It has assessed whether a network of London-wide CCCs is a viable option or if the justification lies with implementing dedicated CCCs for specific projects. The analysis includes:

- How many consolidations centres might be required?
- Where might they be located?
- What materials might be handled?
- What proportion of each commodity might be transported via the consolidation centres?
- What transport options exist to serve inbound and outbound product for each consolidation centre.

Materials

An important issue considered relates the point that the use of a consolidation centre becomes the best option. It has examined whether high volume homogenous commodities delivered directly to site is preferred, leaving consolidation centres to focus on low volume and complex products.

Locations

A selection of potential locations for consolidation centres have been identified on or near major development sites, offering good road access and, ideally, rail freight and/or waterways access. This is not an exhaustive selection is will be designed to explore the potentially different impacts of different locational strategies.

Transport Options

This task has considered the suitability of all transport modes for freight transport at all times of day to CCCs.

The objectives for this part of the study were to consider how CCCs might operate in support of the construction work. For instance:

- What materials might be handled?
- How many consolidations centres might be required?
- Where might they be located?
- What proportion of each commodity might be transported via the consolidation centres?

- What transport options exist to serve inbound and outbound product for each consolidation centre.

2.2.6 Cost Modelling

A revised version of the West London Canal Network (WLCN) cost model has been used for this study. The WLCN cost model allows road journeys to be compared to multimodal journeys *via* waterways and was adapted to include rail. The main modifications required were:

- Allow the road trunking option to be overridden with a rail freight cost. To avoid complexity, PBA's rail cost models was not integrated into the WLCN model.
- The cost and time impact of passing through the consolidation centre replaced the canal origin transfer cost where consolidation centres are used.

These modifications allow the following options to be modelled:

- Road or rail throughout
- Waterways throughout (using the model in standard mode)
- Road or rail to consolidation centre and then final delivery by road (achieved by setting the canal cost to zero)
- Road or rail to consolidation centre and then final delivery by waterway

Road Costs

New parameters have been developed to reflect the types of road vehicles used for materials not already modelled in the WLCN study, particularly fit-out materials such as plasterboard.

Waterways

Where water transport is an option, completely new parameters for waterways movements will be required, not least because the waterways concerned are wider than the WLCN waterways. Intermodal Solutions will define the characteristics of barge / tug combinations to be used.

CCC Benefits

The model has been adapted to include a broad assessment of the different cost structure operating via a CCC or not. Therefore, cost implications are modelled in broad terms, for instance by making an estimate of the amount of time delivery drivers save when using a CCC, or the increased payload of delivery vehicles making consolidated deliveries.

2.2.7 Costs / Benefits

The aim of this task has been to estimate what level of benefits derived from the implementation of CCCs. It takes the form of an outline cost / benefit analysis (CBA) comparing all the derived costs computed in the cost model with the anticipated saving in items such as vehicle kilometres and associated emissions. As part of this task, an evaluation framework has been developed which specifies the criteria that need measuring. The data captured for each criterion is used as inputs into the CBA; moreover, the framework establishes a mechanism that permits monitoring and data capture over the long term. As a result a periodic revision of the CBA can be made.

This aspect is important since very few consolidation centres of any form have been monitored over a long period. It will be a source of valuable information when consideration is given to similar schemes in the future.

The revised model demonstrates the relative impact of various options on operating costs and on the road mileage generated.

Capital costs are not estimated in detail although the broad level of investment in equipment and terminals is estimated for each option.

The study will also consider how the costs of operating the consolidation centre could be funded, by identifying the level of costs and which parties may benefit from using consolidation centres.

3 The function of Construction Consolidation Centres

3.1 Introduction

This section provides details of the role that CCCs perform in the construction materials logistics process. It describes the CCCs in terms of their use at an individual level and as part of a wider London network. However, to place their role in context an overview of current delivery practice is also provided.

Before considering the advantages and disadvantages of construction consolidation centres in detail, it is worth stating what a CCC is. It is generally accepted that a CCC operates as a distribution centre for construction materials and other equipment used on construction projects. Importantly, it is not a warehouse for the long-term storage of materials, but acts as a short-term holding or transhipment point. Materials are delivered to the centre either in bulk or other sized consignments and are released to site as they are called-off by trade contractors. Operating in this way provides a localised just-in-time delivery system, smoothing the flow of materials and delivering usable quantities to trade contractors.

During the heavy “core and shell” stage of construction, most materials will be delivered to site in full HGV loads, and so there is little need for a CCC. Clearly also, a CCC is not suitable for specialised commodities such as bulk cement.

Construction consolidation centres will therefore generally aim to handle materials that are required after the ‘core and shell’ is built or at a progressing stage and, therefore, will mainly serve development sites during the mechanical and electrical, and fit-out stages of the build.

3.2 Current procurement and delivery practice

3.2.1 Background

The systems in place for construction site deliveries are long established, but it appears that little has been done to alter or enhance the practices employed over the years. Deliveries of materials to site typically arrive direct from the supplier. The procurement and delivery of materials is normally arranged by the contractor who is completing the work on-site. Transport might be a supplier's own vehicle or a third party carrier. The procedure for a delivery usually requires the contractor to book or reserve a time through the site transport or logistics manager at least within the week prior to the materials' arrival. Special items that require specific handling (e.g. crane time for lifting) or installation at a certain time will be booked-in further in advance to ensure the correct planning can take place and action taken to provide adequate access both on and off the site.

3.2.2 Delivery booking systems

The construction industry employs essentially three methods of managing deliveries to site: paper based, paper and partial electronic and entirely electronic systems. The type of system used depends upon the company appointed to manage the site logistics.

As noted above deliveries of materials should be booked prior to arrival and this would normally take place at least within the week before delivery by the contractor. With the paper based system contractors complete 'booking forms' which are submitted to the site transport manager for aggregation, reviewing and prioritisation. This action has to be completed to ensure a satisfactory delivery timetable is arranged and this is accomplished through negotiation with the contractors in order to accommodate slot conflicts or priorities.

The paper and partial electronic systems tends to have a paper based booking notification procedure, with the information being transferred into an electronic system for the slot and prioritisation management. Even though information is retained in an electronic format, negotiations with the contractors in order to accommodate slot conflicts or priorities also take place. Once the delivery information is in an electronic system further analysis is possible which can be used to help reduce delivery problems and conflicts.

With entirely electronic systems, bookings are submitted through an online front end and the conflict and slot management maintained electronically. However, as with the other systems, negotiations with the contractors in order to accommodate slot conflicts or priorities also takes place. It is also possible to analyse the delivery information, which can be used to help reduce delivery problems and conflicts.

3.2.3 Functioning of these systems

If these systems were applied correctly it is probable that deliveries could be managed reasonably trouble free. However, misuse of the systems is common place by contractors, suppliers and carriers, and therefore a variety of problems occur, including:

- Failure by contactors to use the booking system and unscheduled deliveries arriving.
- Deliveries arriving late due to supplier dispatch difficulties.
- Deliveries failing to arrive.
- Wrong quantities arriving by mistake or deliberately.
- Delivery vehicles arriving early in hope that they will be dealt with out of turn
- Wrong orders delivered, both accidentally and on purpose.
- Damaged materials arriving at site either as a result of poor handling in transit or insufficient control at point of dispatch.
- No one immediately available to unload vehicle.

In addition, other factors such as inclement weather, mechanical failure of site equipment (e.g. a crane breaking down) and delivery vehicles experiencing problems *en route* contribute to the difficulties that may arise.

The consequence of these events is that delivery vehicles often end up queuing before being unloaded or ultimately being "turned away" with the delivery still onboard. The amount of space available at a site, or the availability of a holding area, will determine the treatment a vehicle receives. Site transport managers will try to accommodate deliveries if possible; where vehicles cannot be queued on-street (e.g. next to the site) they will be requested to drive off and return at an alternative, later time in the day. In the latter situation, some site transport managers will simply tell the driver to comeback at a certain time, others might have a pre-planned route in place which they know will take a driver a certain time to cover, thus providing a suitable interval before the vehicles return.

Checks with the contractors will be made regarding the importance of the delivery and whether it can be rescheduled. Where no alternatives are available the delivery will be refused; for some sites the policy is to refuse all unscheduled deliveries in the belief that contactors, suppliers and carriers will learn the hard way and abide by the system.

Site transport and logistics managers are able to establish the number of unscheduled deliveries and who the persistent offenders are, since every delivery made to site is recorded. Weekly consultation normally takes place between the site managers and contractors to agree work schedules and check that delivery arrangements are in order.

3.2.4 On site storage and handling

The amount of available storage space depends on the site characteristics. For example, at a large site such as White City there is plenty of additional space, and, as such, storage facilities are very good. However at smaller sites, or at larger sites in heavily built up areas, the lack of available storage space can introduce particular problems, such as additional handling of materials, health and safety issues and the inability to accept very large quantities of materials.

The positioning of materials on site depends on a number of factors including the size of the materials, the type of material and the period in which the material needs to be used. In cases where storage space is limited some site logistics managers create specific locations within the building where materials can be held for a longer period, normally materials that will be used or installed at the finishing stage of the project.

Handling of materials when being unloaded or for internal movement depends on the arrangements the main contractor has put in place. Two approaches exists:

- the main contractor is responsible for managing the materials on site from the time of lifting off vehicle to placing at work point
- the subcontractors are responsible for all the materials they order, which includes unloading and directing or moving to storage and/or place of use.

Where the main contractor assumes responsible it will usually have a dedicated materials distribution team on site. This will comprise workers who organise and handle deliveries, thus allowing the various trades' people (e.g. plasterers, electricians, plumbers) to apply themselves uninterrupted in their work.

Where the subcontractors assume or are required to take responsibility, the options for handling material deliveries depend upon factors such as:

- the number of available workers they have on site,
- if their employees are able or qualified to use materials handling equipment,
- if they have sufficient numbers of workers on site when a delivery arrives,

- if they planned for the delivery and matched the required resources,
- if they have adequate or a prepared storage space,

These factors will influence how satisfactorily or not the delivery is received.

3.3 Delivery holding and logistics centres

For construction sites that cover a large area or demand significant quantities of materials or experience particularly difficult access constraints, intermediary logistics centres are an option that can be used. The role of such centres include:

- managing the supply of materials to the work area,
- providing an area in which the fabrication of components such as reinforced concrete framework can be carried out,
- holding and marshalling delivery vehicles until they are required on site,
- providing security checks and delivery directions,
- controlling the number of delivery vehicles going on site,
- ensuring timeslots for specialist handling equipment and crane use are fulfilled.

Such centres may be located remotely from the construction site, as is the case in the building of Heathrow Terminal 5 and Portsmouth Hospital. For these projects, dedicated construction logistic centres have been built a short distance from their respective project sites. Their locations provide suitable access from the main transport routes and at Heathrow the facility also has a railway siding which has been used for the receipt of bulk materials such as steel reinforcing bar, pulverised ash, cement and aggregates.

The key differences between logistics centres and CCCs are:

- the logistics centres do not carry out consolidation of loads from many vehicles to a single vehicle - i.e. no transhipment takes place;
- no storage of materials takes place at logistics centres;
- the logistics centres do not take ownership of the good passing through them;
- the logistics centres do not carry out quality control inspections of arriving goods;
- the logistics centres do not take responsibility for the delivery of the goods.

3.4 The use of individual centres

The principle of a CCC is quite simple: materials and equipment required in the construction of a building are not delivered to the construction site directly from the supplier, but are taken to a centre that is either remote to the site or if the development is a very large project (e.g. Heathrow Terminal 5) located on its perimeter or within the site itself. At this centre all the materials and equipment are consolidated and delivered to the construction site on a regulated basis (which is driven by contractors calling down materials) in order to minimise construction site related freight traffic and smooth the flow of materials deliveries.

A CCC does not have to be dedicated to one development project, but can serve a number. For example, the CCC operating in Bermondsey, South East London acts a as materials consolidation centre for four projects taking place in the City of London.

The types of materials held within a centre can be wide ranging or more specific. In the case of the Bermondsey centre the range of materials stored and distributed is extremely broad and includes equipment required on site (e.g. compressors, cutters) as well as building materials.

Other CCCs might concentrate on specific types of materials. At Charlton in South East London, CSB Logistics focuses on larger build materials, and mechanical and electrical equipment (e.g. curtain walling, lifts, air conditioning units). At this CCC, many of the items going to site are imported into Britain, arriving from mainland Europe by road or in container from further afield via UK ports - e.g. Felixstowe. Characteristics such as size or special requirements for some items means that additional pre-installation fabrication might be needed and therefore off-site works can be carried out (e.g. assembly of curtain walling units or escalators).

The lead and storage time for materials can vary greatly depending on what they are when they have to be used or installed. Typical fit-out materials (e.g. dry walls, electrical fittings, etc.) have relatively short lead times and are not expected to be stored at a CCC for longer than 7 to 10 days. However, for the more specialist items it is possible that they will be retained at a CCC for up to 3 months or perhaps longer.

3.5 London wide network

The idea of a network of CCCs can be considered on two levels - one which addresses the physical / geographic distribution of warehouse facilities to serve prescribed numbers of development sites; and the second in relation to their physical / virtual working.

3.5.1 Physical / geographic distribution

The modelling process described in Section 5 aimed to determine where, and how many, CCCs should be located across London in order to serve the predicted level of development over the period to 2012, excluding any development directly related to the Olympic Games. The modelling exercise estimated the optimum number of CCCs required, taking into account the various parameters that will impact upon their operation. This assumed that all CCCs will handle most non bulk items going to the development sites.

A further issue considered is the size of a CCC, given that construction activity is phased over long periods and that certain types of activity (i.e. much of the core and shell building phase) do not require the support of a CCC. The construction phasing issue is complex, because if a number of developments are being served from the same CCC it is necessary to understand when the peak phasing will occur for all developments - i.e. when do the fit-out stages take place. For example, if the CCC is serving a number of developments and construction is spread over a long period, it is very likely that the construction phases will not necessarily coincide and the CCC required will be smaller than if the same developments are completed in a shorter timeframe where construction phases are likely to coincide and a higher concentration of materials take place. CSB overcome this problem by having access to extra space at different locations and this can be called upon when the central CCC is at capacity.

Another important issue to consider is the location of CCCs in relation to development sites and whether delivery transport is expected to move materials only onward to sites or to serve any located behind the CCC (i.e. forward or backward movements of materials). The alternative is to ensure that CCCs are concentrically located around the centre of London and development sites, to avoid back traffic to sites that are situated behind the CCC.

3.5.2 Physical / virtual working

Whilst the principal of the CCC is to control the delivery of materials to developments from a single point, there may be an advantage to be gained in using a network of suppliers or distributors *in situ* warehouses.

In this approach, deliveries to construction sites would still be controlled and direct deliveries limited as with single point CCCs; the difference lies in where the materials are stored and how the deliveries organised.

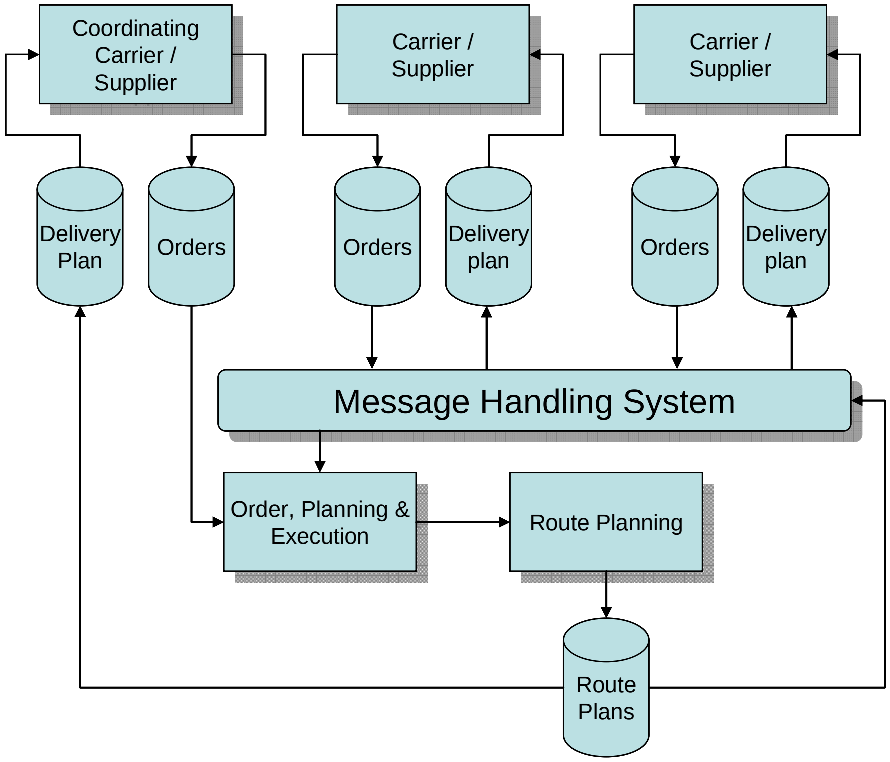
Such an approach is technically more complex than the conventional CCC for two reasons:

- it requires a network of suppliers and carriers to cooperate with each other, in terms of sharing resources and information;
- it would require an integrated systems configuration in which suppliers or distributors warehouses are the points at which materials are stored.

The overarching link in this approach is an information system into which the building contractors' orders are registered and fed into suppliers and distributors ordering systems. As part of the systems carriers (both supplier/distributors own account and contracted third party) are included and a delivery planning program allocates the most appropriate loading and calculates an efficient delivery route to a specific vehicle. This means that vehicles operating for different suppliers/carriers collect and deliver a variety of goods from a range of suppliers that are providing materials for the same construction project.

Such a system has a coordinating partner which carries out the system management. Figure 1 illustrates the conceptual architecture of this approach.

Figure 1: Virtual CCC system configuration



This concept has been used for general deliveries into Tilburg in Holland and was included and evaluated as part of a European Union funded project called SURFF (Sustainable Urban and Regional Freight Flows).

4 Optimisation model and data requirements

4.1 Introduction

The consolidation of building materials at a single point prior to their dispatch to a development site is essentially the same principal used to distribute goods in the manufacturing and retail sectors. Given such similarities in supply chain configuration, it was decided to employ a model in this study which has been successfully used to model logistics networks in the retail and manufacturing sectors. The model used in this study is a bespoke software package developed by Preston Solutions and is described as a Strategic Logistics Network Planning Model (SLNPM) and has been used extensively in recent years for many companies and government departments to examine a wide range of logistics issues.

A strategic logistics network planning model is used to examine the different flows of goods, or distribution channels, from supply points through a network of storage facilities to customer delivery locations. This approach is often used by commercial enterprises to minimise costs and to maximise service levels. It is now being used more frequently by governmental departments to assess emission and sustainability issues of various logistics networks.

Modelling of complex interactions has become an established method in many areas of management and in particular manufacturing and logistics. Modelling an activity is very beneficial as an aid to understanding the issues and consequent decision making. A model is always based on a series of assumptions and relies on the fact that there is a logical system of causes and effects within the real world activity being examined, and that this can be identified, measured and represented in the model, taking into account constraints that may be imposed on these effects. For model building to be successful there needs to be a clear understanding of the real world situation.

4.2 Optimisation model description

4.2.1 Concept

The model employed is a single integrated application used specifically to address supply chain network problems; the movement of building materials in this respect is a supply chain network in which many sources are supplying few consumption points. One clear advantage of this approach is the flexibility to be able to model specific parts of a supply chain, for example demand modelling alone or alternatively all elements of the supply chain can be considered within one model. Fixed constraints can be integrated to produce outcomes that are both customised and cost minimised to specific business criteria. This modelling tool has many features including:

- A network strategy model which is used to design and evaluate a logistics network. It calculates the minimum cost for a given supply chain network configuration subject to any constraints or parameters set by the user. It contains a series of algorithm options that cost minimise across the different constituent elements of the supply chain, for example outbound load consolidation or optimisation of inter-depot movements. Outputs from the network strategy model are provided in detailed reports and are also exportable for analysis. Mapping functionality also gives the ability display aspects of the data and to plot the network design.
- The ability to identify isochrones that illustrate the relationship between customers and/or suppliers locations and warehouses. Isochrones are used to indicate the nearest depot by time or distance so that transport service lead times may be observed.
- Two centre of gravity algorithms which use different parameters to establish where alternative depot facilities should be located. Gravity models can be run with some facilities fixed or excluded as well as supply or demand side exclusions. The optional algorithms are either cost driven or volume driven. The suggested new locations from a gravity model can be used as warehouse locations in a network strategy model.

The modelling approach involves creating a series of logistic networks that are run against various minimising algorithms. Each network consists of a user defined supply chain configuration including supply and demand data. For each supply chain network, subject to any constraints or parameters, the model minimises the network resource costs, or some other defined minimisation criteria. By running a series of models the cost outputs of each may be compared to find the network configuration that meets the requirements of any individual business scope and objectives.

The benefits of modelling are derived from the user's interaction with the model using their own business and logistics expertise in combination with the cost minimising heuristic algorithms. The operator establishes the sensitivities, trade-offs and dynamics within a particular supply chain network thus enabling practical solutions to be delivered. Inherently this is an iterative approach so many models may be run and evaluated as part of the process. In conjunction with this functionality, mapping and tabular outputs are provided so that the different results can be compared.

The basis of this software is an Excel spreadsheet containing data in a number of worksheets. Complex macros, written in Visual Basic, support the analysis and processing of this data, with the results displayed in tabular form on the worksheets, and by mapping through a direct seamless interface with Microsoft's MapPoint software. The analysis and processing is performed by selecting options which offer a number of tasks ranging from geocoding locations to assessing the centre of gravity locations as well as strategic analysis of a depot network. There are nine worksheets in the software as follows:

- Postcodes
- Suppliers
- Customers
- Depots
- Depot Operations
- Inter Depot Flows
- Vehicles
- Cost Functions
- Strategy Results

Each worksheet allows the full use of the Excel software to perform any additional analysis of the data and results.

The model can be operated at various geographical levels, and can use various input constraints. Key outputs of relevance to this study could include:

- Traffic generation and flow analysis
- Identification of optimal logistic locations
- Assessment of different logistics facilities and arrangements

4.3 Data requirements

Since only a small number of CCCs are currently operating, large volumes of data concerning the quantity of materials passing through them to development sites are not readily available. In order to determine the likely quantities of materials passing through the construction system in the period 2007 to 2012, a number of factors were included; these formed the basis of the estimate of CCC required.

4.3.1 Development sites in London

The model requires information related to known developments which currently have planning permission; are in the process of gaining planning permission; and proposed developments yet to apply for planning permission and which are in excess of 1,000 sq m. The following information was collected:

- Numbers of developments
- The total spatial area of each of these developments.
- The expected start and completion dates for each development.
- The location of each development.

4.3.2 Quantities of materials consumed by construction activity

To assist with estimating the quantities of materials delivered to construction sites, data was obtained from Bermondsey CCC on materials throughput between November 2005 and November 2006. This data included:

- Quantities of materials received by the CCC in pallet equivalents.
- Origin of materials.
- Destination of materials.
- The spatial size of the development being served.
- The size (in sq m) of the Bermondsey CCC.
- Other cost and handling time information for the CCC and construction site.

4.3.3 Goods vehicle data

Information was obtained for each of the generic vehicle types being currently used to deliver materials into construction sites, including those used by the Bermondsey CCC. The following vehicle information was obtained:

- vehicle type
- vehicle carrying capacity in tonnes or kilograms
- typical capacity utilisation

- fixed vehicle cost per day, drivers and refuse collector costs per hour and variable cost per mile
- time to collect the refuse at a postcode and time to offload at the transfer or disposal location
- vehicle time utilisation; i.e. the amount of time a vehicle spends on the road working as opposed to off the road due to lack of work, or vehicle repair/maintenance
- typical round time in hours
- length of working day

5 Use of the model

5.1 Introduction

In order to model the potential distribution of CCCs across London three main data sources have been used: locations of planned developments in London from 2007 to 2012, which are over 1,000 sq m in size; the number of deliveries received at the Bermondsey CCC; the number of deliveries dispatched from the Bermondsey CCC to Unilever House construction site. In addition, other information related to the origin of the deliveries and the types of delivery vehicles arriving at CCC and being dispatched to the construction sites has been used for the environment impact appraisal.

The remainder of this section discusses the modelling exercise in detail.

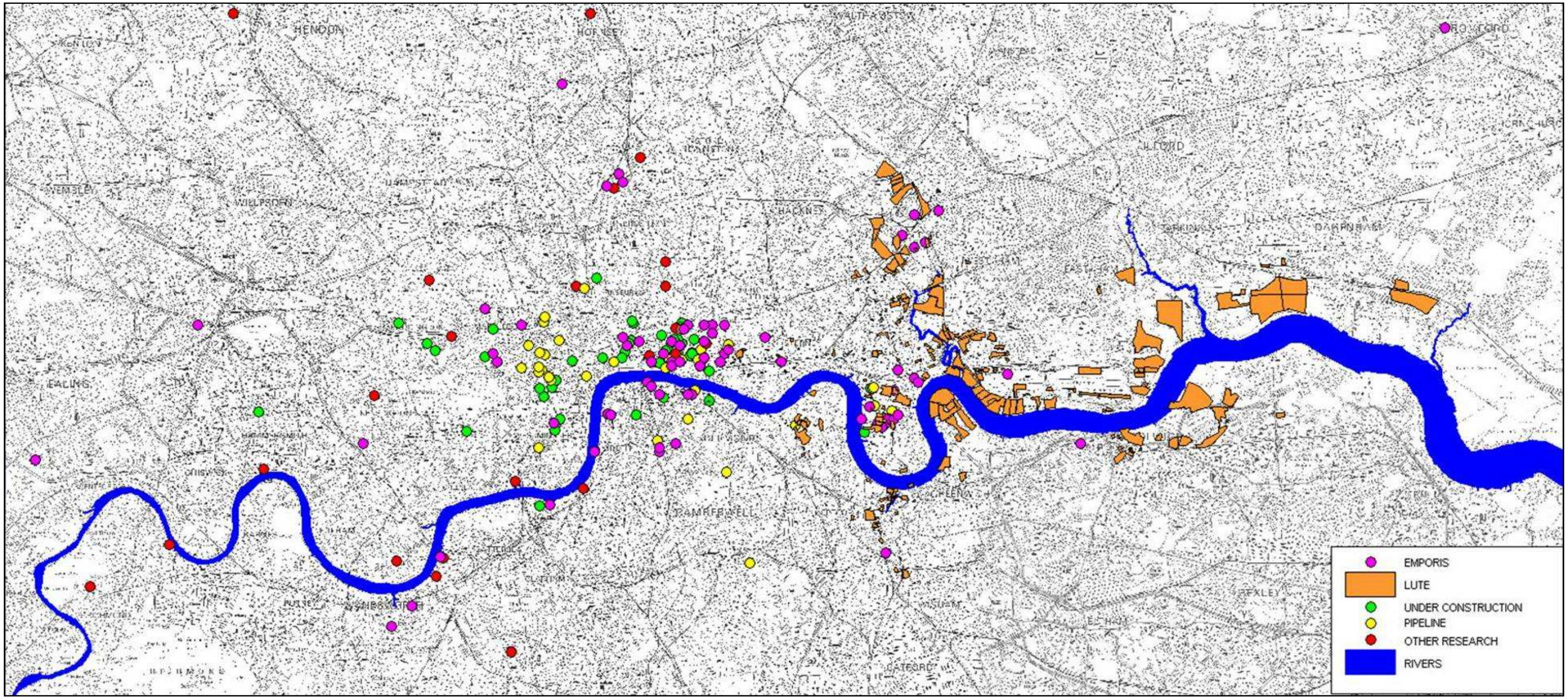
5.2 London development sites

Data regarding the location of new developments that are either starting construction during 2007, have received or are applying for planning permission for future construction was collected from a number of sources, namely Emporis[1], LUTE[2], City Offices[3] and Building[4]. From the combined data it was determined that there will be 581 construction sites in London between 2007 and 2017, providing a total of 18.8 million sq m of residential, industrial, commercial and other use space. It should be noted that most of the construction sites from this data prevail across a central corridor running east-west. Figure 2 shows the extent and locations of the construction activity by source of data.

It is acknowledged that not all major construction sites will have been identified in the study. Further developments could potentially materialise which as yet have not been conceived or entered the planning process, or been publicised. Other areas of construction such as refurbishment of local authority assets, National Health Service assets and government buildings are recognised as potential users of CCCs, but are not included in the study data.

[1] Emporis is a provider of building-related information - http://www.emporis.com
[2] Land Use Trip Ends - from DLR and specifically related to East London
[3] http://www.cityoffices.net/uk/london/index.cfm
[4] http://www.building.co.uk/story.asp?sectioncode=113&storycode=3068895&c=0

Figure 2: Location of forthcoming development site across London



In order to use the data in the modelling, all locations were goecoded such that they could be plotted and included in the calculations.

An important aspect of any development relates to the start and finish date of the construction. Here the data was mixed, in that information from Emporis provided proposed start/finish dates (stated only in years), LUTE supplied start dates, while neither City Offices nor Building had this information.

To complete the modelling it was necessary to include a start/finish dates for all the developments. Since only part of the future development data contained this information it was necessary to apply a factor to those developments where the construction time span was not known. This was achieved by equating the typical length of time it takes to construct a building of specific areas, calculating a time-to-area ratio and applying this to the developments. As a result all construction sites used in the modelling were assigned an estimated construction timeframe.

5.3 Inbound deliveries

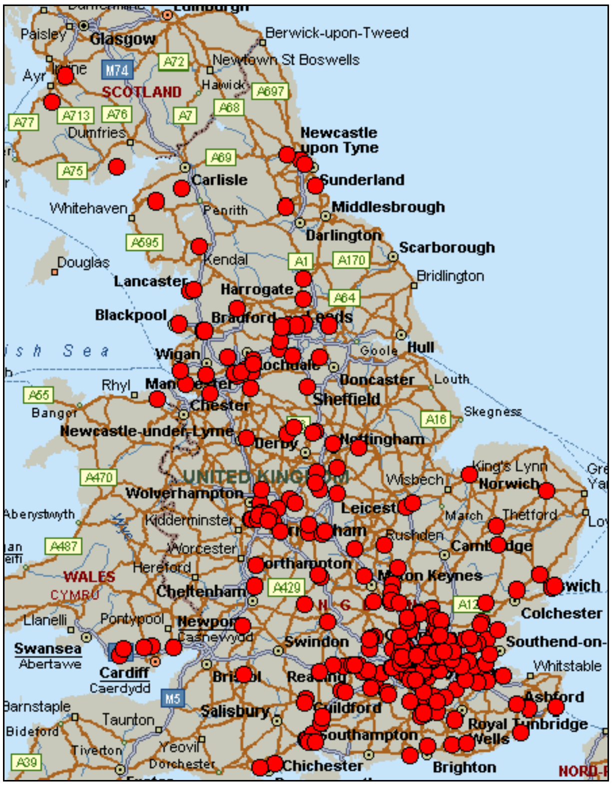
Inbound deliveries refer to goods and materials destined for a construction site having been transported from a supplier or other distribution point. The data inbound deliveries used in the study was ultimately sourced from the Bermondsey CCC, via Constructing Excellence, which is evaluating the performance of the facility. After extensive efforts to obtain further such data, it was concluded that the construction industry did not collect or retain the type of data relevant for the study, nor were they available through published sources.

The inbound deliveries data provided to the study covered a continuous period beginning in November 2005 and concluding in mid-November 2006. This was provided to the study in two datasets, the first for the period November 2005 to July 2006, inclusive; and the second from August 2006 until November 2006.

Analysis of the combined data revealed that 697 suppliers delivered into Bermondsey CCC for Unilever, of which 412 had a recognisable address (i.e. geocodes could be attached to each to use in the model).

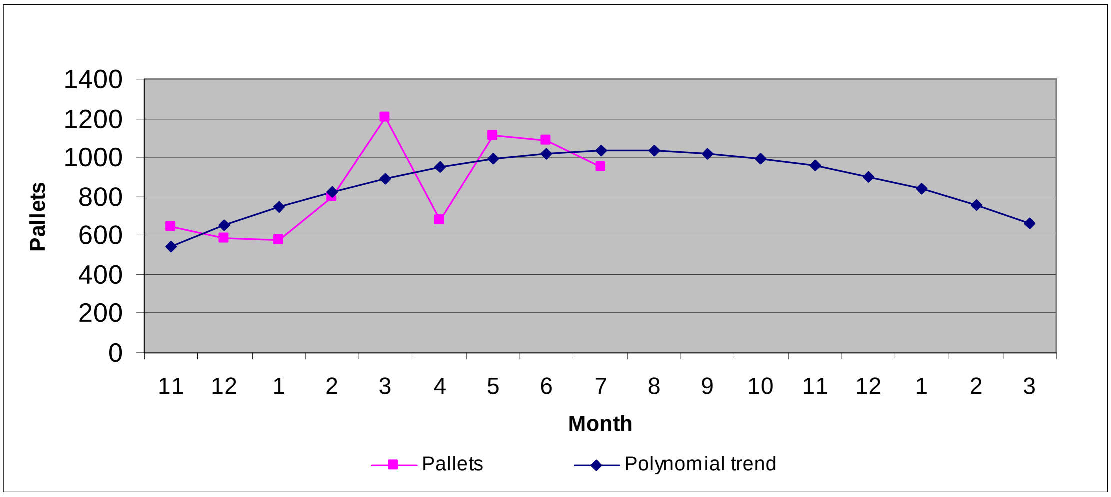
The 697 suppliers delivered 10,713 pallet equivalent units to Bermondsey between November 2005 and November 2006. The 412 suppliers used in model delivered 5,371 pallet equivalent units. Figure 3 shows how widespread the 412 suppliers are that deliver to the Bermondsey CCC. Deliveries received from the Continent are assigned to Dover and Harwich as the supply point in the UK.

Figure 3: Location of suppliers delivering to Bermondsey CCC



In order to understand how many pallets were required per square metre of building space for a typical building site, a calculation was made using supplier data which covered the period November 2005 to July 2006, inclusive. During this period 480 suppliers had delivered the equivalent of 7,673 pallets of goods and materials. Using this data an estimate was calculated for the number of pallets to be delivered for the remainder of the project (i.e. 9 month period to completion in March 2007). This estimate involved extrapolating the real data of 7,673 pallets and making a prediction using a polynomial trend (see Figure 4), which was then converted to an annualised figure.

Figure 4: Estimated annual number of pallets delivered to Unilever development



When annualised, it was predicted that 10,450 pallets would be delivered to the Unilever site. In terms of pallets per square metre of development, as the Unilever building is 23,000m^2, it means that 0.45 pallets are required for each square metre (i.e. Unilever Ratio = 0.45 pallets/m^2) of construction.

With the receipt of the second dataset (August to November 2006) it was possible to update the number of suppliers serving and pallets arriving at the Bermondsey CCC (quoted earlier). Using this information it was possible to validate the annual pallet prediction to the Unilever site amend the construction site demand assumptions. Thus, it was revealed that the original estimate of 10,450 pallets per year was not significantly different from the actual delivery of 10,713 pallets received. Furthermore, neither did the Unilever Ratio alter significantly and only increased to 0.47 pallets/m^2. It was therefore decided to use the original Unilever Ratio of 0.45 pallets/m^2 in subsequent calculations for construction site demand.

5.4 Construction site demand

As stated previously the data collection exercise identified 581 major construction sites to be built in London between 2007 and 2017 comprising 18.8 million m^2.

To assess the extent of pallet demand for these developments, it is assumed that the delivery of goods and materials as pallet equivalent units will commence at the midpoint between construction start and end years, and finish at end year, or 2 years after start year if the duration of construction is more than 4 years. The first period of construction being mainly bulk materials would not use a CCC.

It was decided unnecessary to calculate pallet demand for every year up to 2017, as the year-on-year change was thought unlikely to be significant; therefore construction site pallet demand was created for 2007, 2009, 2011, 2013 and 2015.

To establish the demand for pallets for all construction sites, 2007 was used as the base year. The data indicates that in London 197 construction sites will provide a total of 3.74mn m^2 and by applying the Unilever Ratio, it is estimated they will receive a total of 1,693,844 pallets. Since it is not possible to identify every supplier sending goods and materials to London construction sites, it was assumed that the same number of suppliers for the Unilever project would also supply all London construction sites.

To predict how suppliers will be apportioned to all London construction sites it was necessary to use a grossing-up factor. This was derived as follows:

$$\frac{\text{Original quantity of pallets delivered by supplier x Total number of pallets required by construction sites by year}}{\text{Sum of original quantity of pallets delivered by supplier}}$$

For example, to estimate the quantity of pallets for supplier ‘A’ in 2007, the calculation is:

$$\frac{48 \times 1{,}693{,}844}{5{,}371}$$

= 15,138 pallets

This calculation is made for each supplier for each year modelled (i.e. 2007, 2009, 2011, 2013 and 2015), with the “Total number of pallets required by construction sites by year” changing to reflect the varying demand as construction projects start and finish - e.g. in 2009 supplier ‘A’ will deliver 20,130 pallets. Using this total number of pallets figure an estimate of the deliver frequency was calculated.

Each supplier’s volume and delivery frequency was then apportioned to each CCC in a strategy in proportion to the pallets sent from each of the CCC’s to the construction sites.

5.5 CCC model costings

For the model to calculate the optimum locations of the CCCs in relation to construction sites, it has to take into account the CCC operating costs. For the purpose of the modelling, the costs of running to the Bermondsey CCC have been used in association with predicted number of pallets and predicted ground area of a facility.

As a starting point, the study adapted a published ‘CC Area Ready Reckoner’, which indicates the throughput of pallets per year when compared against the average time for which materials are held - i.e. ‘lag time’. (DTI *et al*, 2004) Table 1 show the version of the ‘ready reckoner’ applied in the study.

Table 1: Ready reckoner for area and annual pallet throughput (sq ft)

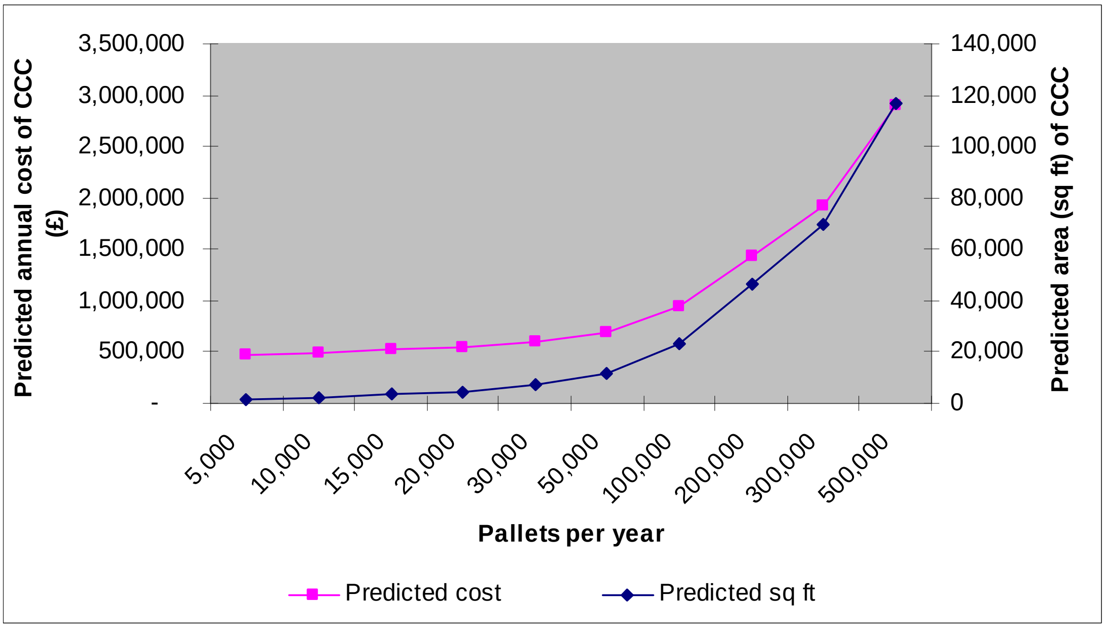
Number of Pallets per year	**200,000**	**100,000**	**50,000**	**30,000**	**20,000**	**15,000**	**10,000**	**5,000**
Average lag time (days)	**Space Requirement (sq ft)**							
1	6,667	3,333	1,667	1,000	667	500	333	167
5	33,333	16,667	8,333	5,000	3,333	2,500	1,667	833
7	46,667	23,333	11,667	7,000	4,667	3,500	2,333	1,167
10	66,667	33,333	16,667	10,000	6,667	5,000	3,333	1,667
15	100,000	50,000	25,000	15,000	10,000	7,500	5,000	2,500
20	133,333	66,666	33,333	20,000	13,333	10,000	6,667	3,333

Source: Adapted from; CC Area Ready Reckoner, Construction Logistics Consolidation Centres report, 2004

For the modelling it was assumed that goods and materials would have a dwell time of no longer than 7 days in the CCC, while the costs were based on Bermondsey CCC which has an area of 50,000 ft^2 and is estimated to cost £1.44 million per year to run. It was also recognised that costs would not grow linear to higher throughput of pallets or increased CCC area. Therefore it was assumed that costs would not double if the size of the CCC doubled, but change exponentially (i.e. 100,000 ft^2 = 1.8 & 25,000 ft^2 = 0.7).

Using this information it was possible to predict the associated costs and area of a CCC when considering the throughput of pallets per year. Figure 5 illustrates the how the cost and size of CCCs change as the number of pallet throughput increases.

Figure 5: Annual pallets versus predicted cost and CCC area (sq ft)



5.6 Base case assumptions

The base case for the modelling is that all goods and materials are delivered directly to the construction site and do not use a CCC. To estimate:

- the number of deliveries,
- the number of pallets delivered,
- the total miles run from the delivery's origin and
- the total cost of delivery,

it was assumed that extra deliveries would be made above those of the deliveries made by a CCC operations, and a time penalty would be incurred. These assumptions were made because the study team were informed that in many instances delivery vehicles to site are either delayed on arrival, or are delayed en route, or are required to wait for an unloading slot close to the site or are sent away to return later. In some instance they are refused delivery all together and have to return on another occasion. Furthermore, because a CCC serves several building sites, some deliveries will arrive at the CCC partially consolidated, meaning that the CCC could handle the same volume with less deliveries than a direct service to a building site.

Thus, it was assumed that inbound deliveries to site equated to additional inbound deliveries to a CCC. To establish the base case the following factors were used:

- 25% more deliveries, 75 minute delay time
- 50% more deliveries, 75 minute delay time
- 50% more deliveries, 100 minute delay time
- 100% more deliveries, 100 minute delay time

6 Results of the modelling

6.1 Establishing the base case

Using the assumptions stated in Section 5.6, a series of alternative base cases were established, which are shown in Table 2.

Table 2: Base case alternatives

Strategy	N^{o} of deliveries	Pallets delivered	Kilometres run	Total cost
25% more deliveries, 75 mins delay time	569,939	1,693,793	25,451,027	£22,411,511
50% more deliveries, 75 mins delay time	683,936	1,693,844	27,592,351	£24,973,556
50% more deliveries, 100 mins delay time	683,936	1,693,844	28,354,465	£28,297,178
100% more deliveries, 100 mins delay time	911,915	1,693,844	33,077,911	£34,595,642

These values are used later in the analysis when considering the impact of using the CCC compared with direct deliveries.

6.2 CCC results

6.2.1 Location of construction sites and CCCs

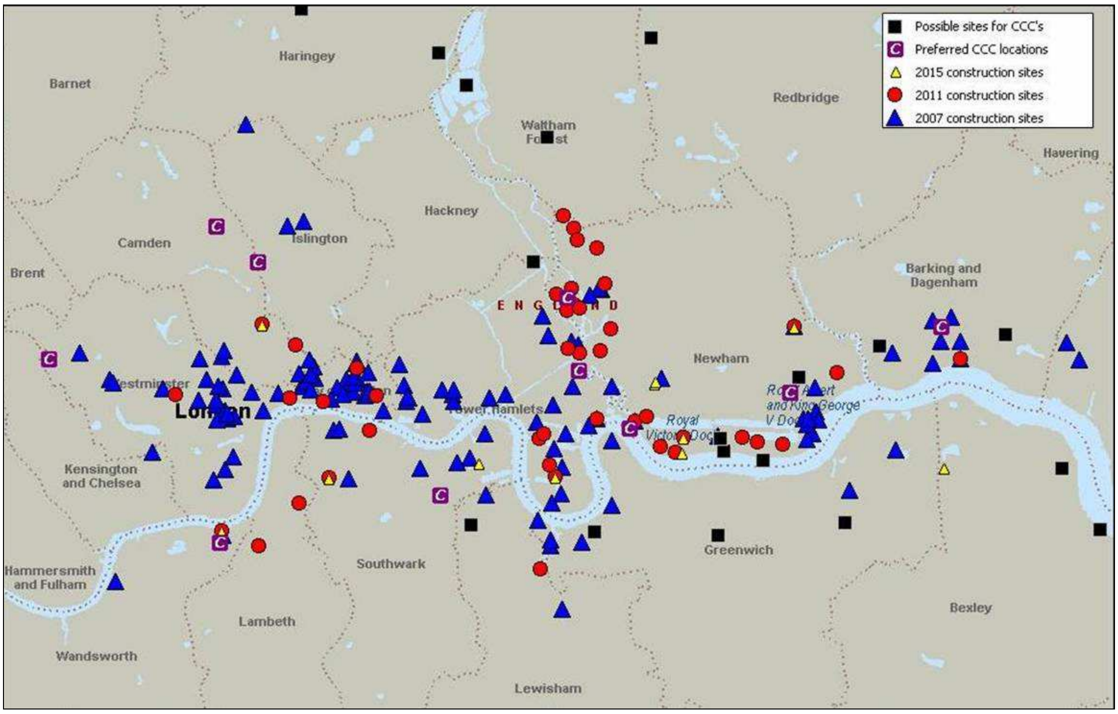
As mentioned in Section 5.4, pallet demand was created for years 2007, 2009, 2011, 2013 and 2015. These years are also used to illustrate the impact of using CCCs.

It total five strategies were run, three based on using a specifically assigned locations for the CCC and two using optimised centre of gravity locations generated by the model. Under the assigned location strategy the model was run to establish impacts of using 10 CCCs, 6 CCCs and 4 CCCs to supply construction sites. For the centre of gravity locations the model was run for 6 CCCs and 4 CCCs. The reasons for using this number of CCCs are provided later in this section. The aim of the strategies was to ensure they could be used continuously up to 2015 rather than being full for short periods and potentially empty at other times.

To identify the complete range of potential locations for CCCs across London, the model was initially run such that it generated sites by allocating CCCs and developments by centre of gravity. Included in the model's parameters data were the coordinates of London's 'Preferred Industrial Locations' and other suitable industrial areas identified by the study team. The results were output as a GIS map.

By assessing the proximity of the preferred industrial locations compared with the centre of gravity locations, it was possible to allocate CCCs to suitable sites without significantly adding to the overall cost of operation. Figure 6 shows the location of the preferred sites for the CCCs in relation to construction sites after the reallocation was decided upon. Within this allocation the Bermondsey CCC was retained.

Figure 6: Construction sites and preferred CCC locations



Having established the initial number of 10 locations for the CCCs, the modelling strategies were run again. This provided a set of results for each of the chosen years, showing how the allocation of sites to a CCC changed over time (see Appendix 2 for the full results table).

Table 3 shows the results for the different iterations of the modelling for 2007, which are discussed in more detail later.

Table 3: Results of modelling of CCCs for 2007

	10 Possible CCC Locations		No of Const. Sites (2007)	CS Dels (2007)	Pallets (2007)	Depot Area (ft2) (2007)	Ave Dist to CS (mls) (2007)	Cost (2007)
1	Newham	Beckton Gateway	15	11,629	216,650	50,479	0.8	£1,476,802
2	Southwark	Bermondsey South East	65	32,732	559,607	130,388	2.2	£3,814,586
3	Haringey	Central Leaside Business Area	13	9,536	169,924	39,592	1.1	£1,158,295
4	Ealing	Great Western Road (part)	4	1,278	22,387	5,216	1.3	£152,601
5	Tower Hamlets	Lower Lea Valley (part)	26	21,397	401,598	93,572	1.0	£2,737,506
6	Newham	Marshgate Lane Area	10	3,367	45,798	10,671	0.6	£312,184
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186
8	Barking & Dagenham	Rippleside	20	6,855	76,906	17,919	1.1	£524,234
9	Gospel Oak	Kentish Town	1	533	10,651	2,482	2.0	£72,603
10	Tileyard Road	Pentonville	27	9,086	141,883	33,059	2.2	£967,148
	Total all Depots		197	100,911	1,693,844	394,665		£11,546,146
	Supply			433,947			14,162,660	£14,444,616
	Delivery			100,911			239,876	£2,747,410
	Total Supply Chain			534,858			14,402,536	£28,738,173
	Cost per Pallet							£16.97

	6 Possible CCC Locations		No of Const. Sites (2007)	CS Dels (2007)	Pallets (2007)	Depot Area (ft2) (2007)	Ave Dist to CS (mls) (2007)	Cost (2007)
2	Southwark	Bermondsey South East	65	32,732	559,607	130,388	2.2	£3,814,586
3	Haringey	Central Leaside Business Area	13	9,536	169,924	39,592	1.1	£1,158,295
5	Tower Hamlets	Lower Lea Valley (part)	41	33,026	618,248	144,052	1.8	£4,214,309
6	Newham	Marshgate Lane Area	10	3,367	45,798	10,671	0.6	£312,184
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186
10	Tileyard Road	Pentonville	32	10,896	174,921	40,757	2.3	£1,192,355
	Total all Depots		177	94,056	1,616,938	376,746		£11,021,915
	Supply			414,244			13,481,884	£13,769,981
	Delivery			94,056			289,104	£2,784,436
	Total Supply Chain			508,300			13,770,988	£27,576,332
	Cost per Pallet							£17.05

	4 Possible CCC Locations		No of Const. Sites (2007)	CS Dels (2007)	Pallets (2007)	Depot Area (ft2) (2007)	Ave Dist to CS (mls) (2007)	Cost (2007)
2	Southwark	Bermondsey South East	69	33,863	570,271	132,873	2.2	£3,887,277
5	Tower Hamlets	Lower Lea Valley (part)	60	44,797	823,306	191,830	1.9	£5,612,099
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186
10	Tileyard Road	Pentonville	32	10,896	174,921	40,757	2.3	£1,192,355
	Total all Depots		177	94,056	1,616,938	376,746		£11,021,917
	Supply			414,244			13,494,708	£13,778,610
	Delivery			94,056			314,494	£2,859,275
	Total Supply Chain			508,300			13,809,202	£27,659,802
	Cost per Pallet							£17.11

After each run, the CCCs that had the least number of construction site allocations were removed from the model, which was then run again. At the end of the first iteration the number of CCCs was reduced to six, with the number ultimately shrinking to four in the third iteration.

Figure 7 illustrates the distribution of construction sites being served by 10 CCC in 2007, while Figure 8 shows the position in 2011. It can be seen that by 2011 the number of construction sites served has significantly fallen, with one CCC unallocated to any sites.

Figure 7: Distribution of 10 CCCs and construction sites they serve in 2007

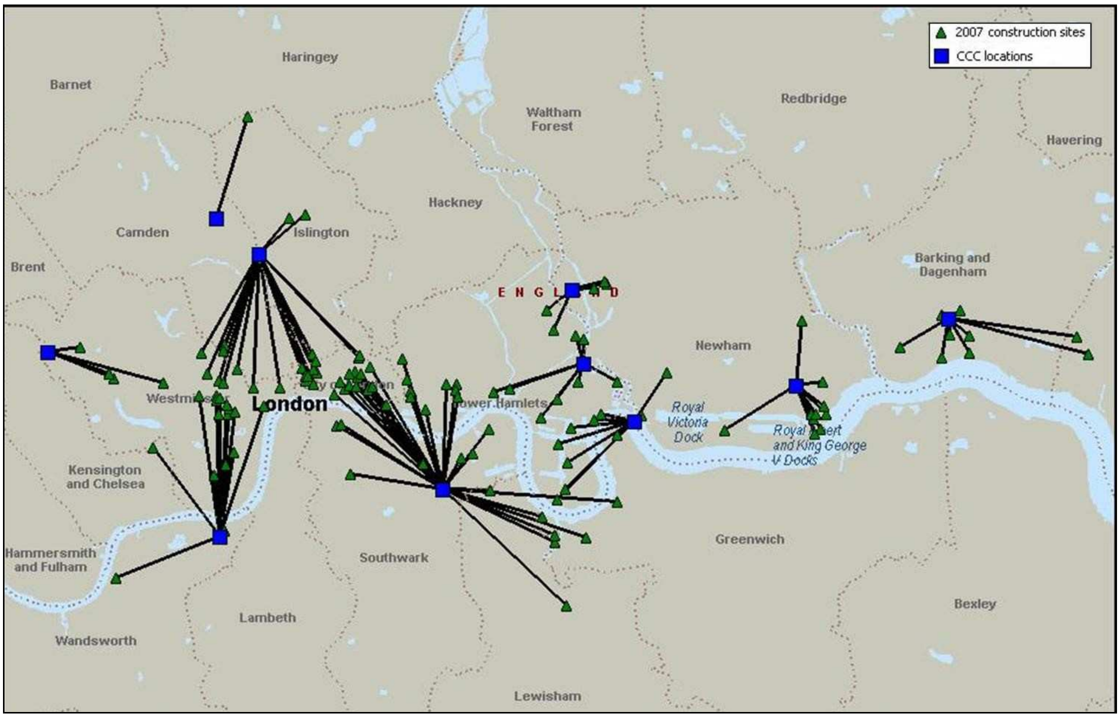
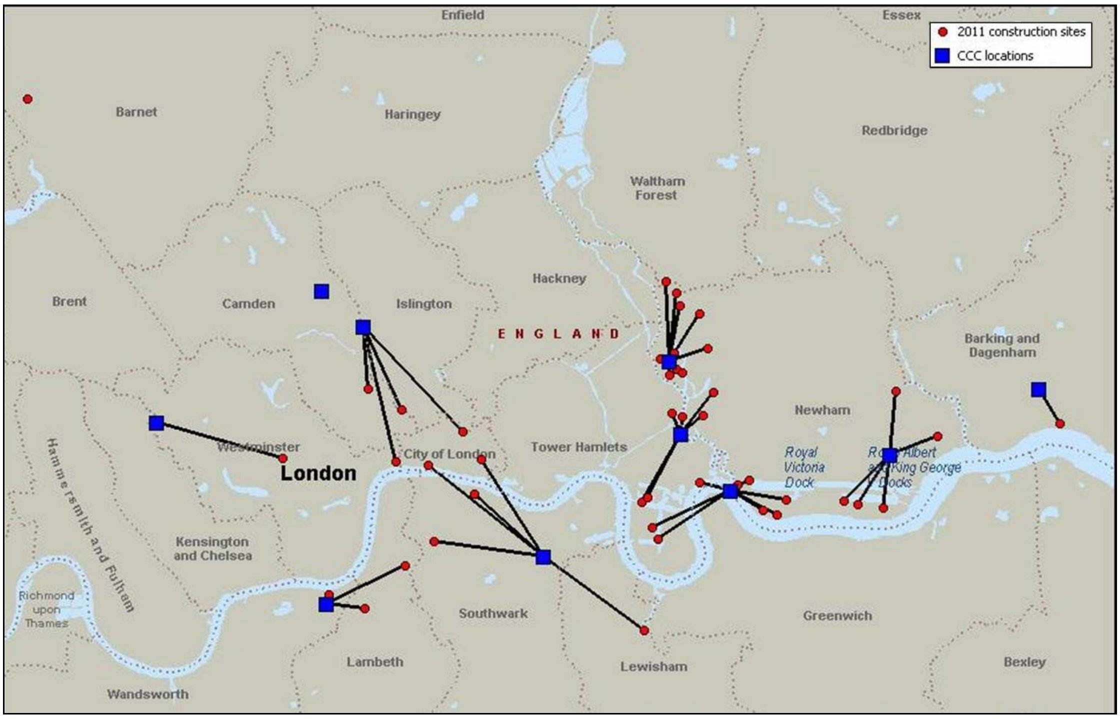
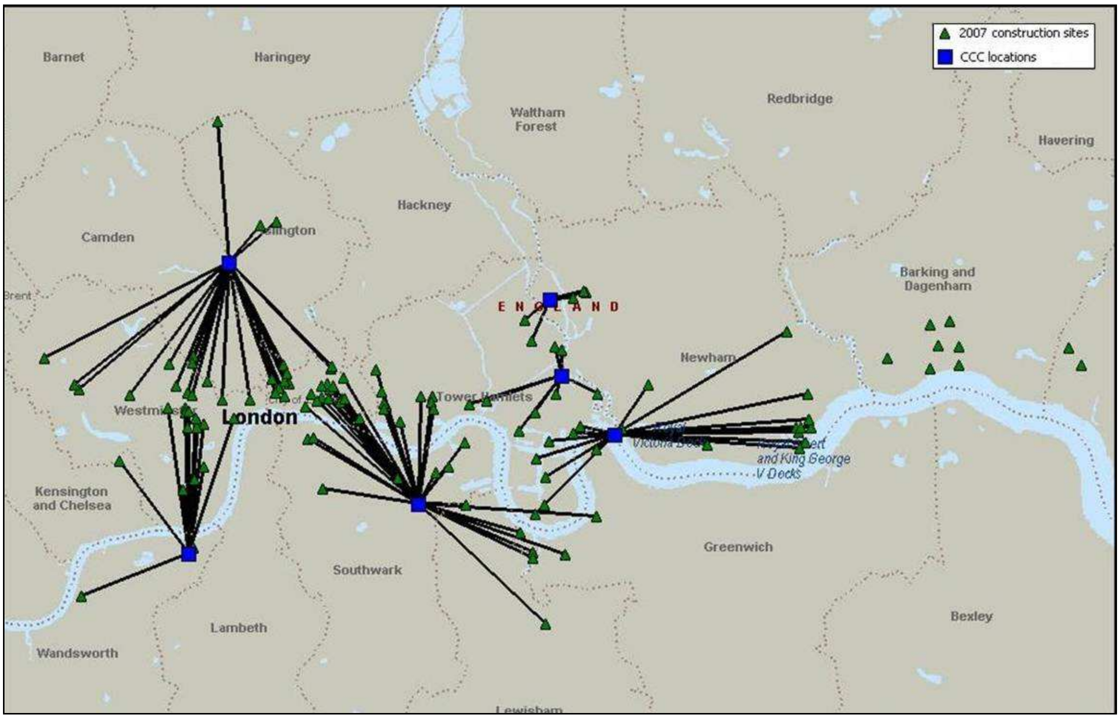


Figure 8: Distribution of 10 CCCs and construction sites they serve in 2011



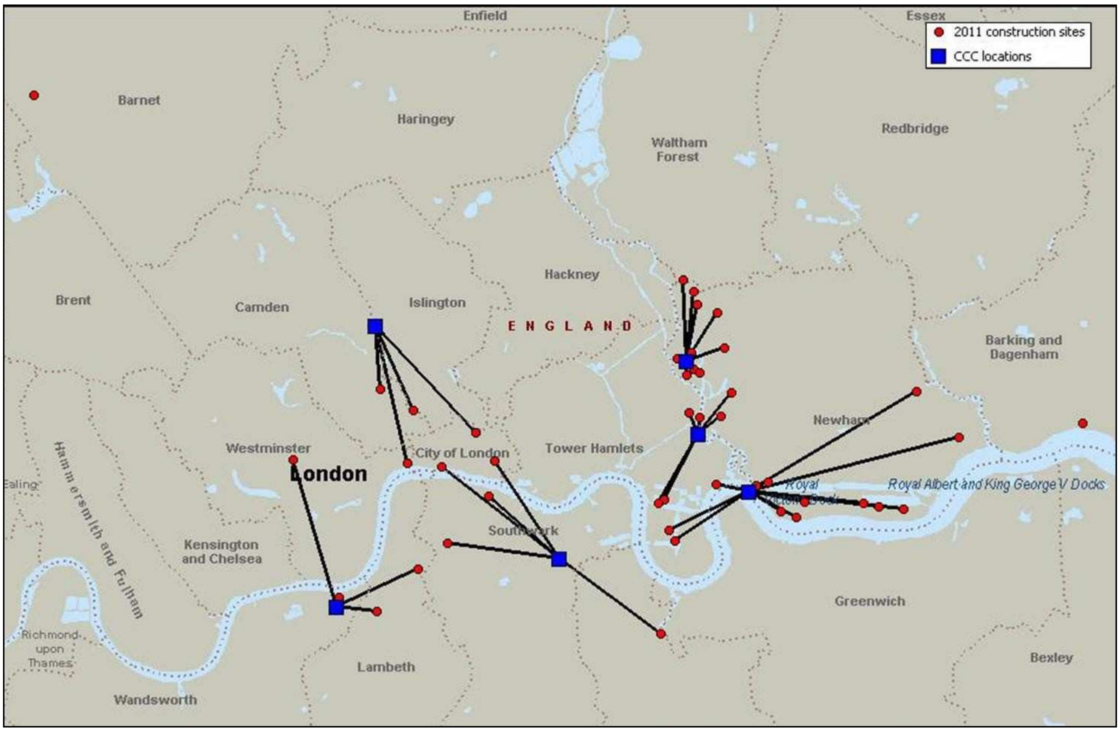
When the 6 CCC option is considered, the allocation of construction sites changes with the result that in 2007 more sites are assigned to two CCCs (Lower lea Valley and Pentonville), while the other four remain the same. However, in the Barking area a group of sites are not reallocated to a CCC because they are outside the driving time parameter of the nearest included CCC and the construction activity would have ceased prior to 2015. Figure 9 illustrates the distribution of construction sites being served by 6 CCCs in 2007.

Figure 9: Distribution of 6 CCCs and construction sites they serve in 2007



By 2011, overall, there are fewer construction sites to allocate, although a number of new developments come on stream in the Lea Valley (the Olympic site area). Figure 10 shows the extent to which the number of construction sites has contracted compared with 2007.

Figure 10: Distribution of 6 CCCs and construction sites they serve in 2011

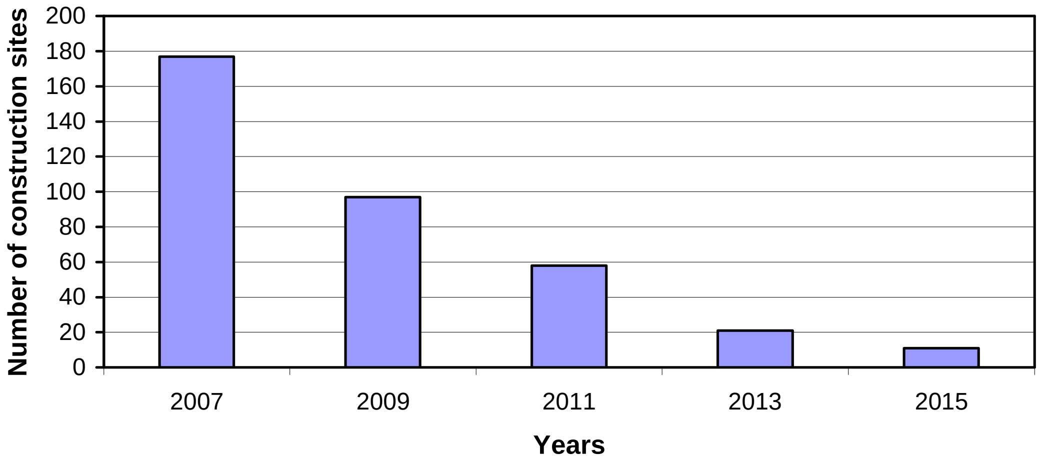


The third and final iteration suggests that four CCCs are used to serve the majority of the construction sites. With this strategy all CCCs will have a continuous allocation of construction sites up to 2015. The four final CCCs are located in:

- Southwark - Bermondsey South East
- Tower Hamlets - Lower Lea Valley
- Wandsworth - Nine Elms
- Pentonville - Tileyard Road

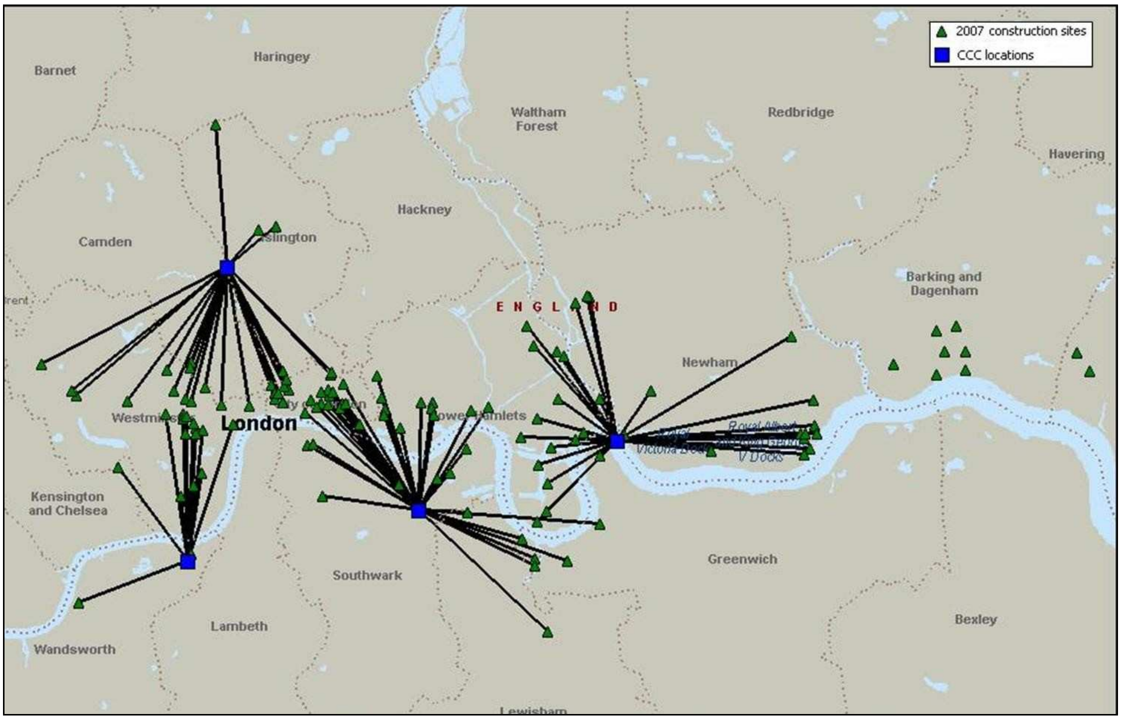
Obviously, based on current data the number of construction sites in existence in 2015 will be relatively few, but in the interceding period it is likely other developments will transpire and utilise the CCCs. Figure 11 indicates the extent to which the number of currently planned construction sites decreases in the run up to 2015.

Figure 11: Number of construction sites to 2015



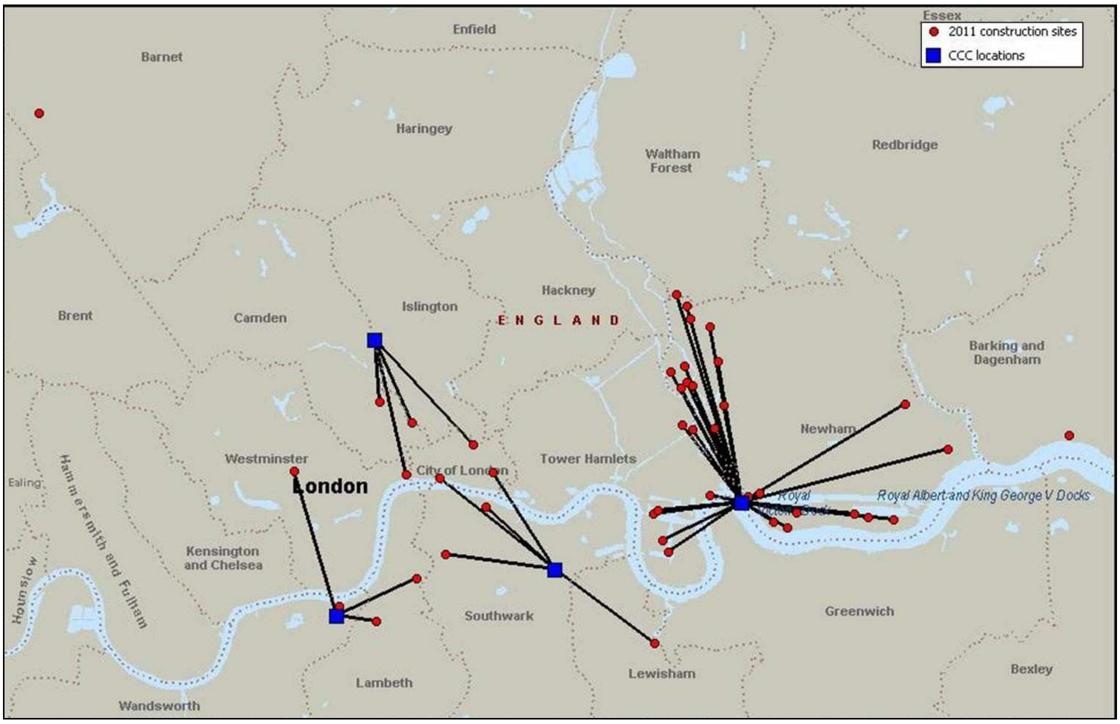
The final distribution of four CCCs is shown in Figure 12, and it can be seen that in this strategy the construction sites in the Barking area remain unallocated. The modelling suggests that since these sites complete in a relatively short time they do not warrant being served by a CCC. However, were other developments to materialise then a CCC could be an option.

Figure 12: Distribution of 4 CCCs and construction sites they serve in 2007



By 2011 the majority of construction activity will, based on current data, take place in the Lower Lea Valley; the number of sites and the CCCs that serve them are shown in Figure 13.

Figure 13: Distribution of 4 CCCs and construction sites they serve in 2011



6.2.2 Interpretation of output tables

The main output from the model is provided in Table 3, presented earlier. As stated the outcomes are considered under a number of parameters, which cover the following:

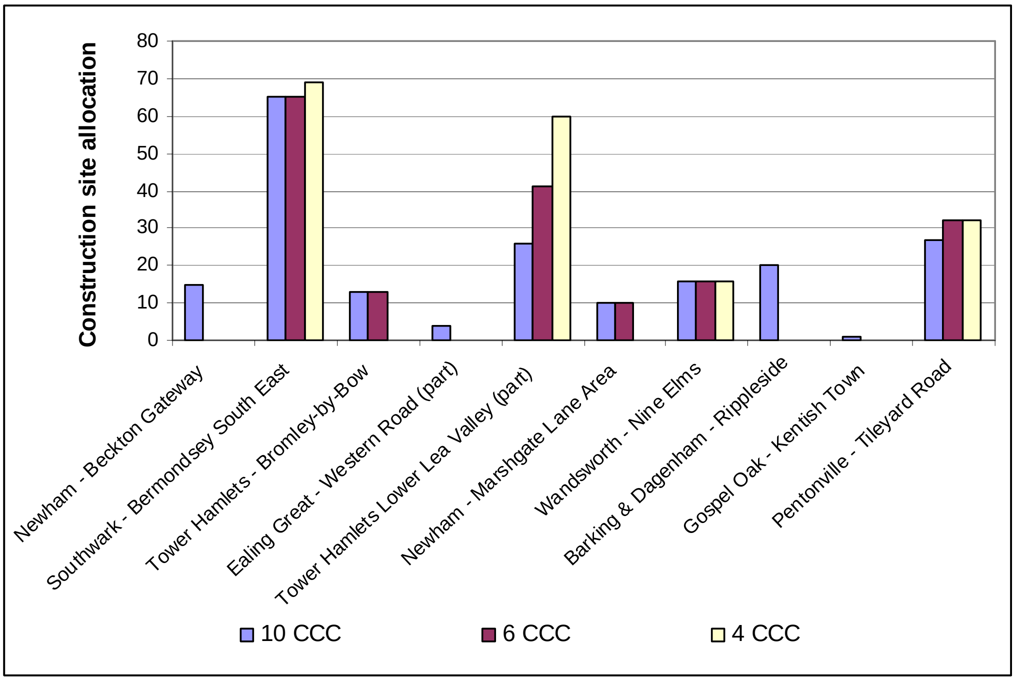
- Number of construction sites (CS) assigned to each CCC
- Total pallet throughput for the year
- Number of deliveries to the construction sites
- CCC area (Depot area)
- Average distance from CCC to construction site
- Operating cost of CCC
- Total supplier deliveries mileage and transport cost
- Total CCC deliveries mileage and transport cost
- Total supply chain cost
- Cost per pallet

The results for first five parameters are considered in detail below. Cost are considered in Section 6.3.

- **Number of construction sites (CS) assigned to each CCC**

  Due to the nature of the data, the number of construction sites decreases over time. The initial number of construction sites is 197 in 2007, but this reduces to 11 sites by 2015. The model tests hundreds of permutations to assign construction sites to CCCs until it has achieved the optimal allocation. Using 2007 as an example year, Figure 14 illustrates the reallocation of construction sites as the number of CCC options is reduced. As stated previously, the aim was to retain only CCCs that would experience continuous use up to 2015.

Figure 14: Assignment of construction sites to CCCs for 2007



- **Total pallet throughput for the year**

  The general principal of calculating the total annual pallet throughput was discussed in Section 5.4. However, as the number of CCC options reduces, the pallet throughput is recalculated to reflect the number and size of the construction sites assigned to the CCCs. The pallet throughput also changes as the number of active construction sites fluctuation over time. See Appendix 2 for more detail.

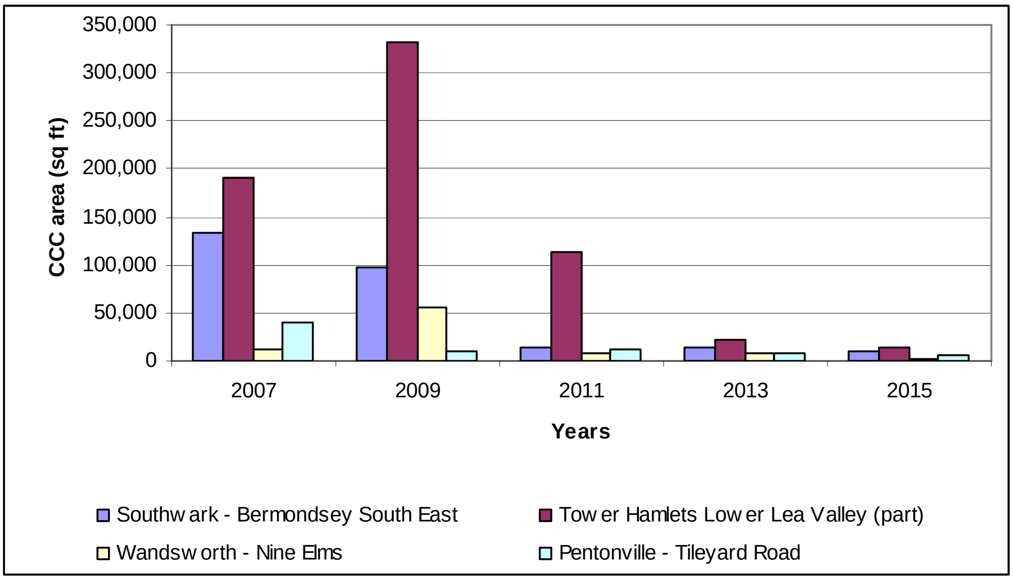
- **Number of deliveries to the construction sites**

This represents the number of deliveries arriving from suppliers and going to the CCCs. The number is calculated using data on the number of deliveries, number of pallets equivalent unit per delivery and the apportionment of suppliers to construction sites.

- **CCC area (Depot area)**

The initial run of the model established the size of facility required to accommodate the estimated annual pallet throughput when using ten CCC. As the number of construction sites fluctuated over time, the indicated size of facility required also changes. However, as the number of CCC options was reduced the size of the facilities required grew. Figure 15 illustrates the area needed in order to meet peak demand.

Figure 15: Changes to facility size requirements



For the years modelled, it is predicted that in 2009 a CCC of approximately 330 thousand sq ft would be required in the Lower Lea Valley to accommodate a throughput of nearly 1.5 million pallets.

This outcome raises number of key issues:

i. Is it desirable to have a CCC of this magnitude?

ii. Is there available space for a CCC of this size?

iii. There are significant transport implications for the local vicinity if a CCC of this size were contemplated - e.g. approximately 73,000 supplier and 40,000 CCC vehicle movements.

These and other issues would have to be considered on an individual basis as and when a CCC might be opted for. Whilst it is desirable to remove construction traffic from a number of building sites, a large number of goods vehicles movements into another area could create equally serious impacts.

- **Average distance from CCC to construction site**

  This parameter was set at no more than 30 minutes drive time from the CCC to the construction site and as a result the distance between construction site and CCC is no more than 3 miles in any strategy. These are quite short distances in this study, because most of the construction sites are located in central London. However, it is expected that these distances would be further if CCCs were located to serve construction taking place in the suburban areas - e.g. 5 to 7 miles.

6.3 CCC financial appraisal

6.3.1 Introduction

The model takes into account a range of input costs for both operating a facility and the delivery transport it carries out. These are split into fixed and variable costs and are based on the Bermondsey CCC in terms of facility costs, and published cost tables for goods vehicle operations. The model outputs are divided between facility costs, supply transport costs and CCC transport costs; combined these constitute total supply chain costs. The overall costs are presented as a ‘cost per pallet’.

6.3.2 Impact on supply chain costs

The modelling predicted that in all cases the freight transport mileage when using a CCC will be less than if direct deliveries are made to the construction site. Table 4 shows the scale of the fewer kilometres driven when materials are delivered through a CCC compared with direct delivery.

Table 4: Difference between direct delivery and total CCC delivery distances (KM)

	Driven Kilometres			
	Direct delivery	**10 CCCs**	**6 CCCs**	**4 CCCs**
25% more deliveries, 75 minutes delay time	25,451,027	-2,273,025	-3,289,376	-3,227,878
50% more deliveries, 75 minutes delay time	27,592,351	-4,414,350	-5,430,700	-5,369,202
50% more deliveries, 100 minutes delay time	28,354,465	-5,176,464	-6,192,814	-6,131,316
100% more deliveries, 100 minutes delay time	33,077,911	-9,899,910	-10,916,260	-10,854,762

Note: CCC numbers are the difference in distance driven - i.e. 25,451,027 - 2,273,025 = 23,178002 km

If these reductions in driven kilometres are considered in terms of percentages, it can be seen in Table 5 that if 25% more trips have to be made by delivery vehicles to construction site and these incur a 75 minute delay for each trip, a 4 CCC option with achieve a 13% reduction in driven kilometres. In the extreme case that 100% more trips have to be made by delivery vehicles to construction site and a 100 minute delay is experienced on each trip, a 4 CCC option with achieve a 43% reduction in driven kilometres.

Table 5: Difference between direct and total CC delivery distances (Per cent)

	Driven Kilometres - percentage reduction			
	Direct delivery KM	**10 CCCs**	**6 CCCs**	**4 CCCs**
25% more deliveries, 75 minutes delay time	25,451,027	9%	13%	13%
50% more deliveries, 75 minutes delay time	27,592,351	17%	21%	21%
50% more deliveries, 100 minutes delay time	28,354,465	20%	24%	24%
100% more deliveries, 100 minutes delay time	33,077,911	39%	43%	43%

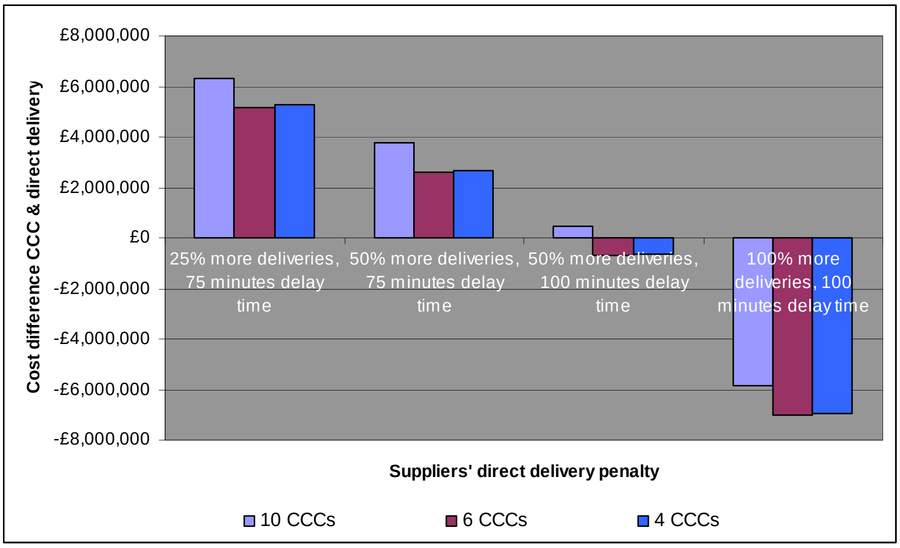
However, the driven kilometre savings do not necessarily translate into overall supply chain cost savings, as the cost of running the CCC has to be included. When the direct delivery cost is compared with the cost of delivering through CCCs, the model suggests that financial advantage is best achieved if extra delivery trips are being made and delay times are significant (50% more deliveries, 100 minutes delay time).

From a modelling point-of-view, trying to derive the delivering route of the supplier's vehicles is complex, since it is not known what further deliveries the vehicle will make after visiting the CCC. Depending on what assumptions are used will influence the results produce.

If a supplier's lorry delivers a load to a construction site it would then, unless it was a full load, travel to another delivery point, and so on until the vehicle is empty. This is the inter-delivery drop distance. To calculate a vehicle's mileage when it has a number of deliveries to make, the model apportions an amount of mileage to each delivery it makes. Thus, if a route is 100 miles for a vehicle and there are 5 deliveries of 3 tonnes each, the equation it uses is 0.5 x 100 x 1 / 5 + 0.5 x 100 x 3 / 15. In other words, half the mileage is apportioned to the number of deliveries and the other half is apportioned to the quantity being delivered.

Figure 16 illustrates the conditions when the supply chain cost of using CCCs is less than that of direct delivery; the bars indicated as negative represent CCC costs which are less than the direct delivery cost.

Figure 16: CCC costs compared with direct delivery costs for 2007



In the cases where the cost of direct delivery is less than using a CCC, it may appear that there is no financial justification for using CCCs. However, when the higher CCC costs are placed into context, the difference is not so discouraging. Considering the 4 CCC strategy for 2007, the total number of sites served is 177 and the cost disadvantage to direct deliveries is approximately £5.25 million, equivalent to around £30,000 per site or about £110 per site per working day. Given that on average it costs about £27 per hour to run a heavy good vehicle, a haulier that is delayed when delivering to a construction will loose about £34 for a 75 minute delay. In these circumstances, it requires approximately three such delays a day for the CCC to breakeven with direct deliveries. Furthermore, this does not account for any form of damage to gods and materials or handling problems that might occur on site at the time of delivery.

6.3.3 Cost per pallet

A useful measure to gauge the cost of handling the goods and materials throughput of CCCs is the cost per pallet. In the case of the 4 CCC strategy, where the facilities are utilised continuously to 2015, the average cost for all years is £16.93 per pallet, with the highest cost being £17.11 for throughput in 2007. When compared with the per pallet cost of direct deliveries it is found that at an individual scenario level the CCC costs are slightly high, although on average the CCC per pallet cost is not dissimilar (see Table 6).

Table 6: Cost per pallet for direct delivery

Direct delivery scenario	Cost per pallet (£)
25% more deliveries, 75 minutes delay time	13.23
50% more deliveries, 75 minutes delay time	14.74
50% more deliveries, 100 minutes delay time	16.71
100% more deliveries, 100 minutes delay time	20.42
Average cost per pallet	*16.28*

6.3.4 Further discussion on costs

The results of the modelling exercise for this study do vary depending upon the scenario being tested and the assumptions being made. However, in all cases the cost of CCC operation varies from a small negative impact to a small positive impact on transport and handling costs. This would suggest that CCC operation could be implemented at little or no cost to the supply chain. Generally speaking, the additional costs of double handling and operating a warehouse are balanced by small reductions in vehicle mileage.

An important issue that the model does not capture concerns other tangible costs which are present, but difficult to measure. Data from the Bermondsey trial suggests that CCC deliveries tend to be made on time and efficiently, as the drivers know the sites and the sites are less congested. Furthermore, materials are less likely to be damaged at the unloading and handling stage or due to poor on-site storage facilities. These factors must be considered as cost-positive, since the improved delivery and condition of materials reduces potential delay and replacement. In contrast, a notable proportion of direct deliveries to building sites:

- are often late, sometimes by several hours,
- are not necessarily booked in for delivery,
- cannot always be accommodated at the site immediately, resulting in a vehicle having to "go away and return later".

Consequently, these features have a detrimental impact on transport and building costs, and the environment. However, they are unvalued and not included in the model, leading to conservative results regarding the true cost of using CCCs.

6.4 Environmental implications

6.4.1 Introduction

Initial findings from the Bermondsey CCC trial have suggested that delivery vehicle trips visiting a construction site can be cut by about 75 per cent, when all deliveries are routed through the CCC. This reduction has implications regarding the environmental impacts for the local areas surrounding the construction site and on the numbers of vehicles using local roads making delivery visits.

These issues are explored in more depth in this section, if CCCs were to be used across London.

6.4.2 Delivery vehicle profile

Using data from the Bermondsey trial it has been possible to establish the division between the types of vehicles carrying goods to construction sites. Bermondsey arrivals (i.e. goods delivered from suppliers) recoded the type of deliver vehicles used. The categories of vehicle were: Articulated lorry (artic), rigid lorry, van, and courier. Using these categories it was possible to apportion delivery vehicles to all deliveries from suppliers. In the case of deliveries received by couriers, these were reassigned to vans and rigid lorries in the proportion of 95 and 5 per cent, respectively. Table 7 indicates the split of vehicles delivering goods to the Bermondsey CCC. It was assumed that this division would also apply to deliveries made direct to sites.

Table 7: Type of delivery vehicles used from suppliers

Supplier delivery vehicle split	Percentage
Articulated vehicles (LGV1)	13%
Rigid vehicles (LGV2)	49%
Vans	39%

NB: LGV = Large Goods Vehicles

In the case of deliveries made from the CCC to sites the division between types of vehicle was 98 per cent by rigid lorry and 2 per cent by van.

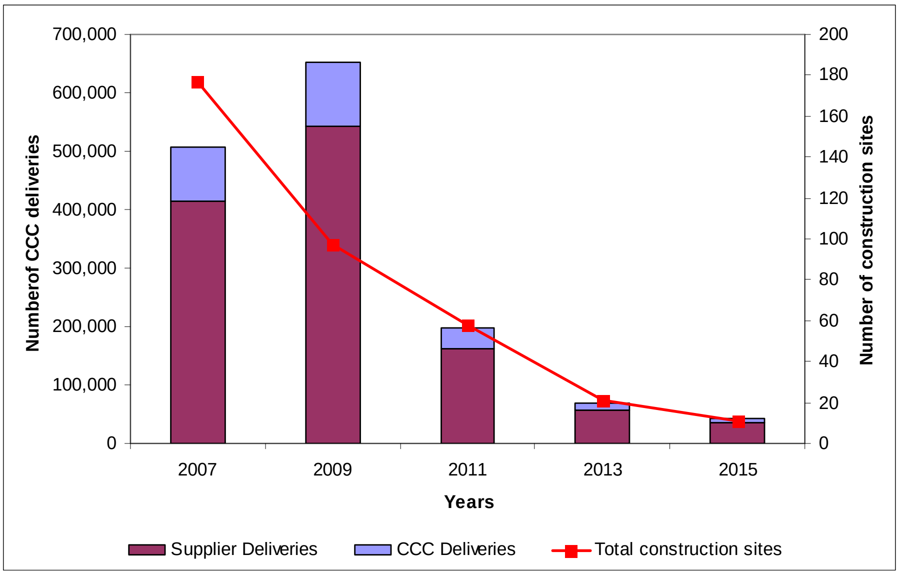
The division between type of vehicle used for in- and outbound deliveries was used in the calculations to determine the levels of CO_2 produced for vehicle activity.

6.4.3 Delivery vehicle activity and levels of CO_2 emissions

The level of vehicle activity and the estimated quantity of CO_2 emissions considers how the situation might change when comparing the base case with use of CCCs. As stated in Section 5.6, it is assumed that deliveries under 'tradition delivery' conditions would experience time and cost penalties. These assumptions are carried through to this section.

The level of vehicle activity is dependent upon the quantity of materials required by the construction sites, which in turn translates into the number of deliveries being made from suppliers. Figure 17 illustrates the total number of supply chain deliveries required through the four CCC network, separated into vehicle deliveries into the facility from suppliers and vehicle deliveries from the CCCs, and the number of construction site being served.

Figure 17: Total supply chain deliveries via 4 CCC locations. [(i)]



[(i)] **Note**:

	2007	2009	2011	2013	2015
Total area where 4 CCCs required (sq ft)	376,746	493,774	148,055	50,994	32,527

As stated in the previous section, the total area of the CCCs also fluctuates within the modelling and the *Note* to Figure 17 indicates the amount required for the respective years. However, it can be concluded that a significant reduction in the number of vehicle deliveries to sites from CCCs compared with direct deliveries to site does take place, which overall is in the order of 80 per cent.

A key reason to the scale of reduced deliveries from the CCCs to construction sites is probably attributable to the level of supplier deliveries that arrive by van. On average vans deliver 1.5 pallets per visit and account for approximately 20 per cent of all delivery drops to the CCC. This implies a substantial level of consolidation takes place for the final delivery to the construction site from the CCC, since the majority of deliveries are consolidated on to larger vehicles.

The model has estimated that to supply all the constructions sites included in the study the kilometres and CO_2 emission would amount to the results shown in Table 8.

Table 8: Kilometres and tonnes (t) of CO_2 emissions for direct deliveries to site in 2007

	Supply trips	
Direct delivery penalty factors	**Kilometres**	**Supply trip CO_2 (t)**
25% more deliveries, 75 minute delay time	25,451,027	19,960
50% more deliveries, 75 minute delay time	27,592,351	21,639
50% more deliveries, 100 minute delay time	28,354,465	22,237
100% more deliveries, 100 minute delay time	33,077,911	25,941

The vehicle kilometres and CO_2 emission results when using CCCs are presented in Table 9.

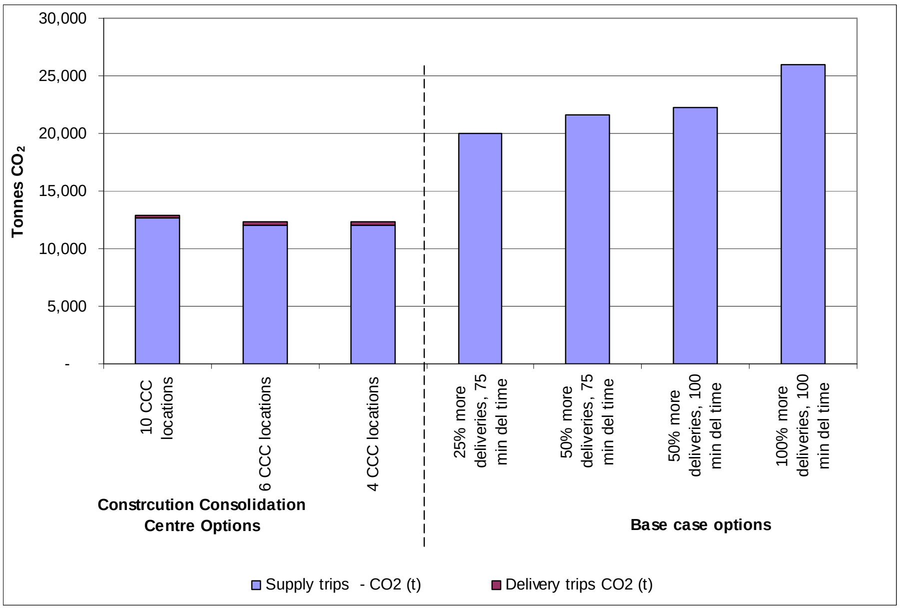
Table 9: Kilometres and tonnes (t) of CO_2 emissions for CCC use in 2007

	Supply trips		CCC Delivery trips	
Number of CCCs	**Kilometres**	**Supply trip CO_2 (t)**	**Kilometres**	**Delivery trip CO_2 (t)**
10 CCC locations	22,791,969	12,663	386,032	223
6 CCC locations	21,696,396	12,054	465,255	269
4 CCC locations	21,717,034	12,066	506,115	293

A comparison of CO_2 emissions between CCC and direct deliveries is made in Figure 18. It can be seen that overall, lower levels of CO_2 are available through the use of CCCs and the overall range of potential savings is 7,700 to 13,600 tonnes for 2007.

Figure 18 also demonstrates the extent to which CO_2 emissions are produced by the delivery from the supplier compared with the emissions produced by CCC originating deliveries. Overall, 98 per cent of CO_2 emissions derive from the supply journey, while 2 per cent are produced for delivery trips, when considering the entire supply via a CCC. However, this is not unexpected given that the average distance travelled from a CCC to construction site is approximately 1.5 miles (2.4km).

Figure 18: Comparison of CO_2 emissions between CCC and base case options in 2007



An important aspect of deliveries which has not been possible to quantify, but is implicit when delivery vehicles are delayed or have to wait for an unloading slot, relates to 'go around' mileage and congestion. If delivery vehicles are required to move away from the site for a short time prior to unloading their presence on London's road will impact upon the air quality and their contribution to congestion. To understand the implications of this practice more fully, would require a comprehensive survey of construction site delivery vehicles through which details about a delay times, 'go around' distances driven, and frequency of occurrences could be measured.

6.4.4 Environmental impact values

In this section the changes that occur in delivery mileage when using CCCs in favour of direct construction site deliveries are considers in terms of an environmental impact value.

There are many methods by which the environmental impact of freight transport can be measured. However, in this study it was decided to use *sensitive lorry miles* (SLM) as these are used by the Department for Transport (DfT)when evaluating the overall benefits that are accrued by removing road freight miles in favour of other modes (e.g. rail and waterborne) and are a recognised means of measuring the environmental of road freight transport.

Within the SLM measure 'values' are assigned on a per mile basis to different road categories according the levels of environmental impact that are assessed to be associated with them. Table 10 shows the environmental impacts and road categories which are used by DfT in the calculating the derived values of net externalities.

Table 10: SLM environmental impact and road categories

Environmental impact	Road location	Road category
Accidents	Motorway	High, Medium, Low Congestion
Noise Pollution	London & Conurbation	Trunk, Principle & Other
Climate Change	Rural & Urban Weighted	Trunk, Principle & Other
Infrastructure Costs		
Road Congestion		
Unquantified		
Taxation		

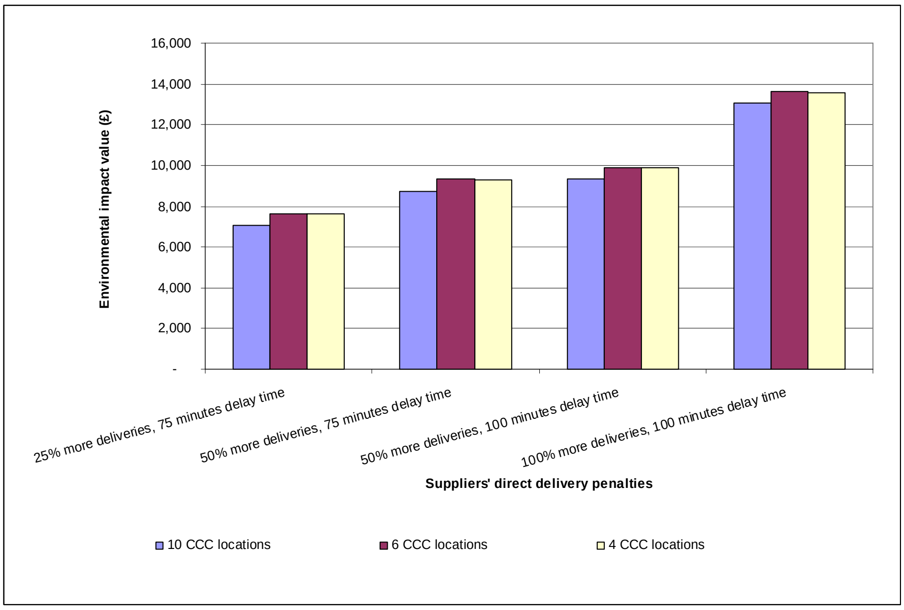
In the study an assumed SLM value was used based on the average pence per mile value for the journey between Bermondsey and the Unilever House, which is immediately north of Blackfriars Bridge. This distance is approximately 3.6 miles with an SLM value equating to £0.58 per mile, which excludes the £0.088 value that is assigned to Rail Costs and not relevant to this study. This value was then multiplied by the difference in total delivery distance for each CCC scenario generated for 2007. Table 11 shows the scale of mileage that is saved in 2007 when CCCs are used in favour of direct deliveries.

Table 11: Difference in mileage between direct and CCC deliveries in 2007

	Difference between direct and CCC delivery in miles			
CCC scenarios	**25% more deliveries, 75 minutes delay time**	**50% more deliveries, 75 minutes delay time**	**50% more deliveries, 100 minutes delay time**	**100% more deliveries, 100 minutes delay time**
10 CCC locations	7,073 mls	8,753 mls	9,350 mls	13,055 mls
6 CCC locations	7,636 mls	9,315 mls	9,913 mls	13,617 mls
4 CCC locations	7,601 mls	9,280 mls	9,878 mls	13,582 mls

The outcomes of the environmental impact value calculation are presented in Figure 19. It shows that, if by not using a CCC and 25 per cent more direct deliveries are made which incur a 75 minute delay time, the environmental benefits (i.e. SLMs saved) are valued at approximately £7,500 for the CCC options. However, if the reliability of direct deliveries is impeded further the SLM savings will be higher, since greater direct delivery mileage is generated.

Figure 19: Environmental impact savings for 2007, measured using sentive lorry mile (SLM) values



These results should be regarded as only indicative since they are based on the construction site located in central London. If a greater number of suburban sites were included, the level of SLMs might be lower, as less sensitive roads (e.g. urban dual carriage ways) would probably feature, which are assessed to have a lower environmental impact value.

6.5 Intermodal linkages to construction consolidation centres

6.5.1 Introduction

For the two principle schemes the evaluation has had to consider the role intermodal linkages would play and the types of materials that could be delivered by non-road modes. However, it must be accepted that road-based deliveries will be the dominant means by which materials will arrive at a CCC, since materials are sourced from many different suppliers.

This analysis starts with a review of the potential role various modes might be able to play.

Alternatives modes might be able to play a role in two aspects of transport:

- Bringing materials from suppliers to the CCC
- Delivering materials from the CCC to construction sites.

6.5.2 Transporting materials from suppliers to the CCC

The work of a CCC can be summarised as bringing in small loads of material from a wide variety of sources and consolidating them into full loads for transport to a small number of building sites.

In contrast, the work of a typical rail terminal or wharf in the construction sector is to bring in large bulk volumes of product from a small number of sources and distribute them to a large number of building sites. The distance from railhead or wharf to construction site is generally very short - less than five miles in London.

Construction industry rail terminals tend to handle bulk materials such as stone, sand, and cement. These are the key inputs into the early stages of construction. In contrast CCCs tend to provide materials for later stages of construction - often referred to as “fit-out”. Such materials tend to be non bulk, often palletised.

These factors would seem to suggest that there would be little benefit in locating a CCC at a rail terminal or wharf. However, there may be good logistics reasons for co-locating these facilities. It may be advantageous for the construction company to hold most or all incoming products at a single location for “just in time” delivery, reducing stockpiles on site. The CCC / terminal operator will build up a good understanding of the construction site over a longer period of operation, and this can be used in scheduling loads and arranging delivery routes.

6.5.3 Transporting materials from the CCC to construction sites

This is an operation which is well suited to transport by water, whether canal or the river, but which is not at all suited to rail movement.

The West London Canal Network Study demonstrated that movement of commodities from a consolidation centre alongside a waterway to a construction site can offer cost and other advantages over road movement, particularly where there are no locks between the two locations.

In this case, it would seem reasonable to add water access as one of the factors in selecting locations for a construction consolidation centre.

7 Conclusions and recommendations

7.1 Introduction

This report aimed to provide Transport for London with a greater understanding of the costs and benefits of using consolidation centres to supply construction sites across London. Each element of the study was developed to present a detailed explanation of how CCCs might serve constructions site, based on current, available 'new development' information to a time horizon of 2015. The data on developments was not exhaustive and many areas of construction were not included. As a result the study tended to focus on large new building projects, but there is scope to include a range of refurbishment project such as those carried out by local authorities, national Government and other organisations. This Chapter aims to draw together the key finding and recommendations from this study.

7.2 Conclusions

The construction industry has, with very few exceptions, been resistant to the concept of CCCs. This is understandable, given the desire by all freight shippers and operators to reduce costs and improve service quality by eliminating double handling. CCC operation is perceived as an operation which adds cost and adds handling (with concomitant risk of damage, loss, and delay).

This study is the first piece of work which has tried to establish whether the widespread use of construction consolidation centres in London is a potential solution to reducing construction site traffic in built up areas and has therefore focused on the transport and supply chain impacts of the CCC system.

There have been a number of significant challenges in conducting the work, but the most important and critical to the modelling, is the general lack of data regarding the consumption of materials by construction projects.

The construction industry does not deploy any systematic means of capturing data in respect of the materials that are consumed by the projects it undertakes. Bills of quantity are no longer employed as a method of gathering information about materials used during a build and quantity estimates are based on cost per square metre. Thus, trying to obtain suitable data was a very difficult task and was only resolved by drawing on data captured by the Bermondsey CCC trial.

The other vital data element required for the modelling is that related to future construction activity. Information on this aspect is available through a number of different sources, although each source only provides a small part of the picture. As a result, information from various sources was collated to provide a reasonable indication of the type of projects that will transpire, which were included in the modelling.

The CCC locations used in the modelling were based on the realistic options taken from the GLA's 'Preferred Industrial Locations' list. These sites matched closely to the centre of gravity positions output by the model. As a result a practical distribution of CCC locations was achieved which form the basis of the CCC strategies. This showed that various sized CCCs were an option, although the strategy that permitted a continuous utilisation of the facilities did suggest that large area warehouses would be required. Clearly, this raises issues such as suitability of site, access, additional space for returns and traffic generation if larger facilities are going to be considered.

The results of the modelling exercise for this study do vary depending on the scenario being tested and the assumptions being made. However, for the permutations used in the study, CCC operations do not display a notable disadvantage in terms of transport and handling costs compared with direct deliveries and could therefore be implemented at little or no cost to the supply chain. Largely, the additional costs of double handling and operating a warehouse are balanced by small reductions in vehicle mileage to site.

In environmental terms, the impact of CCC operation from the model would appear to be small. This is perhaps not surprising as the CCC delivery only takes over for the final journey to the building site of less than 5 miles. However, the assumptions in the model are conservative; for instance, it was assumed that typical building site deliveries are 75 to 100 minutes late. This factor has been added to the direct delivery vehicle journey time in order to compensate experienced delays. In reality, the late vehicles often find it hard to park, and may spend significant periods driving around waiting for a delivery slot or looking for a parking space, adding to congestion and environmental impact.

The modelling exercise suggests that the number of CCCs developed does not have a significant impact on supply chain costs. Therefore development of CCCs should sensibly be a balance of likely demand and the availability of suitable warehouses in the areas specified.

There is no data concerning the impact that vehicles have on air quality and congestion as a result of have to ‘go around’. To have a better understanding of this aspect would require a data gathering exercise to be completed the results of which could be included in future modelling of CCCs.

7.3 Recommendations

The results of this study should be combined with the results being obtained from the Bermondsey CCC trial and used to demonstrate to the construction industry that CCC operation can be implemented at little net cost, but with significant benefits to the industry.

However, a futuristic operation of this type may not be enough to ensure a rapid uptake of CCC operation. One approach would be to develop further subsidised facilities such as Bermondsey. However, this would seem to be difficult to justify when the industry clearly benefits from CCC operation financially. Another approach would be to impose CCC operation at the planning stage. This would be controversial and take some time to have an impact, but would ensure a fundamental take up of users over time.

This study has focused on future major construction projects to utilise CCC facilities. However, CCCs can also be used to service other types of construction projects, including housing, refurbishments, and maintenance. To better understand the needs of these markets further research would be required, but as these would involve public sector bodies to a greater extent (e.g. housing associations), these organisations may be more amenable to CCC operation.

The use of the strategic supply chain analysis tool for this study has proved useful in highlighting cost and operational issues and in comparing different scenarios. A key constraint on the model has been the lack of suitable data - effectively based on one CCC and one major construction site. Any further implementation of CCCs could be used to repopulate the data in the model, improving its usefulness as a tool for TfL and others.

References

Department of Trade and Industry, Wilson James Ltd, Mace Ltd, BAA Plc; *Construction Logistics Consolidation Centre: An Examination of New Supply Chain Techniques - Managing & Handling Construction Materials*, Constructing Excellence, October 2004.

Appendix 1 - Area and cost per pallet factors

	Area (sq ft) / CCC		No of CCC's →					
Year	Pallets/yr	Peak pallets/yr	2	4	6	8	10	12
2007	1,699,369	1,869,306	218,086	109,043	72,695	54,522	43,617	36,348
2009	2,252,476	2,477,724	289,069	144,534	96,356	72,267	57,814	48,178
2011	655,806	721,387	84,162	42,081	28,054	21,041	16,832	14,027
2013	221,505	243,656	28,427	14,213	9,476	7,107	5,685	4,738
2015	148,834	163,717	19,100	9,550	6,367	4,775	3,820	3,183
	Cost (£m) / CCC		No of CCC's →					
Year	Pallets/yr	Peak pallets/yr	2	4	6	8	10	12
2007	1,699,369	1,869,306	£6.28	£3.14	£2.09	£1.57	£1.26	£1.05
2009	2,252,476	2,477,724	£8.33	£4.16	£2.78	£2.08	£1.67	£1.39
2011	655,806	721,387	£2.42	£1.21	£0.81	£0.61	£0.48	£0.40
2013	221,505	243,656	£0.82	£0.41	£0.27	£0.20	£0.16	£0.14
2015	148,834	163,717	£0.55	£0.28	£0.18	£0.14	£0.11	£0.09

Appendix 2 - CCC modelling result tables

Results based on GLA 'Preferred industrial locations'

	10 Possible CCC Locations		2007						2009						2011						2013						2015					
			No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost
1	Newham	Beckton Gateway	15	11,629	216,650	50,479	0.8	£1,476,802	2	34,572	691,450	161,108	1.1	£4,713,296	7	4,212	82,199	19,152	1.1	£560,312							1	682	13,630	3,176	1.2	£92,911
2	Southwark	Bermondsey South East	65	32,732	559,607	130,388	2.2	£3,814,586	24	20,180	384,940	89,691	2.2	£2,623,960	5	2,988	58,990	13,745	2.2	£402,105	5	3,460	63,548	14,807	1.3	£433,175	3	2,043	38,784	9,037	1.3	£264,369
3	Haringey	Central Leaside Business Area	13	9,536	169,924	39,592	1.1	£1,158,295	23	15,048	279,657	65,160	0.9	£1,906,294	13	5,390	78,875	18,378	0.8	£537,654												
4	Ealing	Great Western Road (part)	4	1,278	22,387	5,216	1.3	£152,601							1	353	7,070	1,647	2.5	£48,191												
5	Tower Hamlets	Lower Lea Valley (part)	26	21,397	401,598	93,572	1.0	£2,737,506	34	28,742	552,927	128,832	1.0	£3,769,051	11	7,735	146,733	34,189	0.9	£1,000,211	11	5,122	91,301	21,273	1.0	£622,354	5	2,661	49,162	11,455	1.2	£335,113
6	Newham	Marshgate Lane Area	10	3,367	45,798	10,671	0.6	£312,184	7	6,980	136,275	31,752	0.7	£928,921	14	9,850	178,984	41,703	0.6	£1,220,048												
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186	6	3,180	60,761	14,157	1.5	£414,181	3	1,658	30,756	7,166	0.9	£209,648	3	1,658	30,756	7,166	0.9	£209,648	1	591	11,813	2,752	0.2	£80,523
8	Barking & Dagenham	Rippleside	20	6,855	76,906	17,919	1.1	£524,234							1	886	17,730	4,131	0.7	£120,853												
9	Gospel Oak	Kentish Town	1	533	10,651	2,482	2.0	£72,603																								
10	Tileyard Road	Pentonville	27	9,086	141,883	33,059	2.2	£967,148	2	1,045	17,759	4,138	2.2	£121,056	4	2,591	51,824	12,075	2.1	£353,258	2	1,663	33,255	7,748	2.0	£226,681	1	1,311	26,212	6,107	1.2	£178,677
	Total all Depots		197	100,911	1,693,844	394,665		£11,546,146	98	109,748	2,123,770	494,838		£14,476,757	59	35,666	653,160	152,186		£4,452,280	21	11,903	218,859	50,994		£1,491,858	11	7,287	139,601	32,527		£951,593
	Supply			433,947			14,162,660	£14,444,616		544,090			17,526,465	£17,907,915		167,333			5,397,173	£5,516,267		56,070			1,807,389	£1,850,022		35,764			1,148,416	£1,176,109
	Delivery			100,911			239,876	£2,747,410		109,748			266,952	£3,281,625		35,666			71,003	£986,464		11,903			26,557	£337,010		7,287			17,187	£215,022
	Total Supply Chain			534,858			14,402,536	£28,738,173		653,838			17,793,417	£35,666,297		202,999			5,468,176	£10,955,011		67,973			1,833,946	£3,678,890		43,051			1,165,603	£2,342,724
	Cost per Pallet							£16.97						£16.79						£16.77						£16.81						£16.78

	6 Possible CCC Locations		2007						2009						2011						2013						2015					
			No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost
2	Southwark	Bermondsey South East	65	32,732	559,607	130,388	2.2	£3,814,586	24	20,180	384,940	89,691	2.2	£2,623,960	5	2,988	58,990	13,745	2.2	£402,105	5	3,460	63,548	14,807	1.3	£433,175	3	2,043	38,784	9,037	1.3	£264,369
3	Haringey	Central Leaside Business Area	13	9,536	169,924	39,592	1.1	£1,158,295	23	15,048	279,657	65,160	0.9	£1,906,294	13	5,390	78,875	18,378	0.8	£537,654												
5	Tower Hamlets	Lower Lea Valley (part)	41	33,026	618,248	144,052	1.8	£4,214,309	54	70,692	1,361,350	317,194	1.9	£9,279,696	18	11,948	228,932	53,341	1.7	£1,560,524	11	5,122	91,301	21,273	1.0	£622,354	6	3,342	62,792	14,631	1.6	£428,026
6	Newham	Marshgate Lane Area	10	3,367	45,798	10,671	0.6	£312,184	7	6,980	136,275	31,752	0.7	£928,921	14	9,850	178,984	41,703	0.6	£1,220,048												
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186	6	3,180	60,761	14,157	1.5	£414,181	4	2,012	37,826	8,813	1.4	£257,840	3	1,658	30,756	7,166	0.9	£209,648	1	591	11,813	2,752	0.2	£80,523
10	Tileyard Road	Pentonville	32	10,896	174,921	40,757	2.3	£1,192,355	2	1,045	17,759	4,138	2.2	£121,056	4	2,591	51,824	12,075	2.1	£353,258	2	1,663	33,255	7,748	2.0	£226,681	1	1,311	26,212	6,107	1.2	£178,677
	Total all Depots		177	94,056	1,616,938	376,746		£11,021,915	116	117,124	2,240,743	522,093		£15,274,107	58	34,780	635,430	148,055		£4,331,429	21	11,903	218,859	50,994		£1,491,858	11	7,287	139,601	32,527		£951,594
	Supply			414,244			13,481,884	£13,769,981		574,057			18,429,035	£18,864,253		162,791			5,239,646	£5,361,202		56,070			1,807,389	£1,850,022		35,764			1,147,192	£1,175,521
	Delivery			94,056			289,104	£2,784,436		117,124			378,635	£3,754,134		34,780			86,016	£1,009,529		11,903			26,557	£337,010		7,287			20,498	£224,736
	Total Supply Chain			508,300			13,770,988	£27,576,332		691,181			18,807,670	£37,892,494		197,571			5,325,662	£10,702,161		67,973			1,833,946	£3,678,890		43,051			1,167,690	£2,351,851
	Cost per Pallet							£17.05						£16.91						£16.84						£16.81						£16.85

	4 Possible CCC Locations		2007						2009						2011						2013						2015					
			No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost	No of Const. Sites	CS Dels	Pallets	Depot Area (ft2)	Ave Dist to CS (mls)	Cost
2	Southwark	Bermondsey South East	69	33,863	570,271	132,873	2.2	£3,887,277	27	21,839	415,696	96,857	2.4	£2,833,609	5	2,988	58,990	13,745	2.2	£402,105	5	3,460	63,548	14,807	1.3	£433,175	3	2,043	38,784	9,037	1.3	£264,369
5	Tower Hamlets	Lower Lea Valley (part)	60	44,797	823,306	191,830	1.9	£5,612,099	55	73,268	1,425,556	332,155	1.1	£9,717,361	45	27,188	486,791	113,422	2.1	£3,318,228	11	5,122	91,301	21,273	1.0	£622,354	6	3,342	62,792	14,631	1.6	£428,026
7	Wandsworth	Nine Elms	16	4,500	48,439	11,286	2.1	£330,186	11	12,074	234,753	54,697	0.9	£1,600,203	4	2,012	37,826	8,813	1.4	£257,840	3	1,658	30,756	7,166	0.9	£209,648	1	591	11,813	2,752	0.2	£80,523
10	Tileyard Road	Pentonville	32	10,896	174,921	40,757	2.3	£1,192,355	4	2,317	43,198	10,065	3.0	£294,458	4	2,591	51,824	12,075	2.1	£353,258	2	1,663	33,255	7,748	2.0	£226,681	1	1,311	26,212	6,107	1.2	£178,677
	Total all Depots		177	94,056	1,616,938	376,746		£11,021,917	97	109,498	2,119,203	493,774		£14,445,630	58	34,780	635,430	148,055		£4,331,431	21	11,903	218,859	50,994		£1,491,858	11	7,287	139,601	32,527		£951,594
	Supply			414,244			13,494,708	£13,778,610		542,920			17,429,716	£17,840,117		162,791			5,258,742	£5,374,232		56,070			1,807,389	£1,850,022		35,764			1,147,192	£1,175,521
	Delivery			94,056			314,494	£2,859,275		109,498			353,107	£3,534,010		34,780			137,470	£1,161,205		11,903			26,557	£337,010		7,287			20,498	£224,736
	Total Supply Chain			508,300			13,809,202	£27,659,802		652,418			17,782,823	£35,819,758		197,571			5,396,212	£10,866,868		67,973			1,833,946	£3,678,890		43,051			1,167,690	£2,351,851
	Cost per Pallet							£17.11						£16.90						£17.10						£16.81						£16.85

Appendix 3 - Companies contacted

Kevin Ford	Traffic and Operations manger	Alandale Logistics Ltd	Brunswick House Factory Road Silvertown E16 2EL
Robin Taylor	Traffic Manager	Balfour Beatty & AMEC	UCLH site Grafton Street / Gower Street London WC1E
Chris Massie	Commercial Executive	Clipfine - Construction Support Services	30 John Street Holborn London WC1N 2AT
Adrian Blumenthal	Special Project Director	Constructing Excellence	Warwick House 25 Buckingham Palace Road London SW1W 0PP
John Leach	Managing Director	CSB Logistics	669 Woolwich Road London SE7 8LH
Shaun Cowlam	Head of Site Logistics	T5 Project - BAA	PO Box 620 Longford House 420 Bath Road Longford West Drayton UB7 0NX
Ian Lister	General Manager Major & Special Projects	Wilson James Limited	c/o Bermondsey Consolidation Centre Stockholm Road London SE16