

6 DETAILED DEVELOPMENT PROPOSALS

6.1 Land uses most sensitive to flood damage

The probability of the proposed development flooding is low since the development is mostly located in Flood Zone 1. There is a small area adjacent to the western boundary along the High Road which is in Flood Zone 2. See Figure 2. The portions of the development area that could be affected by Flood Zone 2 are pedestrian areas and all proposed buildings, including the residential development, have been moved away from the Flood Zone 2 extents.

6.2 Consultation

The 2010 FRA (section 8.2.1.1) states "The 2010 surface water drainage strategy is based on an allowable discharge of 150l/s/ha totaling 1260l/s for the 8.4ha development site. This has been agreed in principle with the Environment Agency." In the Buro Happold 2010 Design Note, which is included in the 2010 FRA, Thames Water stated that "this rate (150l/s/ha) will be accepted providing it is proved to be a reduction on the existing discharge rate. They typically require brownfield sites to use the existing connections to the Thames Water sewers. Should the existing connections be incompatible with the proposed drainage design then a further restriction to the allowable discharge rate may be sought by Thames Water".

Further consultation with Thames Water in 2015 has been carried out and they stated that the allowable discharge rate to their sewers will be restricted to the flows occurring during the 1:15 year event critical storm duration factoring in the capacity of the existing sewers and area already draining to the sewer.

6.3 Details of Development layout

The development layout, showing the drainage areas, attenuation areas and drainage system, is in Appendix D.

Four drainage areas, 3.3 hectares in total, discharge into the Moselle via three outfalls; two existing and one new. The new outfall consisting of three 300 diameter pipes has been constructed during Development enabling works. The remaining 3.2 hectares drain into the Thames Water sewers via two outfalls into the sewer in Park Lane, two outfalls into the sewer in Worcester Avenue and one outfall into the sewer in Northumberland Park. The outfall capacity and attenuation capacity are designed to prevent flooding on site for the 1:100 year event plus climate change rainfall event and to prevent any runoff from the development to surrounding areas from the 1:100 year plus climate change event.

5.9 hectares will be drained by a pumped system and 0.6 hectares will be drained by a gravity drainage system. Attenuation is mainly by using underground geocellular tanks and oversized pipes. Attenuation in areas B and C, 0.2 hectares along the western side of the site, is part of the greenroof system.

The runoff from the roofs is collected separately from the runoff from the paved areas. Non return valves will be fitted to the outlets to the Moselle Brook and Thames Water sewers to reduce the risk of backing up from these water bodies.

There will be basements in the residential blocks and hotel but these will be used for parking. These basements will be drained by pumping and flow paths will be directed away from the entrances to the basements.

Table 3 compares the design outfall discharges and the 1 in 100 year brown field rates for each drainage area.

As stated in the Introduction, the allowable discharge rate in the consented 2010 FRA is 150l/s/ha. In recent correspondence, Thames Water have stated that the allowable discharge to their sewer will be restricted to the flows occurring during the 1:15 year event critical storm duration factoring in the capacity of the existing sewers and the area already draining to the sewer. Thames Water is to review the current discharge rates into their sewers. The drainage system for the Project is to be agreed with Thames Water.

There is a discharge rate betterment in all areas except for area A. The attenuation by oversized pipes in Area A is required to prevent flooding from low lying manholes for the 1 in 100 year event plus climate change.

Averaged over the whole site, there is an 85% discharge rate betterment for the 1 in 100 year event plus climate change compared to the 1 in 100 year brown field discharge rate.

The total runoff rate from the site is less than the 150l/s/hectare agreed in principle by the Environment Agency in 2010.

Final agreement of the 2015 drainage strategy with Thames Water is on-going (September 2015).

Table 3 Design Outfall Rates compared with Brown Field rates.

AREA	AREA, HA	OUT - FALL	RECEIVING WATER BODY	ATTENUATION VOLUME, (M3)	DESIGN OUTFALL RATE (L/S)	1 IN 100 YR - 15 MIN STORM BROWN FIELD RATE (L/S)	BETTERMENT
A	0.419	2	Moselle Brook	30	160	150.93	-6%
A1	2.668			1352	70	961.05	93%
B	0.107	3		20	5	38.54	87%
C	0.084	7		21	5	30.26	83%
D	0.192	9	TW sewer – Park Lane	45	35	69.16	49%
E	0.614	6		230	35	221.17	84%
F	1.876	4	TW sewer – Worcester Avenue	827	30	675.76	96%
G	0.19	5			13	68.44	81%
H	0.32	8	TW sewer – Northumberland Park	160	5	115.27	96%
Total	6.47				358	2330.58	85%

6.4 Protection over the development's lifetime

The possible effects of climate change were taken into account when determining the surface water discharge rates and SuDS for the site. Appropriate design and maintenance of SuDS at the site will ensure that the discharge runoff rates do not exceed the allowable discharge values.

Since the western edge of the proposed development abuts Flood Zone 2, the proposed development buildings have been moved away from this area and the space will be developed into an open pedestrian zone.

Figure 3 shows that the 1:1000 year flood outline only affects the extreme western side of the development; the majority of the site is not affected.

The attenuation tanks will empty by 50% in 24 hours to ensure they will function if another storm occurs, (ref 16).

Defra has published Non Statutory technical standards for Sustainable Drainage Systems in March 2015, (ref 15). The non-Statutory standards state that "The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year rainfall event are managed in exceedance routes that minimise the risks to people and property."

The exceedance routes in the Development will direct runoff to the stadium area. Also if there is a failure of the drainage system, the resulting flooding will affect the stadium first.

7 OFF SITE IMPACT

7.1 Effects on flood risk elsewhere

The Project will not affect the flood risk elsewhere as the discharges from the new development are less than the existing.

7.2 Runoff prevention from causing an impact elsewhere

All runoff from the 1:100 year event plus climate change will be collected and attenuated on site. If there is a failure of the drainage system or an event occurs that exceeds the 1 in 100 year plus climate change then the system is designed so that the pitch will flood.

7.3 Opportunities to reduce flood risk elsewhere

The runoff rate from the Project Site will be less than existing consequently reducing surcharging in the system.

7.4 Remaining flood-related risks

The remaining main risks are flooding from reservoir breaches and blockages in the drainage system and pump failure.

7.5 How will these risks be managed

The requirements of the Flood Reservoir Act 1975, revised in 2013, will be followed hence minimizing the risk of reservoir flooding.

It is essential that the drainage system and SuDS components are maintained on a regular basis to ensure that they function properly and avoid localised flooding of the site. This will be carried out by the Tottenham Hotspur Football Club maintenance team.

Exceedance paths will direct runoff to the stadium area.

In the case of emergencies, LBH can maintain the surface water drainage system connections to the culverted Moselle Brook using their permissive powers under the Land Drainage Act.

8

CONCLUSION

The assessment indicates that the Development is a low risk of flooding from surface water, sewers, ground water and reservoir flooding. Although the risk of a reservoir breach is low the consequences would be significant.

The remaining main risks are flooding from reservoir breaches and blockages in the drainage system and pump failure.

The development area is 6.5 hectares. 5.9 hectares will be drained by a pumped system and 0.6 hectares will be drained by a gravity drainage system. Attenuation is mainly by using underground geocellular tanks and oversized pipes.

As in the consented 2010 FRA, the design rainfall intensities have been increased by 20% for calculating the runoff from the stadium roof and the hotel complex and by 30% for the residential block to incorporate Climate change.

Averaged over the whole site, there is an 85% discharge rate betterment for the 1 in 100 year event plus climate change compared to the 1 in 100 year brown field discharge rate. The runoff from the existing site is in the same order of magnitude as the brown field discharge rate.

The exceedance routes in the Development will direct runoff to the stadium area

It is essential that the drainage system and SuDS components are maintained on a regular basis to ensure that they function properly and avoid localised flooding of the site. This will be carried out by the Tottenham Hotspur Football Club maintenance team.

As concluded in the 2010 FRA, the development of this site using on site attenuation would not increase either the existing surface water runoff rate or volume from the site, and therefore would not increase flood risk elsewhere.

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APPENDIX A

2010 FRA

**Northumberland
Development Project
Flood Risk Assessment**

May 2010
Final

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EXECUTIVE SUMMARY

URS Corporation Limited (URS) was commissioned by Savills (L&P) Ltd, on behalf of their client Tottenham Hotspur Property Company Ltd, to carry out a Flood Risk Assessment (FRA) for the redevelopment of the existing Tottenham Hotspur Football Club stadium and the adjacent area known as Wingate Trading Estate in Tottenham, North London in the London Borough of Haringey (LBH). The planning application boundary is 11.14 hectares (ha) made up of 2.67ha of public roadways and other private dwellings leaving 8.47ha for the proposed development elements. The proposed development generally consists of a new a 56,250-seat stadium in the centre of the site, podium areas north and south of the stadium for crown circulation, a food superstore fronting onto Northumberland Park to the north, a 200 unit residential building fronting onto Park Lane and a 150 bedroom hotel fronting onto Worcester Avenue to the east. Based on *Planning Policy Statement 25: Development and Flood Risk* (PPS25), a formal flood risk assessment is required to ensure that flood risks to, or caused by, the proposed development area are successfully managed. A study comprising data collection, a site visit, assessment of the flood risks, and flood mitigation measures was therefore undertaken.

The proposed development is located along High Road in Tottenham, at National Grid Reference 533997E, 191299N. Park Lane forms the development's southern boundary; High Road forms the western boundary; Northumberland Park the northern boundary and Worcester Avenue eastern boundary. The existing Tottenham Football stadium is located within the south-eastern corner of the development site (Appendix B: *Topographical Plan of Existing Site*).

The key hydrological feature in this area is a 3000mm x 1420mm culvert that carries the Moselle Brook south beneath High Road along the western edge of the proposed development (Appendix C: *Thames Water Asset Location Search*). In accordance with the findings of the North London Strategic Flood Risk Assessment¹, Moselle Brook was *originally a natural tributary of the River Lee but has since been mostly culverted and in now artificially flows into Pymmes Brook*. The culvert outfalls into the Pymmes Brook approximately 1.9 km south east of the proposed development. The Environment Agency (EA) website indicates that the majority of the site is located in Flood Zone 1 having a Low Probability or less than 1 in 1000 annual probability of river flooding in any year (<0.1%). The western edge of the scheme that abuts High Road is located in Flood Zone 2 having a Medium Probability or between a 1 in 100 and 1 in 1000 annual probability of river flooding in any year (1% - 0.1%). The EA has supplied TUFLOW modelled flood levels for Moselle Brook adjacent to the proposed development for the extents of Flood Zone 2. URS has taken the data and developed a map (Figure 2: *1000year Flood Extents*) of the scheme area overlain by the predicted Flood Zone 2 flood levels, which range from 11.67m AOD (at the north west corner of the site) to 10.95m AOD (at the south west corner of the site).

The assessment indicates that:

- The existing site is not at significant risk of flooding from land or sewers.
- Groundwater flooding is not a significant flood risk for the existing sites and redevelopment would not significantly lower existing ground levels.

¹ North London Waste Plan, *North London Strategic Flood Risk Assessment*, dated August 2008.

- Post-development discharge during all storm events shall be restricted so that all available on-site gravity flow attenuation is utilised prior to discharging into the culverted Moselle Brook. In this case the proposed 1% annual probability, 15-minute duration storm event discharge rates are 58.4% lower than the existing Brownfield runoff rates. See Section 8.2 for further details.
- The 8.47ha area has been divided into three drainage catchments based on the proposed phases of the development and the types of development.
- Surface water runoff from the hard standing areas has been modelled using the source control WinDes (Version W11.3) drainage software to determine the maximum storage requirements for each catchment. Each catchment has been considered entirely impermeable. A 20%² allowance has been made for climate change per PPS25 for the stadium and superstore areas (Drainage Catchments A and B). A 30%² allowance has been made for climate change per PPS25 for the residential units within the southern area of the proposed development (Drainage Catchment C).
- Hydraulic models of proposed drainage systems were developed by Buro Happold using underground storage, and permeable paving to determine on-site attenuation. Attenuation model results and design principles are detailed in the Buro Happold Design Notes (Appendix F).
- The discharge for each drainage catchment will flow at a rate no greater than 150/l/sec/ha into private surface water sewerage networks and then into sustainable drainage system (SUDS) accordance with the strategy discussed with the Environment Agency (EA). Most of the sites surface water will be flowing into the culverted Moselle Brook, which is classified as a "main river" by the EA. Final on-site storage volumes are subject to construction detail design. Rainwater will be harvested from the roof of the stadium facility and green roofs will be installed above the food superstore to the north and residential buildings to the south of the site to further reduce flood risk. Attenuation for rainfall events with an annual expected probability of 3.3% or more (up to a 1 in 30 year event) will be achieved by using underground storage tanks. The additional attenuation required for rarer events will be achieved through controlled surface level flooding of the ground floor car parking areas for Catchments A and B and in additional underground storage tanks for Catchment C. Other SUDS techniques discussed in Section 8.2 do not present practical or sustainable options for this development.
- Based on the assumptions presented in this report, the development of this site using on site attenuation would not increase either the existing surface water runoff or volume from the site, and therefore would not increase flood risk elsewhere.

The PPS25 *Development and Flood Risk: Practice Guide* (December 2009) requires that a FRA Pro-forma be completed and submitted with the planning application for developments for which a FRA is required. This flood risk assessment answers the questions raised in this pro-forma.

² Table B.2 *Recommended national precautionary sensitivity ranges for peak rainfall intensity ranges for peak rainfall intensities, peak river flows, off shore wind speeds and wave heights.* (PPS25 Annex B)

1. INTRODUCTION

1.1. Background

URS was commissioned in April 2008 by Savills (L&P) Ltd, on behalf of their client Tottenham Hotspur Property Company Ltd, to carry out a FRA for the redevelopment of the existing Tottenham Hotspur Football Club stadium and the adjacent area known as Wingate Trading Estate. The planning application boundary is 11.14 hectares (ha) made up of 2.67ha of public roadways and other private dwellings leaving 8.47ha for the proposed development elements.

Based on PPS25, a FRA is required to ensure that flood risks to, or caused by, a proposed development are successfully managed. A study comprising of data collection, a site visit, assessment of the flood risks, and flood mitigation measures was therefore undertaken. This is the report on the FRA. It has been formatted as suggested in Paragraph 3.82 and Appendix B of the *Planning Policy Statement 25: Development and Flood Risk Practice Guide* published by the Department for Communities and Local Government (December 2009).

Tottenham Hotspur Property Company Ltd is seeking to submit a planning application to obtain permission to construct a new 58,247 seat stadium in the centre of the site, a food store along the Northumberland Park boundary, and residential units along the Park Lane boundary.

1.2. Site Location and Description

The proposed development is located in the London Borough of Haringey (LBH) and encompasses the redevelopment of the existing Tottenham Hotspur Football Club stadium and the adjacent Wingate Trading Estate.

The proposed development is located along High Road in Tottenham. Park Lane forms the development's southern boundary; High Road forms the western boundary; Northumberland Park the northern boundary and Worcester Avenue eastern boundary. The existing Tottenham Football stadium is located within the south-eastern corner of the development site (see Figure 1).

See Appendix B: *Topographical Plan of Existing Site* for the topographical survey carried out by Sterling Surveys, dated October 2007.

The site is located at National Grid Reference TQ 341914 and Ordnance Survey co-ordinates 534107E and 191404N (Figure 1).

2. DEVELOPMENT DESCRIPTION AND LOCATION

2.1. What type of development is proposed and where will it be located?

The development site, as discussed in Section 1.2, is located in the LBH and encompasses the existing Tottenham Hotspur Football Club stadium and the adjacent Wingate Trading Estate.

The proposed development will provide a 56,250-seat stadium in a central location on the site with its main entrance from the High Road. To the north and south of the stadium will be podium areas for crowd circulation on a match day. Beneath the southern podium will be the Club megastore, museum and ticket office. In addition to the stadium and associated podium areas there will be a food superstore fronting onto Northumberland Park to the north with Club leisure space above, a predominantly residential building providing up to 200 units and office floorspace fronting onto Park Lane to the south and a hotel providing up to 150 bedrooms with associated restaurant and bars fronting onto Worcester Avenue to the east. There will also be various small scale commercial, retail and office floorspace located beneath the podium and in four retained buildings along the southern High Road frontage.

The Northumberland Development Project Masterplan drawing by Townshend Landscape Architects showing green roofs, green spaces and hardscapes can be found in Appendix D.

2.2. What is its vulnerability classification?

In accordance with PPS25 *Table D.2: Flood Risk Vulnerability Classification* buildings used for assembly and leisure activities are classed as "Less Vulnerable". There are also residential or dwelling houses planned for the property, which are classed as "More Vulnerable". For a conservative approach, the entire property will be classed as "More Vulnerable".

2.3. Is the proposed development consistent with the Local Development Documents?

The Haringey Council Unitary Development Plan (UDP) was adopted in July 2006. It is the statutory development plan for the whole Borough. The UDP sets out the Council's framework for development, development control and conservation in Haringey.

Policy ENV2: Surface Water Runoff states: *The Council will: (a) require any development which could increase the risk of flooding from surface water run-off to provide a drainage impact assessment; and (b) encourage all built developments to incorporate sustainable drainage systems (SUDS) techniques, where feasible.*

The proposed development is to provide SUDS on-site storage using underground storage that could include any combination of storage tanks, oversized pipes and permeable paving. In addition rainwater will be harvested from the roof of the stadium facility and green roofs will be installed above the residential buildings to ensure discharge from the post development site is reduced as much as feasibly possible utilising gravity flow attenuation discharge into the culverted Moselle Brook.

Policy AC3: Tottenham High Road Regeneration Corridor states: *In order to promote regeneration, proposals for development along Tottenham High Road, as identified on Map 1.1, will be permitted where the following can be demonstrated: (a) that it is sustainable and will positively contribute to the regeneration of the High Road; (b) that it will involve no significant adverse impact on neighbouring residential amenity, and provides a safe and secure environment that combats crime and the fear of crime; (c) it will not result in any loss of public open space; (d) it will not significantly increase the vehicular traffic flow on the High Road; (e) it will not detract from the vitality and viability of the town centres, which should be the focal point for new travel intensive uses; (f) that new housing should promote a more balanced, mixed, sustainable and less transient community, and the proportion of affordable housing should not exceed 50 per cent, the majority of which should be for intermediate forms of housing (shared ownership, key worker and sub market schemes); and (g) change of use to residential will be encouraged outside the defined retail centres, subject to other policies in this plan.*

The UPD further states in paragraphs 1.12 and 1.13 that: *The Tottenham High Road Regeneration Strategy (2002) encompasses the entire length of the High Road. It links the borough boundary with Enfield to the north and Hackney to the south, and incorporates Northumberland Park, Bruce Grove and Seven Sisters. The area has severe environmental, economic and social problems and is in need of regeneration. Major sites for potential redevelopment will act as catalysts for prime regeneration of the High Road and include Tottenham Hotspur Football Club – to support the expansion and redevelopment of the football club.*

Therefore, the development will be consistent with Local Development Documents in terms of the suitability of the redevelopment for the area and in terms of flood risk.

2.4. Please provide evidence that the Sequential Test or Exception Test has been applied in the selection of this site for development type?

The risk based Sequential Test within PPS25 aims to steer new development to ensure that sites with little or no risk of flooding (i.e. lowest probability of flooding, Flood Zone 1) are developed in preference to areas of higher risk.

The EA website indicates that the majority of the site is located in Flood Zone 1 though the western edge of the scheme that abuts High Road is located in Flood Zone 2. The EA has supplied TUFLOW modelled flood levels for Moselle Brook adjacent to the proposed development for the extents of Flood Zone 2. URS has taken the data and developed a map (Figure 2: *EA Flood Zone 2*) of the proposed development area overlain by the predicted Flood Zone 2 flood levels, which range from 11.67m AOD (at the north west corner of the site) to 10.95m AOD (at the south west corner of the site).

A map found in Appendix A of the North London SFRA entitled *Map 8: Flood Risk Zones* confirm the proposed development to be mostly in Flood Zone 1 with the western edge in Flood Zone 2.

In accordance with PPS25's Table D.3: *Flood Risk Vulnerability and Flood Zone Compatibility*, "More Vulnerable" and "Less Vulnerable" uses are appropriate in Flood Zones 1 and 2.

Planning Policy Statement 25: Development and Flood Risk (PPS25) requires that: *LPAs allocating land in LDDs for development should apply the Sequential Test to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.*

If the London Borough of Haringey performed the Sequential Test on this development, it is likely that the development would pass, as the development is consistent with the existing uses of the site and is allowable per PPS25. Table D.3 of PPS25 indicates that an Exception Test is not required for "More Vulnerable" and "Less Vulnerable" developments in Flood Zones 1 and 2.

3. DEFINITION OF THE FLOOD HAZARD

3.1. What sources of flooding could affect the site? (see Annex C PPS25)

Flooding from rivers, the land, groundwater and sewers are the potential sources of flooding at the proposed development.

3.2. For each identified source, describe how flooding would occur, with reference to any historic records wherever these are available

3.2.1. Historical Flooding

The following is relevant historical flooding information from the North London SFRA, Section 5.3.1.5 Haringey Council Flood Management Strategy Report Review:

The Borough of Haringey commissioned a report to consider flood risk from a spectrum of sources in their borough and produce appropriate strategies for the management of flood risk. The report identifies the council as the riparian owner on much of the Moselle Brook meaning that they have a greater responsibility than realised prior to this report.

A number of flooding incidents were reported, the most significant of which was flooding occurring in July 1965. The area around White Hart Lane appeared to be most affected including the White Hart Lane Station and properties on The Roundway. Montagu Road flooded during this event and is also reported to have flooded in 1956. White Hart Lane is also reported to have flooded in 1993 with the Wedges Yard Trash Screen a particular flood hazard.

A map found in Appendix A of the North London SFRA entitled *Map 10: Historic EA Flood Maps* shows the proposed development to be outside the extents of various historic flood events. Additionally, *Map 20: Flooding Incidents* shows that there are no records of flooding incidents within the proposed development area.

The flooding incidences mentioned above are at locations south of the development therefore there is no evidence that the site has ever flooded based on historical flood data.

3.2.2. Flooding from Rivers

The nearest watercourses to the development area is Moselle Brook, which is culverted in a 3000mm x 1420mm box culvert and is located beneath High Road which makes up the western boundary of the development (Appendix C: Thames Water Asset Location Search). In accordance with the findings of the North London SFRA, Moselle Brook was originally a natural tributary of the River Lee but has since been mostly culverted and in now artificially flows into Pymmes Brook. The culvert outfalls into the Pymmes Brook approximately 1.9 km south east of the proposed development.

The Environment Agency (EA) website indicates that the majority of the site is located in Flood Zone 1 having a Low Probability or less than 1 in 1000 annual probability of river flooding in any year (<0.1%). The western edge of the scheme that abuts High Road is

located in Flood Zone 2 having a Medium Probability or between a 1 in 100 and 1 in 1000 annual probability of river flooding in any year (1% - 0.1%). The EA has supplied TUFLOW modelled flood levels for Moselle Brook adjacent to the proposed development for the extents of Flood Zone 2. URS has taken the data and developed a map (Figure 2: EA Flood Zone 2) of the proposed development area overlain by the predicted Flood Zone 2 flood levels, which confirms the website results.

A map found in Appendix A of the North London SFRA entitled *Map 8: Flood Risk Zones* confirm the proposed development to be mostly in Flood Zone 1 with the western edge in Flood Zone 2.

The proposed development is at negligible risk of fluvial flooding during all storms up to and including the 1% annual probability storm event. Only the eastern edge of the site is at minor risk of fluvial flooding during storm events with a 1% to 0.1% annual probability of occurring.

3.2.3. Flooding from Land

Factors influencing the amount of runoff generated from the site include the extent and nature of the surface material. The existing site is a brownfield site and is considered entirely impermeable since it is covered by building and paving. The proposed development would maintain the impermeable surface area.

When climate change is considered, as recommended by PPS25, the peak rainfall intensities would increase by 20% for the commercial developments and 30% for the residential developments. The post-development calculated attenuation volume would also increase.

The northern half of the site, known as Wingate Trading Estate, is bound by Northumberland Park to the north, High Road to the west, Paxton Road to the south and Worcester Avenue to the east. This area is mostly flat between the existing buildings with an average site level of 12.0mAOD with minor level fluctuations of 0.5m. The southern half of the site is bound by Paxton Road to the north, High Road to the west, Park Lane to the south and Worcester Avenue to the east. This area slopes away from the stadium building, which takes up half of the southern portion of the site. The levels range from 11.8mAOD at the north east corner of the site to 11.1mAOD in the north west corner, 10.9mAOD in the south west corner and 10.7mAOD in the south east corner. See Appendix B for the topographical plan of the existing site.

The development of this site is to be undertaken using SUDS that reduce the proposed catchment's surface runoff to exceed the requirements of PPS25 to mimic existing conditions. This discharge rate reduction below the equivalent existing brownfield storm event rate will ensure a reduction in the overall surface water discharge rate from the site. Therefore, adjacent developments should be at **negligible** overland flood risk from the proposed development.

The proposed development is also at **negligible** risk of flooding from adjacent developments. This is due the scheme being bound by roadways on all sides resulting in any drainage from the adjacent lands being intercepted by road drainage networks.

3.2.4. Flooding from Groundwater

The EA Groundwater Source Protection Zones map found on the EA's website indicates that the site is mostly within the outer zone of a groundwater source protection zone. The north west corner is outside the groundwater source protection zones.

The *North London, 256* map, (Solid and Drift Edition, 1:50,000 Series), from the Geological Survey of Great Britain (England and Wales) for the area indicates that the south east third of the site is underlain by Brickearth (Enfield Silt), which overlies Kempton Park Gravel. Kempton Park Gravel overlies London Clay, which in turn overlies Lambeth Group, the Thanet sand formation and then lastly Chalk. The north west two-thirds of the site underlain by the same strata as the south east third beginning with the Kempston Park Gravel layer.

The National Rivers Authority map (1995) *Groundwater Vulnerability of the Thames Estuary, Sheet 40* indicates that the south east third of the site is located over a Non-Aquifer of negligible leaching potential. Non-Aquifers are described as formations that are generally regarded as containing insignificant quantities of groundwater. Groundwater flow through such rocks, although imperceptible, does take place and should be considered in assessing the risk associated with persistent pollutants. The north west two thirds is located over a minor aquifer of high leaching potential. Minor aquifers are either fractured or potentially fractured rocks, which do not have a high primary permeability, or formations of variable permeability including unconsolidated deposits. Although minor aquifers rarely produce large quantities of water for abstraction, they are important for local supplies and in supplying base flow to rivers. Soils of high leaching potential have the potential to allow pollutants to move rapidly to underlying strata or to shallow.

The deeper groundwater, located in the Chalk aquifer beneath the London Clay, is currently rising as a result of decreased abstraction. In response to this situation, Thames Water Utilities, London Underground Limited and the EA formed GARDIT (General Aquifer Research Development and Investigation Team) in 1992. GARDIT have since been attempting to mitigate the problem by increasing groundwater abstraction in London by up to 50 million litres per day (Ml/d). The work by GARDIT has reduced the rate of rise considerably.

Paragraph 8.28 of the Mayor of London's draft water strategy *Water Matters* published in March 2007 states: *Until very recently, rising groundwater levels have left London's underground infrastructure at a real risk from inundation. In 1999, a team started to investigate how best to resolve the problem. It concluded that abstractions from London's groundwater should increase by 50 million litres of water a day. Since then, the Environment Agency has granted licences to take the surplus groundwater. It is the Agency's view that the Chalk groundwater levels are now stable and no longer pose a significant threat to the underground infrastructure.*

A map found in Appendix A of the North London SFRA entitled *Map 12: Groundwater Contours* indicates that the groundwater in the region is between 10 metres and 20 metres below ground level.

In Section 5.3.1.5 of the North London SFRA discusses the conclusions found in the Haringey Council Flood Management Strategy Report. The SFRA reports that *it was concluded that Haringey was at risk from fluvial, sewer and pluvial flooding but not groundwater or tidal flooding.*

Additionally, Section 10.10 of the North London SFRA discusses the SFRA's conclusions for Haringey which includes the following: *The primary source of flood risk to Haringey is fluvial flooding, with the Lower Lee, Moselle Brook and Stonebridge Brook providing the highest flood risk. [...] An assessment of risks from sewer and surface water flooding was undertaken which indicated that the risk of sewers flooding is generally low across the Borough with a small number sewer flood risk zones. [...] Groundwater flooding was found to be a relatively low risk. However the local geology does increase the risk of groundwater flooding and these risk zones were highlighted.* The proposed development was not found to be in a high-risk groundwater-flooding zone.

The site is currently fully paved and the future development's ground cover will also be impermeable.

The above evidence suggests that the proposed development is at negligible risk of groundwater flooding.

3.2.5. Flooding from Sewers

URS spoke with the Thames Water Developer Services Waste Engineer for the London Borough of Haringey to discuss the development of the scheme and its effects on the Thames Water surface water sewerage network. URS was informed that the surface water discharge from a redeveloped or brownfield site may be discharged to the public sewerage system on a 'like for like' basis. Therefore, the new development would be restricted to existing brownfield run-off rates.

A map found in Appendix A of the North London SFRA entitled *Map 13: Sewer Flooding Incidents by Postcode From August 1997 to August 2007* was informed by an extract of the Thames Water flood register. The data is referenced by truncated postcode only and therefore cannot specifically identify the location of a sewerage flooding event. The proposed development is shown to be located in postcode N17, which has one flooding incident recorded due to sewers.

Based on the information above and the findings of the SFRA, the proposed development is at **minor** risk of flooding due to sewers.

3.3. What are the existing surface water drainage arrangements for the site?

The Thames Water Services maps show the approximate location of public surface water and foul sewers and water mains adjacent to the site. Based on these maps the nearest public sewers are separate surface water and foul sewers located beneath all roads surrounding the development and beneath Paxton Road, which crosses through the proposed development area.

The existing developments located at the north east corner of the site that front Worcester Avenue will remain after development. Surface water runoff from these properties drain into the 229mm (9") diameter surface water sewer in Worcester Avenue. Surface water then flows north to join the 305mm (12") diameter surface water sewer in Northumberland Park, along the northern boundary of the scheme. This surface water sewer then collects additional drainage from the adjacent housing and joins the 610mm (24") diameter surface water sewer in High Road and conveys flows south. This sewer collects drainage from the existing developments at the north west corner of the site that will remain after development. The 610mm diameter surface water sewer then joins the 3100mm x 1370mm Moselle Brook conveying flows south of the development. The 229mm (9") surface water sewer in Paxton Road conveys flows west and joins the Moselle Brook culvert.

At the intersection of Park Lane and High Road at the south west corner of the site a second branch of the Thames Water sewerage network begins. It is a 762mm (30") diameter surface water sewer that conveys flows east and changes into a 914mm x 914mm (36" x 36") culvert just south of the existing Tottenham Hotspur Football Club. In Worcester Avenue just north of the intersection with Paxton Road there is a 229mm (9") diameter surface water sewer that conveys flows south towards Park Lane. Here it joins the 914mm x 914mm culvert and continues in an easterly direction.

Internal, private sewers convey the surface water from within the existing site to the Thames Water surface water sewer mains in the surrounding roadways. In accordance with the Buro Happold Design Note, Subject: Planning – Drainage Strategy, dated: 10 May 2010 located in Appendix F, there is still surface water drainage survey work outstanding which when completed will identify the location, pipe size and the resulting capacity of each of these connections.

4. PROBABILITY

4.1. Which flood zone is the site within?

The Environment Agency (EA) website indicates that the majority of the site is located in Flood Zone 1 having a Low Probability or less than 1 in 1000 annual probability of river flooding in any year (<0.1%). The western edge of the scheme that abuts High Road is located in Flood Zone 2 having a Medium Probability or between a 1 in 100 and 1 in 1000 annual probability of river flooding in any year (1% - 0.1%). In accordance with PPS25's Table D.3: *Flood Risk Vulnerability and Flood Zone 'Compatibility'*, More Vulnerable and Less Vulnerable uses are appropriate in Flood Zones 1 and 2.

4.2. If there is a Strategic Flood Risk Assessment covering this site, what does it show?

North London Waste Plan (NLWP) commissioned Mouchel to prepare a Strategic Flood Risk Assessment (SFRA) for the north London boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest entitled *North London Strategic Flood Risk Assessment*, dated August 2008. While the SFRA does not address the proposed development directly, the maps included in Appendix A do cover the site area. *Map 8: Flood Risk Zones* confirm the proposed development to be mostly in Flood Zone 1 with the western edge in Flood Zone 2. *Map 10: Historic EA Flood Maps* shows the proposed development to be outside the extents of various historic flood events. *Map 13: Sewer Flooding Incidents by Postcode From August 1997 to August 2007* shows the scheme to be located in postcode N17, which has one flooding incident recorded due to sewers. Lastly, *Map 20: Flooding Incidents* shows that there are no records of flooding incidents within the proposed development area.

4.3. What is the probability of the site flooding taking account of the contents of the SFRA and of further site-specific assessment?

The probability of the proposed development flooding is low since the majority of the development is located in Flood Zone 1 (less than a 0.1% annual probability of river flooding) with only its western boundary being located in Flood Zone 2 (between 0.1% and 1% annual probability of river flooding).

The EA has supplied TUFLOW modelled flood levels for Moselle Brook adjacent to the proposed development for the extents of Flood Zone 2. URS has taken the data and developed a map (Figure 2: EA Flood Zone 2) of the proposed development area overlain by the predicted Flood Zone 2 flood levels, which confirms the SFRA results.

The proposed development has also been found to be at negligible risk of flooding from land, groundwater and sewers (see Section 3).

4.4. What are the existing rates and volumes of run-off generated by the site?

4.4.1. Surface Water Runoff from the Site

4.4.1.1. Design Rainfall

Buro Happold Consulting Engineers has used the Flood Studies Report (FSR) method in preference to the Flood Estimation Handbook (FEH) for rainfall data as the FEH data *is known to overestimate sub-hourly rainfall in the south east of the country*³. FSR data is also not applicable to the rational approach which needs reliable sub-hourly rainfall totals.

4.4.1.2. Brownfield Runoff Rates and Volume Assessment

CIRIA C697 manual recommends the Modified Rational Method as one way of assessing runoff rates from a development site.⁴ This technique varies from the Rational Method by estimating the runoff coefficient, C as a product of two components: a volumetric runoff coefficient and a dimensionless routing coefficient. Due to the size of this site and the nature of the surface area, it is considered that for this analysis the simple Rational Method could be applied.

The runoff coefficient for roofed areas is generally equal to concrete paved areas and slightly higher than asphalt surfaces. The runoff coefficient for grass ranges between one-third to one-half of that for asphalt surfaces. Typically the runoff coefficient varies depending on the storm return period because it is expected that as a storm return period increases, the surface degree of saturation increases. For example, the runoff coefficient for asphalt surfaces varies from 0.73 for a 1 in 1 year annual probability storm, to a value of 1 for a 0.2% probability storm. This variation was taken into account based on literature recommendations.⁵ Existing runoff rates are presented in Table 2 and 3 below and Appendix E.

TABLE 2 Brownfield Peak Runoff Rates for the existing site - Total (l/s)	
Return Period (years) / Annual Probability of Exceedance (%)	15 minute (0.25hr) Storm Duration
Drainage Catchment A – 1.4 ha	
1 in 1yr	122.6
30 (3%)	355.3
100 (1%)	504.4

³ Validation of FSR and FEH depth/duration/frequency using Met office rainfall data, Aidan Millerick, 2005

⁴ Woods, B.B., Kellagher, R, Martian, P., Jefferies, C., Bray., R., Shaffer, P., The SUDS manual, CIRIA, London, 2007

⁵ Mays, W. L., *Water Resources Engineering*, John Wiley & Sons, Inc., New York 2001

TABLE 2 Brownfield Peak Runoff Rates for the existing site - Total (l/s)	
Return Period (years) / Annual Probability of Exceedance (%)	15 minute (0.25hr) Storm Duration
Drainage Catchment B – 6.4 ha	
1 in 1yr	560.5
30 (3%)	1624.2
100 (1%)	2305.7
Drainage Catchment C – 0.6ha	
1 in 1yr	52.5
30 (3%)	152.3
100 (1%)	216.2

TABLE 3 Brownfield Peak Runoff Volumes for the existing site - Total (m³)	
Return Period (years) / Annual Probability of Exceedance (%)	0.25 hr Storm Duration
Drainage Catchment A	
1 in 1yr	110.3
30 (3%)	319.8
100 (1%)	453.9
Drainage Catchment B	
1 in 1yr	504.4
30 (3%)	1461.8
100 (1%)	2075.1
Drainage Catchment C	
1 in 1yr	47.3
30 (3%)	137.0
100 (1%)	194.5

4.4.1.3. Time of Concentration

The following time of concentrations were used by Buro Happold for each surface water runoff catchment within the WinDes software calculations. Roof areas were split 50/50 between the following time of entries 0-4 and 4-8 minutes. Hard landscaped areas were split 50/50 between the following time of entries 4-8 and 8-12 minutes. The pitch area was split 50/50 between the following time of entries 8-12 and 12-16 minutes. See the Buro-Happold Design Note, Subject: URS RFI, dated: 05 May 2010 in Appendix F for further details.

5. CLIMATE CHANGE

5.1. How is flood risk at the site likely to be affected by climate change?

Flood Zone 3 water surface levels for the Moselle Brook culvert could rise due to increased rainfall intensities as a result of climate change. However, the entire site is above Flood Zone 3 and only the western edge of the site is located on the boundary of Flood Zone 2 having between a 1% and a 0.1% annual probability of flooding in any given year. URS has taken TUFLOW modelled flood levels provided by the EA and developed a map (Figure 2: EA Flood Zone 2) of the proposed development area overlain by the predicted Flood Zone 2 flood levels. This figure confirms the location of the scheme relative to the flood zones. Based on this information, it is unlikely that the proposed development will flood during normal or even extreme storm events.

In addition, the effects of climate change have been accounted for in the WinDes drainage software, which was used to model the maximum storage requirements for the site. The design life for a commercial development is typically 60 years and for a residential development it is 100 years. In accordance with PPS25, Annex B, Table B2: *Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights*, it is recommended that a development built to last until 2068 have the peak rainfall intensities increased by 20% to account for climate change when calculating development runoff. For a residential development built to last until 2108, the peak rainfall intensities should be increased by 30% to account for climate change. These allowances have been added to the rainfall intensities used in the attenuation model for the relevant drainage catchments.

6. DETAILED DEVELOPMENT PROPOSALS

6.1. Please provide details of the development layout, referring to the relevant drawings

The proposed development generally consists of a new a 56,250-seat stadium in the centre of the site, podium areas north and south of the stadium for crown circulation, a food superstore fronting onto Northumberland Park to the north, a 200 unit residential building fronting onto Park Lane and a 150 bedroom hotel fronting onto Worcester Avenue to the east. There will also be various other commercial, retail and office floorspace located in the southern region of the site.

The preliminary scheme drawing can be found in Appendix D.

The proposed drainage layout shall consist of surface water runoff being collected into various SUDS. The SUDS devices will discharge surface water runoff into the Thames Water surface water sewerage network utilising existing connection points. This configuration will mimic the existing drainage condition as explained in Section 3.3.

6.2. Where appropriate, demonstrate how land-uses most sensitive to flood damage have been placed in areas within the site that are at least risk of flooding.

The probability of the proposed development flooding is low since the development is mostly located in Flood Zone 1 though the western boundary adjacent to the High Road is within Flood Zone 2, this is confirmed by both the North London SFRA and the TUFLOW modelled flood levels provided by the EA. See Figure 2: EA Flood Zone 2 for more details. Because of this, the portions of the development area that could be affected by Flood Zone 2 are pedestrian areas and all proposed buildings, including the residential development, have been moved away from the Flood Zone 2 extents. All land uses have been placed in areas within the site that are at the least risk of flooding.

7. FLOOD RISK MANAGEMENT MEASURES

7.1. How will the site be protected from flooding, including the potential impact of climate change, over the development's lifetime?

The possible effects of climate change were taken into account when proposing the surface water discharge rates and SUDS for the site. Proper design and maintenance of SUDS at the site will ensure that the discharge runoff rates do not exceed the proposed discharge values.

Since the western edge of the proposed development abuts Flood Zone 2, the proposed development buildings have been moved away from this area and the space will be developed into an open pedestrian zone.

8. OFF SITE IMPACTS

8.1. How will you ensure that your proposed development and the measures to protect your site from flooding will not increase flood risk elsewhere?

The proposed scheme will be developed in accordance with PPS25, the North London SFRA and The London Plan.

Section F6 of Annex F: Managing Surface Water, of PPS25 states that: *Surface water arising from a developed site should, as far as practicable be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development, while reducing the flood risk to the site itself and elsewhere, taking climate change into account.* Section F10, requires: *volumes and peak flow rates of surface water leaving a developed site to be no greater than the rates prior to the proposed development.*

The **Haringey Council UDP** (adopted July 2006) Policy ENV2: Surface Water Runoff states that *The Council will: (a) require any development which could increase the risk of flooding from surface water run-off to provide a drainage impact assessment; and (b) encourage all built developments to incorporate sustainable drainage systems (SUDS) techniques, where feasible.*

The proposed development's surface water discharge rate will be restricted beyond the requirements of PPS25 to mimic existing conditions by the incorporation of SUDS on-site storage, permeable pavement, and oversized pipes. These measures will ensure discharge from the proposed development is reduced as much as feasibly possible utilising gravity flow attenuation discharge into the culverted Moselle Brook. In this case the proposed 1% annual probability, 15-minute duration storm event discharge rates are 58.4% lower than the existing Brownfield runoff rates.

The above combination of SUDS and the reduced surface water discharge rate will ensure that there is no increase in flood risk elsewhere, following development.

8.2. How will you prevent runoff from the completed development causing an impact elsewhere?

Attenuation systems, discussed in detail below, are possible for each catchment within the site's boundaries. The attenuation will be designed to restrict the surface water discharge rates for post-development conditions to exceed the requirements of PPS25 to mimic existing conditions. The design rainfall intensities for the proposed commercial

elements of the development have been increased by 20%⁶ and a 30% increase has been added for the residential area.

This measure will be installed to ensure that flood risk will not increase elsewhere after redevelopment of the site.

8.2.1. Proposed Site Surface Water Discharge and Attenuation

8.2.1.1. General

Currently the entire scheme drains towards the surrounding roadways and into the Thames Water surface water sewerage network.

The existing scheme area is entirely covered by either buildings or pavement. Either buildings or pavements with minor landscaping will also cover the proposed scheme. Therefore the impermeable area of the scheme will be unchanged.

Rainfall intensities for the attenuation models were increased by 20% for the stadium, food superstore and club house catchments and 30% for the residential catchment to account for increased surface water flows as a result of climate change, as discussed in Section 5.1.

The proposed development's surface water discharge rates relative to the worst case storm of 15 minute duration shall be restricted to meet and exceed the requirements of PPS25 to mimic existing conditions by restricting the proposed 1% annual probability storm event discharge rate to a maximum rate of 150l/s/ha as agreed with the EA.

The following is an excerpt from the Buro-Happold Design Note, Subject: Planning – Drainage Strategy, dated: 10 May 2010 located in Appendix F explaining the surface water drainage strategy including discharge rates and attenuation.

1.1.2. The surface water drainage strategy is based on an allowable discharge of 150l/s/ha totalling 1260l/s for the 8.4ha development site. This has been agreed in principle with the Environment Agency. Thames Water has stipulated that discharge will be restricted to the capacity of the existing connections. There is still work outstanding from the drainage survey which once completed will clarify the capacity of these connections. A further restriction to the allowable discharge rate dictated by Thames Water cannot be ruled out at this stage and would result in increased attenuation volumes to those quoted below. At present work is progressing to try and achieve a gravity system but pumping, at least in part, also cannot be ruled out until a working WinDes model is complete.

[...]

⁶ Table B.2 Recommended national precautionary sensitivity ranges for peak rainfall intensity ranges for peak rainfall intensities, peak river flows, off shore wind speeds and wave heights. (PPS25 Annex B)

1.1.4. The North (Retail) site comprises of the retail store and service yard (1.4ha total). Its storm water system will provide attenuation totalling 370m³. 1 in 30 year attenuation (210m³) will be provided by below ground storage tanks beneath the building footprint. The additional 1 in 100yr attenuation (160m³) will be provided through controlled surface level flooding of the ground floor car parking area. Due to the size of the existing sewer on Northumberland Park the system will discharge southwest to the Moselle Culvert in the High Road. Existing connections will be re-used where possible and flow control devices will limit total discharge to 210l/s. A green roof is proposed for a portion of the retail store which will increase the time of entry for the system and reduce the volume of attenuation required. Run-off from the service yard will pass through an oil separator before entering the system.

1.1.5. The Stadium site including the public realm and hotel (6.4ha total) will have a surface water network that provides attenuation totalling 1640m³. 1 in 30 year attenuation (980m³) will be provided by below ground tanks. It is anticipated that only a portion of the 1 in 100 attenuation requirement (660m³) will be provided by controlled surface level flooding due to site constraints and the remainder will have to be provided below ground. The Stadium will utilise multiple outfalls due to the size of the catchment, the requirement to use existing connections and the complex phasing sequence. The outfalls will be split between the Moselle Culvert in the High Road (east) and the new sewer to be laid in Worcester Avenue (west). Existing connections will be re-used wherever possible and flow control devices will ensure the total discharge from the catchment is limited to 960l/s. The public realm area will be drained by slot drains which will be connected to the main system. Rainwater harvesting is proposed for part of the stadium roof to reduce the mains demand for non-potable water. The pitch drainage will be designed by the specialist pitch contractor Hewitt's but will link into the wider system.

1.1.6. The South (Residential) development (0.6ha) will have a surface water network that provides attenuation totalling 180m³. At present it is assumed that 100% of the 1 in 100 year attenuation will have to be provided below ground and some pumping will be required due to the basement car park. The system will outfall south to Park Lane re-using existing connections where possible with flow control devices installed to limit discharge to 90l/s.

Modelled peak discharge rates for the proposed development from the Buro-Happold Design Note, Subject: URS RFI, dated: 05 May 2010 (Appendix F) compared to the corresponding existing Brownfield discharge rates are presented in Table 5.

Table 5 – Northumberland Development Project SUDS Existing Brownfield vs. Proposed Modelled Discharge Rates (l/s)			
Storm Event Annual Probability	Existing Brownfield Runoff Rate	Modelled Proposed Discharge Rates	Percent Reduction
Drainage Catchment A – 1.4ha			
1 in 1 year	122.6	45	63.3%
3.3% (1 in 30 years)	355.3	140	60.6%
1% (1 in 100 years)	504.4	210	58.4%
Drainage Catchment B – 6.4ha			
1 in 1 year	560.5	215	61.6%
3.3% (1 in 30 years)	1624.2	660	59.4%
1% (1 in 100 years)	2305.7	960	58.4%
Drainage Catchment C – 0.6ha			
1 in 1 year	52.5	20	61.9%
3.3% (1 in 30 years)	152.3	65	57.3%
1% (1 in 100 years)	216.2	90	58.4%

It is estimated that for each catchment site the time of concentration is less than 15 minutes. Therefore, the design discharges for redevelopment conditions are based on a storm duration of 15 minutes.

Buro Happold determined storage requirements for the site using the Flood Studies Report (FSR) rainfall data method and WinDes, Version W.11.3 drainage software. Refer to the Buro-Happold Design Note, Subject: URS RFI, dated: 05 May 2010 in Appendix F.

Surface water discharge is to be restricted to a maximum rate of 150l/s/ha allowed in principle by the Environment Agency for the 1% annual probability storm event.

Table 6 details the proposed attenuation required for each catchment to restrict the proposed development's surface water discharge rates to the values discussed above:

**Table 6 – Northumberland Development Project
Proposed Attenuation Requirements**

Drainage Catchment	3.3% Annual Probability Attenuation (m³)	Additional 1% Annual Probability Attenuation Required (m³)	Total Attenuation Volume (m³)	Attenuation by Controlled Surface Level Flooding (max depth 100mm)
A	210	160	370	160
B	980	660	1640	<660
C	105	75	180	0

See Figure 3 for the indicative proposed location of the on-site storage corresponding with the Buro Happold detailed surface water drainage design.

Redevelopment of this site will be undertaken by using SUDS that meet EA regulations. Options for the reduction and control of surface water run-off, and their suitability relative to this site are discussed below:

8.2.1.2. Source Control Methods

Definition: The control of runoff or pollution at or near the source.

Examples:

Rainwater Harvesting is a system that collects rainwater from where it falls rather than allowing it to drain away. It includes water that is collected from roofs and surrounding surfaces. The rainwater can then be reused as grey water within buildings.

Rain Gardens are a concave landscape area where runoff from roofs is allowed to pond temporarily while infiltrating into deeply constructed soils below.

Green/brown Roofs are systems which cover a building's roof with vegetation that improve rainwater management by absorbing surface water within the vegetation layers reduce surface water runoff from roofs. They can also be laid over a drainage layer, with other layers providing protection, waterproofing and insulation. Green roofs also improve biodiversity on development sites and the quality of water runoff.

Flood Risk Mitigation Suitability:

Rainwater Harvesting would reduce the amount and cost of potable water used within each unit reducing water usage costs. A disadvantage of this option is the high cost involved with buying and installing the tank and the continued maintenance cost to keep the tank in optimum condition. There is also an increase in energy consumption due to additional filtering and pumping. In addition, the EA does not consider the reduction in surface water discharge if rainwater is harvested when calculating surface water storage during extreme storm events and therefore this option does not reduce flood risk.

Rain Gardens would potentially reduce surface water runoff. During prolonged rainfall events the rate at which rainfall is being collected in the concave landscape area would

be greater than the infiltration rate rendering the rain garden ineffective. Additional roof runoff would flow over the pond and discharge directly into underground drains.

Green/ Brown Roofs would potentially reduce surface water runoff. However, during prolonged rainfall events, the roof can become "saturated" and a green roof rendered ineffective as water cannot be absorbed and will discharge directly to the underground drains. This use is also subject to visual acceptability by the community and building roof requirements i.e. steel reinforcement for a long span roof would not make this option a sustainable option.

The EA considers the reduction in surface water discharge when calculating surface water storage during storm events and therefore this option has the potential to reduce flood risk. On the EA's web-site⁷ there is an example that shows how the amount of interception storage can be calculated for a green roof assuming a 100mm thick substrate. In their example the EA determined that, for the assumed green roof, the rainfall depth that can be retained would be 24.5mm. Therefore, for a roof area of 10,000m² the interception storage would be 245m³.

Recommendations:

Source Control Methods are good environmental practices as they reduce water consumption and provide areas of habitat for birds and insects. Rainwater will be harvested from the roof of the stadium facility and green roofs will be installed above the food superstore and the residential buildings to both reduce flood risk and to achieve some Code for Sustainable Homes requirements. The varied levels of the residential facility's roofs would promote the use of different types of seeding and aggregates that will aid in biodiversity.

8.2.1.3. Swales

Definition: Vegetated landscape depressions with a gentle gradient to drain water evenly off impermeable surfaces, mimicking natural drainage patterns. Swales will be dry, but during periods of rainfall a swale will fill slowing and filtering flows through vegetation allowing minor infiltration. In areas where infiltration is not allowed a swale can be lined with an impermeable membrane.

Flood Risk Mitigation Suitability:

Swales will slow drainage flows through the site thereby aid in routing surface water flows across the site and reducing the time of flow concentration.

Recommendations:

Swales are not an option within this site since there is insufficient land available to make this option feasible and the underlying soils are clay with a low infiltration rate.

⁷ <http://www.environment-agency.gov.uk/regions/thames/323147/2093788/>

8.2.1.4. Filter Trenches (Filter Drains and Perforated Pipes)

Definition: Trenches that are filled with permeable material into which flows surface water from the edge of paved areas. A slotted or perforated pipe may be built into the base of the trench to collect and convey the water.

Flood Risk Mitigation Suitability:

Filter Trenches reduce surface water runoff reducing flood risk to adjacent properties, however their ability to attenuate flows is dependant on underlying soil conditions.

Recommendations:

Filter Trenches do not provide significant attenuation of surface water runoff and would not provide a viable option on this site.

8.2.1.5. Permeable Pavement:

Definition: A paving structure that allows rainwater to infiltrate through its surface via joints or voids between the blocks into the underlying layers where water is temporarily stored before infiltration to the ground, reuse or release into a watercourse or other drainage system.

Flood Risk Mitigation Suitability:

The main advantage of this option is the storage capacity within the pavement material reduces the use of storage tanks, cells or over sized pipes. A typical 350mm deep permeable pavement build up should produce 1 cubic meter of storage (through voids within the granular fill) for every 10 square metres of surface area; this is without infiltration to underlying soils, however if infiltration is possible this increases attenuation. A further advantage is that rainwater from buildings can be discharged directly within the pavement material removing the requirement for gullies as the paving is laid flat and surface water infiltrates evenly into the pavement material without ponding occurring.

Pavement material is however a higher quality material than that used in traditional road pavements resulting in additional costs. In addition, sub-base thickness (over and above those required structurally) lead to an increase in imported material and in sub-soil removed from site. Geotextile materials are also required between the granular layers, which increase the costs.

Recommendations:

Permeable pavement is not a viable option for this site since the areas north and south of the stadium will be artificially raised podiums and not compatible with permeable pavement systems. .

8.2.1.6. Basins and Ponds

Definition: Structures designed to attenuate flows by storing runoff during the storm and releasing it at a controlled rate during and after the storm.

Attenuation Ponds are ponds that have a permanent pool of water for water quality treatment. They provide temporary storage for additional storm runoff above the permanent water level (wet ponds may provide amenity and wildlife benefits)

Attenuation Basins are specially engineered depressions that are designed to temporarily store flood water in times of excessive rainfall utilising a restricted outfall structure.

Flood Risk Mitigation Suitability:

Attenuation Basins and Ponds all have potential to provide significant storage of surface water runoff and therefore reduce flood risk

Recommendations:

Site topography and proposed layouts show that the construction of basins or ponds is not a viable option for this previously developed site.

8.2.1.7. Infiltration Devices

Definition: Below ground or surface structures into which surface water is conveyed to allow infiltration into the ground to recharge groundwater sources. Constructing a series of small infiltration devices is a more efficient method of infiltration than a single large structure.

Examples:

Soakaways are permeable underground tanks that allow infiltration through the walls of the tank into the soil.

Infiltration Basins are grassy depressions that allow infiltration through the vegetative layer into the soil. It can be landscaped to provide aesthetic and amenity value.

Flood Risk Mitigation Suitability:

Soakaways or Infiltration Basins collect surface water runoff from the site reducing flood risk to surrounding properties or receiving watercourses.

Recommendations:

Use of soakaways for the attenuation of surface water runoff from the site is not a viable option due to underlying clay soils.

8.2.1.8. On-Site Storage

Definition: Storage constructed on individual development sites that does not use infiltration as the primary form of attenuation and is normally constructed below ground although this may be used in conjunction with other SUDS such as ponds and soakaways.

Examples:

Cellular Storage involves surface water runoff being stored in underground cells or tanks and discharging through a controlled vortex device.

Oversized Sewers are larger in diameter than required to convey 3.3% annual probability (1 in 30 years) storm event. The additional volume in the sewers can then be used in conjunction with swales and soakaways to detain a 1% annual probability (1 in 100 years) storm event. The use of oversized sewers helps reduce the required detention volume that needs to be accounted for in other SUDS devices.

Flood Risk Mitigation Suitability:

Significant attenuation of surface water runoff is possible using on-site storage thereby reducing flood risk to surrounding properties or receiving watercourses.

Recommendations:

Underground drainage storage using geo-cellular storage and oversized sewers are viable options for this site as they can be constructed in functional parking areas and pedestrian areas, therefore not reducing the developable land within this previously developed site.

8.2.1.9. Design for Exceedance

The proposed surface water management system will attenuate all events with a return period less than 30 years. For extreme events, with return periods in excess of 30 years, some controlled surface water flooding of the open spaces has been allowed for as described in *Designing for Exceedance in Urban Drainage*, CIRIA C635. It is estimated that during a 1% annual probability storm event the maximum depth of water would be 100mm. No flooding of property would occur. The maximum extent of this surface water flooding is shown on Figure 3.

The detailed surface water drainage design must demonstrate that the combination of the depth and velocity of the surface water in this area does not create a "Danger for Some", a "Danger for Most" or a "Danger for All" in accordance with Figure 2.1 *Combinations Of Flood Depth And Velocity That Cause Danger To People* within Defra guidance *Flood Risks to People FD2321/TR2*.

8.2.2. Attenuation Conclusions

The recommended SUDS methods for the site are to use on-site underground attenuation and oversized sewers in conjunction with controlled surface flooding of open spaces, as outlined above. Underground storage will be provided to attenuate a 1 in 30 yr storm event and rarer events will be attenuated on site by allowing some surface level flooding.

Rainwater will be harvested from the roof of the stadium facility and green roofs will be installed above the food superstore and the residential buildings to both reduce flood risk and to achieve some Code for Sustainable Homes requirements.

9. RESIDUAL RISKS

9.1. What flood-related risks will remain after you have implemented the measures to protect the site from flooding?

A very small residual risk will remain following development of this site during very extreme storm events from on-site over land flooding in the event the site drainage system is overwhelmed by the extreme storm, however finished floor levels are to be at or raised above the nearest 0.1% annual probability (1 in 1,000 year) flood levels for further protection from flooding. The ground floor levels of the residential, stadium and shopping centre facilities are 11.0mAOD, 12.0mAOD and 11.75mAOD, respectively.

9.2. How, and by whom, will these risks be managed over the lifetime of the development?

LBH, in partnership with the EA will ensure this development and any amendments to the site comply with this Flood Risk Assessment.

It is essential that the SUDS components be maintained on a regular basis to ensure that they function properly and avoid localised flooding of the site. The allocation of responsibility for the maintenance of SUDS should be resolved before planning approval for the development is given. Adoption and maintenance of the flood mitigation works and SUDS, and any private drainage must be arranged by negotiation and agreement between the developer and a suitable maintenance authority, e.g. LBH.

In the case of emergencies, LBH can maintain the surface water drainage system connections to the culverted Moselle Brook using their permissive powers under the Land Drainage Act.

Figures

1 - Location Plan

2 - 1000 Year Flood Extents Map

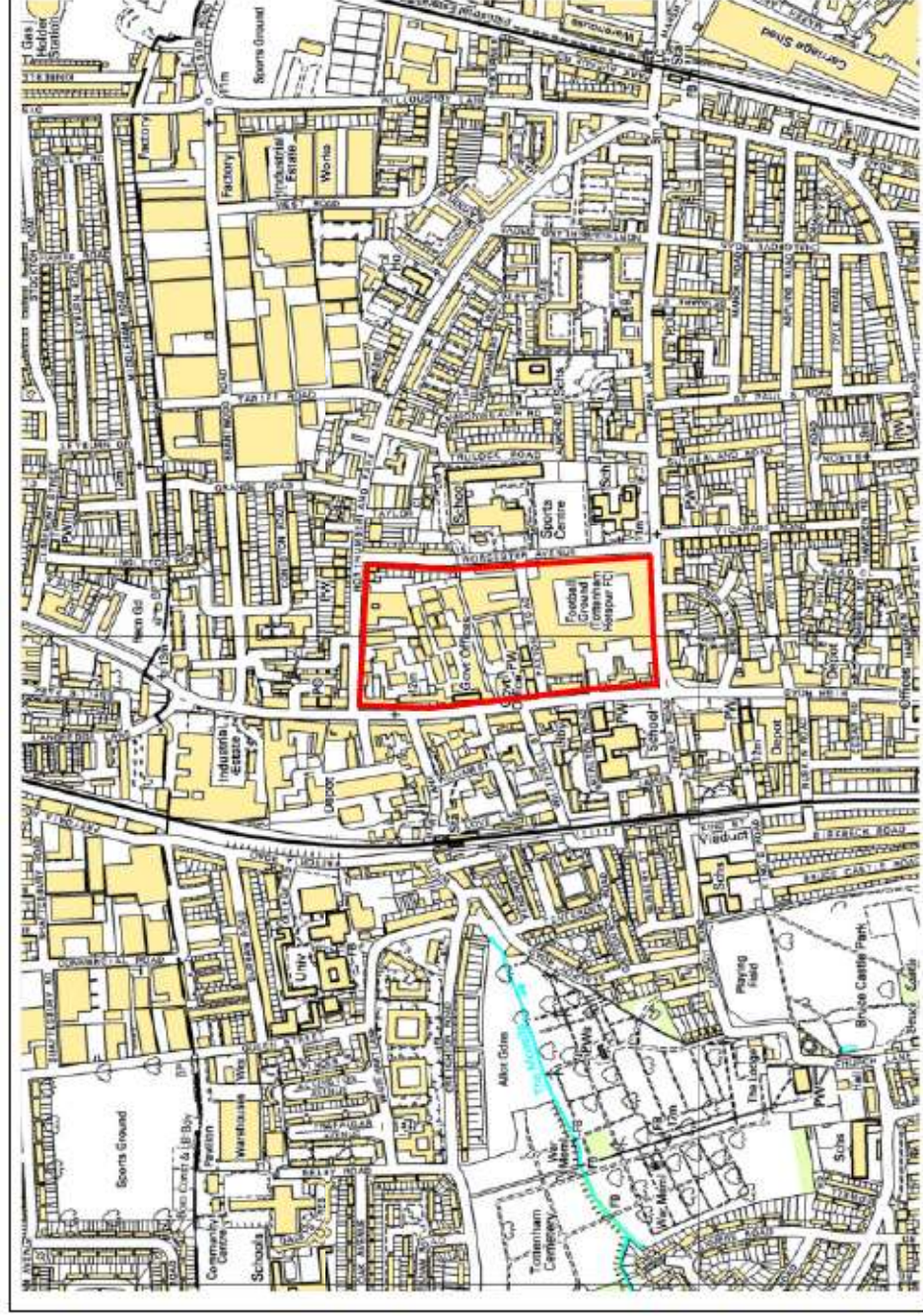
3 - Proposed SUDS Site Location

Figure 1: Location Plan

KEY



Project Area – Northumberland Development Project, North London
Post Code: N17 0TU
Grid Reference: TQ 341914
Ordnance Survey Coordinates: 534107E and 191404N



Legend

Flood Zone 2 -
1000 year flood extents

Site Area

Note

1000 year flood level based on TUFLOW Model and Modelled Outlines for Tottenham Hotspur Football Club, N17 0TU NE17149_SS. ©Environment Agency copyright and/or database right 2008. All rights reserved

Rev	Drawn	App'd	Date	Description
1	DF	JH	07/11/2008	Issue

ISSUED FOR INFORMATION

URS

Office of Origin

BE D FORD

Drawn	Check	Date	Drawn	Check	Date
DF	JH	07/11/2008	JH	JH	07/11/2008
DF	JH	07/11/2008	JH	JH	07/11/2008
DF	JH	07/11/2008	JH	JH	07/11/2008
DF	JH	07/11/2008	JH	JH	07/11/2008
DF	JH	07/11/2008	JH	JH	07/11/2008

DO NOT SCALE

Project

**NORTHUMBERLAND DEVELOPMENT
PROJECT
49326320**

Title

EA FLOOD ZONE 2

Fig.

002

Rev.

1

Sheet No.

1

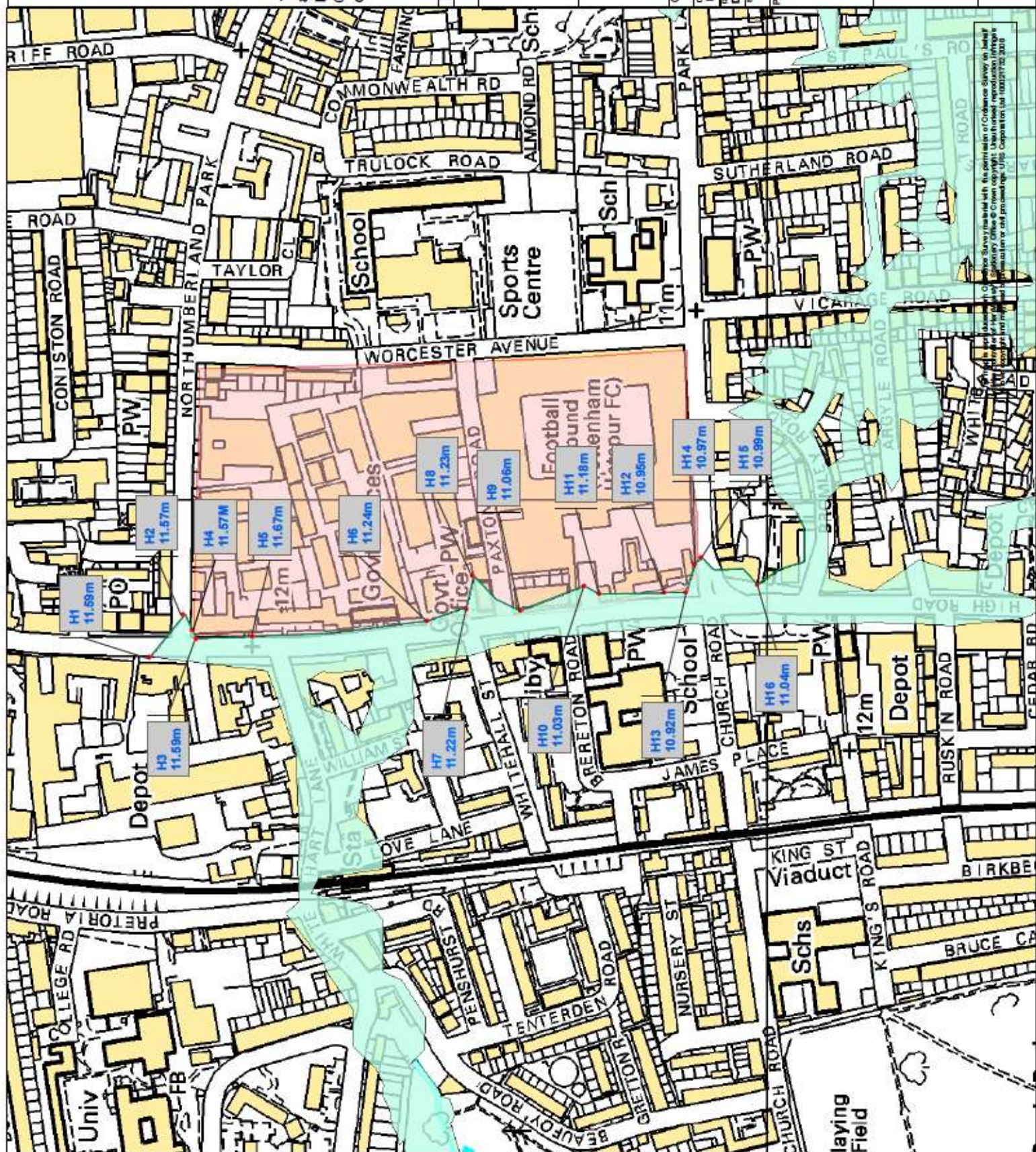
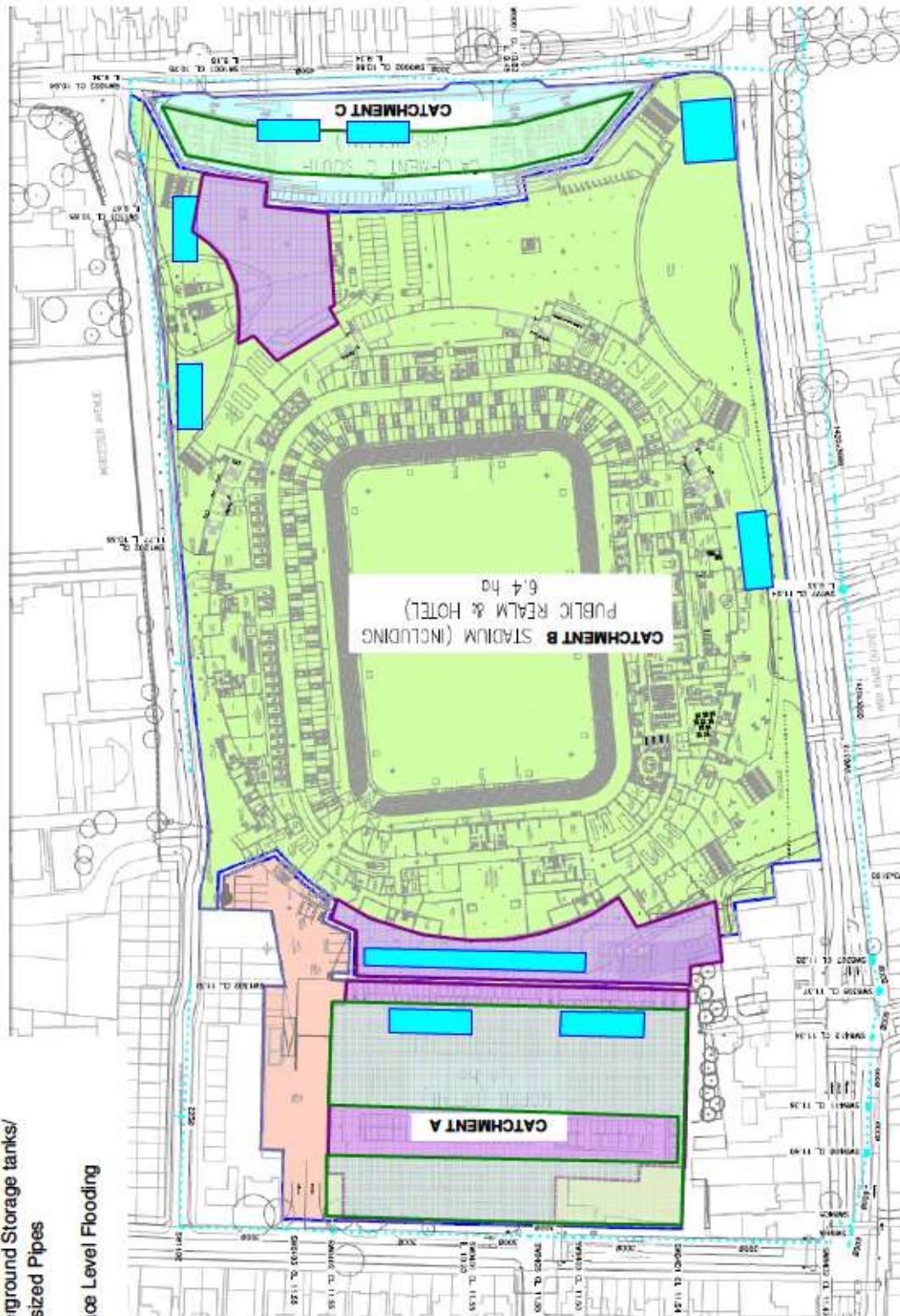


Figure 3: Proposed SUDS Site Location (Indicative)



Appendix A - Environment Agency Correspondence

Karen Denne
URS Corporation Ltd
URS House
Horne Lane
Bedford
MK40 1TS

Our ref: NE17149_SS

Date: 8 August 2008

Dear Ms Denne,

Enquiry regarding Tuflow Model and Modelled Outlines

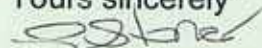
Thank you for your enquiry.

Please find enclosed all of the information you requested on four CD's.

Please Note the TUFLOW Model information are on 3 of the CD's.

If I can be of any further help, please contact me.

Yours sincerely



Sandra Stormer

External Relations Officer

Direct dial 01707 632301

Direct fax 01707 632 610

Direct email thnortheast@environment-agency.gov.uk



"Smith, Jasmine"
<Jasmine.Smith@environment-agency.gov.uk>

14/11/2008 14:15

To <Jennifer_Roberts@URSCorp.com>

cc

bcc

Subject RE: Northumberland Development Project (EA Ref#: NE17149)

History: This message has been forwarded.

Hi Jennifer,

I have been able to speak with an engineer and in answer to your questions:

1. You would not be expected to attenuate the areas outside the private development area as long as there are no proposed works or alterations there.
2. We are happy to allow the 1yr and 30yr storm durations to be attenuated to the 5.0l/s; providing the other storm durations are attenuated to Greenfield rates.

Please can you submit your draft FRA to Karen Foster, Planning Liaison Team, Environment Agency, 9th Floor, 30-34 Albert Embankment, London, SE1 7TL as a pre-planning enquiry. They will consult us and we will allocate an Engineer to review the FRA.

Best regards

Jasmine Smith

Development Control Assistant
Environment Agency - NE Thames

01707 632639 (725 2639)

01707 632515 (725 2515)

Apollo Court, 2 Bishops Square Business Park, St Albans Road West, Hatfield, AL10 9EX

Green Roofs: <http://www.environment-agency.gov.uk/greenroofs>

Guide For Developers: <http://www.environment-agency.gov.uk/developers>

From: Jennifer_Roberts@URSCorp.com [mailto:Jennifer_Roberts@URSCorp.com]

Sent: 14 November 2008 12:03

To: Smith, Jasmine

Subject: Northumberland Development Project (EA Ref#: NE17149)

Click [here](#) to report this email as spam.

Jasmine -

I have 2 questions for a Development Control officer regarding a scheme that I am working on located at post code: N17 0TU (Tottenham Hotspur Football Club). If possible, I would like for someone to get back with me today as I am trying to complete a draft of the FRA that I am authoring by the close of business today.

I have attached a plan of the area. The planning application area is bound in red. The private development areas are bound in blue. The areas in between are either not being redeveloped (ie. the housing at the north west corner and the north east corner) or are improvements to public roadways.

(See attached file: A612_081017.pdf)

My questions are as follows:

1. When preparing the FRA can I assume that the proposed private development would only have to attenuate the private development areas? It would stand to reason that the public roadways and the housing that is to remain would not have to be attenuated.

and

2. In accordance with the *R&D Technical Report W5-074/A Preliminary Rainfall Runoff Management for Developments, Revision C* by the Environment Agency, a minimum flow of 5.0l/s is allowed as the discharge rate from attenuation. In this proposed development's case, the London Borough of Haringey is requiring Greenfield discharge rates though Thames Water would allow existing Brownfield discharge rates. Due to the size of the development areas, the resulting Greenfield rates for the 1yr and 30yr storm events are below 5l/s. Am I allowed to design the attenuation to release the 5.0l/s for the 1yr and 30yr storms per the EA guidance referenced above based on the fact that Thames Water would allow a discharge rate that is at least 4 times the Greenfield discharge rate?

If you have any questions or need further information, please do not hesitate to call or e-mail.

Thank you!

Mrs. Jennifer H. Roberts, CEng MICE, PE(TX)
Senior Engineer
URS Corporation Ltd

URS House
Horne Lane
Bedford
MK40 1TS
Tel no: 01234 349641 (Office)
Tel no: 01234 373789 (Direct Dial)
Fax no: 01234 216268
e-mail : Jennifer_Roberts@URSCorp.com
www.urscorp.eu

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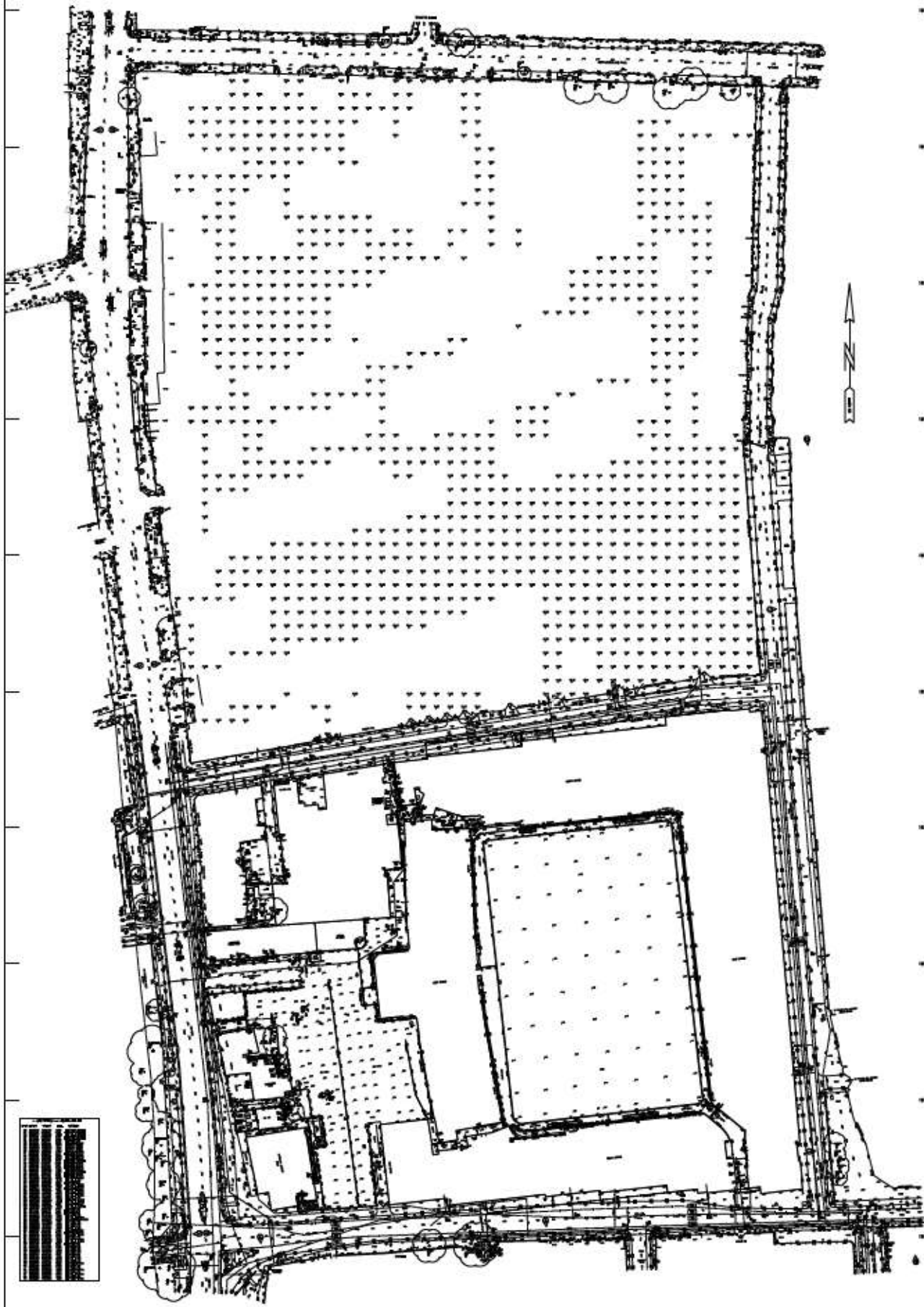
URS Corporation Limited
Place of registration: Scotland
Registered number: 118271
Registered office: 243 West George Street, Glasgow G2 4QE

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Appendix B - Topographical Plan of Existing Site

[illegible]

1

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1

UNCLASSIFIED EDITION INFORMATION	
ORIGIN	IS A SOURCE OF INFORMATION
RELIABILITY	IS A SOURCE OF INFORMATION
USE	IS A SOURCE OF INFORMATION
VALUE	IS A SOURCE OF INFORMATION
NOTE	IS A SOURCE OF INFORMATION

NO	DATE	BY	REVISION
KSS DESIGN GROUP 1 JAMES STREET LONDON W1U 1DR			
TOTTENHAM HOTSPUR FOOTBALL CLUB			
SITE SURVEY			

ISSUED 1 OF 1		SYSTEMS GROUP SLT 040	
SLIST JOB No.		SPURIOUS/2001	
SCALE 1/1000		WINDS 040%	
DATE IN	TIME	DATE IN	TIME
10-08-2001	OCT 2001	01-08-2001	OCT 2001

Appendix C - Thames Water Asset Location Search

Asset Location Search



Karen Denne
URS Corporation Ltd
URS House
Horne Lane
BEDFORD
MK40 1TS

Search address supplied High Road, Paxton Road
Worcester Avenue, Northumberland Park

Your reference N/A
Our reference ALS/ALS Standard/2008_1202140

Search date 13 June 2008

Thames Water Utilities Ltd

Property Insight
PO Box 3189
Slough SL1 4WW

DX 151280 Slough 13

T 0118 925 1504
F 0118 923 6655/57
E searches@thameswater.co.uk
I www.twpropertyinsight.co.uk

Registered in England and Wales
No. 2366661, Registered office
Cleanwater Court, Vastern Road
Reading RG1 8DB

Asset Location Search



Search address supplied: High Road, Paxton Road, Worcester Avenue,
Northumberland Park,

Dear Sir / Madam

An Asset Location Search is recommended when undertaking a site development. It is essential to obtain information on the size and location of clean water and sewerage assets to safeguard against expensive damage and allow cost-effective service design.

This search provides maps showing the position, size of Thames Water assets close to the proposed development and also manhole cover and invert levels, where available.

Please note that none of the charges made for this report relate to the provision of Ordnance Survey mapping information. The replies contained in this letter are given following inspection of the public service records available to this company. No responsibility can be accepted for any error or omission in the replies.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

Contact Us

If you have any further queries regarding this enquiry please feel free to contact a member of the team on 0118 925 1504, or use the address below:

Thames Water Utilities Ltd
Property Insight
PO Box 3189
Slough
SL1 4WW

Tel: 0118 925 1504
Fax: 0118 923 6657

Email: searches@thameswater.co.uk
Web: www.twpropertyinsight.co.uk

Thames Water Utilities Ltd

Property Insight
PO Box 3189
Slough SL1 4WW

DX 151280 Slough 13

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E searches@thameswater.co.uk
I www.twpropertyinsight.co.uk

Registered in England and Wales
No. 2366661, Registered office
Cleanwater Court, Vastern Road
Reading RG1 8DB

Asset Location Search



Waste Water Services

Please provide a copy extract from the public sewer map.

Enclosed is a map showing the approximate lines of our sewers. Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records such as "private" pipework are in some cases available from the Building Control Department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Ltd, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

The sewer level information contained in this response represents all of the level data available in our existing records. Should you require any further information, please refer to the relevant section within the 'Further Contacts' page found later in this document.

For your guidance:

- The Company is not generally responsible for rivers, watercourses, ponds, culverts or highway drains. If any of these are shown on the copy extract they are shown for information only.
- Sewers indicated on the extract of the public sewer map as being subject to an agreement under Section 104 of the Water Industry Act 1991 are not an 'as constructed' record. It is recommended that these details are checked with the developer.

Clean Water Services

Please provide a copy extract from the public water main map.

Enclosed is a map showing the approximate positions of our water mains and associated apparatus. Please note that records are not kept of the positions of individual domestic supplies.

For your information, there will be a pressure of at least 10m head at the outside stop valve. If you would like to know the static pressure, please contact our Customer Centre on 0845 920 0800. The Customer Centre can also arrange for a full flow and pressure test to be carried out for a fee.

Thames Water Utilities Ltd

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I www.twpropertyinsight.co.uk

Registered in England and Wales
No. 2366661, Registered office
Cleanwater Court, Vastern Road
Reading RG1 8DB

Asset Location Search



For your guidance:

- Assets other than vested water mains may be shown on the plan, for information only.
- If an extract of the public water main record is enclosed, this will show known public water mains in the vicinity of the property. It should be possible to estimate the likely length and route of any private water supply pipe connecting the property to the public water network.

Payment for this Search

An invoice is enclosed. Please send remittance to Thames Water Utilities Ltd., PO Box 223, Swindon, SN38 2TW.

Thames Water Utilities Ltd

Property Insight
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Slough SL1 4WW

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E searches@thameswater.co.uk
I www.twpropertyinsight.co.uk

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Cleanwater Court, Vastern Road
Reading RG1 8DB

Asset Location Search



Further contacts:

Waste Water queries

Should you require verification of the invert levels of public sewers, by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our Customer Center on Tel: 0845 920 0800. Alternatively, a survey can be arranged, for a fee, through our Customer Centre on the above number.

If you have any questions regarding sewer connections, building over issues or any other questions regarding operational issues please direct them to our service desk. Which can be contacted by writing to:

Developer Services (Waste Water)
Thames Water
Clear Water Court
Vastern Road
Reading
RG1 8DB

Tel: 0845 850 2777
Fax: 0118 923 6613
Email: developer.services@thameswater.co.uk

Should you require any further information regarding budget estimates, diversions or stopping up notices then please contact:

DevCon Team
Asset Investment
Thames Water
Maple Lodge STW
Denham Way
Rickmansworth
Hertfordshire
WD3 9SQ

Tel: 01923 898 072
Fax: 01923 898 106
Email: devcon.team@thameswater.co.uk

Thames Water Utilities Ltd

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E searches@thameswater.co.uk
I www.twpropertyinsight.co.uk

Registered in England and Wales
No. 2366661, Registered office
Clearwater Court, Vastern Road
Reading RG1 8DB

Asset Location Search



Clean Water queries

Should you require any advice concerning clean water operational issues or clean water connections, please contact our Kew Service Desk by writing to:

Clean Water Design
Thames Water Utilities
1 Kew Bridge Road
Brentford
Middlesex
TW8 0EF

Tel: 0845 850 2777
Fax: 0208 213 8833
Email: developer.services@thameswater.co.uk

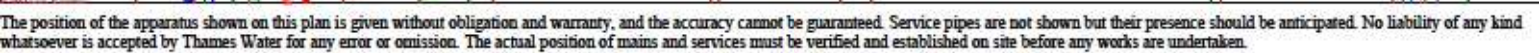
Thames Water Utilities Ltd

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T 0118 925 1504
F 0118 923 6655/57
E searches@thameswater.co.uk
I www.twpropertyinsight.co.uk

Registered in England and Wales
No. 2366661, Registered office
Cleanwater Court, Vastern Road
Reading RG1 8DB

Comments:
SEWERS

Printbox (533843,191191) -> (534161,191509)

Central Mapsheet : TQ3491SW

User : A1CLARK

Time : Fri Jun 13 11:56:15 2008

The position of apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be ascertained on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates no survey information is available.

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At (534140,191439)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534140,191454)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534140,191405)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534141,191464)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534141,191420)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534094,191349)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534095,191347)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534100,191412)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534126,191388)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534139,191351)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534141,191433)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534140,191391)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534136,191350)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534123,191349)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534100,191421)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534101,191413)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534101,191418)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534108,191346)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534058,191286)	there is a MANHOLE with SHORT NUMBER=0201	COVER=	12.15	INVERT=	10.97
At (534060,191285)	there is a MANHOLE with SHORT NUMBER=0202	COVER=	12.11	INVERT=	11.31
At (534063,191265)	there is a MANHOLE with SHORT NUMBER=0203	COVER=	11.94	INVERT=	11.04
At (534061,191262)	there is a MANHOLE with SHORT NUMBER=0204	COVER=	11.84	INVERT=	10.76
At (534042,191240)	there is a MANHOLE with SHORT NUMBER=0205	COVER=	11.72	INVERT=	10.21
At (534065,191244)	there is a MANHOLE with SHORT NUMBER=0206	COVER=	11.66	INVERT=	10.19
At (534067,191244)	there is a MANHOLE with SHORT NUMBER=0207	COVER=	11.76	INVERT=	10.60
At (534013,191479)	there is a MANHOLE with SHORT NUMBER=0401	COVER=	11.58	INVERT=	10.31
At (534021,191482)	there is a MANHOLE with SHORT NUMBER=0402	COVER=	11.69	INVERT=	10.10
At (534066,191478)	there is a MANHOLE with SHORT NUMBER=0403	COVER=	11.60	INVERT=	10.35
At (534089,191481)	there is a MANHOLE with SHORT NUMBER=0404	COVER=	11.74	INVERT=	9.91
At (534124,191232)	there is a MANHOLE with SHORT NUMBER=1201	COVER=	11.86	INVERT=	10.47
At (534123,191230)	there is a MANHOLE with SHORT NUMBER=1202	COVER=	11.84	INVERT=	10.38
At (534122,191399)	there is a MANHOLE with SHORT NUMBER=1301	COVER=	11.74	INVERT=	10.54
At (534116,191316)	there is a MANHOLE with SHORT NUMBER=1304	COVER=	11.82	INVERT=	10.98
At (534123,191478)	there is a MANHOLE with SHORT NUMBER=1401	COVER=	11.69	INVERT=	9.84
At (534120,191476)	there is a MANHOLE with SHORT NUMBER=1402	COVER=	11.60	INVERT=	10.40
At (533870,191238)	there is a MANHOLE with SHORT NUMBER=8224	COVER=	11.37	INVERT=	9.87
At (533867,191241)	there is a MANHOLE with SHORT NUMBER=8225	COVER=	11.41	INVERT=	10.38
At (533866,191390)	there is a MANHOLE with SHORT NUMBER=8306	COVER=	11.37	INVERT=	9.64
At (533861,191304)	there is a MANHOLE with SHORT NUMBER=8310	COVER=	11.30	INVERT=	10.15
At (533864,191307)	there is a MANHOLE with SHORT NUMBER=8311	COVER=	11.36	INVERT=	10.09
At (533856,191333)	there is a MANHOLE with SHORT NUMBER=8331	COVER=	-9999.00	INVERT=	-9999.00
At (533871,191484)	there is a MANHOLE with SHORT NUMBER=8404	COVER=	11.46	INVERT=	9.91
At (533870,191479)	there is a MANHOLE with SHORT NUMBER=8405	COVER=	11.42	INVERT=	9.88
At (533866,191479)	there is a MANHOLE with SHORT NUMBER=8406	COVER=	11.61	INVERT=	10.65
At (533864,191472)	there is a MANHOLE with SHORT NUMBER=8407	COVER=	11.80	INVERT=	10.93
At (533871,191449)	there is a MANHOLE with SHORT NUMBER=8408	COVER=	11.41	INVERT=	9.83
At (533870,191433)	there is a MANHOLE with SHORT NUMBER=8411	COVER=	11.34	INVERT=	9.80

Printbox (533843,191191) -> (534161,191509)

Central Mapsheet : TQ3491SW

User : A1CLARK

Time : Fri Jun 13 11:56:15 2008

The position of apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be ascertained on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates no survey information is available.

At (533870,191408)	there is a MANHOLE with SHORT NUMBER=8412	COVER=	11.35	INVERT=	9.75
At (533864,191403)	there is a MANHOLE with SHORT NUMBER=8413	COVER=	11.35	INVERT=	8.37
At (533993,191509)	there is a MANHOLE with SHORT NUMBER=9510	COVER=	11.79	INVERT=	10.75
At (534095,191375)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534096,191400)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534096,191368)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534096,191380)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534096,191399)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534099,191399)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534100,191400)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534101,191450)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534102,191451)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534124,191386)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534123,191370)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534108,191350)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534108,191376)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534109,191399)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534113,191399)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534113,191415)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534113,191427)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534114,191450)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (533842,191296)	there is a MANHOLE with SHORT NUMBER=8220	COVER=	11.56	INVERT=	10.30
At (533852,191265)	there is a MANHOLE with SHORT NUMBER=8221	COVER=	11.91	INVERT=	10.10
At (533852,191236)	there is a MANHOLE with SHORT NUMBER=8222	COVER=	11.86	INVERT=	10.55
At (533854,191234)	there is a MANHOLE with SHORT NUMBER=8223	COVER=	11.86	INVERT=	10.06
At (533878,191238)	there is a MANHOLE with SHORT NUMBER=8226	COVER=	11.08	INVERT=	-9999.00
At (533879,191243)	there is a MANHOLE with SHORT NUMBER=8227	COVER=	11.06	INVERT=	9.33
At (533897,191244)	there is a MANHOLE with SHORT NUMBER=8228	COVER=	10.86	INVERT=	8.47
At (533896,191254)	there is a MANHOLE with SHORT NUMBER=8229	COVER=	10.85	INVERT=	10.05
At (533893,191202)	there is a MANHOLE with SHORT NUMBER=8233	COVER=	10.74	INVERT=	9.71
At (533884,191385)	there is a MANHOLE with SHORT NUMBER=8308	COVER=	11.25	INVERT=	10.42
At (533881,191398)	there is a MANHOLE with SHORT NUMBER=8309	COVER=	11.43	INVERT=	8.76
At (533889,191310)	there is a MANHOLE with SHORT NUMBER=8313	COVER=	11.03	INVERT=	8.57
At (533885,191487)	there is a MANHOLE with SHORT NUMBER=8401	COVER=	11.46	INVERT=	10.09
At (533884,191483)	there is a MANHOLE with SHORT NUMBER=8402	COVER=	11.55	INVERT=	-9999.00
At (533881,191485)	there is a MANHOLE with SHORT NUMBER=8403	COVER=	11.52	INVERT=	9.20
At (533881,191447)	there is a MANHOLE with SHORT NUMBER=8409	COVER=	11.52	INVERT=	9.02
At (533900,191217)	there is a MANHOLE with SHORT NUMBER=9201	COVER=	10.89	INVERT=	8.35
At (533903,191207)	there is a MANHOLE with SHORT NUMBER=9203	COVER=	10.82	INVERT=	9.77
At (533935,191220)	there is a MANHOLE with SHORT NUMBER=9204	COVER=	11.36	INVERT=	9.88



ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

	Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.
	Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.
	Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.
	Joint
	Trunk Surface Water
	Trunk Foul
	Trunk Combined
	Bio-solids (Sudge)
	Vent Pipe
	Proposed Thames Surface Water Sewer
	Proposed Thames Foul Sewer
	Gallery
	Surface Water Rising Main
	Sudge Rising Main
	Vacuum
	Siphon

Notes:

- 1) All levels associated with the plans are to Ordnance Datum Newlyn.
- 2) All measurements on the plans are metric.
- 3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
- 4) For symbols referred to as 'Other' on this key, please see the plan for further information.
- 5) Most private pipelines are not shown on our plans, as in the past, this information has not been recorded.

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

	AV	Air Valve
	LH	Lamp Hole
	BS	Blind Shaft
	LS	Lifting Shaft
	CP	Catch Pit
	ME	Meter
	DC	Dam Chase
	RE	Rodding Eye
	VC	Vent Column
	VT	Vent
	HB	Hatch Box
	WO	Washout
	Other (specified on plan)	

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

	BD	Backdrop Manhole
	HY	Hydrobrake
	BV	Butterfly Valve
	RI	Retrol Interceptor
	CL	Clough
	PS	Penstock
	DB	Dam Board
	RV	Reflux Valve
	DP	Drop Pipe
	ST	Step
	DS	Drop Shaft
	SV	Sluice Valve
	TA	Tank
	FL	Flume
	FV	Flap Valve
	WW	Weir
	HW	Headwall
	Other (specified on plan)	

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol. Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

	STW	Effluent Discharge
		Undefined End
	SA / SA	Sewer Access / Salsaway
	GU	Gully
		Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

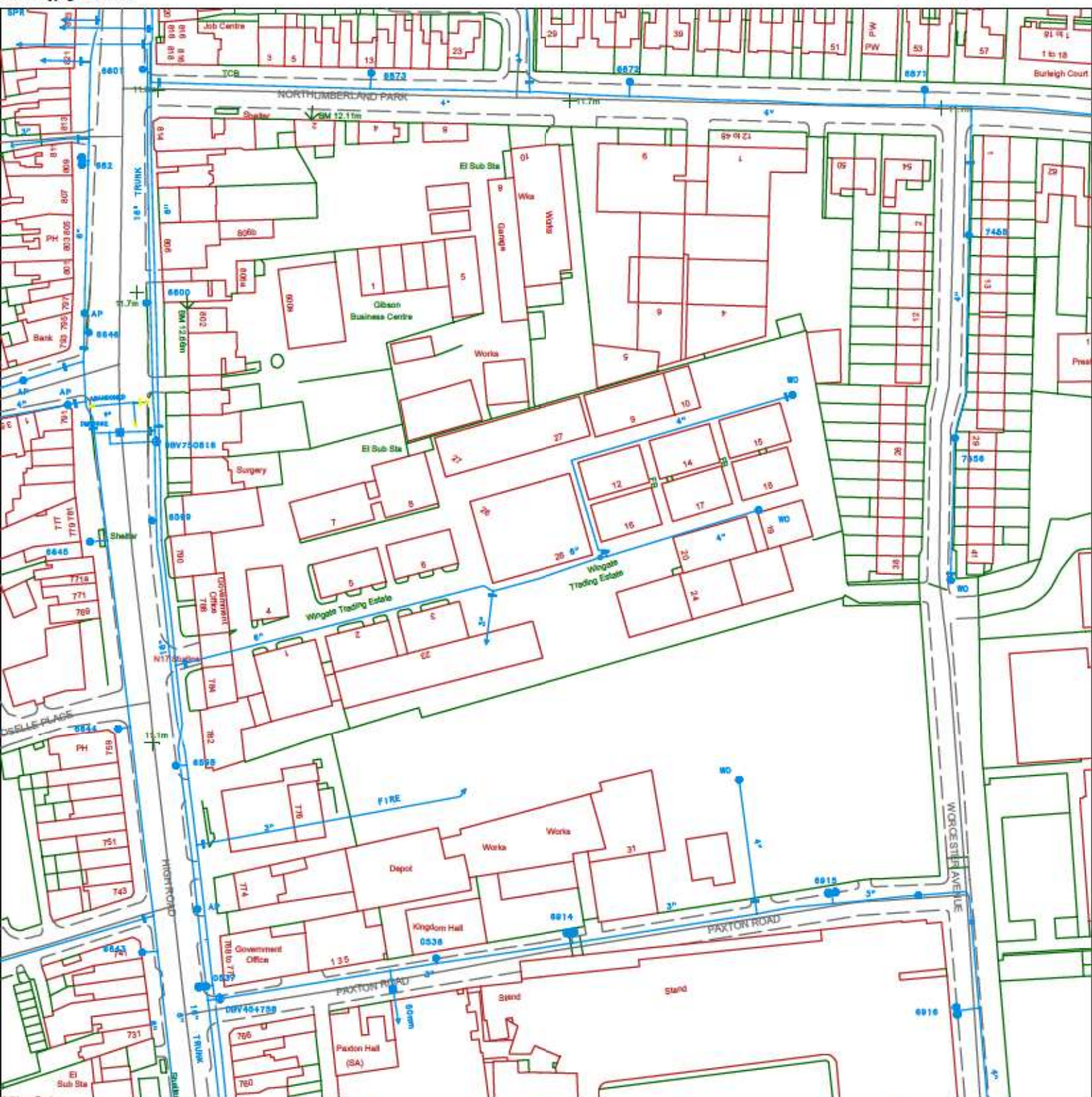
	▲ / ▲	Rubbish of Private Pumping Station
	!	Change of characteristic indicator (C.O.C.I.)
	◆	Sewage Treatment Works
	+ IL	Invert Level
	△	Summit
		Areas
		Lines denoting areas of underground surveys, etc.
	□	Building over Case (BOC No.) or Low Lying Land (LL No.)
	□	Sewage Treatment Works or Pumping Station
	□	Area under Adoption Agreement
	□	Survey Area
	□	Drawing Area or chamber
	□	Licence Area
	□	Area pending Adoption Agreement
	□	Other Area (specified on plan)

Other Sewer Types (Not Operated or Maintained by Thames Water)

	—●—	Foul Sewer
	—○—	Surface Water Sewer
	—●—	Combined Sewer
	— —	Highway Drain
	—~—	Quarried Watercourse
	—●—	Status Unknown
	— —	Proposed
	— —	Abandoned Sewer

6) -9999.00 or 0 on a manhole level indicates that data is unavailable.

7) The text appearing alongside a sewer line indicates the internal diameter of the pipe in millimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. When cover and invert levels appear on a plan they are clearly prefixed by 'CL' and 'IL'. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0118 925 1504.





ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Raw Water Main: A main that carries untreated water rather than water that is safe to drink. These mains are usually found near reservoirs where their purpose is to link reservoirs or to feed untreated water from a reservoir into a water treatment works.

Other (Specified on plan)

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number or are generally included near the main.

Depth of Water Pipes (Normal Cover)

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Hydrants



The abbreviations below indicate the use of the hydrant symbols above.

- FH Fire Hydrant
- WO Washout
- RWH Raw Water Hydrant
- P Private Hydrant

Meters



The abbreviations below indicate the use of the meter symbol above. Meter symbols without an abbreviation should be taken as revenue meters.

- ZM Zonal
- DM District
- WM Waste

Valves



The abbreviations below indicate the type of the valve symbol above.

- BF Butterfly
- BP Bypass
- EV Emptying
- SV Sluice
- Open General Purpose Valve
- Closed General Purpose Valve

The abbreviations below indicate the use of the valve symbol above.

- DBV District Boundary Valve
- DIV District Pressure Valve
- PBV Pressure Boundary Valve
- SSV Stand Shut Valve
- ZBV Zonal Boundary Valve
- ZZ Other (specified on plan)
- Air Valve

The abbreviations below indicate the use of the valve symbol above.

- AV Air Valve
- AC Air Cock (manual air valve)
- AAV Automatic Air Valve

The abbreviations below indicate the use of the valve symbol above.

- PS Pressure Sustaining
- PC Pressure Controlling
- Pressure Reducing
- Reflux Non-Return Valve (NRA)
- Stopcock

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Supply Assets



The abbreviations below indicate the use of the supply asset symbol above.

- BS Booster Station
- PS Pumping Station
- S Inspection Shaft
- SP Pumping Shaft
- SR Service Reservoir
- TO Tower
- TW Treatment Works
- XX Other (specified on plan)

Other Symbols

- Protection Test Point
- Protection Point / Anode
- Pressure Transducer / Critical Pressure Point
- Data Logger
- Tellernary Pit / Chamber
- Other (specified on plan)

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indicates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

Terms and Conditions

All sales are made in accordance with Thames Water Utilities Limited (TWUL) standard terms and conditions unless previously agreed in writing.

1. All goods remain in the property of Thames Water Utilities Ltd until full payment is received.
2. Provision of service will be in accordance with all legal requirements and published TWUL policies.
3. All invoices are strictly due for payment 14 days from due date of the invoice. Any other terms must be accepted/agreed in writing prior to provision of goods or service, or will be held to be invalid.
4. Thames Water does not accept post-dated cheques-any cheques received will be processed for payment on date of receipt.
5. In case of dispute TWUL's terms and conditions shall apply.
6. Penalty interest may be invoked by TWUL in the event of unjustifiable payment delay. Interest charges will be in line with UK Statute Law 'The Late Payment of Commercial Debts (Interest) Act 1998'.
7. Interest will be charged in line with current Court Interest Charges, if legal action is taken.
8. A charge may be made at the discretion of the company for increased administration costs.

A copy of Thames Water's standard terms and conditions are available from the Commercial Billing Team (TW.cashoperations@npower.com).

We publish several Codes of Practice including a guaranteed standards scheme. You can obtain copies of these leaflets by calling us on 0845 9200 800.

If you are unhappy with our service you can speak to your original goods or customer service provider. If you are not satisfied with the response, your complaint will be reviewed by the Customer Services Director. You can write to him at: Thames Water Utilities Ltd. PO Box 492, Swindon, SN38 8TU.

If the Goods or Services covered by this invoice falls under the regulation of the 1991 Water Industry Act, and you remain dissatisfied you can refer your complaint to WaterVoice Thames on 0845 758 1658 (it will cost you the same as a local call) or write to them at 4th Floor (South), High Holborn House, 52-54 High Holborn, London WC1V 6RL.

Ways to pay your bill

By Post – Cheque only, made payable to 'Thames Water Utilities Ltd' writing your Thames Water account number on the back. Please fill in the payment slip below and send it with your cheque to Thames Water Utilities Ltd., PO Box 223, Swindon SN38 2TW	By BACS Payment direct to our bank on account number 90478703, sort code 60-00-01 may be made. A remittance advice must be sent to Thames Water Utilities Ltd., PO Box 223, Swindon SN38 2TW. Or fax to 01793 424599 or email: cashoperations@thameswater.co.uk	Telephone Banking By calling your bank and quoting your invoice number and the Thames Water's bank account number 90478703 and sort code 60-00-01	By Swift Transfer You may make your payment via SWIFT by quoting NWBKGB2L together with our bank account number 90478703, sort code 60-00-01 and invoice number
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Thames Water Utilities Ltd Registered in England & Wales No. 2366661 Registered Office Clearwater Court, Vastern Rd, Reading, Berks, RG1 8DB.



ADE/221079

CHEW ANTHERA
12th December 2004

URS
URS HOUSE
HORNE LANE
BEDFORD
MK40 1TS



Dear Sirs,

-TOTTENHAM HOTSPUR FOOTBALL CLUB WHITE HART LANE

In response to your enquiry dated 3rd December 2004 concerning the above property, I am able to comment as follows:-

An invoice for the sum of forty-two pounds and thirty pence (£42.30), inclusive of VAT will be forwarded to you in due course.

None of the charges made for this report relate to the provision of Ordnance Survey mapping information.

Enclosed is a map showing the approximate positions of our water mains and associated apparatus.

Please note that records are not kept of the positions of individual domestic supplies.

If you need advice concerning any clean water operational issues please contact our Kew Service Desk on TEL: 0845 850 2777. Alternatively write to :

Clean Water Design
Thames Water
1 Kew Bridge Road
Brentford
TW8 0EF

Enclosed is a map showing the approximate lines of our sewers. If you have any questions regarding diversions or any other questions regarding operational issues please direct them to our service desk which can be contacted on TEL: 0845 850 2777. Alternatively write to:

Developer Services Waste
Thames Water,
1 Kew Bridge Road,
Brentford,

Thames Water Utilities Ltd

Asset Data Services
Blake House
1st Floor, Road
Reading RG2 0JN
Tel: 0118 923 6664
Fax: 0118 923 6669
Email: searches@thameswater.co.uk
I www.twsearches.co.uk
Registered in England and Wales
No. 2766661. Registered office
Clearwater Court, Vastern Road
Reading RG1 8PB



Middlesex,
TW8 0EF.

Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records of such "private" pipework are in some cases available from the building control department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Limited, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

If you require to verify the invert levels of the public sewers by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our main customer call centre number 0845 9200 800.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

The replies contained in this letter are given following inspection of the public sewer and water maps and the records available to this Company. No responsibility can be accepted for any error or omission in the replies.

Any general questions you may have should be directed to the Customer Call Centre on 0845 200 800 (all calls charged at local rate).

Should you have any difficulties with any map information that may have been provided for this particular site, please contact Ken Fai Lau on 01189 236630.

Yours faithfully,

Ken Fai Lau
(Asset Data Searches Team)

Thames Water Utilities Ltd
Asset Data Services
Blake House
Manor Farm Road
Reading RG2 0JN
DX 132045 Reading 11
T 0118 923 6664
F 0118 923 6669
E searches@
thameswater.co.uk
I www.twsearches.co.uk
Registered in England and Wales
No. 2366661. Registered office
Clearwater Court, Vastern Road
Reading RG1 8DH

*Need details
about 100m smt*



ADS Water Map Key

If you have any queries about the symbols on this key call the relevant number below:

Asset Location Team: 0118 923 6664
Commercial Drainage & Water Team: 0118 923 6652

Water Pipes

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

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Raw Water Main: A main that carries untreated water rather than water that is safe to drink. These mains are usually found near reservoirs where their purpose is to link reservoirs or to feed untreated water from a reservoir into a water treatment works.

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our fresh water coverage area. These mains are denoted in purple and in most cases have owner of the pipe along them.

Other (Specified on the plan)

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are included near the main.

Private Main: Indicates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

Hydrants

- Single Hydrant
- Double Hydrant

The abbreviations below indicate the use of the hydrant symbols above.

- PH Fire Hydrant
- WO Washout
- RWH Raw Water Hydrant
- P Private Hydrant

Meters

- Meter

The abbreviations below indicate the use of the meter symbol above. Meter symbols without an abbreviation should be taken as revenue meters.

- ZM Zonal
- DM District
- WM Waste

Valves

- Open General Purpose Valve

The abbreviations below indicate the use of the valve symbol above.

- BF Butterfly
- BP Bypass
- EV Emptying
- WW Waste Water

- Closed General Purpose Valve

The abbreviations below indicate the use of the valve symbol above.

- DB District Boundary
- SS Stand Shut
- ZV Zonal Pressure Valve
- ZZ Other (specified on plan)

- Air Valve

The abbreviations below indicate the use of the valve symbol above.

- AV Air Valve
- AC Air Cock (manual air valve)
- AAV Automatic Air Valve

The abbreviations below indicate the use of the valve symbol above.

- PS Pressure Sustaining
- PC Pressure Controlling
- Pressure Reducing
- Reflux
- Stopcock

End items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold

Supply Assets

-

The abbreviations below indicate the use of the supply asset symbol above.

- BS Booster Station
- PS Pumping Station
- SI Inspection Shaft
- SP Pumping Shaft
- SR Service Reservoir
- TO Tower
- TW Tower Works
- XX Other (specified on plan)

Other Symbols

- Protection Test Point
- Protection Point / Anode
- Pressure Transducer
- Data Logger
- Telemetry Pit
- Other (specified on plan)

Depth of Water Pipes (Normal Cover)

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

For enquiries about the depth of transmission tunnels, please ring the number at the top of this key.



ADS Sewer Map Key

If you have any queries about the symbols on this key call the relevant number below:

Asset Location Team: 0118 923 6664

**Commercial Drainage
& Water Team: 0118 923 6652**

Common public sewers

Foul:

A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water:

A sewer used to convey surface water (eg: rain water from roofs, yards and car parks) to watercourses or rivers.

Combined:

Both surface water and foul sewage flow in the same pipe.

Other public sewers

Joint

Trunk Foul

Trunk Surface Water

Trunk Combined

Abandoned

Storm Relief

Bio-Solids (Sludge)

Vent Pipe

Trade Effluent

Proposed

Culverted Watercourse

Gully

Foul Rising Main

Surface Water Rising Main

Combined Rising Main

Sludge Rising Main

Other

Sewer Fittings

A feature in a sewer that does not affect the flow of liquid in the pipe.
Example: a Vent is a fitting as the function of a vent is to release excess gas.

◆ AV	Air Valve	■ LH	Lamp Hole
⋈ BS	Blind Shaft	● LS	Lifting Shaft
■ CP	Catch Pit	■ ME	ME
└ DC	Dam Chase	● RE	Rodding Eye
⋈ DF	Double Flushing Tank / Chamber	■ PT	Test Point
└ SF	Single Flushing Tank / Chamber	■ VC	Vent Column
● GP	Gauging Point	■ VT	Vent
□ GU	Gully	■ XX	Other (specified on plan)
□ HB	Hatch Box		

Operational Controls

A feature in a sewer that changes or diverts the flow of liquid in the sewer.
Example: A hydrobrake limits the flow of liquid passing downstream.

└ BB	Baffle Board	⊙ HY	Hydrobrake
● DD	Backdrop Manhole	■ PI	Petrol Interceptor
⋈ BV	Butterfly Valve	└ PS	Penstock
└ CL	Clough	■ RV	Reflux Valve
└ DB	Dam Board	└ ST	Step
└ DP	Drop Pipe	└ SV	Sluice Valve
● DS	Drop Shaft	■ TA	Tank
└ FL	Flume	└ WB	Weir Board
└ FV	Flap Valve	└ WW	Weir
└ HW	Headwall	■ XX	Other (specified on map)

NOTES:

- 1) All levels associated with digital plans are to Ordnance Datum Newlyn.
- 2) All measurements on digital maps are metric.
- 3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
- 4) For symbols referred to as 'Other' on this key, please see digitised plan for further information.
- 5) Most private pipe work is not shown on our maps, as in the past, this information has not been recorded.

End Items

An end symbol is what happens at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, and Outfall on a surface water sewer indicates that pipe empties into a stream or river.

└ STW	Effluent Discharge	└	Undefined End
⊙	Soakaway	└	Inlet
└	Outfall		

Other Symbols

Symbols used on maps which do not fall under other general categories.

◆	Sewage Treatment Works	△	Summit
▲	Pumping Station	⋈	Change of characteristic indicator (C.O.C.I)
+ IL	Invert Level		

Areas

Lines denoting areas of underground surveys, etc.

└	Building over Case (BOC No.) or Low Lying Land (LLL No.)	└	Licence Area
└	Drawing Area	└	Survey Area
└	Sewage Treatment Works or Pumping Station	└	Area under Adoption
└	Retention Tank area	└	Other Area (Specified on plan)

Private Sewer Types

└	Foul
└	Surface Water
└	Combined
└	Highway Drain
└	Culvert

6) -9999.00 or 0 on manhole level indicates that data is unavailable.

7) The text appearing alongside a sewer line indicates the internal diameter of the pipe in millimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. When cover and invert levels appear on a plan they are clearly prefixed by 'CL' and 'IL'. If you are unsure about any text on the plan, please contact the relevant team on the number at the top of this key.

Printbox (533824,190956) -> (534223,191355)

Central Mapsheet : TQ3491SW

User : JHOLECEK

Time : Fri Dec 10 15:52:32 2004

The position of apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence shall be established on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates no survey information is available.

At (533918,190964)	there is a MANHOLE with SHORT NUMBER=9904	COVER=	10.55	INVERT=	7.84
At (533918,190962)	there is a MANHOLE with SHORT NUMBER=9905	COVER=	10.54	INVERT=	7.83
At (533926,190962)	there is a MANHOLE with SHORT NUMBER=9906	COVER=	10.66	INVERT=	9.02
At (533914,191163)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (533915,191162)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (533856,191024)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534094,191349)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534136,191350)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534108,191346)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534139,191351)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534095,191347)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534123,191349)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (533931,191177)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (533932,191177)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00

Printbox (533824,190956) -> (534223,191355)

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NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates no survey information is available.

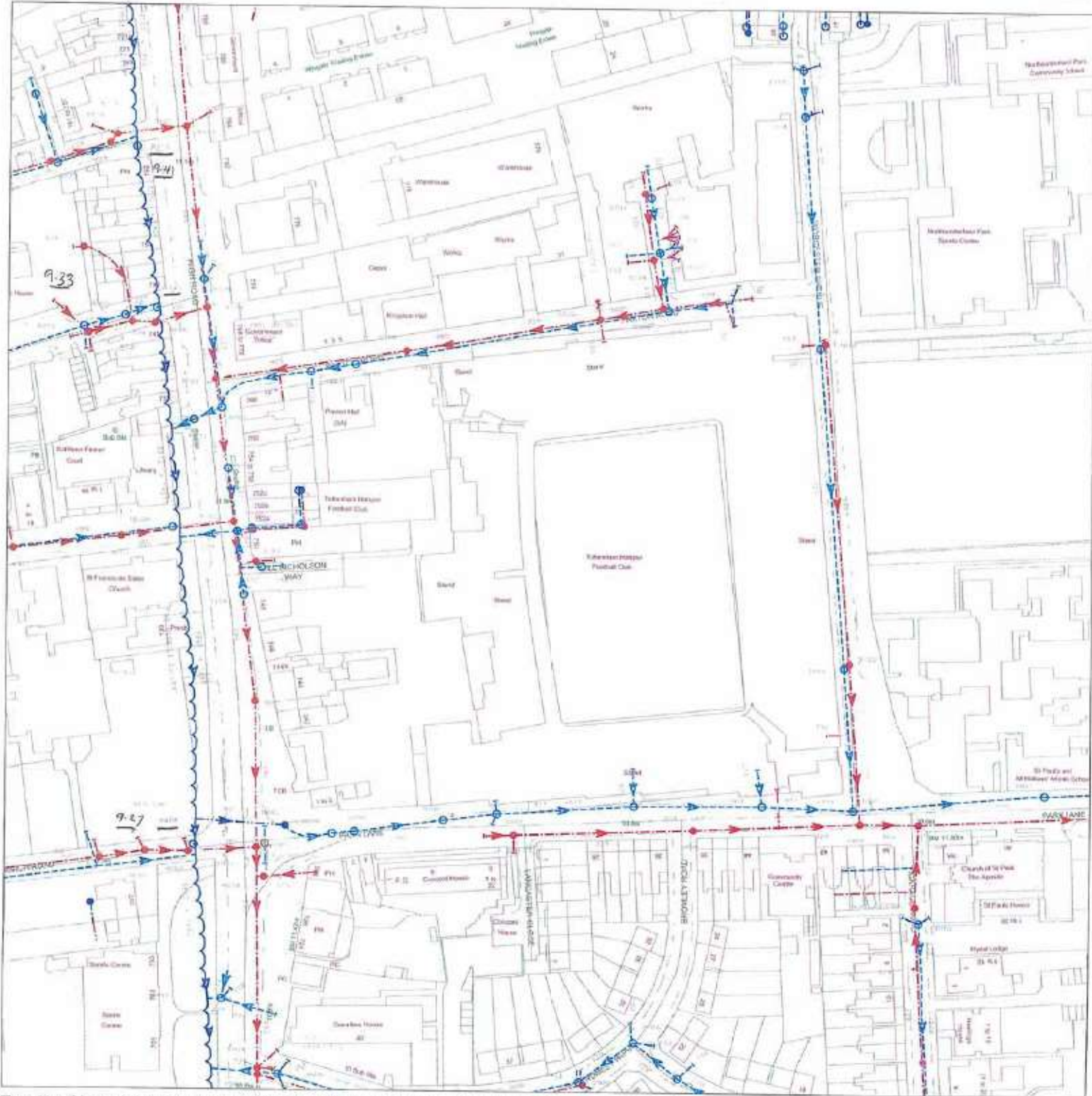
At (534005,191058)	there is a MANHOLE with SHORT NUMBER=0001	COVER=	10.89	INVERT=	9.45
At (534055,191061)	there is a MANHOLE with SHORT NUMBER=0002	COVER=	10.78	INVERT=	9.34
At (534011,191050)	there is a MANHOLE with SHORT NUMBER=0003	COVER=	10.80	INVERT=	9.74
At (534077,191053)	there is a MANHOLE with SHORT NUMBER=0006	COVER=	10.67	INVERT=	9.13
At (534058,191286)	there is a MANHOLE with SHORT NUMBER=0201	COVER=	12.15	INVERT=	10.97
At (534060,191285)	there is a MANHOLE with SHORT NUMBER=0202	COVER=	12.11	INVERT=	11.31
At (534063,191265)	there is a MANHOLE with SHORT NUMBER=0203	COVER=	11.94	INVERT=	11.04
At (534061,191262)	there is a MANHOLE with SHORT NUMBER=0204	COVER=	11.84	INVERT=	10.76
At (534042,191240)	there is a MANHOLE with SHORT NUMBER=0205	COVER=	11.72	INVERT=	10.21
At (534056,191244)	there is a MANHOLE with SHORT NUMBER=0206	COVER=	11.66	INVERT=	10.19
At (534067,191244)	there is a MANHOLE with SHORT NUMBER=0207	COVER=	11.76	INVERT=	10.60
At (534036,190960)	there is a MANHOLE with SHORT NUMBER=0901	COVER=	10.58	INVERT=	9.33
At (534038,190959)	there is a MANHOLE with SHORT NUMBER=0902	COVER=	10.56	INVERT=	8.62
At (534056,190975)	there is a MANHOLE with SHORT NUMBER=0903	COVER=	10.45	INVERT=	9.42
At (534073,190962)	there is a MANHOLE with SHORT NUMBER=0904	COVER=	10.31	INVERT=	9.44
At (534103,191062)	there is a MANHOLE with SHORT NUMBER=1001	COVER=	10.78	INVERT=	9.16
At (534136,191061)	there is a MANHOLE with SHORT NUMBER=1002	COVER=	10.58	INVERT=	9.34
At (534138,191056)	there is a MANHOLE with SHORT NUMBER=1004	COVER=	10.59	INVERT=	8.99
At (534160,191056)	there is a MANHOLE with SHORT NUMBER=1008	COVER=	10.59	INVERT=	8.89
At (534159,191025)	there is a MANHOLE with SHORT NUMBER=1009	COVER=	10.55	INVERT=	8.87
At (534160,191019)	there is a MANHOLE with SHORT NUMBER=1010	COVER=	10.51	INVERT=	9.73
At (534132,191113)	there is a MANHOLE with SHORT NUMBER=1101	COVER=	10.90	INVERT=	9.67
At (534134,191115)	there is a MANHOLE with SHORT NUMBER=1102	COVER=	10.90	INVERT=	9.30
At (534124,191232)	there is a MANHOLE with SHORT NUMBER=1201	COVER=	11.86	INVERT=	10.47
At (534123,191230)	there is a MANHOLE with SHORT NUMBER=1202	COVER=	11.84	INVERT=	10.38
At (534116,191316)	there is a MANHOLE with SHORT NUMBER=1304	COVER=	11.82	INVERT=	10.98
At (534163,190969)	there is a MANHOLE with SHORT NUMBER=1903	COVER=	10.45	INVERT=	9.05
At (534206,191067)	there is a MANHOLE with SHORT NUMBER=2001	COVER=	10.71	INVERT=	9.21
At (533839,191297)	there is a MANHOLE with SHORT NUMBER=8219	COVER=	11.58	INVERT=	10.33
At (533842,191296)	there is a MANHOLE with SHORT NUMBER=8220	COVER=	11.56	INVERT=	10.30
At (533852,191265)	there is a MANHOLE with SHORT NUMBER=8221	COVER=	11.91	INVERT=	10.10
At (533852,191236)	there is a MANHOLE with SHORT NUMBER=8222	COVER=	11.86	INVERT=	10.55
At (533854,191234)	there is a MANHOLE with SHORT NUMBER=8223	COVER=	11.86	INVERT=	10.06
At (533870,191238)	there is a MANHOLE with SHORT NUMBER=8224	COVER=	11.37	INVERT=	9.87
At (533867,191241)	there is a MANHOLE with SHORT NUMBER=8225	COVER=	11.41	INVERT=	10.38
At (533878,191238)	there is a MANHOLE with SHORT NUMBER=8226	COVER=	11.08	INVERT=	-9999.00
At (533879,191243)	there is a MANHOLE with SHORT NUMBER=8227	COVER=	11.06	INVERT=	9.33
At (533861,191304)	there is a MANHOLE with SHORT NUMBER=8310	COVER=	11.30	INVERT=	10.15
At (533864,191307)	there is a MANHOLE with SHORT NUMBER=8311	COVER=	11.36	INVERT=	10.09
At (533833,191321)	there is a MANHOLE with SHORT NUMBER=8314	COVER=	-9999.00	INVERT=	-9999.00
At (533945,191051)	there is a MANHOLE with SHORT NUMBER=9006	COVER=	11.09	INVERT=	9.32
At (533953,191051)	there is a MANHOLE with SHORT NUMBER=9007	COVER=	11.05	INVERT=	9.45
At (533985,191056)	there is a MANHOLE with SHORT NUMBER=9008	COVER=	10.93	INVERT=	9.50
At (533908,191165)	there is a MANHOLE with SHORT NUMBER=9102	COVER=	10.77	INVERT=	8.25
At (533952,191223)	there is a MANHOLE with SHORT NUMBER=9202	COVER=	11.46	INVERT=	9.90
At (533935,191220)	there is a MANHOLE with SHORT NUMBER=9204	COVER=	11.36	INVERT=	9.88
At (533970,191228)	there is a MANHOLE with SHORT NUMBER=9206	COVER=	11.54	INVERT=	9.49
At (533932,191164)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (533933,191163)	there is a MANHOLE with SHORT NUMBER=	COVER=	-9999.00	INVERT=	-9999.00
At (534108,191350)	there is a MANHOLE with SHORT NUMBER=	COVER=	0.00	INVERT=	0.00
At (534115,191333)	there is a MANHOLE with SHORT NUMBER=1303	COVER=	11.84	INVERT=	11.18
At (533859,191041)	there is a MANHOLE with SHORT NUMBER=8001	COVER=	11.85	INVERT=	8.49
At (533876,191043)	there is a MANHOLE with SHORT NUMBER=8002	COVER=	11.58	INVERT=	8.43
At (533892,191043)	there is a MANHOLE with SHORT NUMBER=8003	COVER=	11.18	INVERT=	8.38
At (533894,191046)	there is a MANHOLE with SHORT NUMBER=8004	COVER=	11.12	INVERT=	9.27
At (533827,191155)	there is a MANHOLE with SHORT NUMBER=8102	COVER=	12.37	INVERT=	8.57
At (533866,191159)	there is a MANHOLE with SHORT NUMBER=8103	COVER=	12.23	INVERT=	8.47
At (533885,191163)	there is a MANHOLE with SHORT NUMBER=8106	COVER=	11.41	INVERT=	9.45
At (533897,191244)	there is a MANHOLE with SHORT NUMBER=8228	COVER=	10.86	INVERT=	8.47
At (533896,191254)	there is a MANHOLE with SHORT NUMBER=8229	COVER=	10.85	INVERT=	10.05
At (533893,191202)	there is a MANHOLE with SHORT NUMBER=8233	COVER=	10.74	INVERT=	9.71
At (533871,191303)	there is a MANHOLE with SHORT NUMBER=8312	COVER=	11.12	INVERT=	9.41
At (533889,191310)	there is a MANHOLE with SHORT NUMBER=8313	COVER=	11.03	INVERT=	8.57
At (533916,191099)	there is a MANHOLE with SHORT NUMBER=9001	COVER=	10.55	INVERT=	8.11
At (533917,191045)	there is a MANHOLE with SHORT NUMBER=9002	COVER=	10.81	INVERT=	8.07
At (533927,191053)	there is a MANHOLE with SHORT NUMBER=9003	COVER=	10.94	INVERT=	9.56
At (533920,191034)	there is a MANHOLE with SHORT NUMBER=9004	COVER=	10.72	INVERT=	8.86
At (533920,191047)	there is a MANHOLE with SHORT NUMBER=9005	COVER=	10.78	INVERT=	8.72
At (533905,191185)	there is a MANHOLE with SHORT NUMBER=9101	COVER=	10.74	INVERT=	9.91
At (533909,191162)	there is a MANHOLE with SHORT NUMBER=9103	COVER=	10.72	INVERT=	9.63
At (533916,191150)	there is a MANHOLE with SHORT NUMBER=9104	COVER=	10.93	INVERT=	8.68
At (533918,191148)	there is a MANHOLE with SHORT NUMBER=9105	COVER=	10.86	INVERT=	9.57
At (533911,191138)	there is a MANHOLE with SHORT NUMBER=9106	COVER=	10.65	INVERT=	9.37
At (533900,191217)	there is a MANHOLE with SHORT NUMBER=9201	COVER=	10.89	INVERT=	8.35
At (533903,191207)	there is a MANHOLE with SHORT NUMBER=9203	COVER=	10.82	INVERT=	9.77
At (533905,190990)	there is a MANHOLE with SHORT NUMBER=9903	COVER=	10.68	INVERT=	9.26



The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

100 metre intervals

EAGLE hardcopy facility - Normal Map.
The plot is centred on (534024 , 191156), which is in TQ3491SW. Printed on 10 December 2004 at 15:51:51 by JHOLECEK.
Comments:



The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

100 metre intervals

EAGLE hardcopy facility - Normal Map
 The plot is centred on (534024 , 191156), which is in TQ3491SW. Printed on 10 December 2004 at 15:52:31 by JHOLECEK.
 Comments:

Appendix D - Proposed Site Layout Plans



Appendix E - Existing Site Runoff Rates and Volume Calculations



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	100
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	33.40	133.6
30	0.50	43.00	86.0
60	1.00	52.70	52.7
120	2.00	62.40	31.2
240	4.00	72.00	18.0
360	6.00	77.60	12.9
720	12.00	88.10	7.3
1,440	24.00	99.60	4.2

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.97		0.000
Concrete	0.97	14,000.00	1.400
Grass areas, flat 0-2%	0.36		0.000
Grass areas, average 2-7%	0.46		0.000
Grass areas, steep, over 7%	0.51		0.000
Pervious Paving	0.97		0.000
Gravel	0.80		0.000
Asphalt	0.95		0.000
Total		14,000.00	1.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	504.37	453.93
30	0.50	324.67	584.41
60	1.00	198.96	716.24
120	2.00	117.79	848.07
240	4.00	67.95	978.54
360	6.00	48.83	1,054.65
720	12.00	27.72	1,197.36
1,440	24.00	15.67	1,353.65

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration

Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	30
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	25.70	102.8
30	0.50	32.80	65.6
60	1.00	40.10	40.1
120	2.00	47.40	23.7
240	4.00	69.20	17.3
360	6.00	59.60	9.9
720	12.00	68.30	5.7
1,440	24.00	78.00	3.3

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.89	0.00	0.000
Concrete	0.89	14,000.00	1.400
Grass areas, flat 0-2%	0.30	0.00	0.000
Grass areas, average 2-7%	0.40	0.00	0.000
Grass areas, steep, over 7%	0.45	0.00	0.000
Pervious Paving	0.89	0.00	0.000
Gravel	0.74	0.00	0.000
Asphalt	0.87	0.00	0.000
Total		14,000.00	1.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	355.29	319.76
30	0.50	226.72	408.10
60	1.00	138.59	498.92
120	2.00	81.91	589.75
240	4.00	59.79	860.98
360	6.00	34.33	741.54
720	12.00	19.67	849.78
1,440	24.00	11.23	970.47

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	1
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	10.50	42.0
30	0.50	13.40	26.8
60	1.00	16.60	16.6
120	2.00	20.20	10.1
240	4.00	29.90	7.5
360	6.00	26.80	4.5
720	12.00	31.60	2.6
1,440	24.00	37.20	1.6

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.75	0.00	0.000
Concrete	0.75	14,000.00	1.400
Grass areas, flat 0-2%	0.21	0.00	0.000
Grass areas, average 2-7%	0.29	0.00	0.000
Grass areas, steep, over 7%	0.34	0.00	0.000
Pervious Paving	0.75	0.00	0.000
Gravel	0.60	0.00	0.000
Asphalt	0.73	0.00	0.000
Total		14,000.00	1.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	122.60	110.34
30	0.50	78.23	140.81
60	1.00	48.46	174.44
120	2.00	29.48	212.27
240	4.00	21.82	314.20
360	6.00	13.04	281.63
720	12.00	7.69	332.07
1,440	24.00	4.52	390.91

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration

Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	100
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	33.40	133.6
30	0.50	43.00	86.0
60	1.00	52.70	52.7
120	2.00	62.40	31.2
240	4.00	72.00	18.0
360	6.00	77.60	12.9
720	12.00	88.10	7.3
1,440	24.00	99.60	4.2

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.97		0.000
Concrete	0.97	64,000.00	6.400
Grass areas, flat 0-2%	0.36		0.000
Grass areas, average 2-7%	0.46		0.000
Grass areas, steep, over 7%	0.51		0.000
Pervious Paving	0.97		0.000
Gravel	0.80		0.000
Asphalt	0.95		0.000
Total		64,000.00	6.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	2305.70	2,075.13
30	0.50	1484.21	2,671.58
60	1.00	909.51	3,274.23
120	2.00	538.46	3,876.89
240	4.00	310.65	4,473.34
360	6.00	223.21	4,821.26
720	12.00	126.70	5,473.62
1,440	24.00	71.62	6,188.11

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	30
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	25.70	102.8
30	0.50	32.80	65.6
60	1.00	40.10	40.1
120	2.00	47.40	23.7
240	4.00	69.20	17.3
360	6.00	59.60	9.9
720	12.00	68.30	5.7
1,440	24.00	78.00	3.3

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.89	0.00	0.000
Concrete	0.89	64,000.00	6.400
Grass areas, flat 0-2%	0.30	0.00	0.000
Grass areas, average 2-7%	0.40	0.00	0.000
Grass areas, steep, over 7%	0.45	0.00	0.000
Pervious Paving	0.89	0.00	0.000
Gravel	0.74	0.00	0.000
Asphalt	0.87	0.00	0.000
Total		64,000.00	6.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	1624.17	1,461.75
30	0.50	1036.43	1,865.58
60	1.00	633.55	2,280.79
120	2.00	374.44	2,695.99
240	4.00	273.33	3,935.92
360	6.00	156.94	3,389.90
720	12.00	89.92	3,884.73
1,440	24.00	51.35	4,436.44

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	1
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	10.50	42.0
30	0.50	13.40	26.8
60	1.00	16.60	16.6
120	2.00	20.20	10.1
240	4.00	29.90	7.5
360	6.00	26.80	4.5
720	12.00	31.60	2.6
1,440	24.00	37.20	1.6

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.75	0.00	0.000
Concrete	0.75	64,000.00	6.400
Grass areas, flat 0-2%	0.21	0.00	0.000
Grass areas, average 2-7%	0.29	0.00	0.000
Grass areas, steep, over 7%	0.34	0.00	0.000
Pervious Paving	0.75	0.00	0.000
Gravel	0.60	0.00	0.000
Asphalt	0.73	0.00	0.000
Total		64,000.00	6.400

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	560.45	504.40
30	0.50	357.62	643.71
60	1.00	221.51	797.44
120	2.00	134.77	970.38
240	4.00	99.75	1,436.35
360	6.00	59.60	1,287.43
720	12.00	35.14	1,518.01
1,440	24.00	20.68	1,787.03

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	100
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	33.40	133.6
30	0.50	43.00	86.0
60	1.00	52.70	52.7
120	2.00	62.40	31.2
240	4.00	72.00	18.0
360	6.00	77.60	12.9
720	12.00	88.10	7.3
1,440	24.00	99.60	4.2

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.97		0.000
Concrete	0.97	6,000.00	0.600
Grass areas, flat 0-2%	0.36		0.000
Grass areas, average 2-7%	0.46		0.000
Grass areas, steep, over 7%	0.51		0.000
Pervious Paving	0.97		0.000
Gravel	0.80		0.000
Asphalt	0.95		0.000
Total		6,000.00	0.600

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	216.16	194.54
30	0.50	139.14	250.46
60	1.00	85.27	306.96
120	2.00	50.48	363.46
240	4.00	29.12	419.38
360	6.00	20.93	451.99
720	12.00	11.88	513.15
1,440	24.00	6.71	580.14

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration

Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	30
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	25.70	102.8
30	0.50	32.80	65.6
60	1.00	40.10	40.1
120	2.00	47.40	23.7
240	4.00	69.20	17.3
360	6.00	59.60	9.9
720	12.00	68.30	5.7
1,440	24.00	78.00	3.3

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.89	0.00	0.000
Concrete	0.89	6,000.00	0.600
Grass areas, flat 0-2%	0.30	0.00	0.000
Grass areas, average 2-7%	0.40	0.00	0.000
Grass areas, steep, over 7%	0.45	0.00	0.000
Pervious Paving	0.89	0.00	0.000
Gravel	0.74	0.00	0.000
Asphalt	0.87	0.00	0.000
Total		6,000.00	0.600

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	152.27	137.04
30	0.50	97.17	174.90
60	1.00	59.40	213.82
120	2.00	35.10	252.75
240	4.00	25.62	368.99
360	6.00	14.71	317.80
720	12.00	8.43	364.19
1,440	24.00	4.81	415.92

Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration



Project: Northumberland Development Project

Assessment of the brownfield site runoff rates and total volumes using the rational method

$$Q_p = 2.78 I \left(\sum_i C_i A_i \right)$$

Q_p (l/s) = peak discharge corresponding to a given rainfall intensity, duration, and frequency

C_i (dimensionless) = runoff coefficient of i th subcatchment

I (mm/hr) = rainfall intensity, average in time and space

A_i (ha) = drainage area of i th subcatchment

RETURN PERIOD (YEARS)

Return Period (years)	1
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RAINFALL INTENSITY

FSR Method from "Principles, Methods and Practice" - The Wallingford Procedure, Volume 1 September 1981

Storm Duration (min)	Storm Duration (hr)	Rainfall Depth (mm)	Rainfall Intensity (mm/hr)
15	0.25	10.50	42.0
30	0.50	13.40	26.8
60	1.00	16.60	16.6
120	2.00	20.20	10.1
240	4.00	29.90	7.5
360	6.00	26.80	4.5
720	12.00	31.60	2.6
1,440	24.00	37.20	1.6

DRAINAGE AREA

Subcatchment	Runoff Coefficient for Selected Return Period	Area	
		m ²	ha
Roofed	0.75	0.00	0.000
Concrete	0.75	6,000.00	0.600
Grass areas, flat 0-2%	0.21	0.00	0.000
Grass areas, average 2-7%	0.29	0.00	0.000
Grass areas, steep, over 7%	0.34	0.00	0.000
Pervious Paving	0.75	0.00	0.000
Gravel	0.60	0.00	0.000
Asphalt	0.73	0.00	0.000
Total		6,000.00	0.600

PEAK DISCHARGE

Storm Duration (min)	Storm Duration (hr)	Peak Discharge (l/s)	Total Volume (m ³)
15	0.25	52.54	47.29
30	0.50	33.53	60.35
60	1.00	20.77	74.76
120	2.00	12.64	90.97
240	4.00	9.35	134.66
360	6.00	5.59	120.70
720	12.00	3.29	142.31
1,440	24.00	1.94	167.53

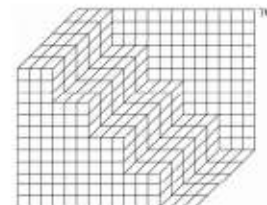
Notes:

1. Rainfall Intensities calculated by WinDes modelling software using FSR method - M5-60 = 20.000mm, R = 0.45

Assumptions associated with the Rational Method:

- 1) The computed peak rate of runoff at the outlet point is a function of the average rainfall rate during the time of concentration
- 2) The storm duration is taken as the time of concentration of the drainage area
- 3) Rainfall intensity is constant throughout the storm duration

Appendix F - Buro Happold Design Notes



Buro Happold

Design Note

project NDP & THFC Stadium
subject Planning – Drainage Strategy
job no 023970 & 023962
date 10th May 2010

Revision	Description	Issued by	Date	Approved (signature)
00	E-mail Response	TGM	10/05/2010	
01	Foul Drainage Included	TGM	11/05/2010	

1.0 Surface Water Drainage

(Extract from ES)

(i) Surface Water Drainage

- 1.1.1. The site currently appears to drain to separate Thames Water surface and foul water sewers. The proposed drainage strategy will maintain the separation in these networks. Local network upgrades are proposed on Worcester Avenue with the addition of a new sewer. The surface water drainage system design splits the site into three main catchment areas; the North (Retail), the Stadium (including Public Realm & Hotel), and the South (Residential).
- 1.1.2. The surface water drainage strategy is based on an allowable discharge of 150l/s/ha totalling 1260l/s for the 8.4ha development site. This has been agreed in principle with the Environment Agency. Thames Water has stipulated that discharge will be restricted to the capacity of the existing connections. There is still work outstanding from the drainage survey which once completed will clarify the capacity of these connections. A further restriction to the allowable discharge rate dictated by Thames Water cannot be ruled out at this stage and would result in increased attenuation volumes to those quoted below. At present work is progressing to try and achieve a gravity system but pumping, at least in part, also cannot be ruled out until a working WinDes model is complete.
- 1.1.3. The site has a high water table (+8.5-9.4 AOD) approximately 2-3m below existing ground level. The site is also underlain by a stratum of London Clay, so infiltration has been ruled out. The surface water design will attenuate a 1 in 100 year critical storm event plus climate change within the site boundary. Attenuation for a 1 in 30 year storm will be provided by below ground storage tanks while the additional 1 in 100 yr attenuation will be provided by controlled surface level flooding where possible. Where the site layout or levels do not allow this the additional attenuation will need to be provided below ground. A 20% increase for climate change was applied to the North and Stadium developments corresponding to a design life of less than 80 years. A 30% increase for climate change was applied to the South development due to a design life in excess of 80 years. The design criterion outlined in 1.1.2. and 1.1.3. has been used to define the size of all surface water infrastructure including attenuation requirements.
- 1.1.4. The North (Retail) site comprises of the retail store and service yard (1.4ha total). Its storm water system will provide attenuation totalling 370m³. 1 in 30 year attenuation (210m³) will be provided by below ground storage tanks beneath the building footprint. The additional 1 in 100yr attenuation (160m³) will be provided through controlled surface level flooding of the ground floor car parking area. Due to the size of the existing sewer on Northumberland Park the system will discharge southwest to the Moselle Culvert in the High Road. Existing connections will be re-used where possible and flow control devices will limit total discharge to 210l/s. A green roof is proposed for a portion of the retail store which will increase the time of entry for

the system and reduce the volume of attenuation required. Run-off from the service yard will pass through an oil separator before entering the system.

- 1.1.5. The Stadium site including the public realm and hotel (6.4ha total) will have a surface water network that provides attenuation totalling 1640m³. 1 in 30 year attenuation (980m³) will be provided by below ground tanks. It is anticipated that only a portion of the 1 in 100 attenuation requirement (660m³) will be provided by controlled surface level flooding due to site constraints and the remainder will have to be provided below ground. The Stadium will utilise multiple outfalls due to the size of the catchment, the requirement to use existing connections and the complex phasing sequence. The outfalls will be split between the Moselle Culvert in the High Road (east) and the new sewer to be laid in Worcester Avenue (west). Existing connections will be re-used wherever possible and flow control devices will ensure the total discharge from the catchment is limited to 960l/s. The public realm area will be drained by slot drains which will be connected to the main system. Rainwater harvesting is proposed for part of the stadium roof to reduce the mains demand for non-potable water. The pitch drainage will be designed by the specialist pitch contractor Hewitt's but will link into the wider system.
- 1.1.6. The South (Residential) development (0.6ha) will have a surface water network that provides attenuation totalling 180m³. At present it is assumed that 100% of the 1 in 100 year attenuation will have to be provided below ground and some pumping will be required due to the basement car park. The system will outfall south to Park Lane re-using existing connections where possible with flow control devices installed to limit discharge to 90l/s.

2.0 Foul Water Drainage

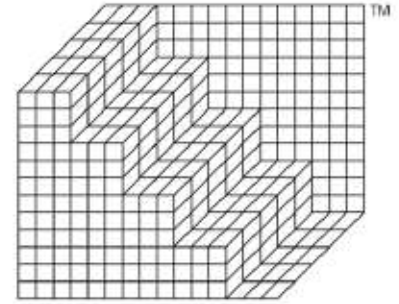
(Extract from ES)

(i) Pollution Prevention

- 1.1.1. Drainage from areas where the risk of pollution is raised, such as car/coach parking areas and stadium and commercial service areas will be separated from other drainage areas with treatment appropriate to the potential contaminant or discharge to the foul sewer. Permanent parking areas will have pollution control measures such as hydrocarbon removal through oil separators.

(ii) Foul Drainage

- 1.1.2. The site currently appears to drain to separate Thames Water surface and foul water sewers. The proposed drainage strategy will maintain the separation in these networks. The foul water drainage system design splits the site into three main catchment areas; the North (Retail), the Stadium (including Public Realm & Hotel), and the South (Residential).
- 1.1.3. Discharge rates have not been finalised at this stage although early discussions with Thames Water indicate that they are likely to have sufficient capacity in their network to accommodate the flows and outline approval has been obtained. As a result it is also anticipated that no attenuation will be required. The proposed network will work under gravity wherever possible with pumping minimised. The system will also have adequate access points to guarantee future maintenance.
- 1.1.4. The development will have multiple outfalls to the Thames Water foul sewer network and re-use existing connections wherever possible. North (Retail) site will predominantly outfall north to Northumberland Park. The Stadium site will outfall west to the High Road and the South (Residential) site will outfall south to Park Lane.



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Design Note

project Northumberland Development Project
subject URS RFI
job no 023962
date 05/05/2010

1. Introduction

This document provides a summary of the drainage design to date. The design adopts the allowable discharge rate of 150 l/s/ha agreed in principle with the EA. Thames Water have stated this rate will be accepted providing it is proved to be a reduction on the existing discharge rate. They typically require brownfield sites to use the existing connections to the Thames Water sewers. Should the existing connections be incompatible with the proposed drainage design then a further restriction to the allowable discharge rate may be sought by Thames Water. If this were the case then the storage requirement will increase.

2. Catchments

The site is split into three catchments; North (Retail), Stadium (Including Public Realm and Hotel) and South (Residential). The location of each catchment and its associated area are shown on CSK100 (Rev 01) at the end of this design note.

3. Climate Change

A 20% increase for climate change was applied to the stadium and north (retail) developments corresponding to a design life of less than 80 years. A 30% increase for climate change was applied to the south (residential) development due to a design life in excess of 80 years.

4. Rainfall Data

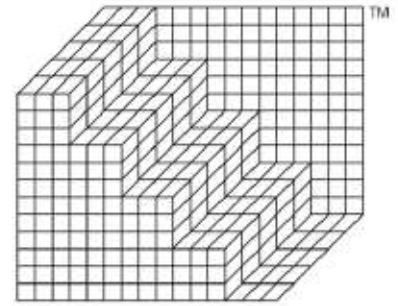
The Flood Studies Report (FSR) method was preferred to the Flood Estimation Handbook (FEH) method as the FEH data is known to overestimate sub-hourly rainfall in the south east of the country¹. FEH data is also not applicable to the rational approach which needs reliable sub-hourly rainfall totals¹.

FSR: $M5_{60} = 20.000$

$R = 0.450$

5. Storage

Underground storage will be provided to attenuate a 1 in 30 yr storm event. A 1 in 100 yr storm event will be attenuated on site through surface level flooding in accordance with designing for exceedance². Where this is not possible then the extra storage for 1 in 100 yr event will be provided underground. Underground



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storage will consist of geo-cellular storage tanks and/or oversized pipes.

Surface level flooding will utilise car parking and hard landscaped areas

to contain and control flooding as advised in PPS25³. Storage was

calculated using the source control function of WinDes (Version W11.3).

Roof areas were split 50/50 between the following time of entries 0-4 and

4-8 minutes. Hard landscaped areas were split 50/50 between the following time of entries 4-8 and 8-12

minutes. The pitch area was split 50/50 between the following time of entries 8-12 and 12-16 minutes. The

time of entries are approximate only and will be refined once a WinDes model is developed for the site.

Discharge will be restricted at the outfalls by throttle pipes (this may be subject to change at detailed

design). The number, location and size of outfalls will be finalised during detailed design.

6. Maximum Discharge Rates

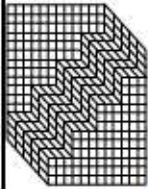
These are calculated from the modified rational method using FSR rainfall data. Discharge rates relate to the worst case storm of 15 minute duration.

References:

- 1 Validation of FSR and FEH depth/duration/frequency using recent Met Office rainfall data, Aidan Millerick, 2005.
- 2 Designing for exceedance in urban drainage – good practice, CIRIA C635, 2006.
- 3 PPS25: Development and Flood Risk, Communities and Local Government, 2010.

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Revision	Description	Issued by	Date	Approved (signature)
01	Updated for Second Planning Submission	TGM	05/05/10	
00	Drainage Design Note	TGM	31/03/09	



Buro Happold

Project Northumberland Development Project	Project No. 023962	Revision 02
Title Surface Water Strategy	Made By TGM	Date 05/05/2010
Stage Planning Submission - Draft	Checked By NTH	Date 05/05/2010

Catchment Land Use	Area (ha)	Time of Entry (% of total catchment)				Proposed Discharge Rate (l/s)	Maximum Discharge Rates (l/s)			Storage Volume Req. (m ³)	
		0-4 (mins)	4-8 (mins)	8-12 (mins)	12-16 (mins)		1 in 1yr	1 in 30yr	1 in 100yr	1 in 30yr + CC	1 in 100yr + CC
A North (Retail)	1.4	40%	50%	10%		210	45	145	210	210	370
B Stadium (Including Public Realm & Hotel)	6.4	20%	40%	30%	10%	960	215	660	960	980	1640
C South (Residential)	0.6	50%	50%			90	20	65	90	105	180
Total	8.4					1260	280	870	1260	1295	2190

Notes:

1. 1 in 30yr storage will be provided below ground.
2. 1 in 100yr storage will be provided above ground if possible in line with Designing for Exceedence.
3. Below ground storage will consist of geo-cellular storage tanks and/or oversized pipes.
4. FSR method applied; $M5_{60} = 20,000$, $R = 0.450$
5. Discharge restricted to 150 l/s/ha (Agreed in principle with EA, discussions ongoing with TW further restrictions may apply).
6. Runoff coefficients; $Cv = 0.75$ (1in1yr), $Cv = 0.89$ (1in30yr), $Cv = 0.97$ (1in100yr)

