AGAR GROVE

DRAINAGE AND FLOOD RISK

DECEMBER 2013

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Agar Grove, Camden

Flood Risk Assessment and Drainage Strategy

On Behalf of: **London Borough of Camden**

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Executive Summary

This Flood Risk Assessment (FRA) has been prepared by Peter Brett Associates LLP (PBA) to support a planning application for the proposed redevelopment of Agar Grove. The proposed redevelopment involves the demolition of 112 existing homes (low rise element of the existing estate), comprehensive refurbishment of Lulworth House and creation of circa 500 new homes.

The site is shown on the Environment Agency (EA) Flood Zones map as lying within Flood Zone 1, defined as follows:

> **Flood Zone 1 'low probability'** – less than 1 in 1000 (0.1%) annual probability of river flooding, or 1 in 1000 (0.1%) annual probability of tidal flooding.

The main source of flood risk associated with the site relates to surface water as the site is located within a Critical Drainage Area (CDA).

A Surface Water Drainage Strategy (SWDS) has been prepared for the site which provides details of the drainage strategy being prepared along with the Sustainable Drainage Systems (SUDS) to be used and confirmation that the surface water runoff will be restricted to the mean annual flood flow rate.

The site lies within Flood Zone 1, with no detrimental impact on flood flow routes or floodplain storage capacity, and does not require the undertaking of the Sequential Test (as the site is already within the area of lowest probability of flooding).

In considering the proposals, the following key aspects have been addressed;

- Vulnerability to flooding from all sources;
- Protection of occupants of the new development;
- No increased flood risk to third parties as a result of the development;

Flood risk will be appropriately mitigated through measures including:

- A Surface Water Drainage Strategy;
- Appropriate incorporation of SuDS for the site;
- Utilisation of rainwater butts (residential) and rainwater harvesting for irrigation;
- Provision of below ground storage tanks to attenuate rainwater in extreme storm events, designed for a 100 year rainfall event including a 30% allowance for climate change
- Provision of appropriate exceedance flood routes away from buildings and structures on and around the site.

As such, the FRA confirms that the development is satisfactory, it does not increase flood risk and does not detrimentally affect third parties, in accordance with the objectives of the NPPF.

1 Introduction

1.1 The Planning Application

1.1.1 This Report is submitted in support of a planning application by the London Borough of Camden ("the applicant") for the redevelopment of the Agar Grove Estate in Camden.

1.1.2 Agar Grove Estate was constructed by the London Borough of Camden in the 1960s and comprises 249 residential units; two small retail units; and community facilities. The Estate consists of a series of low / medium rise blocks of flats and an 18 storey tower (Lulworth House) along with areas of open space and surface car-parking.

1.1.3 The site is centrally located in the borough to the east of Camden town centre in a predominantly residential area which comprises a mix of period housing; post-war municipal estates; 20th century in-fill; and some remnants of light-industrial activity.

1.1.4 The Estate is bordered to the north by Agar Grove beyond which sits an area of mid-to-late 19th century high-quality terraces and villas focused around Camden Square.

1.1.5 To the east lies Camley Street which is occupied by low rise light-industrial units. Beyond Camley Street lies the mainline railway into St Pancras and then the 1960s Benson and Forsyth Maiden Lane Estate which is also undergoing refurbishment as part of the Council's estate programme. Further to the south-east is the Kings Cross development area.

1.1.6 To the south is the London Overground railway line beyond which sits a pocket of low rise late 20th century housing. To the west is a predominantly residential area heading back towards Camden town.

Figure 1 - An aerial view of the Agar Grove Estate (Google)

1.1.7 The Agar Estate Regeneration project forms part of Camden's 'Community Investment Programme' (CIP) which aims to generate investment, deliver new homes and regenerate neighbourhoods. A detailed description of the application proposals is provided in the Design and Access Statement which, in broad terms, comprises:

- Demolition of the existing low-rise blocks (with the exception of the children's centre) and comprehensive refurbishment of Lulworth House
- Creation of 493 new homes [net increase of 244units] including a mix of social rent, shared-ownership and private units designed to meet current housing needs and space standards (including a single decant for the majority of existing tenants)
- Replacement community and retail facilities along with new small-scale business space; and
- Landscaped open and amenity spaces to support the development and contribute towards the creation of a high-quality environment.

1.2 Scope of the Flood Risk Assessment

1.2.1 This FRA focuses on assessing the practical flood risk issues at the site as follows:

- Identification of all the potential sources of flooding at the site (i.e. fluvial, tidal, pluvial, groundwater, surface water);
- Assessment of the existing flood risk at the site and the potential impact of the proposals;
- Consideration of the flood risk implications, taking into account the potential allowance for climate change over the lifetime of the development, and the identification of the measures to mitigate flood risk.

2 The Existing Site

2.1 Topography

2.1.1 A topographical survey of the site undertaken by Greenhatch Group (April, 2013) is included in Appendix B

2.1.2 Site levels vary across the site from approximately 28.50m AOD to 32.90m AOD. The lowest part of the site is in the south western corner (28.47m AOD) with levels rising up towards the north eastern corner of the site where levels reach 32.90m AOD. The rise is fairly uniform across the site.

2.2 Watercourses and Flood Defences

2.2.1 The site is located within Camden, where there are no fluvial watercourses in the vicinity of the site.

2.2.2 The Regents Canal flows in a west to east direction and is located approximately 200m south of Agar Grove Estate. The water levels within the Regents Canal are controlled by British Waterways and they are considered to pose a minimal risk of flooding.

2.3 Geology and Groundwater

2.3.1 Refer to the PBA Phase 1 Ground Condition Assessment for details.

2.3.2 The geology of the site is typically made ground, on London Clay, on Lambeth Group.

2.3.3 No information on groundwater levels is available, however from consideration of the geomorphological setting of the site and the underlying ground conditions, it is expected that groundwater level will typically be within 1.0 to 2.0 m of ground level.

2.4 Site Access

2.4.1 The main site access for vehicles is located at the north-eastern boundary of the site. In addition to this, a number of pedestrian access points are located off Agar Grove and Wrotham Road to the west.

2.5 Existing Drainage Arrangements

2.5.1 A desk study review was carried out on all information available that showed the existing public drainage systems and also on the topographical survey showing the profile of the site and the existing impermeable areas. From this information the current drainage regime has been inferred. The information used for this study is included in the appendices of this report and listed as follows:

- Topographical Survey – Greenhatch Group Drawing 18313_ OGL (Appendix B).
- Thames Water asset plans and sewer flooding history (Appendix E),
- Conisbee drawing 050236 SK21 Agar Children’s Centre Existing Drainage (Appendix D)
- Conisbee drawing 060236 DL(0)03 Agar Children’s Centre Drainage Layout (Appendix D)
- Haverstock Associates Drawing 858-102 Agar Children’s Centre Demolition and Tree Removal Record Plan (Appendix D)
- Camden Drawing Agar Drainage 2 (Appendix D)

2.5.2 Information has been taken from these drawings to prepare PBA drawing 28732-C-502 – Existing Drainage included in Appendix D.

2.5.3 Several of the site's drainage runs were picked up by the topographical survey. The existing drainage information shows that hard surfaces and roofs within the site generally drain via gullies and rain water pipes to connect into the below ground drainage system. This system drains towards the south of the site where it connects into the existing 1100mm x 750mm combined sewer running westward beneath the Agar children's centre before turning south to cross the railway and continue to the south of the site.

2.5.4 Prior to construction, a full drainage connectivity and CCTV condition survey should be undertaken to determine the condition and full connectivity of the elements of the site's existing drainage that are to be retained. The drainage proposals identify which drains should be retained and which should be removed however the full upstream connectivity of all drains indicated to be removed should be checked and the drain diverted if necessary.

2.5.5 The Thames Water asset plans do not show the full length of the 1100mm x 750mm combined sewer as is shown on the Conisbee drainage drawings for the Agar Children's Centre and as shown on the topographical survey. The line and level of this sewer will require further investigation as described in Section 6.12 of this report.

2.5.6 Within the site, the existing catchment areas of hardstanding and roof areas are presented in Table 1. An estimated runoff rate to the existing below ground drainage system is also provided in this table based on a rainfall intensity of 50.82mm / hour. This rainfall intensity is taken from the Flood Estimation Handbook (FEH) data for the site and is the volume of rainfall anticipated in a 1 in 100 year 60 minute storm event.

2.5.7 The catchment area of the Agar Children's Centre has been excluded from these calculations as the existing drainage system will remain un-altered by the development proposals.

Table 1 - Existing drainage catchment areas

Total Site Catchment Area (m^2)	Existing Roof Area (m^2)	Existing Paved Area (m^2)	Existing Soft Landscaping Area (m^2)	Existing Estimated Discharge Rate (assume 50.82mm/hr) (l/s)
25345	4511	13142	7692	285

Figure 2 - Typical street view of the existing Agar Grove Estate

3 Development Proposals

3.3.1 The proposed redevelopment of the site involves the phased demolition of the existing residential blocks and replacement with medium density residential blocks, including private and communal gardens. The redevelopment will take place over a number of phases to enable existing residents to be re-housed as part of a single decant strategy.

3.3.2 PBA Drawing No. 28732-C-SK05 - Proposed Phasing Boundaries included in Appendix C provides an indicative outline of the phasing of the redevelopment.

3.3.3 The existing Lulworth Tower, which is located at the centre of the site, is to be retained and refurbished as part of the scheme, marginally expanding the footprint and adding an additional two floors.

3.3.4 As part of the scheme a new access route will be constructed off Agar Grove into the development site.

3.3.5 Details of the architecture and landscape architecture proposals are shown in the plans located in Appendix C and within the design and access statement.

Figure 3 - Proposed site layout - ref. Grant Associates drawings

4 Flood Risk Policy Context

4.3 National, Regional and Local Planning Policy

4.3.1 This FRA has been prepared in accordance with the relevant national, regional and local planning policy and statutory authority guidance as follows:

- National policy regarding flood risk as contained within the **National Planning Policy Framework (NPPF)** dated March 2012, issued by Communities and Local Government and the accompanying **'Technical Guidance to the National Planning Policy Framework'** also dated March 2012;

- Regional Planning policy contained within **The London Plan** (July, 2011) with reference to the following policies;

  Policy 5.12 Flood Risk Management "*Development proposals must comply with the flood risk assessment and management requirements set out in PPS25 (now replaced by the NPPF) over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 and Catchment Flood Management Plans*"

  Policy 5.13 Sustainable Drainage '*Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy*:

  1. *store rainwater for later use*
  2. *use infiltration techniques, such as porous surfaces in non-clay areas*
  3. *attenuate rainwater in ponds or open water features for gradual release*
  4. *attenuate rainwater by storing in tanks or sealed water features for gradual release*
  5. *discharge rainwater direct to a watercourse*
  6. *discharge rainwater to a surface water sewer/drain*
  7. *discharge rainwater to the combined sewer.*

  Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation'.

- **The London Plan Supplementary Planning Guidance (SPD)** document '**Sustainable Design and Construction**' (May 2006), which provides details of the Mayor's required standard in relation to surface water drainage systems;

- Local Planning Policy contained in the '**Camden Core Strategy 2010-2025 Local Development Framework'** adopted November 2010, with specific reference to **CS13 Tackling climate change through promoting higher environmental standards** extract '**Water and surface water flooding**' which states that future development should:

  "avoid harm to the water environment, water quality or drainage systems and prevents or mitigates local surface water and downstream flooding, especially in areas up-hill from, and in, areas known to be at risk from surface water flooding such as South and West Hampstead, Gospel Oak and King's Cross."

- The **London Borough of Camden Development Policy DP23; Water**;

- The North London **Strategic Flood Risk Assessment (SFRA)** (August, 2008) provides flood risk information across all of the north London boroughs;

- The London Borough of Camden **Preliminary Flood Risk Assessment (PFRA)** (April, 2011) is a high level assessment of flood risk focusing on historic and potential future floods. The PFRA is a statutory document produced by the council under the Flood Risk regulation;

- The 'Drain London – London Borough of Camden **Surface Water Management Plan (SWMP)** (April, 2011) provides details on the management of surface water within the borough;

4.4 Vulnerability and the NPPF Sequential Test

4.4.1 The NPPF follows a sequential risk-based approach in determining the suitability of land for development in flood risk areas, with the intention of steering all new development to the lowest flood risk areas.

4.4.2 NPPF Technical Guidance Table 2 confirms the 'Flood risk vulnerability classification' of a site, depending upon the proposed usage. This classification is subsequently applied to Table 3 to determine whether:

- The proposed development is suitable for the flood zone in which it is located, and;

- Whether an Exception Test is required for the proposed development.

4.4.3 The proposal is for residential use ('buildings used for dwelling houses'), which is classified in Table 2 of the Technical guidance to the NPPF as 'more vulnerable' development.

4.4.4 All development is appropriate in Flood Zone 1, and it is not necessary to undertake the Sequential Test, since the site is already located in the area at lowest probability of flooding, thereby complying with the aims of the sequential approach.

4.5 Code for Sustainable Homes Category 4: Surface Water Runoff

4.5.1 This FRA demonstrates the proposed development would comply with the mandatory elements and achieve the following credits in any Code for Sustainable Homes application (based on guidance in the Code for Sustainable Homes Technical Guidance, November 2010):

SUR 1 'Management of Surface Water Runoff from Development'

- *1. One credit can be awarded by ensuring there is no discharge from the developed site for rainfall depths up to 5mm.*

- *2. One credit can be awarded by ensuring that the run-off from all hard surfaces shall receive an appropriate level of treatment in accordance with The SuDS Manual to minimise the risk of pollution.*

SUR 2 'Flood Risk'

- *Two credits are available for developments situated in Zone 1 – low annual probability of flooding (as defined in PPS25 Development and Flood Risk) and where the site-specific Flood Risk Assessment (FRA) indicates that there is low risk of flooding from all sources.*

4.5.2 Two credits are achieved as the site lies within Flood Zone 1 and this FRA demonstrates there is a low risk of flooding from all sources. It should be noted that whilst the FRA is prepared in accordance with the NPPF, it remains in accordance with Planning Policy Statement 25

('PPS25'), the previous policy on development and flood risk that was replaced with the NPPF in March 2012.

4.6 BREEAM Domestic Refurbishment

4.6.1 The refurbishment of Lulworth will be subject to the requirements of BREEAM Domestic Refurbishment. That is:

4.6.2 Where run-off as a result of the refurbishment is managed on site using source control achieving the following requirements:

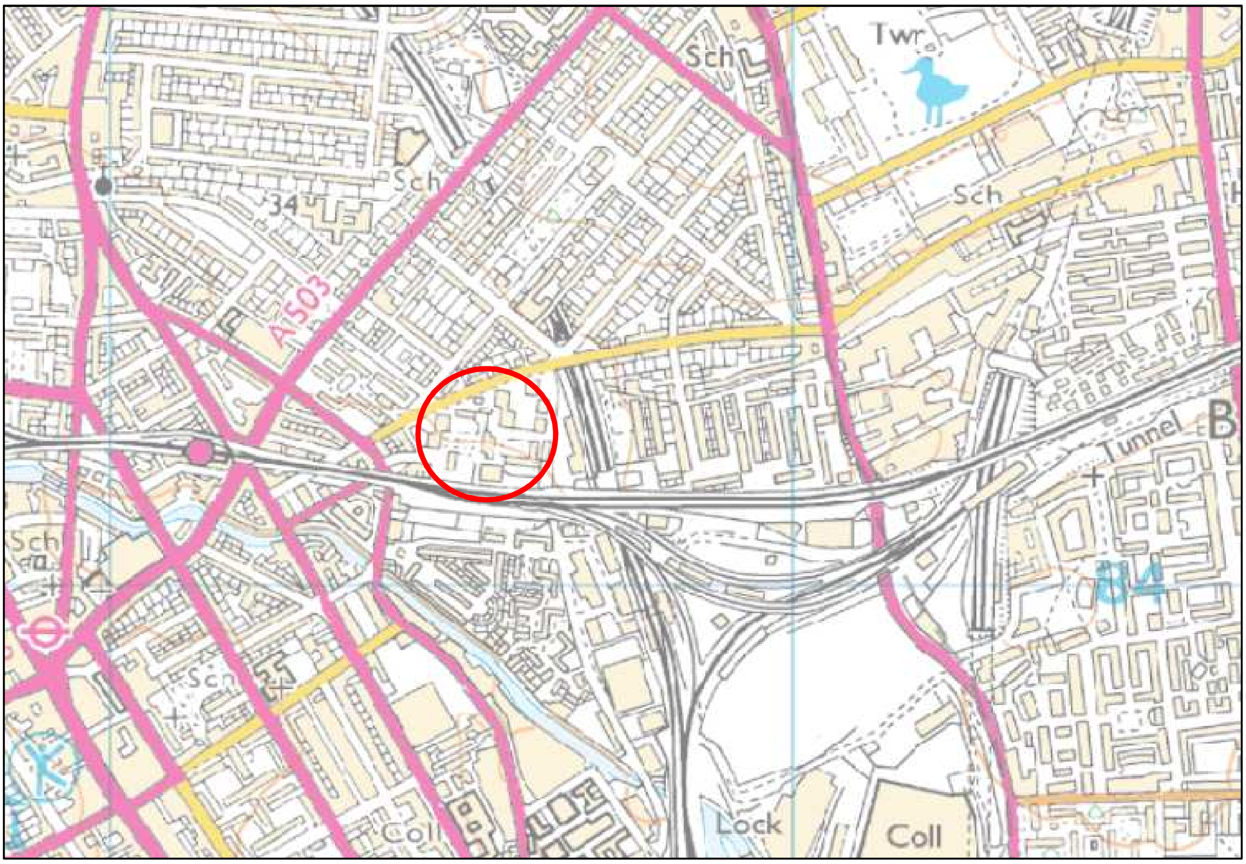
- *The peak rate of run-off as a result of the refurbishment for the 1 in 100 year event has been reduced by 75% from the existing site.*
- *The total volume of run-off discharged into the watercourses and sewers as a result of the refurbishment, for a 1 in 100 year event of 6 hour duration has been reduced by 75%. An allowance for climate change must be included for all of the above calculations, in accordance with the current best practice (PPS25, 2010).*

5 Flood Risk

5.3 Flood Zone Map

5.3.1 The initial phase in identifying whether a site is potentially at risk of flooding is to consult the EA's Flood Zone maps, available on the EA's website and reproduced in Figure 4 below

Figure 4 - EA Flood Zone Map Extract



This indicates that the site lies in the unshaded Flood Zone 1 'low probability'; land assessed as having less than a 1 in 1000 (<0.1%) annual probability of fluvial or tidal flooding.

5.4 Flood Risk from Artificial Sources

5.4.1 The EA provide maps showing the risk of flooding in the event of a breach from reservoirs, based only on large reservoirs (over 25,000 cubic metres of water). Figure 5 shows that the site is bordered by land with a potential risk of reservoir flooding, (identified from the EA map as from Highgate Ponds No. 2 & 3).This land is part of the wider railway alignment, which is lower than the surrounding ground levels of the site. The site is outside the areas at risk and the risk of flooding from artificial sources is therefore considered to be low.

Figure 5 - EA 'Flood Risk from Artificial Sources'

5.4.2 It should be emphasised that the risk of flooding from reservoir breach is very small; the EA are the enforcement authority for the Reservoirs Act (1975) and all large raised reservoirs are inspected and supervised by reservoir panel engineers.

5.5 Strategic Flood Risk Assessment

5.5.1 As noted in Section 1.2, the North London SFRA provides overall flood risk information for the area.

5.5.2 The information of specific relevance to the site is as follows (copies of referenced maps are included in Appendix E):

- Camden does not have any fluvial watercourses within its borough (Map 8; Flood Risk Zones), as a result the flood risk from this source to the site is deemed low. This site is located with Flood Zone 1;
- SFRA Map 10 'Historic EA Flood Map' shows that the site has not been impacted by historic flood events;
- Groundwater flooding is considered to be of low risk (SFRA Map 12: Groundwater Contours);
- The site has not been impacted by historic flood events caused by surcharging sewers (1975 and 2002) as shown in SFRA Map 22: Camden Flood Mapping.

5.6 Preliminary Flood Risk Assessment

5.6.1 The Preliminary Flood Risk Assessment (PFRA) has not identified the site as being impacted by past flood events or particularly susceptible to future surface water flood events.

5.7 Surface Water Management Plan

5.7.1 The London Borough of Camden 'Surface Water Management Plan' (SWMP) provides the following information of relevance to the site;

5.7.2 The site is located within a Critical Drainage Area (CDA), though it should be noted that surface water modelling indicates that a large area of central London is located within a CDA partly due to the flat gradient and amount of impermeable surfacing.

5.7.3 The SWMP defines a CDA as follows;

A discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.

5.7.4 Surface Water modelling for Camden indicates a widespread vulnerability to surface water flooding. This has been identified as partly being due to the flat gradient of the borough and 'noisy' digital terrain used for the modelling.

5.8 Impact of Climate Change

5.8.1 In considering flood risk to the site, it is necessary to fully consider the potential impacts of climate change for the lifetime of the development within the mitigation measures. This is detailed in the Technical Guidance to the NPPF, paragraphs 11 to 15 'Taking climate change into account'.

5.8.2 Paragraph 13 of the Technical Guidance to NPPF states that 'In making an assessment of the impacts of climate change on flooding from the land, rivers and sea as part of a flood risk assessment, the sensitivity ranges in table 5 may provide a precautionary response to the uncertainty about climate change impacts on rainfall intensities, river flow, wave height and wind speed."

5.8.3 The Technical Guidance to the NPPF provides contingency allowances for potential sea level rise in Table 4, whilst potential increases in peak river flow and rainfall intensity are provided in Table 5. The potential for increased flood probability as the result of possible climate change has been addressed through the use of these climate change allowances in the hydraulic modelling and should be taken into account in the consideration of mitigation measures (i.e. ground floor levels, surface water drainage).

5.9 Flow Routes and Flood Storage

5.9.1 The site lies in Flood Zone 1 and there are no watercourses in the area. As such, there will be no impact on floodplain storage or flood flow routes.

6 Surface Water and SuDS Proposals

6.1 Overview

6.1.1 A Surface Water Drainage Strategy (SWDS) has been produced for the development by PBA, with design plans and drawings included in Appendix D. This section provides a commentary of the design of the surface water drainage strategy and details of the SuDS to be included within the proposals.

6.1.2 As the site lies within Flood Zone 1 and is a significant distance from any watercourses, the primary flood risk is from surface water runoff. This section demonstrates that the development is safe in this regard and does not increase flood risk to third parties.

6.1.3 The NPPF recognises that flood risk and other environmental damage can be managed by minimising changes in the volume and rate of surface runoff from development sites, and recommends that priority is given to the use of Sustainable Drainage Systems ('SuDS') in new development, this being complementary to the control of development within the floodplain.

6.2 Design Principles for Surface Water Management

6.2.1 Key design principles in the following guidance documents steer the approach to managing surface water runoff at the site:

- Building Regulations hierarchy of drainage (H3);
- Interim Code of Practice for SuDS;
- CIRIA best practice guidance, including the use of the 'SUDS management train';
- London Plan Policy 5.13 hierarchy;
- London Borough of Camden Development Policy DP23; Water;
- The Code for Sustainable Homes;
- BREEAM Domestic Refurbishment

6.3 Design of the Surface Water Management System

6.3.1 The design of the surface water management system is shown on PBA drawing 28732-C-503 included in Appendix D.

6.3.2 The strategy for the proposed surface water management system is first developed in consideration of the 'drainage hierarchy' of The London Plan Policy 5.13. This consideration is summarised in Table 2.

Table 2 - Drainage hierarchy

Drainage Hierarchy		Consideration
1	Store rainwater for later use	Waterbutts are proposed in several of the private garden areas where rainwater pipes are suitably located. The locations of the rainwater pipes are to be determined at detailed design stage. Further opportunities for rainwater recycling are proposed for irrigation use. In communal areas and public open space rainwater storage tanks connected to hand operated pumps are proposed to meet the water demands of residents own planting. The locations and sizes of these water tanks are shown on PBA drawing 28732-C-503 – Proposed Drainage.

	Drainage Hierarchy	Consideration
2	Use infiltration techniques, such as porous surfaces in non-clay areas	The geology of the site is typically made ground, on London Clay, on Lambeth Group. No information on groundwater levels is available, however from consideration of the geomorphological setting of the site and the underlying ground conditions, it is expected that groundwater level will typically be within 1.0 to 2.0 m of ground level. Owing to the typically poor permeability of these soils and the risks associated with contamination pathways in the made ground, it is anticipated that infiltration of surface water into the ground will not be suitable at this site. Further infiltration testing should however be undertaken at detailed design stage and drainage proposals subsequently adapted to incorporate infiltration techniques where suitable. Despite the anticipated poor infiltration potential of the geology and subgrade, raingardens, urban swales, bioretention areas and permeable pavements are proposed extensively through the site to slow the time of concentration of water entering the below ground system, and to as far as possible, filter surface water runoff from debris and pollutants. To prevent flooding, such features will have overflow connections to the below ground drainage system but there should be minimal discharge from the site in day-to-day rainfall events whilst also serving to nourish the plants and keep the below ground system clear of debris.
3	Attenuate rainwater in ponds or open water features for gradual release	Large open water features are not considered to be feasible for the development given the density of development proposed in which other land uses are preferred for amenity value.
4	Attenuate rainwater by storing in tanks or sealed water features for gradual release	Surface water will only be discharged to the public sewer at a restricted rate so the drainage system will be designed to store water on site that backs up in the system in storms up to the 1 in 100 year (+30% climate change) event. Below ground attenuation tanks are to be provided to accommodate surface water runoff that cannot be recycled, infiltrated or attenuated in any of the above hierarchies.
5	Discharge rainwater direct to watercourse	There are no watercourses located within vicinity of the site.
6	Discharge rainwater to a surface water sewer/drain	Thames Water sewer records in the area show the site to be served by a Combined Sewer, therefore drainage via a surface water drain is not an option.
7	Discharge rainwater to the combined sewer	Thames Water have existing combined water sewers/drains in the vicinity of this site. It is proposed the site will continue to discharge to these sewers, with the runoff from the new-build elements of the development throttled to discharge at a restricted rate.

6.4 SuDS Hierarchy

6.4.1 The SUDS features proposed to be employed within the drainage system have been appraised for their suitability and function based on the SUDS Hierarchy (Environment Agency 2006), as well as the general engineering constraints and amenity function within the site. This appraisal is presented in Table 3 below.

Table 3 - SuDS Hierarchy extract from 'SuDS: A Practical Guide. Environment Agency (2006)'

SUDS Technique	Flood Reduction	Pollution Reduction	Landscape and Wildlife Benefit	Consideration
Living Roofs	●	●	●	Green roofs and brown roofs are being provided on the majority of roofs around the site as shown on architectural drawings included in Appendix C. All green and brown roofs will serve to absorb and retain the first 5mm of rainfall providing no surface water discharge from their catchment. Where easy access can be provided, intensive green roofs are proposed which will have a greater contribution towards the reductions in volume of water runoff and peak rate of runoff. The details of the green and brown roofs and their contributions towards the drainage system will be determined at detailed design stage as these factors depend heavily on the details of the specific specialist design of the roof.
Constructed Wetlands	●	●	●	There are no constructed wetlands, balancing ponds, detention basins, or retention ponds proposed around the site because of the spatial constraints resulting from the unit density required from this development, and because alternative uses of the external space are considered to provide a better amenity value at this location.
Balancing Ponds	●	●	●	
Detention Basins	●	●	●	
Retention Ponds	●	●	●	
Filter Strips and Swales	●	●	●	Bioretention areas, rain gardens and urban swales are provided extensively around the site. All impermeable external surfaces will shed water either directly to a bioretention area or swale, or via cannels or gullies to french drains or filter drains.
Soakaways, Infiltration Trenches and Basins	●	●	●	As explained in Table 2 above, the site is located on a geology of London Clay which has an insufficient percolation rate to support infiltration from soakaways, infiltration trenches and basins.
Gravelled Areas	●	●		Gravel surfacing is proposed in the private courtyard areas of the site. Because surface water will not infiltrate to ground, the gravel areas will be drained by a series of french drains which connect into the below ground drainage system.
Solid Paving Blocks	●	●		Permeable block paving systems and permeable rubber crumb play surfaces are provided extensively around the site.

SUDS Technique	Flood Reduction	Pollution Reduction	Landscape and Wildlife Benefit	Consideration
Porous Paviours	•	•		The pavement construction of these areas will be lined (tanked) in an impermeable membrane with the voids in the subbase providing the storage volume and flow route through the pavement. All permeable pavements will be drained by a french drain or a fin drain with a connection to the below ground drainage system.
Oversized Pipes and Tanks	•			Surface water will only be discharged to the public sewer at a restricted rate so the drainage system will be designed to store water on site that backs up in the system in storms up to the 1 in 100 year (+30% climate change) event. Below ground attenuation tanks are to be provided to accommodate surface water runoff that cannot be recycled, infiltrated or attenuated in any of the above hierarchies.
Storm Cells	•			

4.5 Proposed Surface Water Drainage Catchments

6.4.2 The hydraulic design of the proposed drainage system will depend on the volume and flow rate of water that runs off from roofs and hardstanding surfaces to collect in the below ground drainage system.

6.4.3 The layout and build-out phasing of the proposed development has formed 5 sub-catchments within the site. These sub-catchments are shown on PBA drawing 28732-C-504.

6.4.4 Table 4 presents a summary of these proposed drainage catchments which are then compared to the drainage catchments of the existing site in Table 5.

Table 4 - Proposed Drainage Catchment Areas

Sub Catchment	1	2	3	4	5	Whole Site
Total Area (m^2)	2695	10082	3724	1965	6879	25345
Roof Area (m^2)	946	2575	1685	714	2061	7981
Impermeable Hardstanding (m^2)	653	3799	807	938	3085	9282
Permeable Block Paving / Permeable Asphalt (m^2)	376	1325	514	126	867	3208
Permeable Gravel Surfacing (m^2)	114	343	0	101	184	742

Sub Catchment	1	2	3	4	5	Whole Site
Permeable Rubber Crumb Play Surfacing (m^2)	0	681	282	0	78	1041
Permeable Timber Deck Surfacing (m^2)	194	226	0	0	0	420
Soft Landscaping (m^2)	606	2040	718	86	682	4132

Table 5 - Drainage Catchment Areas Comparison

Site Area m^2	Existing Soft Landscaping Proportion	Proposed Soft Landscaping Proportion	Proposed Permeable Surfacing Proportion (Soft Landscaping + Permeable Surfaces)
25345	30%	16%	38%

6.4.5 Whilst Table 5 demonstrates that the development proposals reduce the provision of soft landscaping, this is mitigated by the SuDS features and permeable surfaces proposed for the redevelopment which provide an overall increase in the area of permeable surfaces within the site. Green roofs have been excluded from this calculation, however they will be provided on several of the proposed buildings and surface water runoff from paved areas will generally drain to adjacent rain gardens (soft landscaping areas specially designed to receive large volumes of surface water runoff). These features will serve to minimise surface water discharge volume and rate to the public sewer in day-to-day rainfall events and contribute towards the storage volume required in more extreme design storm events.

6.6 Proposed Allowable Discharge Rates

6.6.1 The London Borough of Camden Development Policy DP23 Water requires that;

"All new build developments where run-off is likely to have an impact on buildings downstream are to include a green or brown roof and/or a rainwater harvesting system with the aim of achieving a 'greenfield' runoff rate. A greenfield runoff rate is one that reflects the natural rate of water runoff from the site before it was developed. All other development that increases the amount of impervious surface will be expected to minimise the amount and rate of runoff from the site to at least the existing rate."

6.6.2 This policy is in line with the compliance requirements for the mandatory elements of The Code for Sustainable Homes whereby;

"Where there is an increase in impermeable area, the peak rate of runoff over the development lifetime, allowing for climate change, will be no greater for the developed site than it was for the pre-development site. This should comply at the 1 year and 100 year return period events"

6.6.3 Overriding this, as is applicable for the Agar Grove site;

"If it cannot be satisfied that "the post development volume of runoff, allowing for climate change over the development lifetime is no greater than it would have been before the development", then the post development peak rate of runoff must be reduced to the mean annual flood flow rate".

6.6.4 It is therefore proposed that the discharge rate to the public sewer is restricted to the mean annual flood flow rate for the site (known as QBAR). This means that the connecting public sewers will never receive more water than what would be generated by the mean annual flood flow rate.

6.6.5 The calculation of the mean annual flood flow rate has been undertaken in accordance with IoH Report 124 - Flood estimation for small catchments (Marshall and Bayliss 1994) as is required by the Code for Sustainable Homes. The results of these calculations are presented in Table 6 below.

6.6.6 In accordance with Code for Sustainable Homes SUR1, Soil Type 5 has been used to calculate the peak rate of runoff for brownfield sites.

Table 6 – Greenfield runoff rates

Site Area (m^2)	Mean Annual Flood Flow Rate, QBAR (l/s)	1 in 1 Year Peak Flood Flow Rate, Q1 year (l/s)	1 in 100 Year Peak Flood Flow Rate, Q100 years (l/s)
25345	32.4	27.5	65.5

6.6.7 It can be seen in Table 6 that throttling flow to the mean annual flood flow rate represents a 50% reduction in flow rate in the event of a 1 in 100 year storm.

6.6.8 The proposed development will reduce the discharge rate of surface water from the site by throttling the discharge from the new-build areas to the mean annual flood flow rate for the site (known as QBAR). The proportion of this proposed reduction is presented in Table 7 (below).

Table 7 - Existing and Proposed Discharge Rate Comparison

Existing Estimated Discharge Rate (assume 50.82mm/hr) (l/s)	Design Restricted Discharge Rate (l/s)	Proposed / Existing
285	32.4	11%

6.7 New Connections to the Public Sewer

6.7.1 As is shown on PBA Drawing 28732-C-503 there are 3 new connections proposed to the public sewer. The number and locations of these connections has been designed in consideration of the proposed phased build-out and the natural sub-catchments within the development layout.

6.7.2 The overall discharge rate from the site of 32.4 l/s has therefore been distributed between these three connections on a pro rate basis considering their upstream catchment area.

6.7.3 Table 8 presents the proportioned discharge rates for each of the 5 sub catchments based on their catchment area.

6.7.4 Where this calculation results in a peak flow rate of less than 5 l/s, the limiting discharge rate is increased up to a level of no more than 5 l/s at the point of discharge from the site to reduce the risk of blockage in accordance with the best practice set out in the Preliminary Rainfall Runoff Management for Developments Revision E, dated January 2012, Defra /EA.

Table 8 - Proposed allowable discharge rates

Sub Catchment	1	2	3	4	5	Whole Site

<table>
<tr><th>Sub Catchment</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>Whole Site</th></tr>
<tr><td>Proportioned Allowable Discharge Rate (l/s)</td><td>3.4</td><td>12.9</td><td>4.8</td><td>2.5</td><td>8.8</td><td>32.4</td></tr>
<tr><td>Discharge to Connection Point #</td><td>1</td><td colspan="3">2</td><td>3</td><td>-</td></tr>
<tr><td>Connection Point Design Discharge Rate (l/s)</td><td>5.0</td><td colspan="3">18.9</td><td>8.5</td><td>32.4</td></tr>
</table>

6.8 Surface Water Attenuation Requirements

6.8.1 Prior to connection of the new below ground drainage system into the existing sewer network, the flow will be throttled to the mean annual flood flow rate by a flow control device. Storage tanks will therefore be provided within the network to accommodate excess surface water that backs up behind the flow throttle in severe storm events.

6.8.2 Considering a 1 in 100 year (+30% climate change) storm event, it is estimated using Microdrainage WinDES that the volumes of the storage tanks presented in Table 9 will be required for each sub catchment.

6.8.3 The catchment areas for this storage estimation do not include the permeable block paving areas and the permeable gravel surfacing areas. Although these areas will be drained with connections to the site's below ground drainage system and pass through the attenuation tanks, their own attenuation volume will be provided within the voids of their own subbase.

Table 9 - Attenuation requirements

Sub Catchment	1	2	3	4	5	Whole Site
Roof Area + Hard Landscaping Area (m^2)	1599	6374	2492	1652	5146	17263
Attenuation Tank Volume (m^3)	109	525	190	113	411	1348

6.8.4 The attenuation volumes shown are the upper bound of the range of storage volumes provided by the Quick Storage Estimate Function in Microdrainage WinDES. This range is explained by Microdrainage as follows:

"Storage varies with different configurations of controls and storage structures. The program will look at two extreme cases to provide an estimate of the range of storage required. This estimate may be used as a starting point for detailed design but it must never be used as a final design as the variables it assumes are significant. In certain circumstances it is also possible to achieve a final design outside the range shown".

6.8.5 Whilst the surface water drainage strategy includes several surface drainage features including bioretention areas and rain gardens, they have not been designed to contribute towards the sitewide attenuation capacity requirement when water backs up behind the flow controls at the outfalls. All of the necessary attenuation storage volume is provided in the below ground attenuation tanks and in the subbase of the permeable surfaces, so the surface drainage features are not designed to flood in design storm events.

6.9 SUDS Elements and Maintenance

6.9.1 It is anticipated that the estate's maintenance contractor will be responsible for maintaining the proposed surface water drainage systems including the rain gardens and permeable paving systems. It is anticipated that all proposed foul water sewers and lateral drains will be adopted and maintained by Thames Water. The precise scope of adoption would need to be agreed with Thames Water however it is likely that all drains that serve more than one building will be adopted. The maintenance regimes of the proposed drainage are considered below.

Living Roofs

6.9.2 Green and brown roofs are provided on the majority of roofs around the site as shown on the architectural drawings included in Appendix C.

6.9.3 All of the living roofs trap at least a small volume of water within their structure which will never leave the building but will evaporate away or be absorbed by growing plants. As such it is considered that at least the first 5mm of rainfall incident on the living roofs will never enter the below ground drainage system.

6.9.4 The living roofs will also serve to slow the time of concentration of surface water before it enters the below ground drainage system, thus reducing the peak rate of discharge; however the extent to which the green or brown roof will achieve this function is dependent on the specific type of living roof used and can vary between suppliers. The current proposals indicate which roofs will be brown, extensive green or intensive green however the specific selection of a supplier's product will not be made until detailed design stage. When proprietary living roof systems have been selected, the reduction in the peak rate of runoff and the overall reduction in the volume of runoff will be determined, enabling a subsequent reduction in the volume of the below ground attenuation tanks provided.

6.9.5 It is anticipated that the estate's maintenance contractor will maintain the proposed green roofs.

Figure 6 - Typical living roof (reference McLaw Living Roofs)

Permeable Block Paving Systems

6.9.6 Permeable block paving systems are proposed in the majority of parking bays around the site. In these instances the permeable block paving will fulfil the role normally performed by road gullies, whereby rainwater landing on surrounding hard impermeable surfaces will runoff towards the permeable block paving by crossfalls and longfalls designed in the road. The surface water will then percolate through the block paving to the high void subbase below. A perforated pipe will run the length of the permeable block paving system to provide an outlet for water within the subbase. This will then connect into the below ground drainage system.

6.9.7 The maintenance of permeable block paving systems is typically as described by the Hanson Formpave Product Directory 2010;

"All paved surfaces will require occasional cleaning. In normal circumstances, regular sweeping will be sufficient. It is recommended that this should be carried out in the spring and after leaf fall in autumn. It should be noted that lighter coloured blocks may exhibit tyre marks and will therefore require more cleaning and maintenance when used in certain situations. Following routine maintenance it may be necessary to re-dress the surface with 2-4mm clean gritstone. Ultimately, perhaps after 25 years or more, areas of the laying course may become filled with silts and toxins. If this occurs the surface blocks should be uplifted and the affected areas of laying course material and geotextile disposed of. The existing sub-base can be left in situ. Fresh geotextile and laying course stone should be installed and the existing surface blocks re-used."

Figure 7 - Typical example of permeable block paving

Rain Gardens, Bioretention Areas and Swales

6.9.8 Rain gardens are proposed on the southern face of Block F. Rainwater pipes on the southern face of the building will discharge into raised planting areas which will themselves drain by weep holes at the finished surface level. Water will run across the paved area in surface channel features and drain into the swale area indicated on the PBA proposed drainage drawing.

6.9.9 Rain gardens will need to be maintained in the same manner as other planted areas. Overflow drainage pipes and gullies should be rodded / jetted, cleaned and silt removed as part of the sitewide drainage maintenance regime.

Figure 8 - Typical raingarden / bioretention area (reference Blue Green Building)

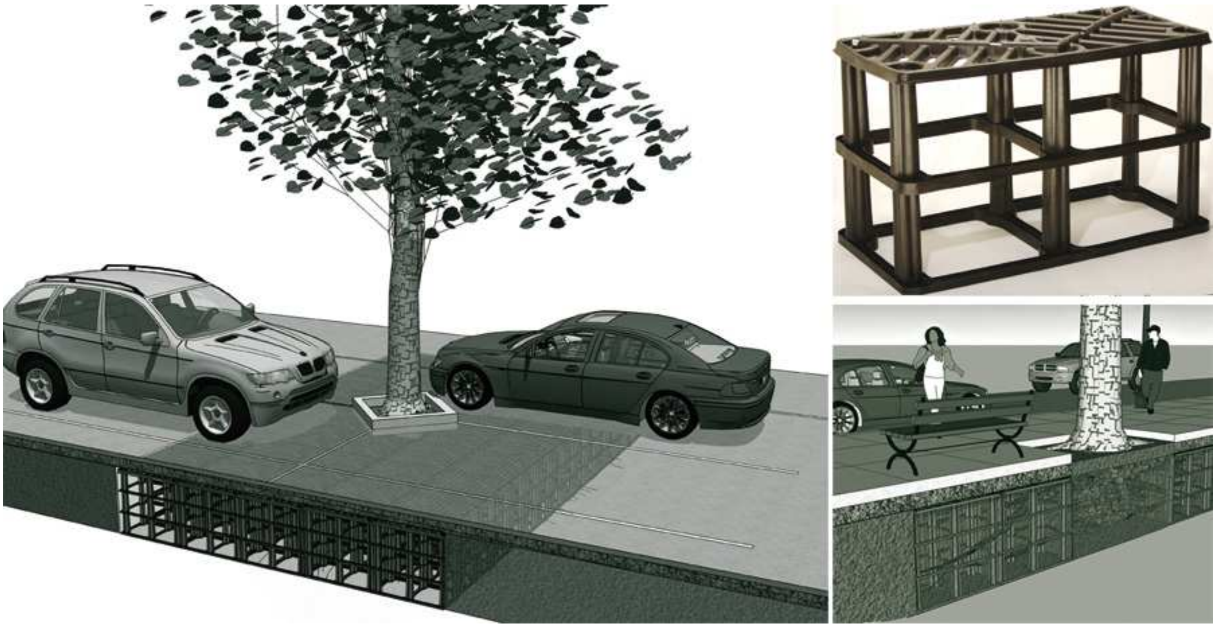
Tree Pits and Silva Cells

6.9.10 Where determined to be suitable, tree pits in paved areas will be surrounded with Deeproot Silva Cells to aid root nourishment and growth in the subgrade which would otherwise be densely compacted.

6.9.11 Silva Cells provide a below ground structure that is firm enough for pavements to be constructed on top but the structure is filled internally with loosely compacted loam or bioretention soil. Tree roots can effectively grow within the loam of the Silva Cell as they will have much more access to air and moisture than the surrounding subgrades.

Figure 9 - Photograph of Silva Cell installation

Figure 10 - Typical Silva Cell layout



Rainwater Harvesting

6.9.12 Below ground rainwater harvesting tanks are proposed in several of the courtyard areas. The volumes of the tanks are presented in Table 10 below.

6.9.13 Where appropriately located, rainwater pipes will connect into the below ground tanks feeding the tanks with clean roof water. The tanks will be fitted with a hand pump at the surface for residents to collect the water for watering of plants and play.

6.9.14 Similarly, where rainwater pipes are located in suitable positions, waterbutts will be fitted in private garden areas for residents to use when watering plants.

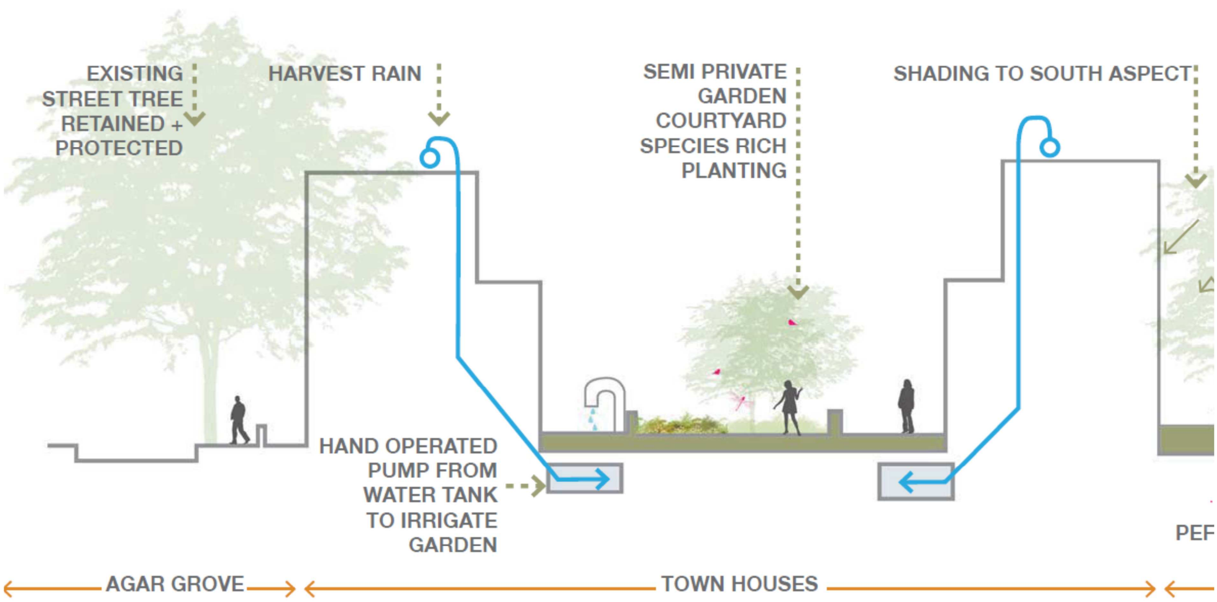
6.9.15 Both rainwater harvesting tanks and waterbutts will have overflow connections to the below ground drainage system for use when the tanks are full of water.

6.9.16 The rainwater harvesting tanks are not designed to contribute towards the attenuation volume requirement for the site because there is a chance they may be full during a severe storm. However, when they do have spare capacity, they will hold some volume of water back from entering the below ground drainage system.

Table 10 - Rainwater harvesting tanks

Blocks	A	CDE	FGHI	JKL	Whole Site
Rainwater Harvesting Tank Volume (litres)	1080	1170	2970	2220	7440

Figure 11 - Conceptual rainwater harvesting proposals (Grant Associates Stage C Proposals)



6.10 Overland Flows and Exceedance

6.10.1 The proposed overland flows are shown on PBA drawing 28732-C-504 included in Appendix D. This drawing demonstrates the principles of the proposed site topography that will serve to drain water away from buildings towards the SUDS features and which connect into the below ground drainage system. As described in section 6.8.5, the surface drainage features are not designed to flood in design storm events, but rather the below ground attenuation tanks and the subbases of the permeable surfaces will provide the required attenuation volume.

6.10.2 In exceedance storm events more severe than the 1 in 100 year (+30% climate change) storm, the same topography will serve to direct flood water away from the buildings and flow towards the low points of the site. In severe flood events it is not anticipated that all of the flood water will be retained on site, but some will flow towards the surrounding streets and roads, and away from surrounding buildings.

6.11 Approvals and Adoption

6.11.1 A pre-development enquiry was submitted to Thames Water on 23rd September 2013 presenting the proposed layout of the site, the post-development discharge rates and the proposed sewer diversions.

6.11.2 A response was received from Thames Water on 03.10.13 indicating that the proposed discharge rates are acceptable. This response is included in Appendix E of this Flood Risk Assessment.

6.11.3 Prior to construction, a section 104 agreement under the Water Industry Act 1991 is required for the adoption of all sewers and lateral drains. It should be noted that imminent changes to the section 104 agreement will mean that the agreement must be in place prior to that commencement of construction works of any part of an adoptable sewer. Early consultation with Thames Water to establish the agreement is recommended.

6.11.4 A Section 106 Agreement under the Water Industry Act 1991 will be required for the proposed connections to the public sewer.

6.11.5 The outline drainage proposals were also sent to the Environment Agency on 16.09.13. A response was received 26.09.13 indicating a general acceptance of the proposals provided additional detail is provided with the flood risk assessment on the flow of surface water though surface features in the drainage system. This response is included in Appendix E.

6.11.6 The Agar Grove Estate Stage C Outline Design Report has been reviewed by the Environment Agency Planning Team (See EA Letter; Dated 26/10/2013 included in Appendix E) who have welcomed the inclusion of the SUDS measures. The FRA has addressed the points raised by the EA relating to the drainage strategy; as such we do not anticipate further concern.

6.12 Diversions and Abandonment Works

6.12.1 The proposed drainage abandonment works are indicated on PBA drawing 28732-C-503. Existing drainage that is to remain live is also indicated on this drawing.

6.12.2 There are three possible sewer diversions required for the Agar Grove development as indicated on PBA drawing 28732-C-503. All diversions are subject to agreement with Thames Water.

6.12.3 The proposed sewer diversion around the proposed Plot A is likely to be required as shown.

6.12.4 The proposed diversion of the 1100mm x 750mm combined sewer around Plot B is shown with an upstream connection in Camley Street. The location of this connection is to be determined by an upstream connectivity survey of the existing sewer.

6.13 Residual Risk

6.13.1 The proposed development is located within the ‘low probability’ Flood Zone 1 (less than 1 in 1000 annual probability of river or tidal flooding).

6.13.2 The development will incorporate a surface water drainage scheme designed to ensure there is a reduction in peak runoff, up to the extreme 1 in 100 (1%) annual probability plus allowance for climate change rainfall event.

6.13.3 As such, the residual risk is considered to be low.

7 Conclusion

7.3.1 This FRA has been prepared to support a planning application for the phased redevelopment of the Agar Grove Estate in Camden. The proposed redevelopment involves the demolition of 112 existing homes (low rise element of the existing estate), comprehensive refurbishment of Lulworth House and creation of circa 500 new homes.

7.3.2 The site lies within Flood Zone 1 ‘low probability’ where the chance of fluvial or tidal flooding is less than 1 in 1000 (<0.1%) annual probability.

7.3.3 A robust Surface Water Drainage Strategy (SWDS) has been prepared for the redevelopment, details of which are provided in Section 4. The following features have been incorporated into the Surface Water Drainage Strategy for the development site;

- Extensive use of rain gardens, green roofs and permeable paving systems to minimise the discharge of surface water to the public sewer in day-to-day rainfall events.
- The provision of waterbutts for irrigation and other rainwater recycling systems to reduce the volume of surface water runoff and to reduce the demand on the potable water supply.
- Provision of below ground storage tanks to attenuate rainwater that backs up behind the flow control device in extreme storm events in areas where flooding of the site would be unacceptable.

7.1.4 These measures ensure that the peak discharge rate from the site to the public sewer is limited to the mean annual flood flow rate.

7.3.5 In conclusion, the future users of the site will be safe and there will be no increase in flood risk elsewhere; thus meeting the requirements of the NPPF.