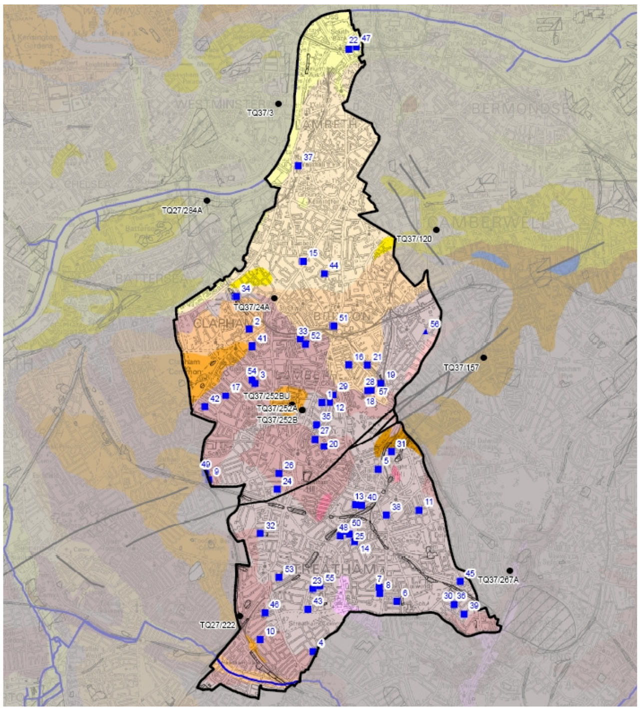
Lambeth Surface Water Management Plan

Intermediate Assessment of Groundwater Flooding Susceptibility

Tier 2
March 2011



Prepared for

Lambeth

Revision Schedule

Lambeth Surface Water Management Plan
March 2011

Rev	Date	Details	Prepared by	Reviewed by	Approved by
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Abbreviations

ACRONYM	DEFINITION
BGS	British Geological Survey
DEFRA	Department for Environment, Fisheries and Rural Affairs
EA	Environment Agency
RBMP	River Basement Management Plan
LiDAR	Light Detection and Ranging
SFRA	Strategic Flood Risk Assessment
SUDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Glossary

TERM	DEFINITION
Aquiclude	Formations that may be sufficiently porous to hold water, but do not allow water to move through them.
Aquifer	Layers of rock sufficiently porous to hold water and permeable enough to allow water to flow through them in quantities that are suitable for water supply.
Aquitard	Formations that permit water to move through them, but at much lower rates than through the adjoining aquifers.
Climate Change	Long term variations in global temperature and weather patterns, caused by natural and human actions.
Flood defence	Infrastructure used to protect an area against floods, such as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floods and Water Management Act	Legislation constituting part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to help protect ourselves better from flooding, to manage water more sustainably and to improve services to the public.
Fluvial flooding	Flooding by a river or a watercourse.
Groundwater	Water that is underground. For the purposes of this study, it refers to water in the saturated zone below the water table.
Pluvial Flooding	Flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.
Risk	The product of the probability and consequence of the occurrence of an event.
Sewer flooding	Flooding caused by a blockage, undercapacity or overflowing of a sewer or urban drainage system.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques. The current study refers to the 'infiltration' category of sustainable drainage systems e.g. soakaways, permeable paving.

1 Introduction

1.1 Groundwater Flooding

1.1.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels.

1.1.2 Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. Basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

1.1.3 It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, pluvial and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

1.1.4 The need to improve the management of groundwater flood risk in the UK was identified through DEFRA's Making Space for Water strategy. The review of the July 2007 floods undertaken by Sir Michael Pitt highlighted that at the time no organisation had responsibility for groundwater flooding. The Flood and Water Management Act identified new statutory responsibilities for managing groundwater flood risk, in addition to other sources of flooding and has a significant component which addresses groundwater flooding.

1.2 The Current Report

1.2.1 The Greater London Authority (GLA) has commissioned Capita Symonds with Scott Wilson to complete Tier 2 of the Surface Water Management Plan (SWMP) for Lambeth Borough Council. A SWMP is a plan which outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and run-off from land, small water courses and ditches that occurs as a result of heavy rainfall (DEFRA, March 2010).

1.2.2 The current report provides an intermediate assessment of groundwater flooding susceptibility as part of the SWMP Tier 2, and provides recommendations for Tier 3.

1.2.3 The following sections outline the geology and hydrogeology in the Lambeth Borough Council (BC) administrative area. From this analysis:

- Potential groundwater flooding mechanisms are identified;
- Evidence for groundwater flooding is discussed;
- Areas susceptible to groundwater flooding are recognised; and
- Recommendations are provided for further investigation.

2 Topography, Geology and Hydrogeology

2.1 Topography and Hydrology

2.1.1 The study area is located in south London and is defined by the administrative area of Lambeth BC. It comprises typically heavily developed areas in the north, interlinked with small sections of open space more commonly found in the southern extent of the study area (Level 1 SFRA, June 2008).

2.1.2 The Tidal River Thames forms part of the northern boundary of the Lambeth BC area, flowing north eastwards from Nine Elms and Vauxhall in the west to the Oxo Tower in the east. The 3.2 km frontage is actively defended by raised embankments and hard defences that protect the area from large scale flood events (Level 1 SFRA, June 2008).

2.1.3 The tidal limit of The River Thames is situated at Teddington Weir, approximately 15 km upstream of Lambeth BC. Therefore the borough is potentially at risk from tidal flooding from the Thames (Level 1 SFRA, June 2008)

2.1.4 The River Effra, described as a lost river of London, is culverted along its entire course and flows entirely underground. The River Effra rises to the south of the Lambeth BC area near Crystal Palace, and flows in a northerly direction through Norwood Cemetery, Dulwich, Herne Hill, Brockwell Park, Brixton, Kennington to flow out into the Thames by Vauxhall Bridge (Level 1 SFRA, June 2008).

2.1.5 A 1 km stretch of the River Graveney, a tributary to the River Wandle, runs through the Streatham / Norbury area to the southern extent of the Borough, joining the Wandle at South Wimbledon. The source of the River Graveney is located in the vicinity of Selhurst and the upper reaches are often referred to as the River Graveney / Norbury Brook. The watercourse is canalised throughout the study area having artificial banks and bed (Level 1 SFRA, June 2008).

2.2 Geology

2.2.1 Figures 1 and 2 provide bedrock and superficial geological information for Lambeth BC and the surrounding area. The British Geological Survey (BGS) geological sheet 270 (South London) presents a geological cross section, which has been used to improve the conceptual understanding of the area.

Bedrock Geology

2.2.2 The bedrock geology of the area comprises the Chalk aquifer, which in turn is overlain by the Thanet Sand Formation (fine grained sand), Lambeth Group (clay with beds of sand), London Clay Formation (clay and silt) and the Claygate Member (sand, fine grained silt and clay). The Harwich Formation, which outcrops to the east of the Lambeth BC, between the London Clay Formation and the Lambeth Group, is not present at outcrop within the Lambeth BC area.

2.2.3 A geological fault, named as the Streatham Fault, is present within the south of the study area as shown by Figure 1. It runs from the south west to north east and passes through Streatham Hill.

2.2.4 Figure 1 shows that within the Lambeth BC the London Clay Formation dominates the surface bedrock geology in the majority of the study area. Two exceptions are where the London Clay Formation is overlain by the Claygate Member; near to Crystal Palace (south east tip), and where the underlying Lambeth Group outcrops in the Brockwell Park area.

2.2.5 The BGS sheet 270 indicates that in the Bermondsey area, north east of the Lambeth BC study area, the London Clay Formation thins and is around 10 m thick. The BGS sheet 270 also shows that beneath the London Clay Formation in the Bermondsey area, the Lambeth Group, Thanet Sand Formation and the Chalk Formation are around 15 m, 7 m and 210 m thick, respectively.

Superficial Geology

2.2.6 Superficial deposits are present in much of the study area, and are shown by Figure 2. The superficial deposits consist of various River Terrace Deposits (gravel, sandy and clayey in part), Head, Langley Silt Member and Alluvium.

2.2.7 The River Terrace Deposits are subdivided into members that are differentiated on the basis of altitude but are often geologically similar. The six members are the Black Park Gravel Member, Lynch Hill Gravel Member, Boyn Hill Gravel Member, Hackney Gravel Member, Taplow Gravel Formation, and the Kempton Park Gravel Formation.

2.2.8 On the hills to the south of the Lambeth BC area, namely the Streatham Hill and Knights Hill, there are small deposits of Black Park Gravel Member. Small deposits of Lynch Hill Gravel Member and Hackney Gravel Member are also present at the southern tip of the Lambeth BC. However, the majority of the River Terrace Deposits are located in the central and northern parts of the Lambeth BC. In the Brixton and Clapham area in the central part of the Lambeth BC there are significant deposits of Taplow Gravel Formation, Hackney Gravel Member, Lynch Hill Gravel Member and Boyn Hill Gravel Member. To the north of these deposits the Kempton Park Gravel Formation extends towards the River Thames.

2.2.9 Significant deposits of Head (clay silt, sand and gravel) are distributed across the central and southern parts of the Lambeth BC area. A ribbon of Alluvium (mainly sand, silt and clay) follows the River Thames to the north of the Lambeth BC area. There are also small deposits of Langley Silt Member (sandy clay and silt) and Sand and Gravel of Uncertain Age in the central / northern and southern areas of the Lambeth BC area, respectively.

2.3 Hydrogeology

2.3.1 The hydrogeological significance of the various geological units within the study area is provided in Table 1. The range of permeability likely to be encountered for each geological unit is also incorporated in Table 1, based on BGS permeability data.

Table 1 Geological Units in the Study Area and their Hydrogeological Significance

Geological Unit		Permeability	Hydrogeological Significance
Superficial Deposits	Head	Very low to very high	Secondary (Undifferentiated). Variable (probably an aquitard but sand or gravel horizons may locally form an aquifer).
	River Terrace Deposits (Black Park Gravel Member, Lynch Hill Gravel Member, Boyn Hill Gravel Member, Kempton Park Gravel Formation, Hackney Gravel Member and Taplow Gravel Formation)	High to very high	Secondary Aquifer (A)
	Alluvium along River Thames	Not defined / not permeable	Secondary (Undifferentiated)
	Langley Silt Member	Not defined / not permeable	Unproductive strata
Bedrock Geology	Chalk Formation	Very high	Principal Aquifer
	Thanet Sand Formation	High	Secondary Aquifer (A)
	Lambeth Group	Very low to moderate	Secondary Aquifer (A)
	Harwich Formation	High to very high	Secondary Aquifer (A)
	London Clay Formation	Very low to low	Aquiclude
	Claygate Member	Low to high	Secondary Aquifer (A)

'Principal Aquifer' - layers that have high permeability. They may support water supply and/or river base flow on a strategic scale.
'Secondary Aquifer (A)' - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
'Secondary (Undifferentiated) - In most cases, the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
'Aquitard' - allows some groundwater movement (see glossary)
'Aquiclude' - does not allow groundwater movement (see glossary)

Bedrock Geology

2.3.2 The London Clay Formation is an aquiclude and does not permit significant groundwater flow. It is classified by the Environment Agency as unproductive strata.

2.3.3 The physical properties for minor aquifers in England and Wales (Allen et al., 1997) suggests 'The Thanet Sand Formation, Lambeth Group and the Harwich Formation are often considered as a single groundwater unit, known as the 'Basal Sands' aquifer, which is in hydraulic continuity with the Chalk'. The Chalk, which outcrops to the south and east of the Lambeth BC study area, is classified as a principal aquifer. However, the majority of the Lambeth BC is underlain by London Clay Formation, which does not permit groundwater flow and confines the water table in the Chalk and Basal Sands. Therefore the Chalk and overlying 'Basal Sands' are not considered pertinent for the majority of the study area. This notwithstanding, the Lambeth Group does outcrop in a small area near Brockwell Park, and, in this area, is of some interest to the current study.

2.3.4 The Claygate Member permits groundwater flow but can significantly vary in permeability. The unit is the youngest part of the London Clay Formation and comprises orange sands interbedded with pale clays. The Claygate Member is hydraulically separated from that of the Chalk and Basal Sands by the significant thickness of London Clay Formation. This scenario may lead to the development of a perched water table(s), which may also be in hydraulic continuity with overlying superficial deposits. The Claygate Member only has a small outcrop area in Lambeth BC, near Crystal Palace in the south, and is therefore of limited interest to the current study.

2.3.5 The hydrogeological significance of the faults is unknown. It is unclear whether, in the east of the Lambeth BC area where the London Clay Formation is thin, the faults will act as a vertical pathway for groundwater through the London Clay Formation. This scenario would also require potential water levels within the underlying Chalk and Basal sands aquifer to rise above the base of the London Clay Formation.

Superficial Geology

2.3.6 River Terrace Deposits over the study area are expected to behave as a Secondary Aquifer (A) and are of significant interest to this study. They are likely to form perched aquifers over the underlying London Clay Formation aquiclude in the Lambeth BC area.

2.3.7 Head deposits are generally expected to behave as aquitards, although sand and gravel horizons may locally form a secondary aquifer depending on their lateral extent and thickness. These deposits may be in hydraulic continuity with the Claygate Member (bedrock geology) aquifer in the Crystal Palace area.

2.3.8 Alluvium along the River Thames is classified as Secondary (Undifferentiated) by the Environment Agency, which suggests variable permeability. The BGS permeability data set does not consider the Alluvium along the River Thames, which suggests limited data or no permeability.

Groundwater Levels

Bedrock Geology

2.3.9 Water level monitoring data was provided by the Environment Agency for ten observation boreholes in the study area and the associated hydrographs are provided in Appendix 1; borehole locations are shown on Figures 1 and 2. Eight of the boreholes are understood to monitor Chalk Formation water levels, one monitors the Lambeth Group and the remaining borehole monitors the Thanet Sand Formation.

2.3.10 The hydrographs in Appendix 1 demonstrate that bedrock groundwater levels have been at significant depth below ground level for the whole of the monitoring period (1985 – 2010). Water levels were closest to ground level during the late 1990s at Sunshine Services (TQ37/120), located north east of Brixton, just outside the Lambeth BC boundary in Camberwell. However, they were still around 8 m below ground level.

2.3.11 The hydrographs for many of the boreholes demonstrate a slow but steady rise in groundwater level between 1987 and 1999. However, in the year 2000, there was a sharp fall in Chalk water levels at Sunshine Services (TQ37/120), and in particular, at Brixton (TQ37/252A) and Battersea (TQ27/284A). This is likely to be in response to increased groundwater abstractions in the Battersea and Brixton areas (Source Protection Zones are shown on Figure 4). Following a brief recovery in 2002, groundwater levels continued to fall until around 2007 (by up to 30 m at TQ37/252A). However, in recent years groundwater levels appear to have recovered to a degree, perhaps reflecting a reduction in groundwater abstraction.

2.3.12 A short record of manual dip data for Brixton Low Tube (TQ37/252BL) and Brixton Sands (TQ37/252BU) exists for the period 1988-1992. These water level data are thought to represent the Thanet Sand Formation and Lambeth Group aquifers. The manual dips suggest a water level of around 45-50 m below ground level, which is similar to that observed for the Chalk observation borehole (TQ37/252A). However, the Thanet Sand Formation and Lambeth Group aquifers do not show the same magnitude of water level fluctuation observed for the Chalk, suggesting only a partial hydraulic continuity.

Superficial Geology

2.3.13 Deposits of Alluvium, Head and, in particular, River Terrace Deposits, are expected to form perched aquifers over the London Clay Formation aquiclude in the lower elevation areas e.g. where lost rivers exist. The Environment Agency does not monitor groundwater levels in any of these superficial aquifers. It is recommended that under Tier 3 of the Drain London project, borehole logs are obtained from the BGS, which often provide details of water strikes and therefore an indication of depth to groundwater.

Hydraulic Relationships

Surface Water / Groundwater Interactions

2.3.14 The London Clay Formation aquiclude overlies the Chalk, Thanet Sand Formation and Lambeth Group aquifers in the majority of the Lambeth BC area, and hydraulically separates them from the surface water courses and permeable superficial deposits. The only exception to this is within the Brockwell Park area, where the London Clay Formation is absent and the Lambeth Group outcrops. However, observation borehole data suggest that bedrock groundwater levels are at least 30 m below ground level, and so the Lambeth Group aquifer will not contribute to surface water flows.

2.3.15 With respect to permeable superficial deposits, perched water tables are expected to exist within the Alluvium, Head, and in particular, the River Terrace Deposits, and some hydraulic continuity is expected with surface water courses. However, this would depend on the extent of flood defences and whether the rivers are concrete lined. For example, it is known that the River Graveney / Norbury Brook is canalised throughout the study area having artificial banks and bed. This is likely to heavily restrict any groundwater / surface water interactions.

Water Supply Abstractions

2.3.16 In the 19th Century groundwater water supplies in London were obtained from the shallow superficial and bedrock deposits. In the early 20th Century this was abandoned in favour of deeper boreholes and wells into the Chalk (Jones et al., 2000). The majority of the Lambeth BC area is overlain by London Clay Formation, which does not permit groundwater flow and therefore the Chalk (and overlying Basal Sands) abstractions are not considered pertinent for the majority of the study area i.e. they will not have an impact on groundwater flooding susceptibility. In addition to this, although the Lambeth Group does outcrop in the east of the Lambeth BC area (near Brockwell Park), as discussed earlier, groundwater levels are currently at least 30 m below ground level.

2.3.17 There may be some smaller private abstractions from the superficial deposits and this information is held by the Environment Agency.

Artificial Groundwater Recharge

2.3.18 Water mains leakage data for the Lambeth BC administrative area were not provided for this study. It should be noted that additional recharge to perched groundwater tables by leaking mains could result in a local rise in groundwater levels. This rise might not prove significant under dry conditions, but could exacerbate the risk of groundwater flooding and other sources of flooding following periods of heavy rainfall.

2.3.19 The drainage/sewer network can act as a further source of artificial recharge. When pipes are installed within principal or secondary aquifers, the groundwater and drainage network may be in partial hydraulic connection. When pipes are empty, groundwater may leak into the drainage network with water flowing in through cracks and porous walls, draining the aquifer and reducing groundwater levels. During periods of heavy rainfall when pipes are full, leaking pipes can act as recharge points, artificially recharging the groundwater table and subsequently increasing groundwater levels with potential impacts on groundwater quality.

3 Assessment of Groundwater Flooding Susceptibility

3.1 Groundwater Flooding Mechanisms

3.1.1 Based on the hydrogeological conceptual understanding of the study area, the potential groundwater flooding mechanisms that may exist are:

- **Claygate Member outcrop area in the Crystal Palace area:** Water levels within the outcropping Claygate Member will be perched on top of the London Clay Formation aquiclude. This means that basements / cellars in this area may be at risk from groundwater flooding following periods of prolonged rainfall, increased utilisation of infiltration SUDs and / or artificial recharge from leaking pipes.
- **Superficial aquifers along the River Thames and River Graveney / Norbury Brook:** groundwater flooding may be associated with the substantial sand and gravel River Terrace Deposits, or to a lesser degree with Head and Alluvium deposits, where they are in hydraulic continuity with surface water courses. Stream levels may rise following high rainfall events but still remain ‘in-bank’, and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits. It is noted that groundwater / surface water interactions will be limited by modifications to the surface water courses e.g. canalisation of River Graveney / Norbury Brook. However, without evidence in the form of groundwater levels, this groundwater flooding mechanism cannot be ruled out.
- **Superficial aquifers not in hydraulic continuity with surface water courses (various locations):** a third mechanism for groundwater flooding is associated with substantial River Terrace Deposits (gravel and sand) and Head deposits, but occurs where they are not hydraulically connected to surface water courses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars. It is also worth noting that groundwater levels are likely to be closer to ground level in those areas where historic / lost rivers were located i.e. where ground elevation is lower.
- **Impermeable (silt and clay) areas downslope of superficial aquifers in the southern half of Lambeth BC:** a fourth mechanism for groundwater flooding may occur where groundwater springs / seepages form minor flows and ponding over impermeable strata where there is poor drainage. This mechanism may occur as a result of natural (e.g. rainfall) or artificial (e.g. water main leakage) recharge.
- **Artificial ground in various locations:** a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this artificial ground is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements, or may equally be considered a drainage issue. Areas mapped by the BGS as containing artificial ground are shown in Figures 1, 2 and 3. It is noted that the artificial ground deposits are mostly over the London Clay Formation and, depending on the composition of the artificial ground, may allow the development of a perched aquifer.

3.2 Evidence of Groundwater Flooding

3.2.1 Figures 1 and 2 show the location of a number of groundwater flooding incidents between 2000 and 2010 within the study area that have been reported to the Environment Agency. The data set incorporates the data reviewed within the Level 1 SFRA (June 2008), which contained data for the period 2000 to 2004. In addition, two potential groundwater flooding incidents at Ferndene and Dulwich Road, provided by the Lambeth BC and detailed within the Level 1 SFRA, are also shown on the Figures.

3.2.2 Table 2 provides details for the Environment Agency and Lambeth BC reported groundwater flooding incidents, including the local geology and the date of the incident.

Table 2 Groundwater Flooding Records

Bedrock Geological Unit*	Overlying Superficial Deposits*	Grid Reference	N°**	Reported Incident	Date
London Clay Formation	None	TQ3087074397	1	Water in cellar	11/06/2007
	RTD – Hackney Gravel Member	TQ2972075577	2	flooded basement, most likely a drainage issue	04/01/2007
	Head	TQ2981274714	3	Flooded Cellar	07/02/2007
	Head	TQ3073370415	4	Damp cellar	22/11/2006
	None	TQ3177173333	5	Water in basement	21/08/2007
	None	TQ3206971218	6	Several groundwater/ water leak problems. Thames Water deny leaks. Location of historic spar suggests gw issues.	27/04/2006
	None	TQ3178671438	7	possible groundwater flooding	23/12/2005
	None	TQ3179971344	8	Possible groundwater flooding	23/12/2005
	Head	TQ2907873164	9	GW flooding enquiry	27/11/2006
	Head	TQ2989670603	10	GW flooding enquiry	03/01/2007
	None	TQ3241872675	11	Water in cellar Xmas and last 2 weeks	02/10/2000
	Nr Head	TQ3100074400	12	Wet Basement	09/10/2000
	None	TQ3141272766	13	Water seeping through front of house only	06/11/2000
	None	TQ3139872172	14	Water in cellar	21/11/2000
	RTD – Kempton Park Gravel Formation	TQ3057876666	15	Water in cellar	22/11/2000
	RTD - Taplow Gravel Formation	TQ3130675001	16	Water in Cellar	28/11/2000
	Head	TQ2934874509	17	Water in Basement	03/02/2004
	RTD - Taplow Gravel Formation	TQ3160074600	18	Standing water in cellar	18/01/2001
	Nr Head	TQ3180874714	19	Water under floor slab	24/01/2001
	Head	TQ3090073700	20	Water in basement	29/01/2001
	RTD - Taplow Gravel Formation	TQ3160075000	21	Waterlogging at building site	21/03/2001
	Alluvium	TQ3130180072	22	Flooded cellar	30/03/2001
	None	TQ3073371410	23	Bad drainage around house	29/05/2001
	Nr Head	TQ3017073010	24	Damp problem under floor of ground floor flat	13/06/2001
	None	TQ3131472287	25	Spr(?) gushing beneath apple tree in garden	18/06/2001
	Head	TQ3019573270	26	Water coming into basement, possibly gw and bad drainage due to flash rainfall.	09/08/2001
	Head	TQ3076273814	27	Basement flooded recently	17/08/2001
	RTD - Taplow Gravel Formation	TQ3165074604	28	Basement flat flooded	12/08/2001
	Head	TQ3105574523	29	Cellar being flooded by underground Effra River.	09/08/2001
	None	TQ3297671167	30	Possible gw flooding	24/09/2001

Bedrock Geological Unit*	Overlying Superficial Deposits*	Grid Reference	N°**	Reported Incident	Date
	Nr head	TQ2990072300	32	Allowed water to reach settled level in basement. Also c. 15 nearby properties in Mount Ephraim Lane & Norfolk House Road.	11/10/2001
	Head – Nr RTD	TQ3052975414	33	basement flooded in August.	15/10/2001
	Nr to RTD	TQ2951076102	34	Water in basement	17/10/2001
	None	TQ3078474044	35	Water in basement	01/11/2001
	None	TQ3297671167	36	Water entering his house from outside	04/12/2001
	RTD – Kempton Park Gravel Formation	TQ3050078200	37	Waterlogged Pitches	20/12/2001
	None	TQ3190072600	38	Boggy garden	19/03/2002
	Nr Head	TQ3313271014	39	Water affecting bottom flat	17/07/2002
	None	TQ3151372755	40	Water pouring into cellar in dry period of July	05/09/2002
	Head – Nr RTD	TQ2977375303	41	Water in lift shaft	08/11/2002
	Head – Nr RTD	TQ2901974330	42	Flooded basement	02/01/2003
	None	TQ3065671092	43	Cellar flooded	02/01/2003
	RTD – Kempton Park Gravel Formation	TQ3090976471	44	basement flooding	09/01/2003
	None	TQ3307071532	45	River' flowing through basement	14/01/2003
	Head	TQ2996871037	46	Water in basement	22/01/2003
	Alluvium	TQ3142080110	47	Water in basement	23/01/2003
	None	TQ3116872263	48	Regular seepage into garden from up gradient. Waterlogged garden	26/02/2003
	Head – Nr RTD	TQ2902373276	49	Flooding under buildings; Common boggy	12/03/2003
	None	TQ3126472335	50	Regular seepage into garden from up gradient. Waterlogged garden	19/05/2003
	RTD - Taplow Gravel Formation	TQ3105975627	51	Water entering cellar and damp up walls	05/06/2003
	Head	TQ3062075341	52	Water table problem	14/10/2005
	None	TQ3019871594	53	Cellar flooding now, but not in last 5 years.	04/09/2009
	Head	TQ2976574766	54	Pooling of water in cellar for last two weeks.	05/10/2009
	None	TQ3084471463	55	Flooding in basement	03/09/2008
	Nr Boyn Hill Gravel Member	TQ3251875539	56	Ferndene Road - potential GW flooding	Unknown
	Edge of Head and RTD – Taplow Gravel Formation	TQ3170174450	57	Dulwich Road - potential GW flooding	Unknown
Lambeth Group / London Clay Formation	None	TQ3198073610	31	Surface flooding around estate since October last year	10/10/2001

Note: RTD = River Terrace Deposits, Nr = Near, * Geology of incident based on plotted location (Figures 1, 2 and 3) and Environment Agency record
** Incident reference number as shown on Figures 1, 2 and 3.

3.2.3 Table 2 demonstrates that many of the flooding incidents are referenced as flooding of cellars / basements, which is a common outcome of a rising water table following a period of heavy or persistent rainfall, particularly in shallow aquifers often associated with superficial deposits.

3.2.4 Numbers 1, 5 to 8, 11 to 14, 19, 23 to 25, 30, 32, 34 to 36, 38 to 40, 43, 45, 48, 50, 53, 55, and 56 are located over the London Clay Formation where there are no overlying superficial deposits. The London Clay Formation is an aquiclude and does not permit groundwater flow. Therefore based on the available information to date, these incidents are probably related to poor drainage over clayey soils following heavy rainfall i.e. they are not true groundwater flooding incidents. However, it is worth noting that for the sites located downslope of superficial deposit aquifers, springs / seepages may form part of the flood waters. Rolling ball analysis would be required to confirm this as part of a more detailed study.

3.2.5 Incidents 22 and 47 are reported to be on the London Clay Formation where it is overlain by Alluvium deposits, near to the River Thames. Alluvium is expected to behave as an aquitard, with limited groundwater flow. Therefore, these incidents are possibly related to poor drainage and surface water flooding. However, it is conceivable that some of this surface water is derived from springs / seepages associated with the River Terrace Deposits further to the south. Rolling ball analysis would be required to confirm this.

3.2.6 Incident 31 is located on the London Clay Formation but close to the Lambeth Group outcrop. As identified in Section 2, groundwater levels in the Lambeth Group are at significant depth below ground level and would not cause groundwater flooding. Therefore this flooding incident, described as ‘Surface flooding around estate since October last year’, is probably related to poor drainage and a different source of flood water.

3.2.7 All of the other incidents are reported to be on the London Clay Formation where it is overlain by significant Head or River Terrace Deposits. A water table is expected to be present within these superficial deposits, perched above the London Clay Formation aquiclude. These incidents are therefore likely to be true groundwater flooding incidents and largely represent flooding of basements and gardens. However, it also noted that the incidents located on Head deposits, which are expected to have a variable permeability, may also be a consequence of poor drainage conditions and surface water run-off.

3.2.8 Figure 2 shows that many of the groundwater flooding incidents are located near to / along lost rivers such as the River Effra (drainage in these areas now enters the Thames Water drainage network and the surface water courses no longer exist). These will be topographic lows and perched groundwater tables are likely to be close to ground surface in these areas, so that there is an increased susceptibility to groundwater flooding.

3.2.9 There are no reported groundwater flooding incidents near to the River Graveney in the south, but this is potentially because the watercourse is canalised throughout the study area (Level 1 SFRA, June 2008).

3.3 Groundwater Flooding Susceptibility Datasets

Increased Potential for Elevated Groundwater

3.3.1 Areas where there is increased potential for groundwater levels to rise within 2 m of ground surface, following periods of higher than average recharge, are shown in Figure 3. These are separated into permeable superficial deposits and bedrock (consolidated) aquifers. The data set was produced for the whole of the Drain London project area, derived from four individual data sources:

- British Geological Survey (BGS). Groundwater Flood Susceptibility maps;
- Environment Agency (EA). Thames Estuary, 2100 groundwater hazard maps;

- Jacobs. Groundwater emergence maps; and
- JBA. Groundwater flood maps.

3.3.2 However, in the Lambeth BC area, only the BGS groundwater flooding susceptibility and EA Thames Estuary 2100 data sets were available.

3.3.3 Figure 3 shows that within the Lambeth BC area, the increased potential for elevated groundwater is associated with permeable superficial deposits, not bedrock (consolidated) aquifers. This is in broad agreement with the groundwater flooding mechanisms identified in Section 3.1. The permeable superficial deposits that have been identified as having an increased potential for elevated groundwater are the River Terrace Deposits and Head, where they overlie the London Clay Formation aquiclude, ground elevations are low (e.g. near to lost / historic surface water courses).

3.3.4 A fairly good correlation exists between groundwater flooding incidences and areas mapped as having an increased potential for elevated groundwater. However, the exceptions to this are:

- Reported groundwater flooding incidents that are located on the London Clay Formation aquiclude, but with no overlying permeable superficial deposits. The increased potential for elevated groundwater data set does not take into account the potential for groundwater springs to rise from aquifers and flow over impermeable geology. Rolling ball analysis would be required to assess the likelihood of this mechanism as part of a more detailed study. It is possible that many of the incidents are simply not related to groundwater conditions.
- A number of reported groundwater flooding incidents are located where permeable superficial deposits exist, but not within areas with increased potential for elevated groundwater. Either these are not true groundwater flooding incidents, or the BGS data set may need to be refined at these locations.

3.3.5 In general, it is thought that the approximate areas identified by Figure 3 as having increased potential for elevated groundwater are sensible. However, some areas that may have increased potential have been identified as having no potential for elevated groundwater, probably due to limited water level data being available. The Environment Agency does not monitor groundwater levels in the superficial deposits within the Lambeth BC area.

3.4 Summary of Groundwater Flooding Susceptibility

Current Susceptibility

3.4.1 Due to the significant thickness of underlying London Clay Formation in the majority of the borough, the susceptibility from groundwater flooding from rising groundwater levels in the Chalk and 'Basal Sands' is considered to be negligible. Where the Lambeth Group outcrops in the east of the Lambeth BC (Brockwell Park area), groundwater levels are suppressed due to regional groundwater abstractions. Therefore, the key groundwater flooding mechanisms are associated with permeable superficial deposits.

South east where Claygate Member is underlain by London Clay Formation (Crystal Palace area)

3.4.2 The Claygate member is classified as a secondary aquifer and is water bearing, with potential for a perched groundwater table(s) on the London Clay Formation aquiclude. Consequently, site specific investigations will be important for any proposed development sites, particularly those considering basements / underground structures such as soakaways.

Lower elevation land where London Clay Formation is overlain by superficial deposits, including those areas where historic / lost rivers existed

3.4.3 Figure 3 shows that the superficial deposits in these areas have an increased potential for elevated groundwater. Whilst no groundwater level data for the superficial deposits are available, where groundwater tables exist they are expected to be close to or at ground level. Therefore basements and cellars may be at risk from groundwater flooding and use of structures such as sheet piling may exacerbate the problem if they intercept the water table.

3.4.4 Superficial deposits are likely to be variable in composition across the Lambeth BC area. Site investigation will be key for any proposed development sites, to understand the local groundwater conditions, particularly those areas located near to lost rivers (where topographic lows exist).

Land where London Clay Formation outcrops at surface

3.4.5 The London Clay Formation is an aquiclude and does not permit groundwater flow. Therefore in areas where there are no overlying superficial deposits and the London Clay Formation is of an appreciable thickness, the potential for elevated groundwater levels is considered to be negligible. However, where the London Clay Formation has been removed and replaced with more permeable artificial ground, there may be increased potential of elevated groundwater as groundwater becomes trapped in these deposits.

3.4.6 Finally, it is possible that groundwater springs could emerge from permeable superficial deposits and flow over the London Clay Formation, resulting in groundwater flooding. It is recommended that rolling ball analysis is undertaken as part of a more detailed assessment.

3.5 Future Potential for Elevated Groundwater

3.5.1 Susceptibility to groundwater flooding in the Lambeth BC area may change as a result of climate change, or changes to water management. One of the climate change predictions includes an increase of high rainfall events. This could lead to further groundwater flooding in the Lambeth BC area due to increased perched groundwater levels and associated spring flows. It is also noted that a shift in drainage policy, with increased infiltration SUDS, may also lead to increased incidents of groundwater flooding. The small perched superficial deposit aquifers will be sensitive to increased recharge due to their limited storage capacity.

3.6 Importance of Long Term Groundwater Level Monitoring

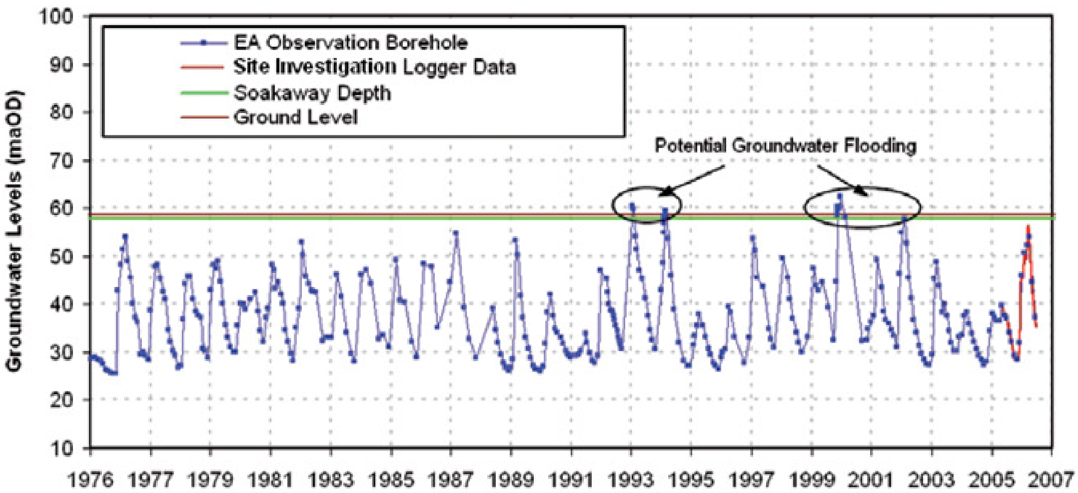
3.6.1 Groundwater flow direction, depth to groundwater, topography and the degree of artificial influence in the subsurface (e.g. leaking water mains or groundwater abstractions) play an important role when considering the susceptibly of an area to groundwater flooding. Without long term (and continuous) groundwater monitoring, it is not possible to derive groundwater level contours, understand groundwater / surface water interactions or likely maximum seasonal fluctuations. Therefore it is not possible to provide a detailed assessment of potential for elevated groundwater or provide detailed advice on suitability for infiltration SUDS.

3.6.2 It is probably not sufficient to rely on the work undertaken by developers through the planning application process, unless longer term (and continuous) monitoring is included as a condition attached to planning approval. Groundwater levels are often only measured once, or, at most, for a number of weeks. It would be advisable for Lambeth BC, in combination with the Environment Agency, to begin long term monitoring of superficial deposit groundwater levels.

3.6.3 It is also important to understand how changing policies relating to infiltration SUDS can impact upon groundwater levels. For example, the introduction of infiltration SUDS (e.g. soakaways) may cause a rise in peak groundwater levels. This could prevent soakaways from operating and the reduction in unsaturated zone thickness may not be acceptable to the Environment Agency owing to its responsibilities under the Water Framework Directive. It may also cause groundwater flooding of infrastructure, basements / cellars etc that were designed and constructed during a period of reduced groundwater recharge.

3.6.4 Long term groundwater level monitoring is required to support decision making with respect to future land development and future co-ordinated investments to reduce the risk and informing the assessment of suitability for infiltration SUDS.

Schematic demonstrating the importance of long term groundwater level monitoring



4 Water Framework Directive and Infiltration SUDS

4.1.1 The Water Framework Directive approach to implementing its various environmental objectives is based on River Basin Management Plans (RBMP). These documents were published by the Environment Agency in December 2009 and they outline measures that are required by all sectors impacting the water environment. The Thames River Basin District is considered within the current study, since infiltration Sustainable Drainage Systems (SUDS) have the potential to impact the water quality and water quantity status of aquifers.

4.1.2 Improper use of infiltration SUDS could lead to contamination of the superficial deposit or bedrock aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SUDS is likely to help improve aquifer quality status and reduce overall flood risk.

4.1.3 Environment Agency guidance on infiltration SUDS is available on their website at: http://www.environment-agency.gov.uk/business/sectors/36998.aspx. This should be considered by developers and their contractors, and by Lambeth BC when approving or rejecting planning applications.

Key Water Level Considerations (Figure 3)

4.1.4 The areas that may be suitable for infiltration SUDS exist where there is a combination of high ground and permeable geology. However, consideration should be given to the impact of increased infiltration SUDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at a down gradient location. This type of analysis is beyond the scope of the current report.

4.1.5 It is important to be aware of groundwater level conditions at a potential development site. The maximum likely groundwater levels should be assessed, to confirm that soakaways will continue to function even during prolonged wet conditions. The areas where there is increased potential for elevated groundwater are shown on Figure 3.

Key Geological Considerations (Figure 4)

4.1.6 The infiltration SUDS suitability assessment shown on Figure 4 is based on minimum permeability data obtained from the BGS. There also exist maximum permeability data, however, only the minimum permeability is used, as this is understood to be more representative of the bulk permeability.

4.1.7 Three permeability zones have been identified:

1) **Infiltration SUDS potentially suitable:** Minimum permeability is high or very high for bedrock (and superficial deposits if they exist).
2) **Infiltration SUDS potentially unsuitable:** Minimum permeability is low or very low for bedrock (and superficial deposits if they exist).
3) **Infiltration SUDS suitability uncertain:** Minimum permeability is low or very low for bedrock and high or very high for superficial deposits OR minimum permeability is low or very low for superficial deposits and high or very high for bedrock.

4.1.8 The third category is required because the thickness of superficial deposits is uncertain. If they are thick and impermeable, shallow soakaways may not intercept underlying higher permeability bedrock. If they are thin and permeable, but perched over impermeable bedrock, they may not have the capacity to receive the additional recharge from infiltration SUDS. Under the third category, it is particularly important that the developer undertakes an appropriate site investigation to determine infiltration SUDS suitability.

4.1.9 No areas within the Lambeth BC area have been identified as being potentially suitable for infiltration SUDS. However, much of the northern half of the borough has been identified as having an uncertain suitability for infiltration SUDS with a need for enhanced site investigation. These areas are associated with River Terrace Deposits overlying the London Clay Formation aquiclude. Site investigation is required to identify the thickness of the deposits and demonstrate that they have the ability to store and transmit groundwater without causing flooding / drainage issues.

4.1.10 It is noted that this is a high level assessment and only forms an approximate guide to infiltration SUDS suitability; a site investigation is required to confirm local conditions.

Key Water Quality Considerations (Figure 10)

4.1.11 Where possible, infiltration SUDS should be located away from areas of historic landfill (as shown on Figure 4) and areas of known contamination or risk of contamination. This is to ensure that the drainage does not re-mobilise latent contamination or exacerbate the risk to groundwater quality and possible down gradient groundwater receptors, such as abstractors, springs and rivers. A preliminary groundwater risk assessment should be included with the planning application.

4.1.12 Restrictions on the use of infiltration SUDS also apply to those areas within Source Protection Zones (SPZ). Developers must ensure that their proposed drainage designs comply with the available Environment Agency guidance.

4.1.13 The above notwithstanding, it is understood that the SPZs in the Lambeth BC administrative area are associated with groundwater abstractions from the Chalk Formation. Except for the Brockwell Park area, the Chalk Formation is expected to be hydraulically isolated from the surface superficial aquifers that overlie the London Clay Formation. Therefore, the restrictions associated with SPZs are unlikely to apply, so long as a suitable risk assessment is included as part of any planning application.

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 The following conclusions can be drawn from the current study:

- The London Clay Formation hydraulically separates the underlying Chalk principal aquifer from overlying superficial deposits in the majority of the borough. Where the London Clay Formation is absent in the Brockwell Park area, Lambeth Group groundwater levels are suppressed due to regional groundwater abstractions and are expected to be at least 30 m below ground level.
- The superficial deposits, particularly the River Terrace Deposits, are expected to form a significant perched aquifer over the London Clay Formation aquiclude, particularly in areas of lower elevation along the historic / lost rivers. Whilst there is monitoring of Chalk groundwater levels in the area, the Environment Agency / Lambeth BC do not currently monitor groundwater levels in the superficial deposits.
- A perched water table(s) may exist within the Claygate Member in the south east (near to Crystal Palace). However, there is no monitoring of this unit by either the Environment Agency or Lambeth BC.
- A number of potential groundwater flooding mechanisms have been identified. Of significance are those flooding mechanisms associated with the superficial aquifers. Underground structures including basements and cellars are at most risk from groundwater flooding.
- Areas with increased potential for elevated groundwater have been identified using a number of data sets, including the BGS groundwater flooding susceptibility data set. These appear to be sensible; they are in agreement with the identified groundwater flooding mechanisms i.e. they highlight areas of low ground level with permeable superficial deposits.
- Groundwater flooding incident data provided by the Environmental Agency have been assessed and a reasonable correlation exists with areas mapped as having an increased potential for elevated groundwater. However, there are a number of discrepancies between these data sets. These are potentially a result of (i) the BGS groundwater flooding susceptibility data set not taking into account groundwater springs / seepages from superficial deposits that flow onto the impermeable London Clay Formation, or (ii) the increased potential for elevated groundwater data set needing to be refined. Alternatively, those flood incidents may not be related to groundwater conditions.
- The majority of the groundwater flooding incidents are thought to be related to perched water tables within superficial deposits, particularly the River Terrace Deposits. Many of the groundwater flooding incidents are located near to / along lost rivers such as the River Effra. These will be topographic lows and perched groundwater tables are likely to be close to ground surface in these areas, so that there is an increased susceptibility to groundwater flooding.
- The assessment of increased potential for elevated groundwater and suitability for infiltration SUDS could be improved by additional groundwater level / river stage monitoring and the development / use of a numerical groundwater model.

5.2 Recommendations

5.2.1 The following recommendations are made based on the current study. These will allow for a more detailed assessment of increased potential for elevated groundwater and suitability for infiltration SUDS:

- The areas identified as having increased potential for elevated groundwater should be compared with those areas identified as being susceptible to other sources of flooding e.g. fluvial, pluvial and sewer. An integrated understanding of flood risk will be gained through this exercise;
- Acquisition of 1:10,000 scale geological mapping, if it exists, for the areas identified as being at potential risk from groundwater flooding;
- Information on mains leakage, foul sewer leakage and groundwater infiltration should be obtained from Thames Water, if available;
- Data identifying properties with basements / cellars should be used to improve the understanding of susceptibility to groundwater flooding;
- Site investigation reports for historic development sites could be reviewed to obtain additional groundwater level information, to improve the conceptual understanding of the area. Water level information on BGS borehole logs will be another source of information;
- Rolling ball analysis in GIS should be undertaken at Tier 3 to identify the drainage paths of water emerging from elevated superficial aquifers.
- Monitoring boreholes should be installed in the River Terrace Deposits and Head, fitted with automatic level recording equipment for a minimum period of one year and water quality sampling undertaken. At this point a review of the monitoring network should be undertaken and an update on potential for elevated groundwater analysis and infiltration SUDS guidance provided.
- The proposed monitoring boreholes should assist the Environment Agency with water quality and quantity assessments for the next River Basin Management Plan. Therefore, site selection should be agreed with the Environment Agency and the necessity for water quality monitoring agreed;
- Construction of a numerical groundwater model for the River Terrace Deposits should be considered when at least 3 years of monitoring has been undertaken. The model could then be used as a tool for assessing the impact of infiltration SUDS, other water management options and climate change on the aquifers.

6 References

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- Ellison, R A, Woods, M,A, Allen, D, J, Forster, A, Pharoah, T, C and King , C. 2004. Geology of London. Memoir of the British Geological Survey, Sheets 256, 257, 270 and 271.
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- Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J, and Robinson, V K., 2000. The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report, WD/00/4. 39pp. Environment Agency R&D Publication 68.

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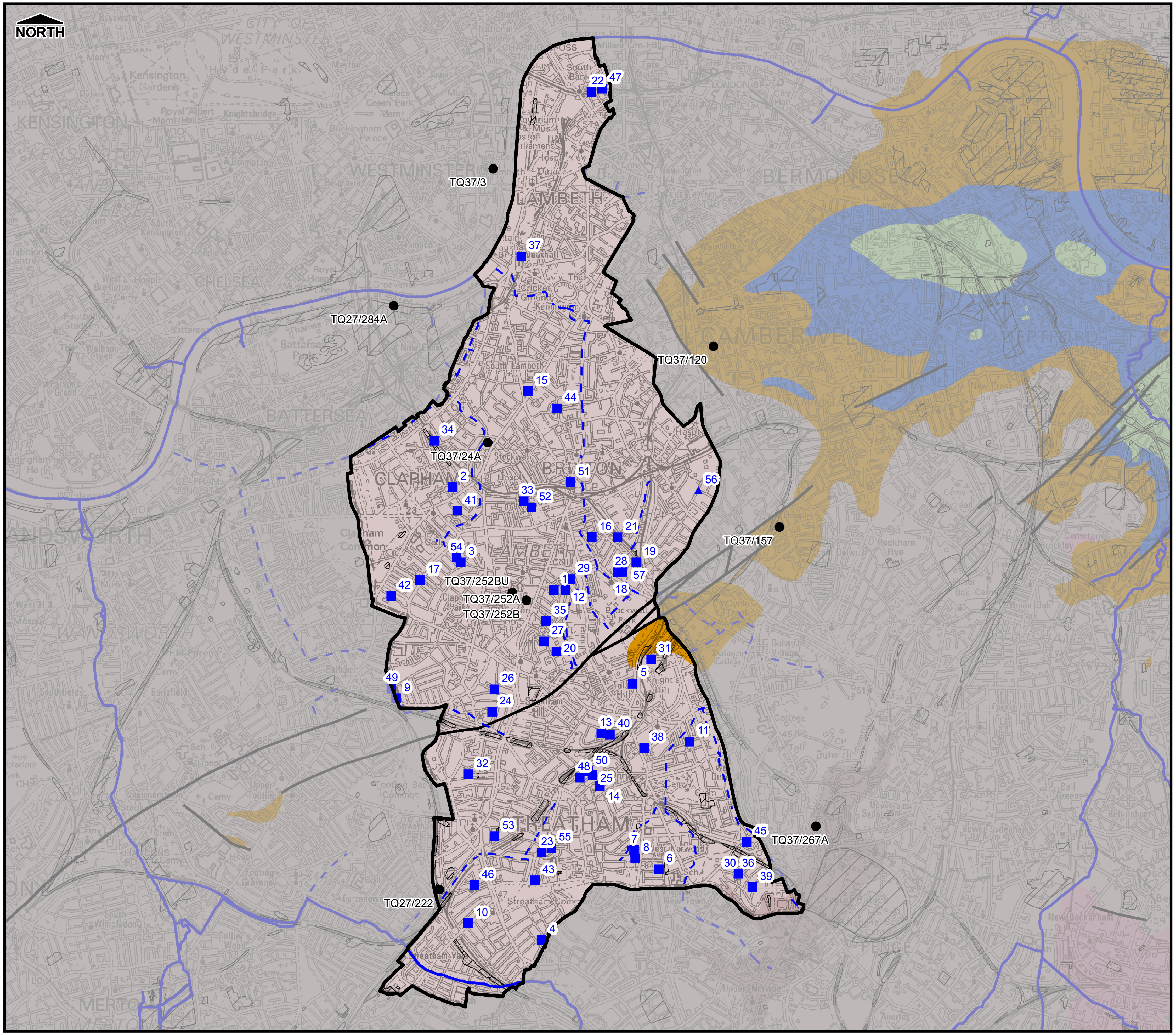

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Legend

- Lambeth Borough Council
- Groundwater Flood Incident (EA Records)
- Groundwater Flood Incident (Other Records)
- Environment Agency Monitoring Borehole
- Lost Rivers (Lambeth BC. 2011)
- Main Rivers
- Faults
- Artificial (Undivided)

Bedrock Geology

- Bagshot Formation
- Claygate Member
- London Clay Formation
- Lambeth Group
- Harwich Formation
- Thanet Sand Formation
- Upper Chalk (Undifferentiated)
- Middle Chalk (Undifferentiated)
- Lewes Nodular Chalk Formation
- New Pit Chalk Formation

Notes

London Borough of Lambeth

Lambeth

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	22/03/2011	C.Woolhouse	S.Cox

Bedrock Geology

Consultants

CAPITA SYMONDS Flood Risk Management
Scott Wilson

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Drain London Programme Board Members

Environment Agency
Thames Water
LONDON COUNCILS
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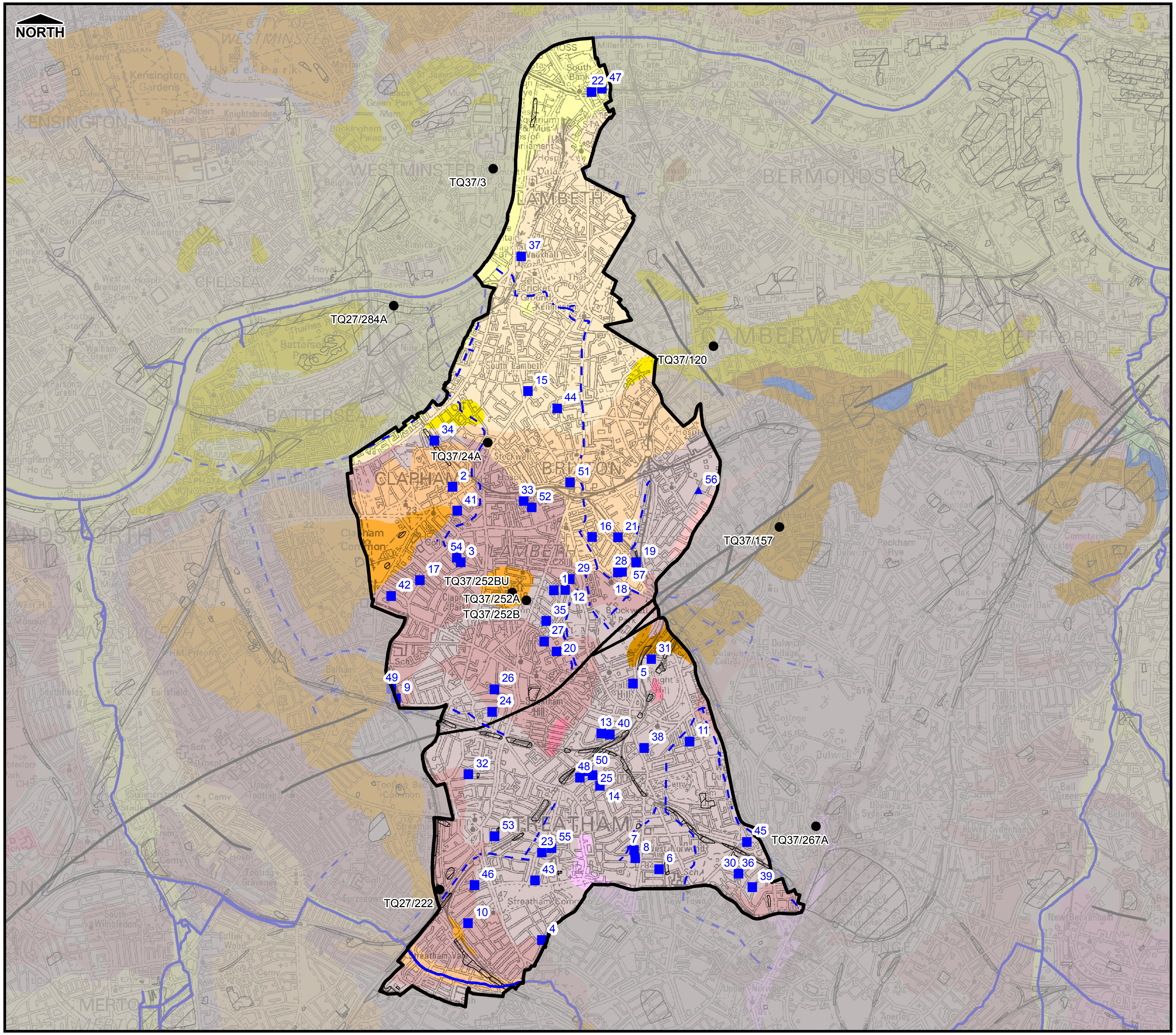
FIGURE 1



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- Lambeth Borough Council
- Groundwater Flood Incident (EA Records)
- Groundwater Flood Incident (Other Records)
- Environment Agency Monitoring Borehole
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- Main Rivers
- Faults
- Artificial (Undivided)

Superficial Geology

- Head
- Peat
- Alluvium
- Langley Silt Member
- Kempton Park Gravel Formation
- Taplow Gravel Formation
- Hackney Gravel Member
- Lynch Hill Gravel Member
- Boyn Hill Gravel Member
- Black Park Gravel Member
- Sand and Gravel of Uncertain age

Bedrock Geology

- Bagshot Formation
- Claygate Member
- London Clay Formation
- Lambeth Group
- Harwich Formation
- Thanet Sand Formation
- Upper Chalk (Undifferentiated)
- Middle Chalk (Undifferentiated)
- Lewes Nodular Chalk Formation
- New Pit Chalk Formation

London Borough of Lambeth

Lambeth

Surface Water Management Plan

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Bedrock and Superficial Geology

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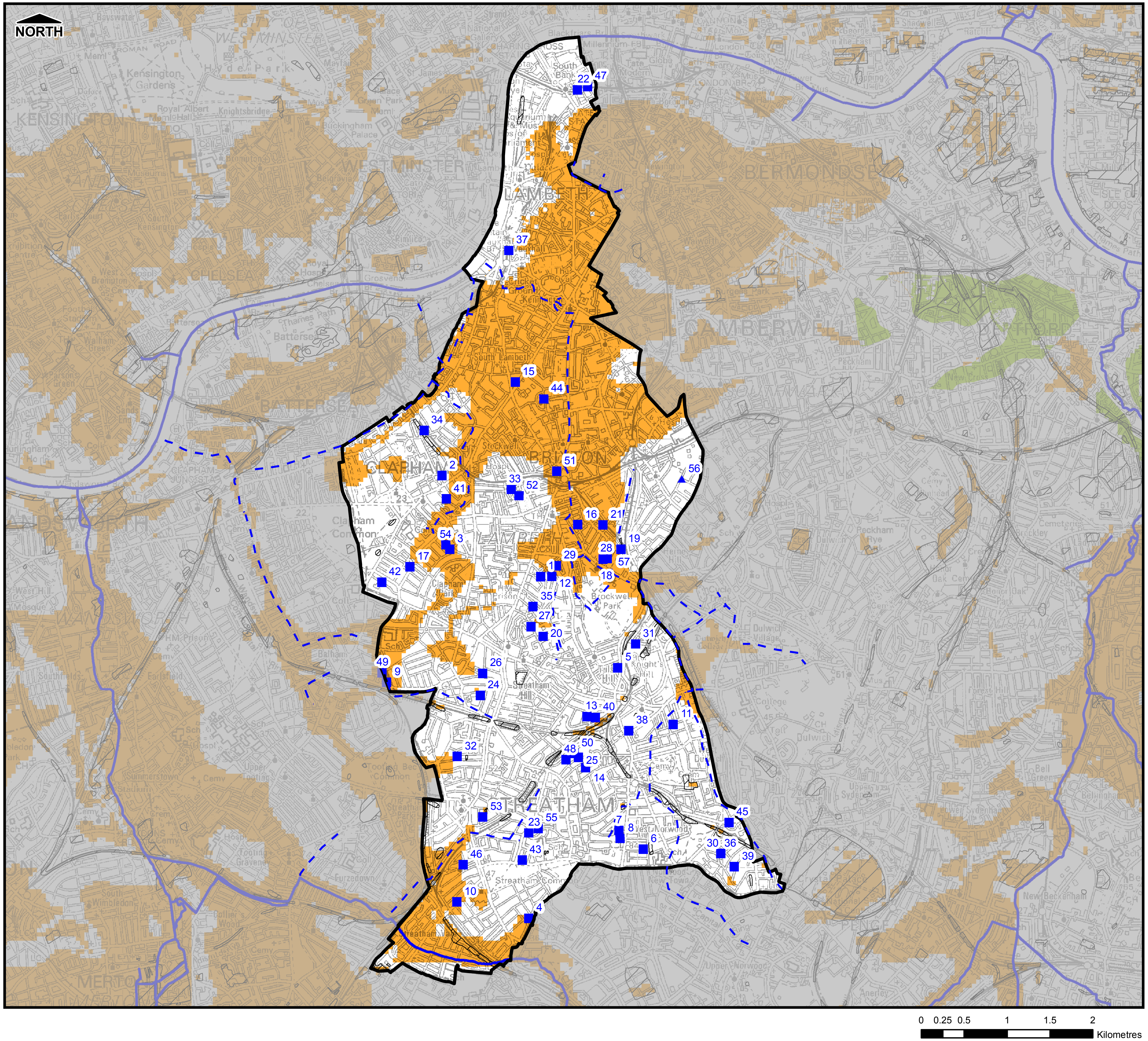
FIGURE 2

Filepath: D134786 Drain London_Tier 2_Group 7\700 Technical\711 GIS\01 Layout\Lambeth\Bedrock & Superficial Geology.mxd



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Legend

- Lambeth Borough Council
- Groundwater Flood Incident (EA Records)
- Groundwater Flood Incident (Other Records)
- Main Rivers
- Lost Rivers (Lambeth BC. 2011)
- Artificial (Undivided)

Increased Potential for Elevated Groundwater in

- Permeable Superficial Deposits
- Consolidated Aquifers

Notes

1.The increased Potential for Elevated Groundwater map shows those areas within the London Boroughs where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2m of the groundsurface. Such groundwater rise could lead to the following:

-Flooding of basements of buildings below ground level;
-Flooding of buried services or other assets below ground level;
-Inundation of farmland, roads, commercial, residental and amenity areas;
-Flooding of ground floors of buildings above ground level; and Overflowing of sewers and drains

2.Incident records shown are generally unconfirmed and may include issues such as water main bursts or non-groundwater related problems.
3.Areas not shown to have increased potential for elevated groundwater should be considered to have a low potential for elevated groundwater - Lack of information does not imply 'no potential' of elevated groundwater in that area.
4.Includes groundwater flood mapping provided by JBA consulting, Copyright. Jeremy Benn Associates Limited 2008-2011, partially derived from data supplied by the Environment Agency.

London Borough of Lambeth

Lambeth

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Increased Potential For Elevated Groundwater

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FIGURE 3

Filepath: D134786 Drain London_Tier 2_Group 7\700 Technical\711 GIS\01 Layout\Lambeth\Increased potential for elevated GW.mxd

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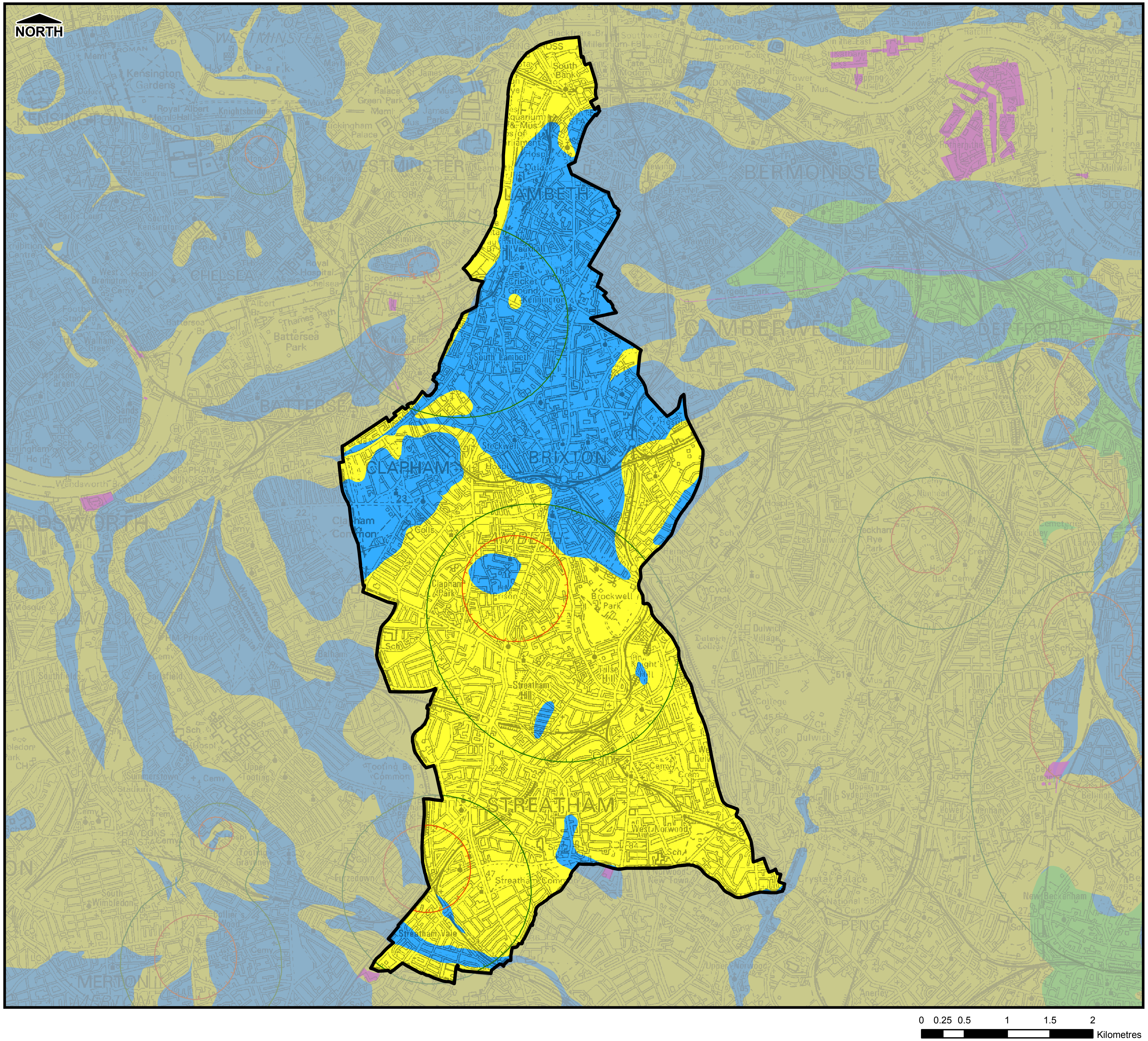

Legend

- Lambeth Borough Council

EA Groundwater Source Protection Zone

- Inner Zone
- Outer Zone
- Historic Landfill Site

Infiltration SUDS Suitability

- Infiltration SUDS potentially suitable
- Infiltration SUDS potentially unsuitable
- Infiltration SUDS Suitability Uncertain -Site investigation required

Notes

This map forms an approximate guide to Infiltration SUDS Suitability. However, for all new developments, site investigation is required to confirm local geology, depth to groundwater and infiltration rates.

London Borough of Lambeth

Lambeth

Surface Water Management Plan

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Infiltration SUDS Suitability Map

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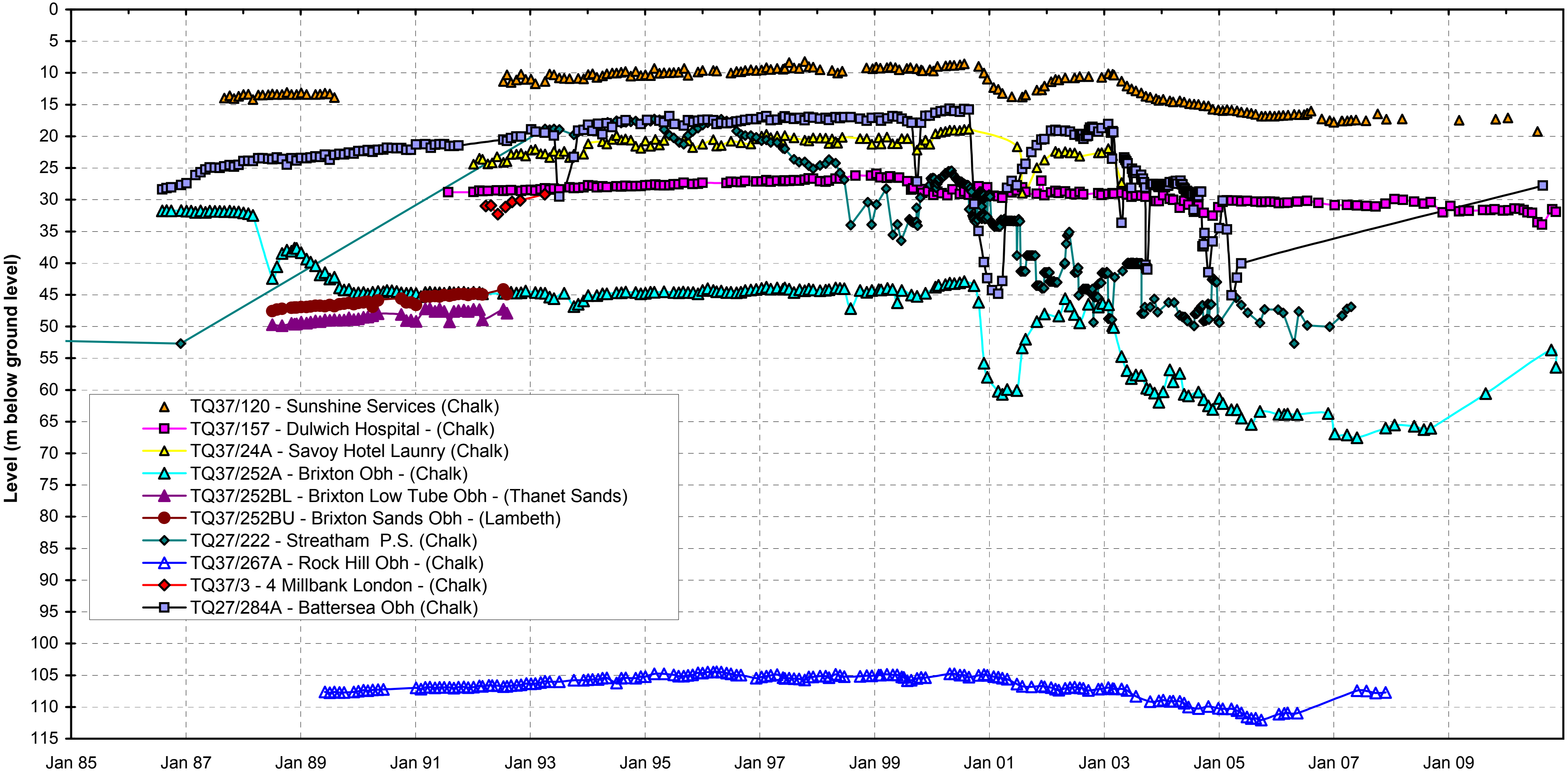
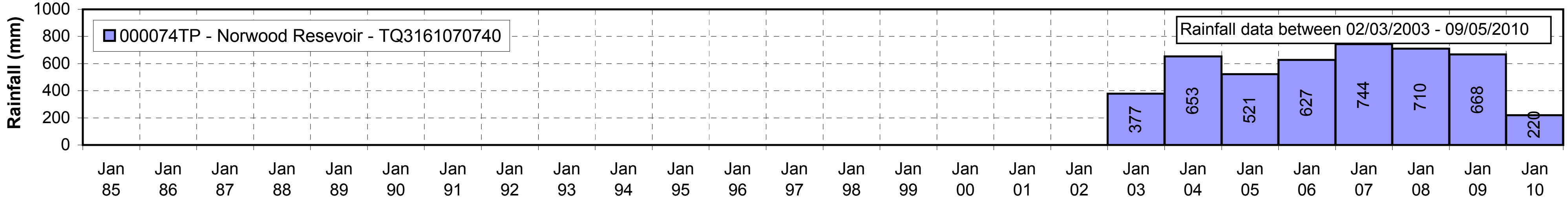
FIGURE 4

Filepath: D134786 Drain London_Tier 2_Group 7\700 Technical\711 GIS\01 Layout\Lambeth\Infiltration SUDS Suitability Map.mxd

Appendix 1

Environment Agency
Observation Borehole Water Level Data





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Lambeth WL records.xls 11/04/2011

Scott Wilson