Greggs Bakery, Twickenham (Scheme 2)

Flood Risk Assessment

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		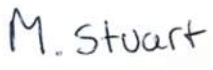		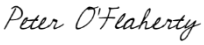
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Executive Summary

Waterman has been commissioned by London Square Developments Ltd to undertake a Flood Risk Assessment in relation to the proposed development located at the former Greggs Bakery Site, located at Gould Road, Twickenham TW2 6RT.

Environment Agency mapping indicates that the Site is located predominantly within Flood Zone 1, denoting a low probability of flooding, with a small area along the northern boundary with the River Crane located within Flood Zone 2, denoting a medium probability of fluvial flooding.

Interrogation of the Environment Agency's modelled flood levels against the existing ground levels at the Site has shown that levels along the River Crane are generally above 10.30m AOD indicating that the banks would not be overtopped up to and above the 1 in 1000 year event. However, a small, low-lying area to the east of the site, just upstream of the railway bridge, would be at risk of flooding to a depth of 0.075m during the 1 in 1000 year event. This flooding would be contained to a small area and would not affect the rest of the Site. It is therefore considered that the Site is at low risk of fluvial flooding.

The risk of flooding from tidal, pluvial, groundwater and artificial sources has also been assessed and found to be low.

Infiltration testing confirmed the ground conditions are not suitable for discharge to ground. However, further testing would be undertaken at more locations across the site at the detailed design stage to confirm this. Surface water runoff would therefore discharge to the River Crane via a pumped discharge as a gravity connection is not feasible to levels.

The existing runoff rate for the site has been calculated to be 145.3 l/s. It is proposed to restrict runoff to the greenfield 100 year rate of 8.9 l/s, providing a 94% reduction in flows.

To restrict surface water runoff to this rate, a minimum of 646m^3 of storage would be provided in the sub-base layer of the proposed permeable paving located below the access road and car parking areas. In addition to the pumped discharge some of the sub-base would be unlined to allow some slow infiltration to ground.

The pollution hazard level of surface water runoff from the development is classified as 'very low' for the residential roofs and 'low' for the car parking areas and access road. A level of treatment appropriate to the pollution hazard level of the development would be provided by the green roof and permeable paving to ensure that the quality of surface water discharged to ground and the River Crane is acceptable.

The on-site drainage network and SuDS would be managed and maintained for the lifetime of the development by an appropriate managing body, ensuring they remain fit for purpose and function appropriately.

Foul flows from the Site would discharge by gravity to the Thames Water combined sewer network. The existing and proposed peak foul discharge rates have been calculated using the water consumption method to be 1.0 l/s and 0.9 l/s respectively. As such, the proposed development would result in a nominal decrease in peak foul flow rates from the Site.

This report demonstrates that the proposed development has a low probability of flooding from fluvial, tidal, groundwater and artificial sources, and confirms that surface water runoff can be managed sustainably to ensure that flood risk is not increased elsewhere. It is considered that the information contained within this report satisfies the requirements of the NPPF and Local Policy.

1. Introduction

1.1. Waterman has been commissioned by London Square Developments Ltd to undertake a Flood Risk Assessment (FRA) in relation to the proposed development at the former Greggs Bakery Site (hereafter referred to as 'the Site'), located at Gould Road, Twickenham TW2 6RT.

Site Description

1.2. The Site is approximately 1.130 hectares (ha) in size and currently comprises a former Greggs Bakery factory and an end of terrace house (No.2 Gould Road) (Figure 1). The Site is bounded by the River Crane to the north, existing residential properties to the east and west, and Edwin Road to the south.

Figure 1: Site Location Plan

Site Boundary

Source: Google Maps

1.3. The topographic survey (Appendix A) indicates that ground levels across the Site are relatively flat, generally ranging between 10.0 to 10.5m AOD for the majority of the Site. However, there is a slight downward gradient of approximately 1:190 from south to north, towards the River Crane. The high point of 10.79m AOD occurs to the southwest of the Site, adjacent to the southern boundary with Edwin Road. The low point of 9.81m AOD occurs to the northeast of the Site, adjacent to the railway embankment.

Development Proposals

1.4. The development proposals (Appendix B) the demolition of existing buildings (with retention of a single dwelling) and redevelopment of the site to provide up to 97 residential units and 883m^2 industrial floorspace (Use Class E(g) (iii)) and 117m^2 of affordable workspace (Class E) with associated hard and soft landscaping, car parking and highways works and other associated works.

Scope of report

1.5. This report assesses the potential effects of tidal, fluvial, pluvial (surface water), groundwater and artificial sources of flooding upon the proposed development, in line with local and national planning policy. The management of surface water runoff has also been assessed, and a strategy to effectively manage runoff whilst working within site specific constraints is proposed, so as not to increase flood risk elsewhere. An assessment has also been made of the existing and proposed foul discharge from the Site, and a proposed strategy developed.

2. Planning Policy and Guidance

National Planning Policy Framework

2.1. The National Planning Policy Framework[i] (NPPF) 2021 states that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.

2.2. The aim of the Sequential Test is to steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding.

2.3. If it is not possible for development to be located in zones with a lower risk of flooding (taking into account wider sustainable development objectives), it may be necessary to demonstrate through the Exception Test that:

- The development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

2.4. The NPPF states that when determining planning applications, Local Planning Authorities (LPA) should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific Flood Risk Assessment. Development should only be allowed in areas at risk of flooding where it can be demonstrated that:

- Within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- The development is appropriately flood resistant and resilient;
- It incorporates Sustainable Drainage Systems (SuDS), unless there is clear evidence that this would be inappropriate;
- Any residual risk can be safely managed; and
- Safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

2.5. Major developments should incorporate SuDS unless there is clear evidence that this would be inappropriate. The systems used should:

- Take account of advice from the lead local flood authority;
- Have appropriate proposed minimum operational standards;
- Have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
- Where possible, provide multifunctional benefits.

2.6. Flood risk vulnerability is split into five classifications in Annex 3 of the NPPF as follows:

- Essential Infrastructure, e.g. essential transport and utility infrastructure, wind turbines;
- Highly Vulnerable, e.g. emergency services (those required to be operational during flooding), basement dwellings;
- More Vulnerable, e.g. residential dwellings, hospitals, schools, hotels, drinking establishments;

- Less Vulnerable, e.g. retail, offices, storage and distribution, leisure, restaurants; and
- Water-Compatible Development, e.g. docks, marinas, wharves.

Planning Practice Guidance

2.7. The Planning Practice Guidance[ii] (PPG) provides additional guidance to LPAs to ensure effective implementation of the planning policies set out within the NPPF regarding development in areas at risk of flooding.

2.8. The PPG states that developers and LPAs should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of SuDS. Referencing information provided by the Environment Agency (EA), the PPG provides advice on taking account of climate change, setting out recommended contingency allowances for net sea level rise and peak rainfall intensities. It also advises on flood resilience and resistance measures when dealing with the residual risks remaining after applying the sequential approach and mitigating actions.

2.9. The PPG also includes advice on flood risk vulnerability and flood zone compatibility. The following flood zones refer to the probability of river and sea flooding, without the presence of defences:

- Zone 1 - low probability: less than 1 in 1000 annual probability of river or sea flooding (<0.1%) in any year;
- Zone 2 - medium probability: between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% to 0.1%) or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% to 0.1%) in any year;
- Zone 3a - high probability: 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability flooding from the sea (>0.5%) in any year; and
- Zone 3b - the functional floodplain: where water has to flow or be stored in times of flood; identification should take account of local circumstances but would typically flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme 1 in 1,000 (0.1%) flood.

Sequential and Exception Test

2.10. The aim of the Sequential Test is to steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding.

2.11. If it is not possible for development to be located in zones with a lower risk of flooding (taking into account wider sustainable development objectives), it may be necessary to demonstrate through the Exception Test that:

- The development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- The development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

2.12. As the development area of the Site is located within Flood Zone 1 the Sequential Test is passed by default and the Exception Test is not required.

London Borough of Richmond Upon Thames Local Plan

2.13. The London Borough of Richmond upon Thames (LBRT) Local Plan[iii] was adopted in July 2018. The Local Plan sets out policies and guidance for development in the borough over the next 15 years and replaces previous policies within the Core Strategy and Development Management Plan.

2.14. Policy LP18 of the Local Plan concerns river corridors. Under this policy, all development proposals alongside or adjacent to any of the boroughs river corridors should:

a. *"Retain existing public access to the riverside and alongside the river; and*

b. *Enhance existing public access to the riverside where improvements are feasible; or*

c. *Provide new public access to the riverside where possible, and maintain existing points of access to the foreshore subject to health and safety considerations. There is an expectation that all major development proposals adjacent to the borough's rivers shall provide public access to the riverside.*

d. *Provide riparian life-saving equipment where required and necessary."*

2.15. Policy LP21 of the Local Plan deals with Flood Risk and Sustainable Drainage. This policy states that all development within the borough should avoid, or minimise, contributing to all sources of flooding, including fluvial, tidal, surface water, groundwater and flooding from sewers, taking account of climate change and without increasing flood risk elsewhere.

2.16. It also states that LBRT will require Sustainable Drainage Systems (SuDS) to be used in all development proposals. Applicants will have to demonstrate that their proposals comply with the following:

1. *A reduction in surface water discharge to greenfield run-off rates wherever feasible.*

2. *Where greenfield run-off rates are not feasible, this will need to be demonstrated by the applicant, and in such instances, the minimum requirement is to achieve at least a 50% attenuation of the sites surface water runoff at peak times based on the levels existing prior to the development."*

London Borough of Richmond upon Thames Preliminary Flood Risk Assessment

2.17. The LBRT Preliminary Flood Risk Assessment (PFRA)[iv] was published in May 2011 and provides a high-level summary of significant flood risk, based on available and readily driveable information, describing the probability and harmful consequences of past and future flooding.

2.18. The scope of the PFRA was to consider flooding from surface runoff, groundwater, sewers and ordinary watercourses and the interaction these sources have with main rivers and the sea.

London Borough of Richmond upon Thames Strategic Flood Risk Assessment

2.19. LBRT's Strategic Flood Risk Assessment (SFRA)[v] was published in March 2021 and supersedes the 2016 SFRA. It aimed to deliver the planning and flood risk requirements as defined by the 2019 National Planning Policy Framework (NPPF), to be compliant with the latest policy requirements and to utilise the latest data to better assess flood risk.

2.20. The SFRA provides a strategic overview of all forms of flood risk throughout the borough, now and

in the future. The document, and the associated web-based mapping delivered as part of the SFRA, were designed to help address local requirements, manage development requirements, and manage the risk of flooding posed to both residents and buildings. The local requirements addressed as part of this SFRA include climate change impacts, localised flood issues, and specific policies and interpretations of the Flood Zones.

2.21. The updates carried out in 2016 incorporated updates to local and national policy, inclusion of more recent data on flood risk and climate change, among other things.

London Borough of Richmond upon Thames Surface Water Management Plan

2.22. Produced in June 2011, the London Borough of Richmond upon Thames Surface Water Management Plan[vi] (SWMP) outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall.

2.23. The SWMP study was undertaken as part of the Drain London Project in consultation with key local partners who are responsible for surface water management and drainage in the London area including the Greater London Authority, Thames Water, the Environment Agency, Network Rail and Transport for London. The Partners have worked together to understand the causes and effects of surface water flooding so that they can agree the most cost effective way of managing surface water flood risk in the long term.

Non-statutory Technical Standards for Sustainable Drainage Systems

The Non-Statutory Technical Standards for Sustainable Drainage Systems[vii] was published in March 2015 and is the current guidance for the design, maintenance and operation of SuDS.

2.24. The standards set out that the peak runoff rates should be as close as is reasonably practicable to the greenfield rate, but should never exceed the pre-development runoff rate.

2.25. The standards also set out that the drainage system should be designed so that flooding does not occur on any part of the Site for a 1 in 30 year rainfall event, and that no flooding of a building (including basement) would occur during a 1 in 100 year rainfall event.

It is also noted within the standards that pumping should only be used when it is not reasonably practicable to discharge by gravity.

London Plan and London Plan Supplementary Planning Guidance

2.26. The London Plan[viii] sets out the Mayor's policies for development in London and was adopted in March 2021. Policy SI 12 Flood Risk Management, indicates the following .

- Current and expected flood risk from all sources across London should be managed in a sustainable and cost-effective way in collaboration with the Environment Agency (EA), Lead Local Flood Authority (LLFA), developer and providers.
- Development proposals should ensure that flood risk is minimised and mitigated, and that residual risk is addressed. This should include, where possible, making space for water and aiming for development to be set back from the banks of watercourses.
- Developments Plans and development proposals should contribute to the delivery of the measures set out in Thames Estuary 2100 Plan. The Mayor will work with the Environment Agency and relevant local planning authorities, including authorities outside London, to safeguard

an appropriate location for a new Thames Barrier.

- Development proposals for utility services should be designed to remain operational under flood conditions and buildings should be designed for quick recovery following a flood.
- Development proposals adjacent to flood defences will be required to protect the integrity of flood defences and allow access for future maintenance and upgrading. Unless exceptional circumstances are demonstrated for not doing so, development proposals should be set back from flood defences to allow for any foreseeable future maintenance and upgrades in a sustainable and cost-effective way.
- Natural flood management methods should be employed in development proposals due to their multiple benefits including increasing flood storage and creating recreational areas and habitat.

2.27. Policy SI 13 regarding Sustainable Drainage indicates that Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features. Furthermore, the policy outlines a specific drainage hierarchy and indicates that permeable paving should be used unless there are robust justifications, these items are discussed in further detail under Section 4 of this report

Water Industry Act

2.28. Thames Water is the local Sewerage Undertaker and provides sewerage services under the guidance of the Water Industry Act 1991.

2.29. Under Section 106 of the Water Industry Act, the developer currently maintains the automatic right to ‘communicate’ with the public foul water sewer system.

3. Sources of Potential Flooding

Tidal and Fluvial

3.1. The nearest waterbody to the Site is the River Crane, located adjacent to the Site's northern boundary and is fluvial at this location. The nearest tidal waterbody to the Site is the River Thames, located approximately 840m to the southeast. Therefore, it is considered that the primary source of flood risk is fluvial.

3.2. The EA's Flood Map for Planning (Figure 2) shows that the Site is predominantly located within Flood Zone 1, denoting a low probability of flooding, however, there is a small area to the north of the site, adjacent to the River Crane, located within Flood Zone 2, indicating a medium probability of fluvial flooding.

Figure 2: Environment Agency Flood Map for Planning

Source: https://flood-map-for-planning.service.gov.uk

3.3. The EA have provided modelled water levels for the River Crane for a number of return periods up to the 1 in 1000 year event (Appendix C). The modelled water levels are presented in Table 1 below.

Table 1: Environment Agency's Modelled Water Levels

Node Label	1 in 100 year	1 in 100 year plus climate change (20%)	1 in 1000 year
C536	9.645	9.898	9.915

3.4. It is worth noting that the EA have updated their guidance on climate change allowances in 2021,

therefore the data provided by the EA doesn't take the latest guidance into account. However, the latest allowance for this area is 17%, as such the information contained in Table 1 provides a more conservative approach in assessing a greater allowance for climate change.

3.5. Ground levels along the northern boundary of the Site fluctuate around 10.30m AOD for the majority of the area that fronts on to the River Crane, indicating that the majority of the bank would not be overtopped during the 1 in 1000 year event. However, there is a low point of 9.84m AOD to the east of the Site, just upstream of the railway bridge. This area could be at risk of flooding to a maximum depth of 0.075m during the 1 in 1000 year event.

3.6. The flooding would be contained to a small, low-lying area of approximately 34m^2 to the northeast of the Site. In order to ensure no impact on floodplain compensation levels in this area would remain as existing. The extent of Flood Zone 2 shown on the Flood Map for Planning is therefore smaller in reality. This confirms that the rest of the Site is located within Flood Zone 1 with a low probability of flooding from fluvial and tidal sources.

Offsets to River Crane

3.7. To preserve access to the River Crane for maintenance by the EA, a minimum offset of 8m would be provided from the top of bank (which appears to be a reinforced concrete wall) to any proposed buildings (Appendix D). Offsets to the River Crane would be in excess of 8m for the majority of the length of the River throughout the Site. All street furniture that falls within this offset would be removeable to allow access as and when required.

3.8. This would provide betterment over the existing situation, where offsets to the River are below 3.6m for a large part of the length of the River throughout the Site (Appendix D).

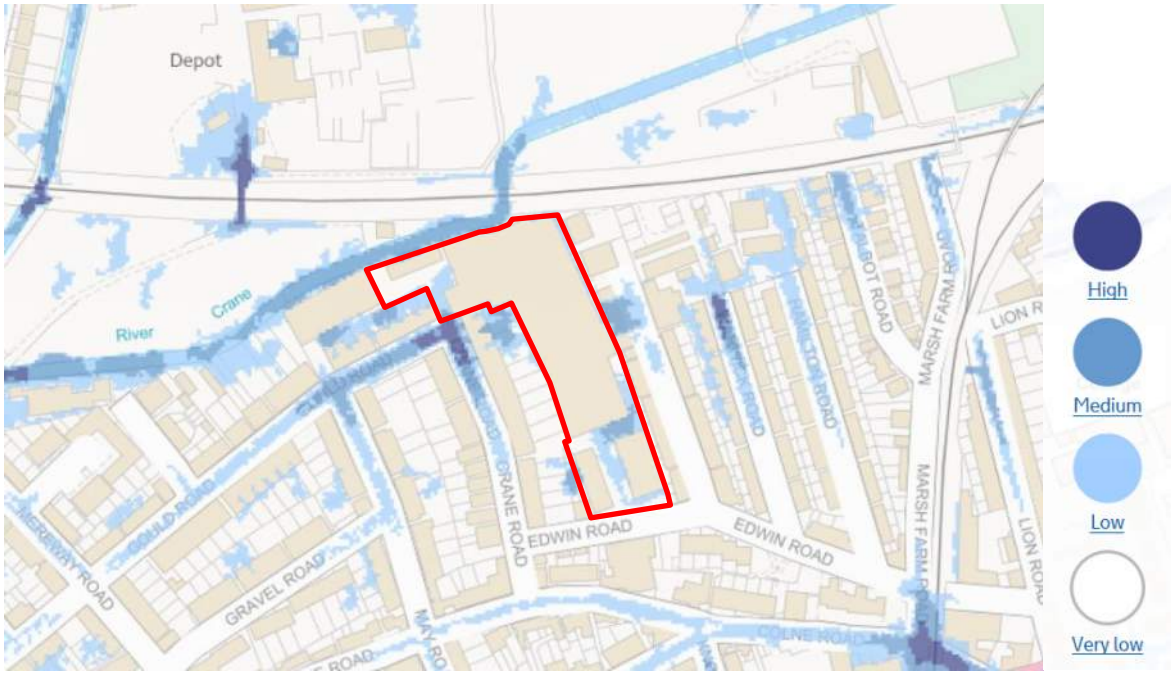
Pluvial

3.9. Pluvial flooding, also known as surface water flooding, occurs when natural and engineered drainage systems have insufficient capacity to deal with the volume of rainfall and are overwhelmed resulting in flooding. Pluvial flooding can occur in urban areas during extreme, high intensity, short duration summer rainfall events. This flood water would then be conveyed via overland flow routes dictated by local topography.

Overland Surface Water

3.10. The EA's Risk of Flooding from Surface Water mapping (Figure 3 overleaf) indicates that parts of the Site are at low to high risk of surface water flooding, and areas surrounding the Site, namely the intersection of Gould Road and Crane Road, are at low risk (0.1% to 1% annual chance) to high risk (greater than 3.3% annual chance) of flooding.

Figure 3: Environment Agency's Risk of Flooding from Surface Water Mapping



Site Boundary

Source: https://flood-warning-information.service.gov.uk

3.11. To further interrogate the EA's detailed Risk of Flooding from Surface Water mapping, it was overlaid on topographic survey of the Site (Appendix E). This indicated that during the 'medium risk' scenario (1% to 3.3% annual probability of flooding), the intersection of Gould Road and Crane Road could be subject to a maximum flood level of approximately 10.16m AOD.

3.12. Ground floor Finished Floor Levels (FFLs) across the Site would be set at a minimum 10.20m AOD, this would provide protection against the potential surface water flood risk. The ground levels at the Site entrance at the intersection of Gould Road and Crane Road would also be maintained to prevent the creation of new overland flow routes onto the Site.

3.13. Based on the above assessment, the risk of surface water flooding from overland flows to the Site is considered to be low.

Sewer

3.14. LBRT SFRA online mapping (Appendix F) indicates that the Site is located in an area with between 1 and 10 records of sewer flooding.

3.15. Thames Water have confirmed (Appendix G) that there have been no incidents of flooding due to surcharging public sewer within the vicinity of the Site.

3.16. Based on the above assessment, the risk of sewer flooding to the Site is considered to be low.

Groundwater

3.17. The Sites underlying geological profile has been established through a Geo-environmental Investigation (GI)[ix] carried out by AP Geotechnics in September 2017. Table 2 presents a summary of the Sites underlying geology.

Table 2: Site Geology

Stratum	Estimated Thickness
Made Ground	0.15m to 1.70m (0.40m to 1.70m bgl)
Superficial Clay (pockets encountered throughout the Site)	0.30m to 1.10m (1.30m to 2.00m bgl)
Kempton Park Gravel	5.10m to 7.75m (6.90m to 9.15m bgl)
London Clay	Over 13.10m (to base of borehole at 20.00m bgl)

3.18. Based on borehole records from the GI, groundwater has been observed at a minimum depth of 2.4m below ground level (bgl) towards the centre of the Site, adjacent to the south-eastern corner of the existing factory building. The maximum depth of groundwater encountered was 4.2m bgl in the north-eastern corner of the Site. Across the majority of the Site groundwater was encountered at depths between 2.70m and 4.0m bgl.

3.19. LBRT online SFRA mapping (Appendix F) indicates that the Site is located within an area with 'potential for groundwater flooding to occur at surface'.

3.20. As groundwater was encountered at a minimum of 2.4m bgl during the GI, it is unlikely that groundwater flooding would be an issue at the Site.

3.21. There are no proposed basements within the scheme that could impact the flow of groundwater beneath the Site, and therefore there is unlikely to be an effect on groundwater levels in the vicinity of the Site as a result of the scheme.

3.22. The risk of groundwater flooding to the Site itself and the impact of the development on groundwater flooding to others is therefore considered to be low.

Artificial Sources

3.23. The EA's online Risk of Flooding from Reservoirs mapping (Figure 3 overleaf) shows the maximum extent likely to be affected in a reservoir breach scenario. This map indicates that the Site would remain free of flooding if a reservoir were to fail.

3.24. The map shows that the Site is outside to the maximum extent of flooding from a reservoir failure when river conditions are normal, referred to as the 'dry day failure' scenario.

3.25. The Site is, however, located in an area with an area with potential for flooding when a failure coincides with a 1 in 1000 year flood event on receiving watercourses. On closer inspection of the EA's mapping, the Site is shown to be affected by a breach from the Queen Elizabeth II and the Queen Mother reservoirs.

3.26. It is worth noting that under the Reservoirs Act 1975, the reservoir operator has a responsibility to frequently inspect and maintain a reservoir to a high standard of protection and therefore the occurrence of a breach is considered highly unlikely.

3.27. The LBRT SFRA does not identify any other artificial sources of flood risk in the area, therefore, the risk of flooding from artificial sources is considered to be low.

Figure 4: Environment Agency's Risk of Flooding from Reservoirs Mapping

Key

Site Boundary

Source: https://flood-warning-information.service.gov.uk/long-term-flood-risk

Summary

3.28. Based on the above assessment, the Site is considered to be at low risk of flooding from tidal, fluvial, pluvial, groundwater and artificial sources of flooding. The potential for the development to increase flood risk through increasing surface water runoff is considered in Section 4.

4. Surface Water Drainage

Existing Drainage

4.1. Thames Water records (Appendix G) indicate several sewers within the vicinity of the Site. These are shown in Table 3.

Table 3: Existing Drainage

Location	Sewer
Edwin Road	225mm diameter surface water sewer
Edwin Road	225mm diameter combined sewer
On-site	375mm diameter combined sewer
On-site	914mm diameter combined sewer
Crane Road	300mm diameter combined sewer
Crane Road/On-site	225mm diameter combined sewer
Gould Road	225mm diameter combined sewer
Gould Road	Unknown diameter surface water sewer

Proposed Drainage

4.2. The proposed drainage system would be designed to convey surface and foul water separately. The design would be in accordance with BS EN 752 – Drain and Sewer Systems Outside Buildings[x], BS EN 12056 – Gravity Drainage Systems Inside Buildings[xi] and Approved Document H of Building Regulations[xii].

4.3. In accordance with Building Regulations and the PPG, the following hierarchy of surface water disposal would be adhered to, in decreasing order of preference.

I. Discharge to ground;

II. Discharge to surface water body;

III. Discharge to a surface water sewer; and

IV. Discharge to a combined sewer.

Discharge to Ground

4.4. The Sites underlying geology comprises Kempton Park Gravel with pockets of Clay found throughout the Site. Therefore, discharge to ground may be possible. Soakage tests were undertaken in one location in the northern area of the Site (access to other areas was not available), the resultant infiltration rates were poor and given to be between 4.47×10^{-6} to 4.62×10^{-6} m/s (Appendix H). Solely discharging runoff to ground would therefore not be feasible, therefore discharge to the River has also been considered. Further soakage tests would be carried out at the detailed design stage to confirm infiltration rates across the wider Site.

Discharge to Surface Water Body

4.5. The River Crane is located adjacent to the Site's northern boundary. In addition to discharging to ground an outfall would be provided to the River Crane in the event that further infiltration testing (undertaken at the detailed design stage) does not have positive results.

Sustainable Drainage Systems

4.6. The most sustainable way to drain surface water runoff is through the use of sustainable drainage systems (SuDS), which need to be considered in relation to site-specific constraints.

4.7. SuDS mimic the natural drainage system and provide a method of surface water drainage which can decrease the quantity of water discharged, thereby reducing the risk of flooding. In addition to reducing flood risk, SuDS can improve water quality, and provide biodiversity and amenity benefits.

4.8. A variety of SuDS devices are available to reduce or temporarily attenuate the discharge of surface water runoff. The potential for SuDS was considered throughout the development. Table 4 outlines the potential SuDS devices and their constraints and opportunities at the Site.

Table 4: SuDS Devices Constraints

Device	Description	Constraints/Comments	✓/×
Green/brown roofs (source control)	Provide soft landscaping at roof level which reduces surface water runoff	There are no constraints to the incorporation of green roofs into the development	✓
Infiltration devices & Soakaways (source control)	Store runoff and allow water to percolate into the ground via natural infiltration	There are no constraints to the incorporation of infiltration devices into the development	✓
Pervious surfaces (source control)	Storm water is allowed to infiltrate through the surface into a storage layer, from which it can infiltrate and/or slowly discharge into sewers	There are no constraints to the incorporation of pervious surfaces into the development	✓
Rainwater harvesting (source control)	Reduces the annual average rate of runoff from the site by reusing water for non-potable uses e.g. toiler flushing or water butts	There are no constraints to the incorporation of rainwater harvesting into the development	✓
Swales (permeable conveyance)	Broad, shallow channels that convey/store runoff, and allow infiltration (ground conditions permitting)	There are no constraints to the incorporation of swales into the development. However, as permeable paving with an unlined area for infiltration is proposed, these are not considered necessary	×

Filter drains & perforated pipes (permeable conveyance)	Trenches filled with granular materials (which are designed to take flows from adjacent impermeable areas) that convey runoff while allowing infiltration (ground conditions permitting)	There are no constraints to the incorporation of filter drains into the development. However, as permeable paving with an unlined area for infiltration is proposed, these are not considered necessary	×
Filter strips (permeable conveyance)	Wide, gently sloping areas of grass or dense vegetation that remove pollutants from runoff from adjacent areas	Due to the limited free external space available on-site, filter strips are not considered feasible	×
Infiltration basins (end of pipe treatment)	Depressions in the surface designed to store runoff and allow infiltration through the base	Due to the limited free external space available on-site, infiltration basins are not considered feasible	×
Bio-retention systems/ rain garden (end of pipe treatment)	A shallow landscaped depression which allows runoff to pond temporarily on the surface before filtering through vegetation and underlying soils	There are no constraints to the incorporation of rain gardens into the development. However, as permeable paving with an unlined area for infiltration is proposed, these are not considered necessary	×
Dry ponds (end of pipe treatment)	Depressions in the surface designed to store runoff without infiltration through the base	Due to the limited free external space available on-site, dry ponds are not considered feasible	×
Underground attenuation (end of pipe treatment)	Oversized pipes or geo-cellular tanks designed to store water below ground level	Sufficient storage would be provided within the permeable paving. Therefore, underground attenuation is not considered to be necessary	×

Green Roof/Brown Roofs

4.9. Green/brown roofs would provide a bio-diverse habitat in addition to capturing rainwater and naturally slowing the rate of runoff. Green roofs are proposed on the flat areas of roof on Blocks A, C and F (Appendix B).

Pervious Surfaces

4.10. Pervious surfaces allow for the infiltration of runoff through otherwise impermeable surfaces such as roads and pavements. Pervious paving is proposed within the access road and car parking areas to the east and north of the Site (Appendix I).

4.11. It is proposed to leave a section of the sub-base of the pervious paving unlined to allow infiltration through the base (Appendix I). In line with Building Regulations a 5m offset from buildings to soakaways is required, therefore the first 5m of subbase would be lined to prevent infiltration.

Rainwater Harvesting

4.12. The inclusion of rainwater harvesting would reduce the demand on potable water as recycled water could be used for washing down external areas and watering plants. However, it cannot be guaranteed that there would always be sufficient demand for recycled water to ensure an empty tank is available prior to a high intensity rainfall event, when the storage is most needed. Therefore, rainwater harvesting has not been taking into consideration within the surface water runoff calculations presented later in the drainage strategy. Water butts would be included for the residential units for irrigation of private gardens.

Proposed Surface Water Drainage Strategy

4.13. The total Site area within the red line boundary is 1.130ha, however, 0.152ha of this in the proposed scenario would be permeable (Appendix J). Therefore, the attenuation calculations are based on an impermeable area of 0.978ha.

4.14. The existing discharge rate for the Site has been calculated for the 100 year 60 minute event based on a Site area of 1.130ha. Using the Modified Rational Method (Appendix K) this gives an existing runoff rate of 145.3 l/s.

4.15. The potential to discharge to ground has been considered throughout the design process, however, soakage tests carried out in January 2018 indicated infiltration rates of between $4.47x10^{-6}$ and $4.62x10^{-6}$ m/s. These rates indicate infiltration could be poor at the Site and therefore a combination of infiltration and a pumped discharge (gravity connection would not be possible due to levels) to the River Crane is proposed.

4.16. In line with the requirements of the London Plan, it is proposed to restrict discharge from the Site to the 100 year greenfield rate. This has been calculated using the IoH 124 methodology to be 8.9 l/s, providing a 94% reduction in flows.

4.17. MicroDrainage Source Control module has been used to undertake preliminary calculations of the attenuation required at the Site. Source Control considers all storm durations for the 1 in 100 year event and includes a 40% allowance for the effects of climate change. Results show (Appendix K) that to restrict discharge to the River Crane at a total of 8.9 l/s, 646m^3 of attenuation is required.

4.18. This storage would be provided in the sub-base layer of the permeable paving proposed within the access road and car parking areas (Appendix I). The permeable paving would cover an area of 4500m^2, an allowance of 10% has been given for utilities trenches (to be confirmed at the detailed design stage) which brings the useable area to 4050m^2. The permeable paving would have an effective storage depth of 0.6m and 30% porosity. To allow for infiltration, 1580m^2 of this area would be unlined and a 5m offset would be provided from all buildings to the unlined areas of sub-base, in line with Building Regulations.

4.19. As previously stated, it is also proposed to include green roofs on blocks A, C & F buildings which will provide initial treatment of runoff generated form these areas. The remaining areas would be treated by the permeable paving.

4.20. The pollution hazard level of surface water runoff from the development is classified as 'very low' for the residential roofs and 'low' for the car park and highway. A level of treatment appropriate to the pollution hazard level of the development would be provided by the green roof and permeable paving to ensure that the quality of surface water discharged to ground, and the River Crane is acceptable.

Sustainable Drainage Systems Management Plan

4.21. The PPG sets out the requirement for developers to consider the operation, management and maintenance of all SuDS proposed. The on-site drainage network and SuDS would be privately managed and maintained for the lifetime of the development, ensuring that they remain fit for purpose and function appropriately.

4.22. Post-construction, an on-site management company would be responsible for the SuDS included within the scheme. Table 5 presents an indicative maintenance schedule of the anticipated maintenance and repairs, in line with guidance from the CIRIA SuDS Manual.

Table 5: SuDS Maintenance Schedule

SuDS Device/Task	Frequency
Green/Brown Roofs	
Inspect system to replace dead plants as required and ensure plants are sufficiently watered (during establishment period)	As required
Inspect system to replace dead plants (post establishment period)	Annually (in autumn)
Remove nuisance and invasive vegetation, including weeds	Six monthly or as required
Inspect system to ensure substrate is not eroded and inlet / outlet drains are not blocked	Annually or as required (after severe storms)
Pervious Surfacing	
Inspection of main structure, pipework and filtration devices and remove any sediment/debris	Quarterly or as required
Jetting of main structure to remove any sediment build-up	Annually or as required
Rainwater Harvesting	
Inspect system for debris and sediment build-up	Annually (and following poor performance)
Cleaning of tank, inlets, outlets, gutters, and roof drain filters of silts and other debris	Annually (and following poor performance)

5. Foul Water Drainage

5.1. The proposed foul drainage system would be designed in accordance with BS EN 752 – Drains and Sewer Systems Outside Buildings[x], BS EN 12056 – Gravity Drainage Systems Inside Buildings[xi], and Approved Document H of Building Regulations[xii].

5.2. The proposed foul flows from Town Houses A to D, Building E and the eastern side of Building F would connect into the 375mm diameter combined sewer running south to north through the Site, and flows from the western part of Building F, and Buildings H and G would connect into the 300mm diameter combined sewer crossing the site access from Crane Street.

5.3. The existing and proposed foul discharge rates have been calculated using the water consumption method to be 1.0 l/s and 0.9 l/s respectively (Appendix L). Therefore, the proposed development would result in a nominal decrease in the peak foul flow rates from the Site. It is anticipated that this would be acceptable to Thames Water.

5.4. If new connections are required, these would be made to the public sewer system through a S106 agreement with Thames Water, under the Water industry Act 1991.

6. Impact on Existing Drainage Infrastructure

6.1. As part the proposed surface water drainage strategy, surface water runoff would discharge directly to ground through infiltration where possible and to the River Crane via a pumped discharge if infiltration is slow or not possible. Therefore, providing betterment by reducing the amount of flow discharging into the public sewer network.

6.2. The proposed development would provide a 1.5m minimum offset from proposed buildings to the 375mm diameter combined sewer and 914mm diameter combined trunk sewer passing through the Site. This provides betterment over the existing situation as currently access is provided only to part of the 375mm diameter sewer, and no access is provided to the 914mm diameter combined trunk sewer.

6.3. The consultation process to build near a sewer has been started with Thames Water and negotiations are ongoing. Further work would be required post-planning.

7. Conclusions

7.1. EA mapping indicates that the Site is located predominantly within Flood Zone 1, denoting a low probability of flooding, with a small area along the northern boundary with the River Crane located within Flood Zone 2, denoting a medium probability of fluvial flooding.

7.2. Interrogation of the EA's modelled flood levels against the existing ground levels at the Site has shown that levels along the River Crane are generally above 10.30m AOD indicating that the banks would not be overtopped up to and above the 1 in 1000 year event. However, a small, low-lying area to the east of the site, just upstream of the railway bridge, would be at risk of flooding to a depth of 0.075m during the 1 in 1000 year event. This flooding would be contained to a small area and would not affect the rest of the Site. It is therefore considered that the Site is at low risk of fluvial flooding.

7.3. The risk of flooding from tidal, pluvial, groundwater and artificial sources has also been assessed and found to be low.

7.4. Infiltration testing confirmed the ground conditions are not suitable for discharge to ground. However, further testing would be undertaken at more locations across the Site at the detailed design stage to confirm this. Surface water runoff would therefore discharge to the River Crane via a pumped discharge as a gravity connection is not feasible due to levels.

7.5. The existing runoff rate for the Site has been calculated to be 145.3 l/s. It is proposed to restrict runoff to the greenfield 100 year rate of 8.9 l/s, providing a 94% reduction in flows.

7.6. To restrict surface water runoff to this rate, a minimum of 646m^3 of storage would be provided in the sub-base layer of the proposed permeable paving located below the access road and car parking areas. In addition to the pumped discharge some of the sub-base would be unlined to allow some slow infiltration to ground.

7.7. The pollution hazard level of surface water runoff from the development is classified as 'very low' for the residential roofs and 'low' for the car parking areas and access road. A level of treatment appropriate to the pollution hazard level of the development would be provided by the green roof and permeable paving to ensure that the quality of surface water discharged to ground, and the River Crane is acceptable.

7.8. The on-site drainage network and SuDS would be managed and maintained for the lifetime of the development by an appropriate managing body, ensuring they remain fit for purpose and function appropriately.

7.9. Foul flows from the Site would discharge by gravity to the Thames Water combined sewer network. The existing and proposed peak foul discharge rates have been calculated using the water consumption method to be 1.0 l/s and 0.9 l/s respectively. As such, the proposed development would result in a nominal decrease in peak foul flow rates from the Site.

7.10. This report demonstrates that the proposed development has a low probability of flooding from fluvial, tidal, groundwater and artificial sources, and confirms that surface water runoff can be managed sustainably to ensure that flood risk is not increased elsewhere. It is considered that the information contained within this report satisfies the requirements of the NPPF and Local Policy.

8. References

[i] Ministry of Housing, Communities and Local Government, February 2019. *National Planning Policy Framework*

[ii] Ministry of Housing, Communities and Local Government, March 2014. *Planning Practice Guidance*

[iii] London Borough of Richmond upon Thames, July 2018. *Local Plan.*

[iv] London Borough of Richmond upon Thames, May 2011. *Preliminary Flood Risk Assessment.*

[v] London Borough of Richmond upon Thames, March 2021 . *Strategic Flood Risk Assessment Update.*

[vi] London Borough of Richmond upon Thames, June 2011. Surface Water Management Plan

[vii] Department for Environment, Food and Rural Affairs, March 2015. *Non-statutory technical standards for sustainable drainage systems.*

[viii]Greater London Authority, March 2021. *The London Plan*.

[ix] AP Geotechnics, September 2017. *Former Greggs Bakery: Phase II Geo-environmental Investigation.*

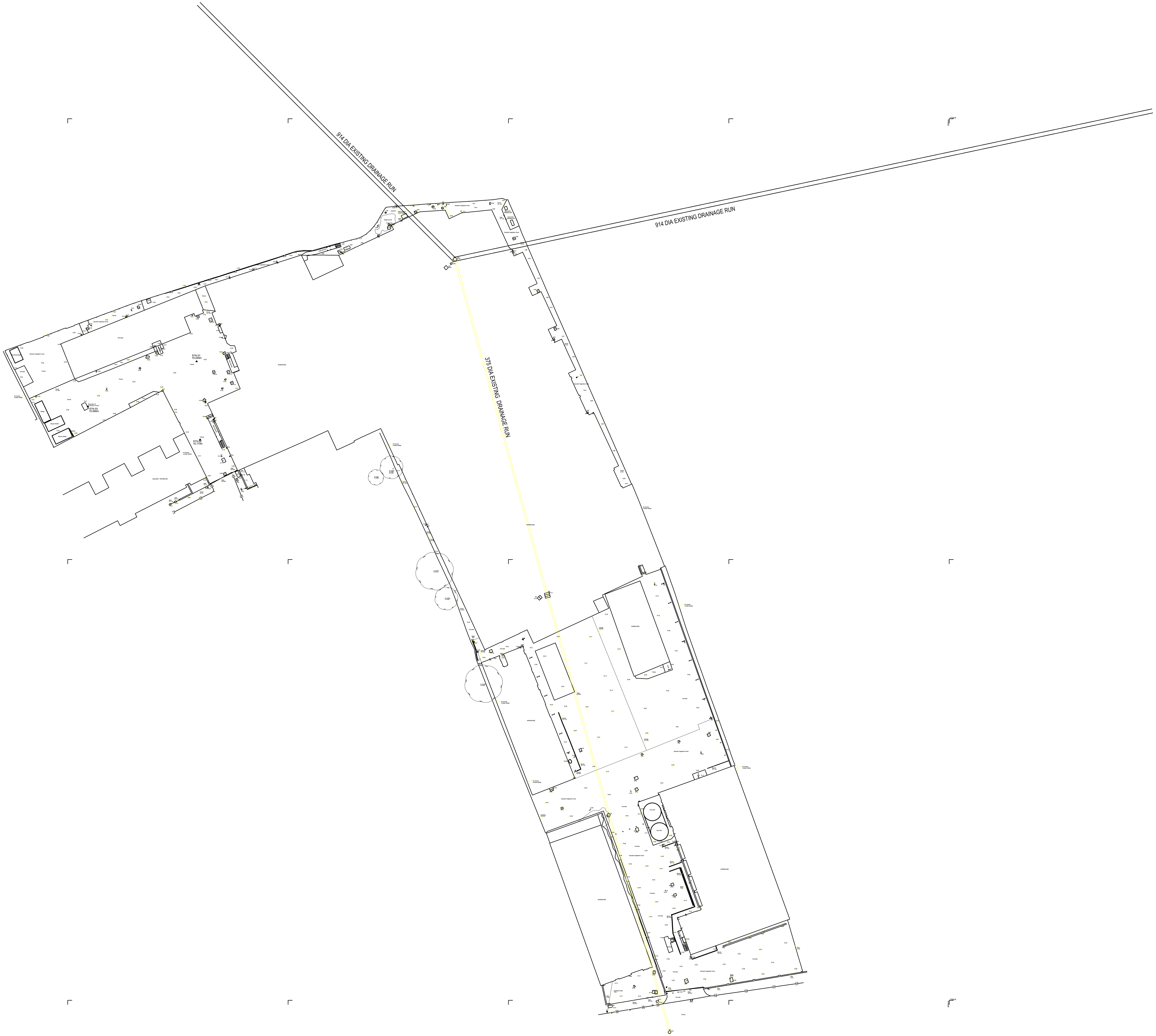
[x] British Standards Institution, April 2008. *BS EN 752:2008 – Drain and Sewer Systems Outside Buildings.*

[xi] British Standards Institution, September 2000. *BS EN 12056-2:2000 – Gravity Discharge Systems Inside Buildings*

[xii] HM Government, 2010. *The Building Regulations: H, Drainage and Waste Disposal.*

APPENDICES

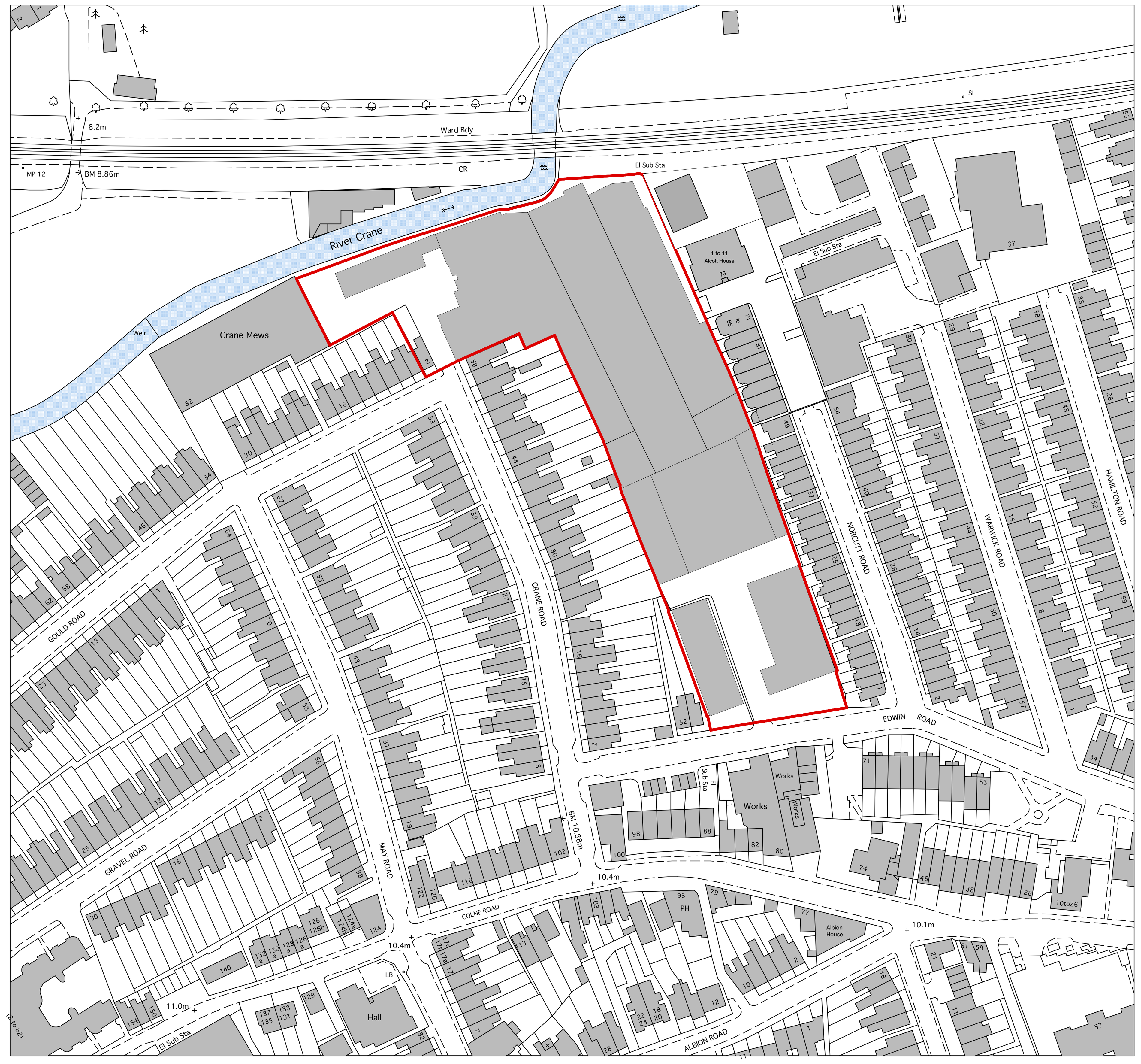
A. Topographic Survey


914 DIA EXISTING DRAINAGE RUN
914 DIA EXISTING DRAINAGE RUN
375 DIA EXISTING DRAINAGE RUN

B. Development Proposals

0m 10m 25m 50m 100m

N



General notes

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Areas are measured and calculated generally in accordance with RICS 'Property Measurement', 2nd Edition (January 2018). All areas have been calculated in metric units.

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Drawing notes

Electronic file reference

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50	Planning DRAFT	11/02/22	CS	ES	

KEY

Site boundary

Purpose of information

The purpose of the information on this drawing is for:

- [ ] Planning
- [x] Information
- [ ] Comment
- [ ] Client approval
- [ ] Construction

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LONDON SQUARE

Client

London Square

Project title

Greggs Bakery Site Twickenham

Drawing title

Site Location Plan

Scale @ A1 size	Date
1:1250	**Dec '21**

Drawing Nº

GBT-ASA-ZZ-ZZ-DR-A-0051

Status & Revision

R50

Assael

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Electronic file reference

Status R:	Revision	Date	DRN	CHK	CDM
54	Planning Submission	28/06/2022	CS	ES	

Key

Area safeguarded for future pedestrian bridge

Future bridge provision

Purpose of information

The purpose of the information on this drawing is for:

- Planning [x]
- Information [ ]
- Comment [ ]
- Client approval [ ]
- Construction [ ]

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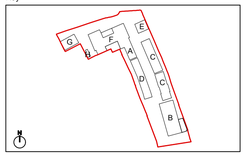
Key



Client

London Square

Project title

Greggs Bakery Site
Twickenham

Drawing title

Proposed
Ground Floor Plan

Scale @ A1 size	Date
1:500	**28/06/22**

Drawing N°

GBT-ASA-ZZ-00-DR-A-0250

Status & Revision

R54

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Electronic file reference

Status R:	Revision	Date	DRN	CHK	CDM
54	Planning Submission	28/06/2022	CS	ES	

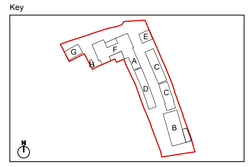
Purpose of information

The purpose of the information on this drawing is for:

- [x] Planning
- [ ] Information
- [ ] Comment
- [ ] Client approval
- [ ] Construction

All information on this drawing is not for construction unless it is marked for construction.

Key



Client

London Square

Project title

Greggs Bakery Site
Twickenham

Drawing title

Proposed
Roof Plan

Scale @ A1 size	Date
1:500	**28/06/22**

Drawing N°

GBT-ASA-ZZ-05-DR-A-0255

Status & Revision

R54

Assael

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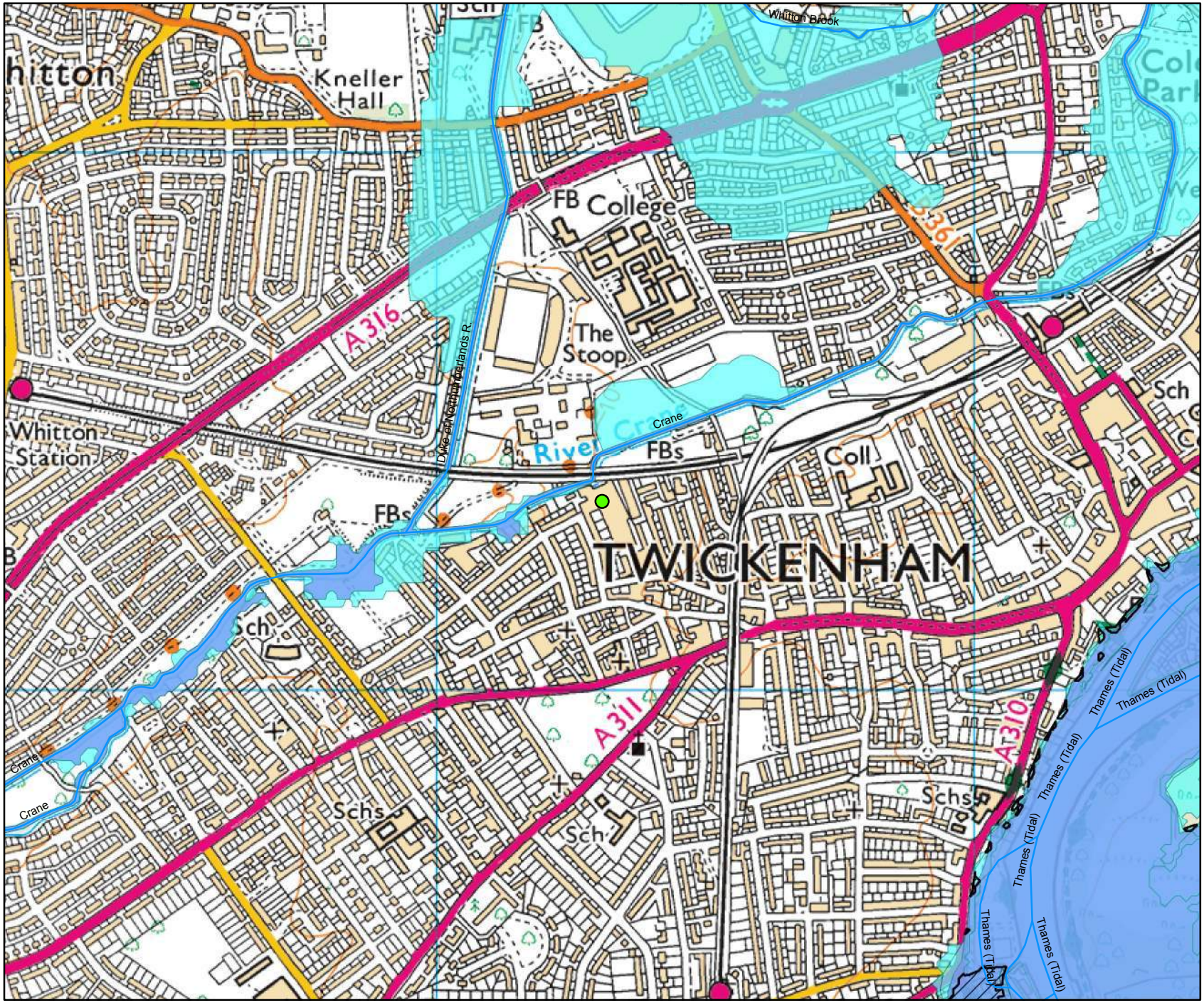
C. Environment Agency Consultation

Flood Map for Planning centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 150 300 600
Metres

Legend

- Main Rivers
- Site location

Flood Map for Planning

- Flood Storage Area
- Areas Benefiting from Flood Defences
- Flood Zone 3
- Flood Zone 2

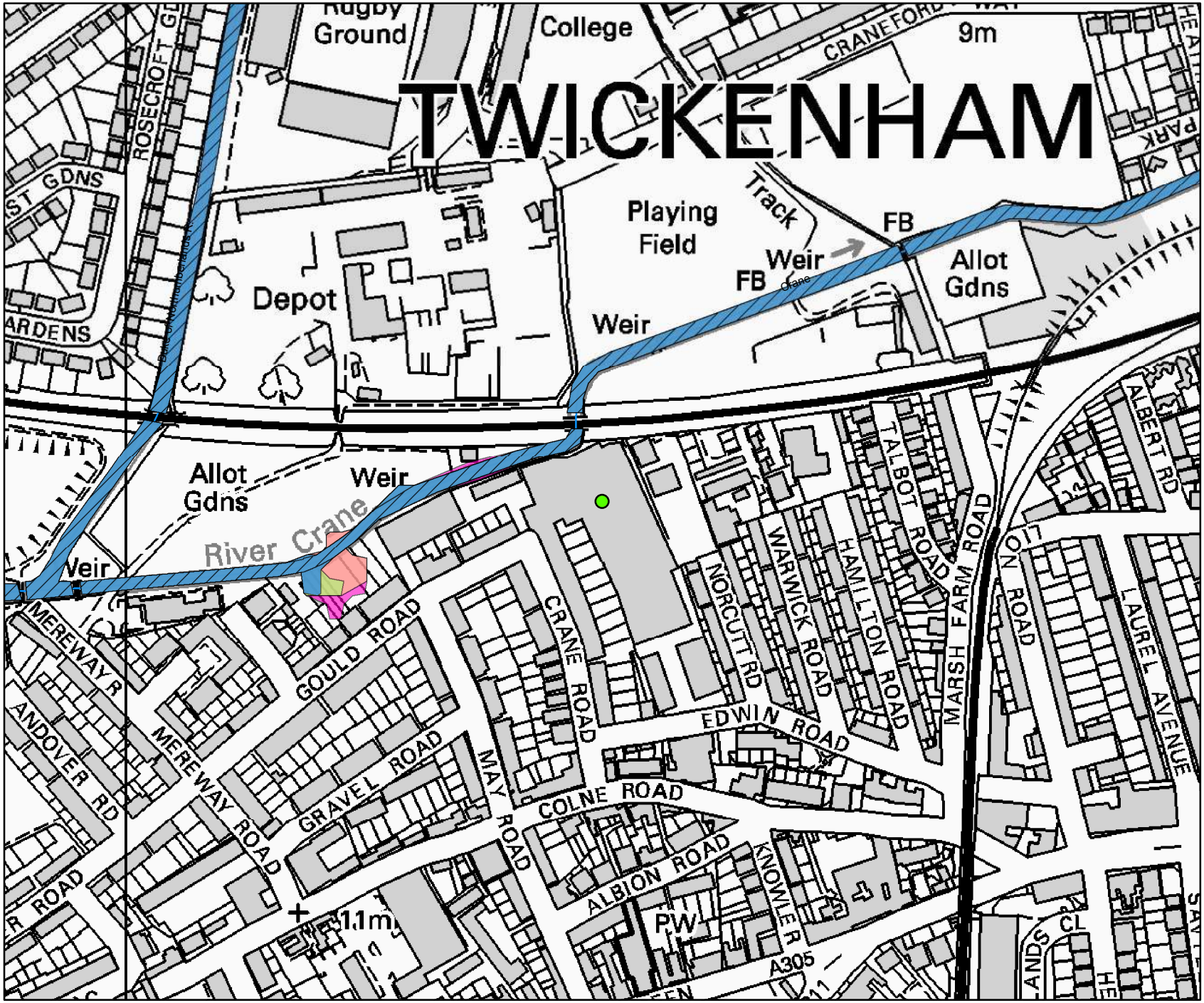
Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

- Main Rivers
- Site location

Defended Flood Outlines

- 1 in 5 (20%) Defended
- 1 in 10 (10%) Defended
- 1 in 20 (5%) Defended
- 1 in 50 (2%) Defended
- 1 in 100 (1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.
Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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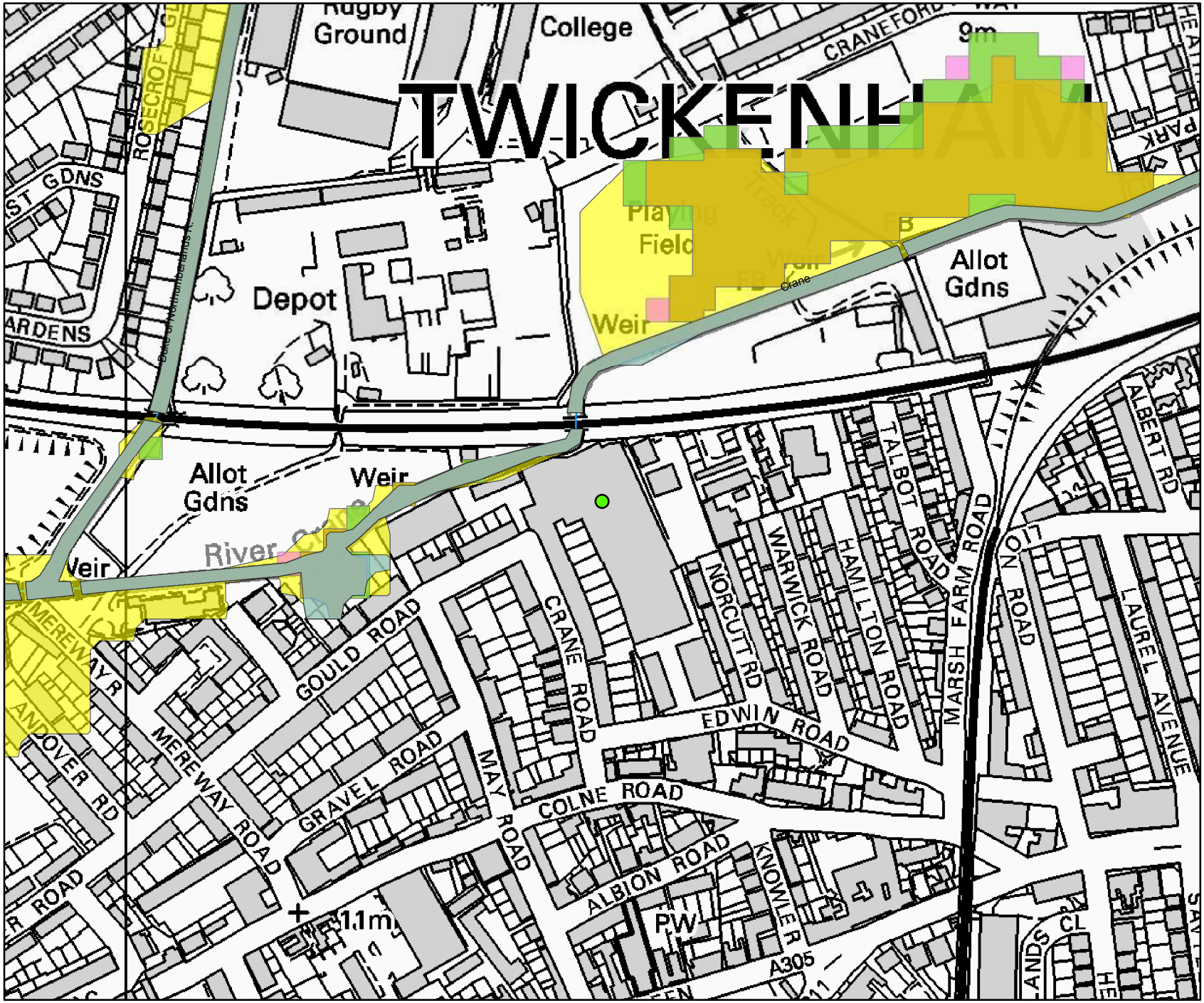
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

- Main Rivers
- Site location

Defended Flood Outlines

- 1 in 100+20% (*CC) Defended
- 1 in 100+25% (*CC) Defended
- 1 in 100+30% (*CC) Defended
- 1 in 100+70% (*CC) Defended
- 1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.
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Partnerships & Strategic Overview,
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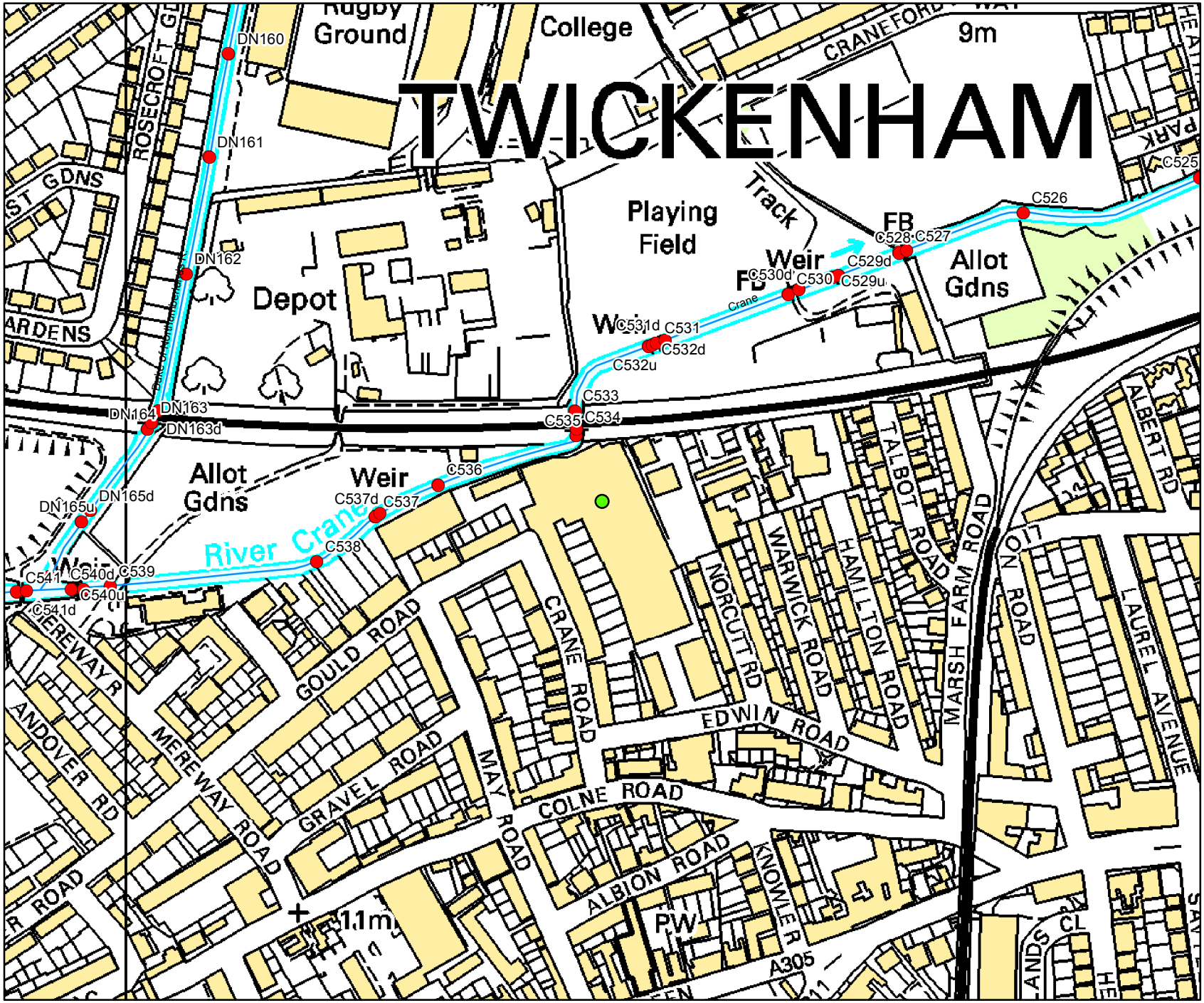
Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 50 100 200
Metres

Legend

- Main Rivers
- Site location

1D Node Results

- Node Results

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.
Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: HNL107059JH

The following information has been extracted from the River Crane Mapping Study (Halcrow 2008)

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Caution:

The modelled flood levels and extents are appropriate for catchment wide strategic flood risk mapping. However, for more detailed flood risk assessment it is recommended that each of the underlying flood mapping, hydraulic modelling and hydrological assumptions are re-evaluated to determine the appropriateness in a more detailed analysis.

All flood levels are given in metres Above Ordnance Datum (mAOD)
All flows are given in cubic metres per second (cumecs)

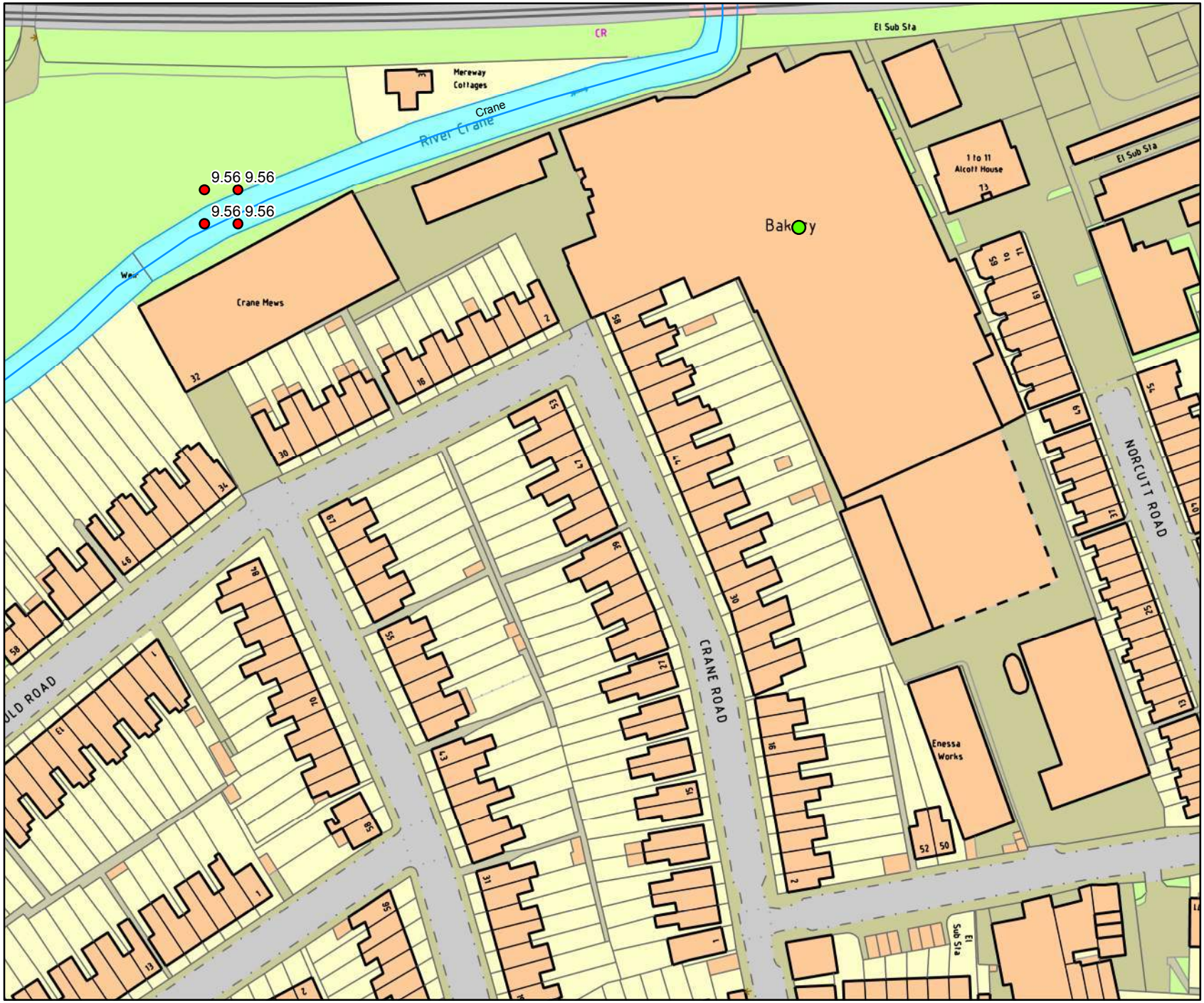
MODELLED FLOOD LEVEL

			Return Period									
Node Label	**Easting**	**Northing**	**5 yr**	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**1000yr**
C541	514930	173296	10.104	10.191	10.235	10.279	10.320	10.384	10.364	10.553	10.609	10.719
C541d	514930	173296	10.103	10.190	10.232	10.276	10.317	10.379	10.359	10.541	10.592	10.693
C540u	514967	173295	9.997	10.079	10.119	10.161	10.200	10.258	10.233	10.394	10.439	10.542
C540d	514967	173295	9.622	9.696	9.732	9.770	9.806	9.860	9.814	9.955	9.996	10.115
C539	514993	173299	9.748	9.824	9.861	9.899	9.935	9.990	9.956	10.102	10.143	10.249
C538	515124	173311	9.611	9.683	9.718	9.754	9.788	9.838	9.794	9.917	9.950	10.053
C537	515163	173341	9.575	9.649	9.685	9.722	9.757	9.808	9.760	9.884	9.919	10.027
C537d	515163	173341	9.501	9.574	9.610	9.646	9.681	9.732	9.677	9.799	9.832	9.948
C536	515203	173360	9.462	9.537	9.573	9.610	9.645	9.698	9.637	9.759	9.793	9.915
C535	515294	173393	9.383	9.460	9.497	9.536	9.573	9.628	9.553	9.680	9.716	9.854
C534	515296	173397	9.353	9.430	9.467	9.506	9.543	9.598	9.518	9.644	9.679	9.822
C533	515293	173409	9.153	9.209	9.236	9.263	9.289	9.329	9.230	9.296	9.316	9.461
C532u	515341	173452	9.091	9.147	9.173	9.200	9.227	9.267	9.148	9.206	9.225	9.433
C532d	515341	173452	8.989	9.042	9.068	9.093	9.119	9.158	9.016	9.047	9.051	9.324
C531	515346	173453	8.982	9.035	9.061	9.086	9.112	9.151	9.006	9.035	9.038	9.317
C531d	515346	173453	8.982	9.035	9.061	9.086	9.112	9.151	9.006	9.035	9.038	9.300
C530	515432	173485	8.912	8.964	8.990	9.015	9.041	9.080	9.001	9.069	9.084	9.231
C530d	515432	173485	8.912	8.964	8.990	9.015	9.039	9.073	9.001	9.063	9.076	9.195
C529u	515460	173500	8.878	8.929	8.955	8.980	9.004	9.038	8.967	9.028	9.041	9.161
C529d	515460	173500	8.479	8.526	8.548	8.571	8.592	8.623	8.644	8.742	8.769	8.778
C528	515504	173513	8.425	8.471	8.494	8.516	8.537	8.568	8.603	8.705	8.734	8.729
C527	515506	173513	8.431	8.478	8.500	8.523	8.544	8.575	8.609	8.711	8.740	8.736
C526	515584	173537	8.270	8.316	8.339	8.362	8.383	8.413	8.497	8.610	8.641	8.601
C525	515698	173562	8.046	8.093	8.115	8.138	8.159	8.191	8.203	8.292	8.314	8.349
DN166	514954	173302	9.997	10.079	10.119	10.161	10.200	10.258	10.233	10.394	10.439	10.542
DN165u	514974	173335	9.975	10.055	10.094	10.135	10.172	10.230	10.206	10.364	10.407	10.512
DN164	515016	173397	9.899	9.981	10.021	10.063	10.103	10.162	10.138	10.298	10.344	10.464
DN163	515016	173401	9.903	9.986	10.027	10.069	10.108	10.167	10.143	10.300	10.345	10.463
DN163d	515016	173401	9.903	9.985	10.026	10.067	10.106	10.166	10.141	10.297	10.341	10.458
DN162	515040	173498	9.828	9.910	9.951	9.994	10.034	10.094	10.070	10.220	10.266	10.392
DN161	515056	173574	9.762	9.845	9.888	9.934	9.972	10.033	10.011	10.154	10.202	10.340
DN160	515067	173641	9.722	9.805	9.849	9.897	9.935	9.997	9.975	10.115	10.164	10.314
DN165d	514977	173344	9.951	10.031	10.070	10.111	10.149	10.207	10.183	10.338	10.382	10.491

MODELLED FLOWS

			Return Period									
Node Label	**Easting**	**Northing**	**5 yr**	**10 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**1000yr**
C541	514930	173296	26.855	28.691	29.598	30.528	31.401	32.702	32.934	37.471	38.701	39.000
C541d	514930	173296	26.855	28.691	29.598	30.528	31.401	32.702	32.934	37.471	38.701	39.000
C540u	514967	173295	26.853	28.691	29.598	30.528	31.401	32.703	32.934	37.435	38.616	39.000
C540d	514967	173295	24.115	25.400	26.036	26.678	27.278	28.150	28.591	31.34	32.061	32.542
C539	514993	173299	24.115	25.400	26.036	26.678	27.277	28.149	28.591	31.327	32.038	32.549
C538	515124	173311	24.114	25.399	26.036	26.678	27.276	28.149	28.597	31.266	31.96	32.583
C537	515163	173341	24.112	25.399	26.036	26.678	27.275	28.149	28.6	31.252	31.944	32.533
C537d	515163	173341	24.112	25.399	26.036	26.678	27.275	28.149	28.6	31.252	31.944	32.533
C536	515203	173360	24.112	25.399	26.036	26.678	27.274	28.149	28.605	31.246	31.936	32.517
C535	515294	173393	24.113	25.399	26.035	26.677	27.274	28.149	28.608	31.234	31.918	32.503
C534	515296	173397	24.113	25.399	26.035	26.677	27.274	28.149	28.61	31.234	31.918	32.504
C533	515293	173409	24.113	25.399	26.036	26.677	27.274	28.149	28.619	31.235	31.92	32.504
C532u	515341	173452	24.113	25.399	26.035	26.677	27.274	28.149	28.629	31.231	31.91	31.412
C532d	515341	173452	24.113	25.399	26.035	26.677	27.274	28.149	28.629	31.231	31.91	31.412
C531	515346	173453	24.113	25.399	26.035	26.677	27.274	28.149	28.643	31.231	31.91	31.411
C531d	515346	173453	24.113	25.399	26.035	26.677	27.274	28.149	28.643	31.231	31.91	31.411
C530	515432	173485	24.112	25.399	26.035	26.677	27.274	28.149	26.348	27.906	28.247	31.394
C530d	515432	173485	24.112	25.399	26.035	26.677	27.274	28.149	26.348	27.906	28.247	31.394
C529u	515460	173500	24.112	25.399	26.035	26.677	27.274	28.149	26.332	27.903	28.243	31.390
C529d	515460	173500	24.112	25.399	26.035	26.677	27.274	28.149	26.332	27.903	28.243	31.390
C528	515504	173513	24.112	25.399	26.035	26.677	27.274	28.149	26.329	27.902	28.242	31.384
C527	515506	173513	24.112	25.399	26.035	26.677	27.274	28.149	26.329	27.902	28.242	31.384
C526	515584	173537	24.112	25.399	26.035	26.678	27.274	28.149	26.324	27.95	28.309	31.391
C525	515698	173562	24.112	25.399	26.035	26.677	27.273	28.149	28.522	31.052	31.726	32.460
DN166	514954	173302	2.739	3.291	3.562	3.851	4.123	4.554	4.354	6.107	6.591	6.600
DN165u	514974	173335	2.735	3.290	3.562	3.851	4.123	4.554	4.352	5.86	6.304	6.600
DN164	515016	173397	2.735	3.290	3.562	3.852	4.123	4.555	4.352	5.84	6.282	6.600
DN163	515016	173401	2.735	3.290	3.562	3.852	4.123	4.555	4.352	5.828	6.261	6.600
DN163d	515016	173401	2.735	3.290	3.562	3.852	4.123	4.555	4.352	5.828	6.261	6.600
DN162	515040	173498	2.734	3.290	3.563	3.852	4.124	4.556	4.353	5.821	6.241	6.700
DN161	515056	173574	2.734	3.290	3.563	3.853	4.125	4.558	4.354	5.8	6.214	6.700
DN160	515067	173641	2.734	3.290	3.563	3.854	4.126	4.558	4.356	5.787	6.209	6.800
DN165d	514977	173344	2.735	3.290	3.562	3.851	4.123	4.554	4.352	5.86	6.304	6.600

Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60

Metres

Legend

- Main Rivers
- Site location

2D Node Results: Heights

- 1 in 10 (10%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

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https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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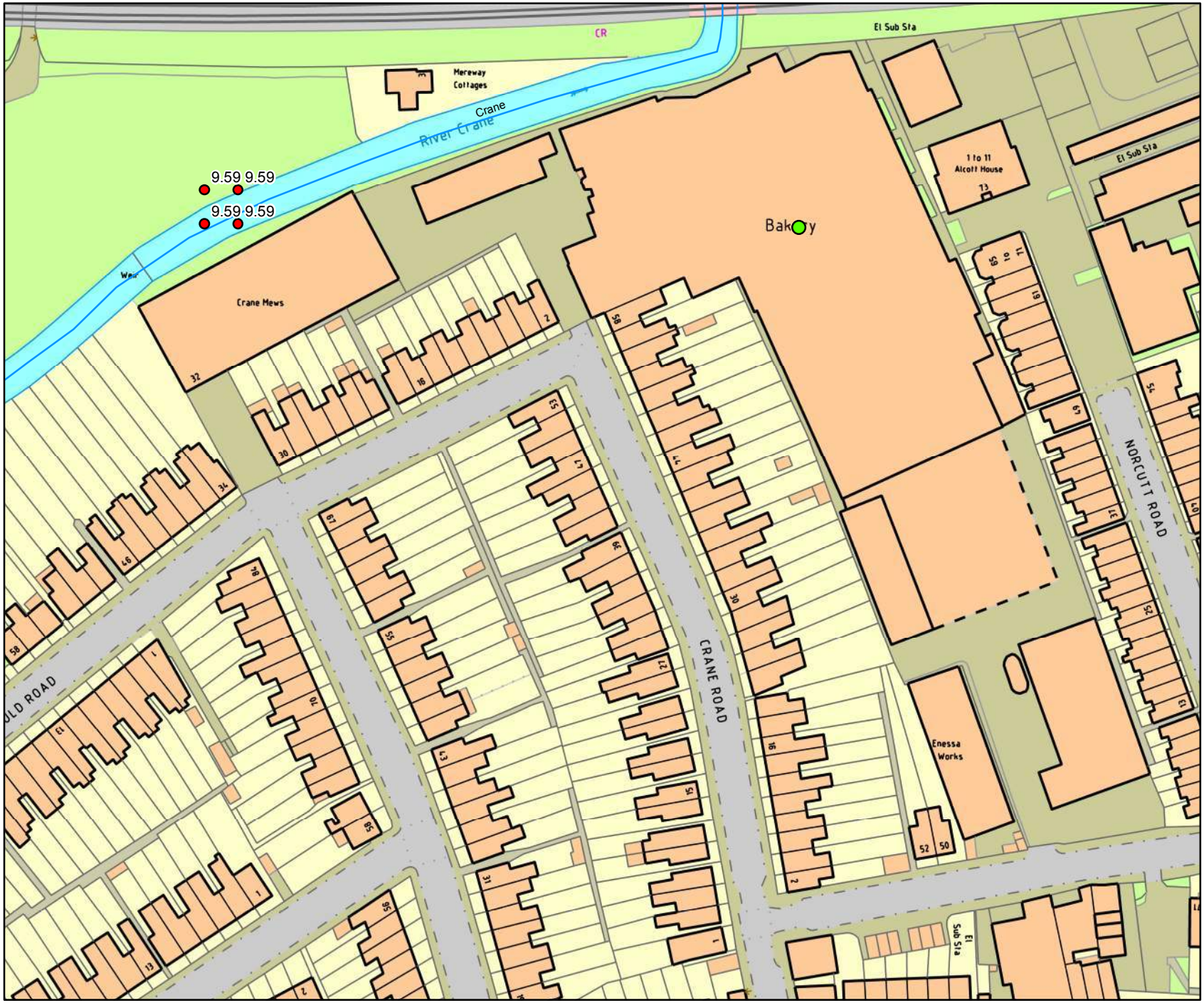
Hertfordshire & North London

Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

- Main Rivers
- Site location

2D Node Results: Heights

- 1 in 20 (5%) Defended

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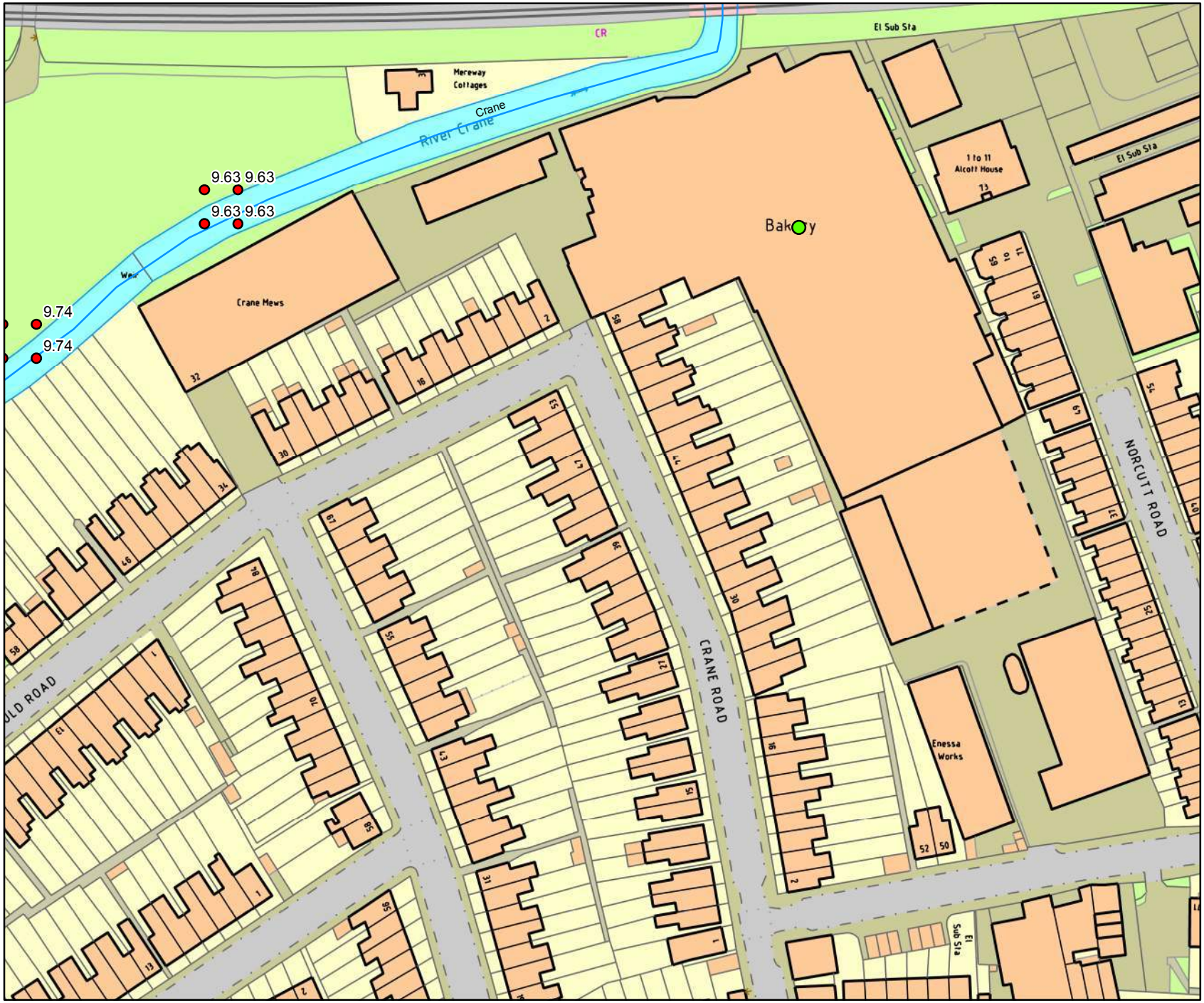
Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
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N

0 15 30 60

Metres

Legend

Main Rivers

Site location

2D Node Results: Heights

1 in 50 (2%) Defended

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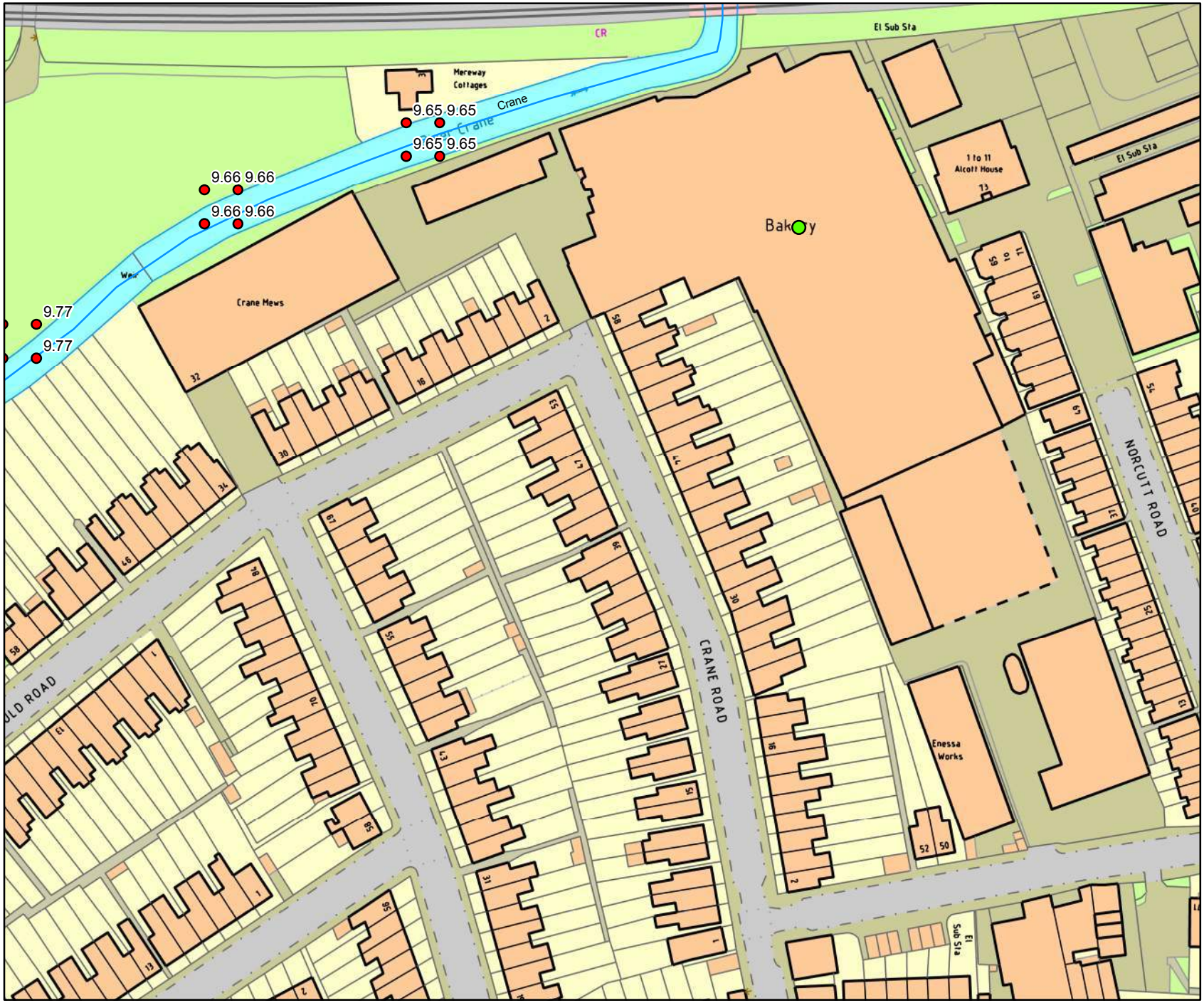
Detailed FRA centred on: Greggs Bakery, Twickenham - 21/11/2018 - HNL107059JH



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

Main Rivers

Site location

2D Node Results: Heights

1 in 100 (1%) Defended

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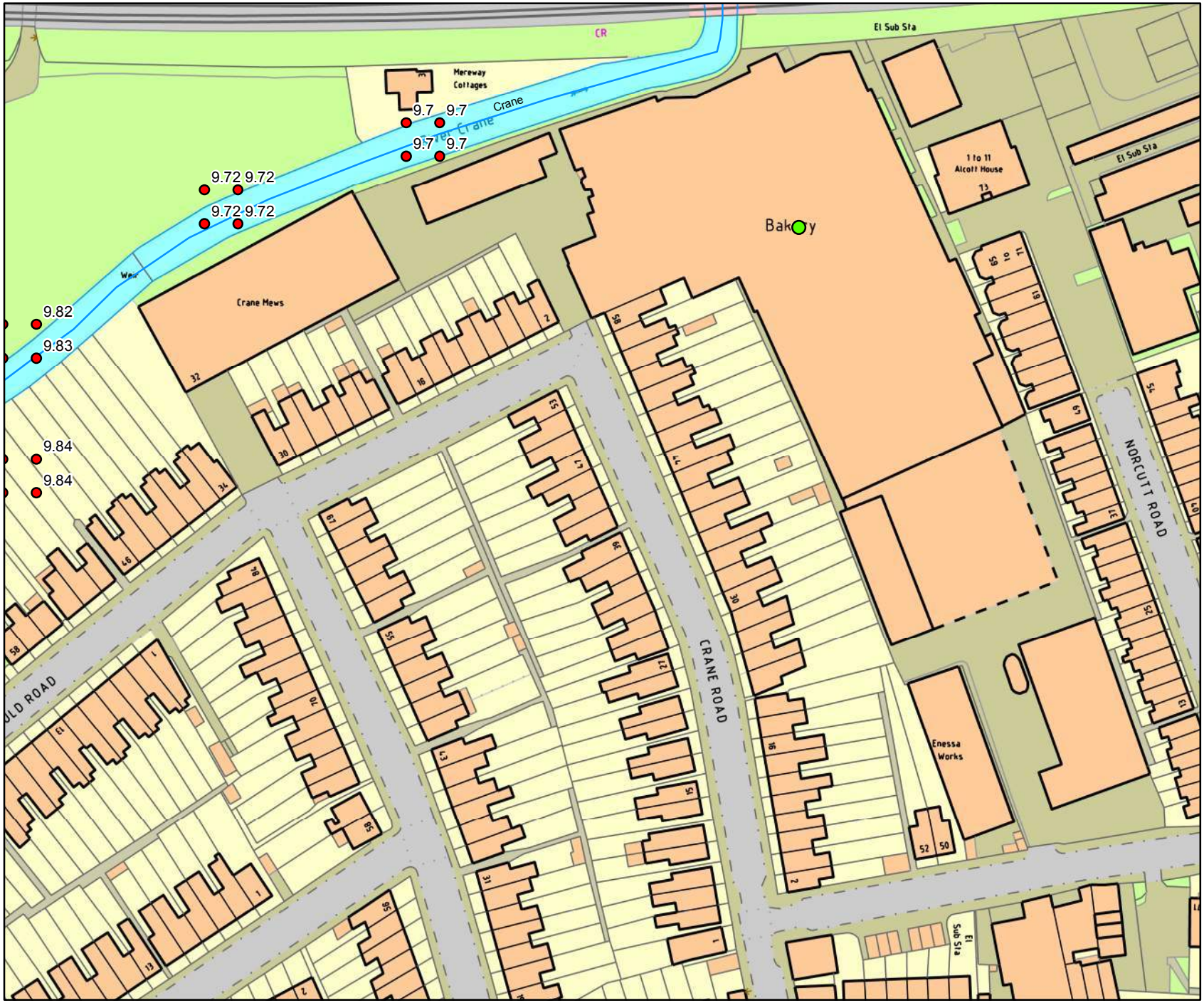

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60

Metres

Legend

- Main Rivers
- Site location

2D Node Results: Heights

- 1 in 100+20% (*CC) Defended

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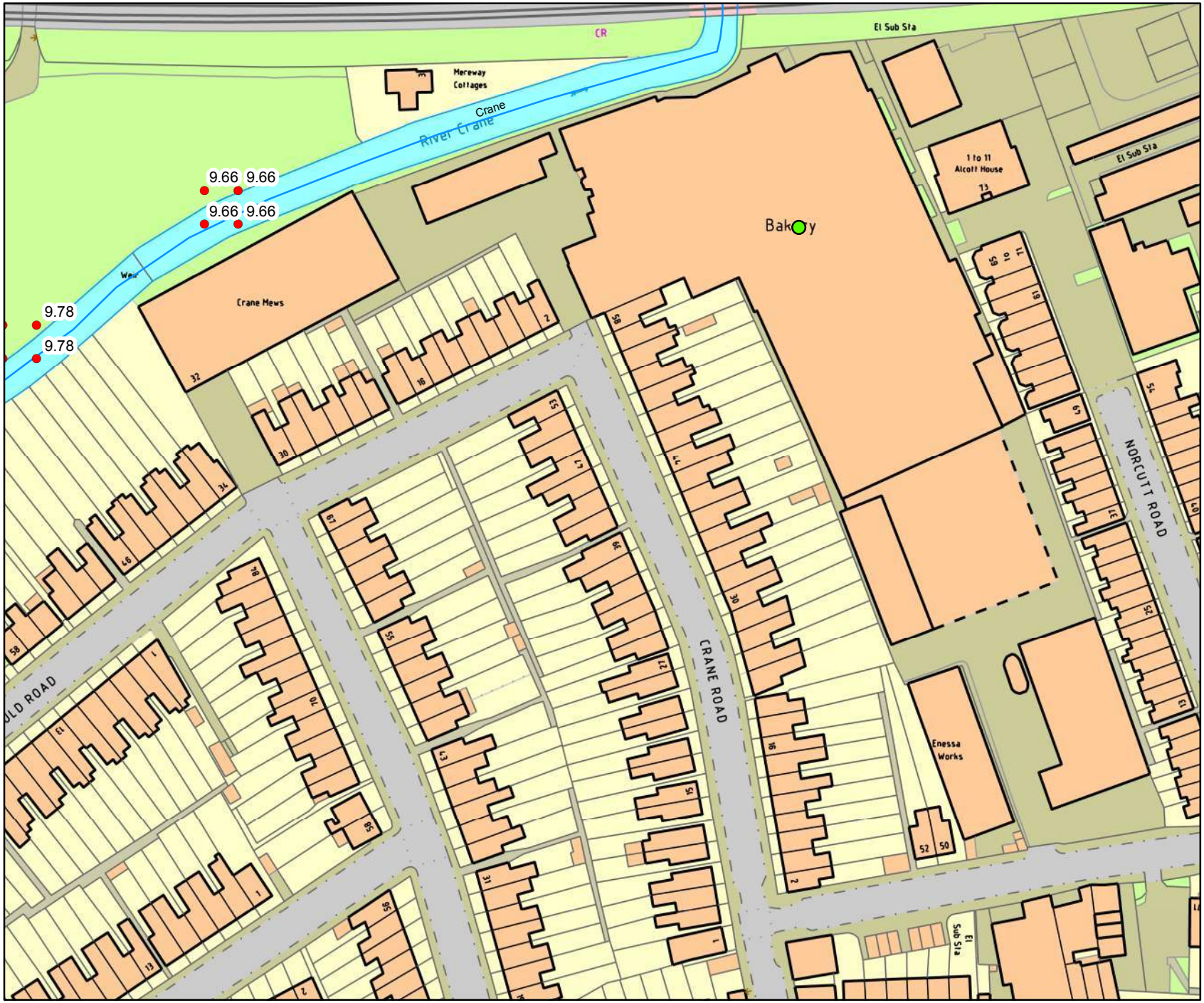

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

- Main Rivers
- Site location

2D Node Results: Heights

- 1 in 100+25% (*CC) Defended

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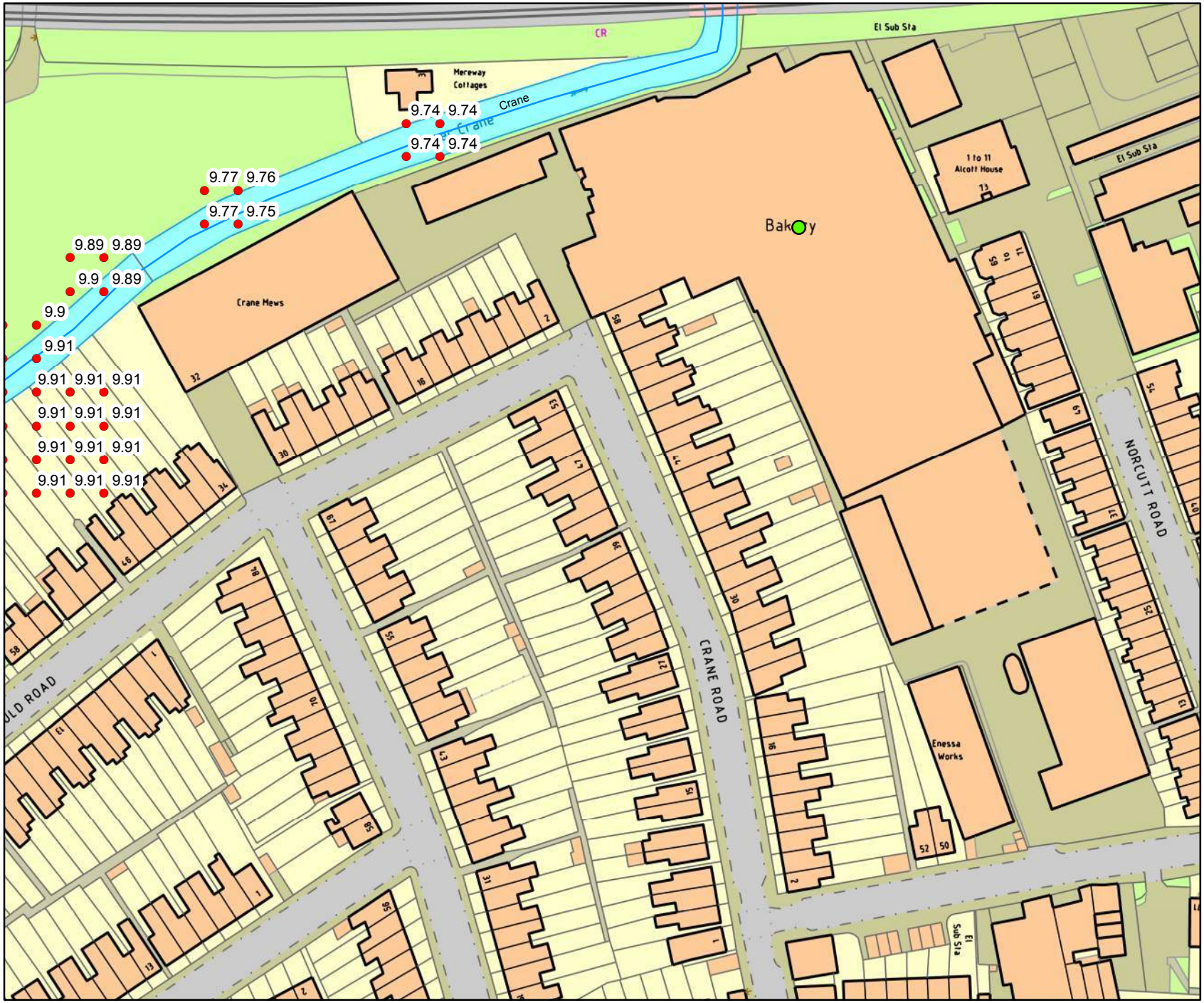

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Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

- Main Rivers
- Site location

2D Node Results: Heights

- 1 in 100+35% (*CC) Defended

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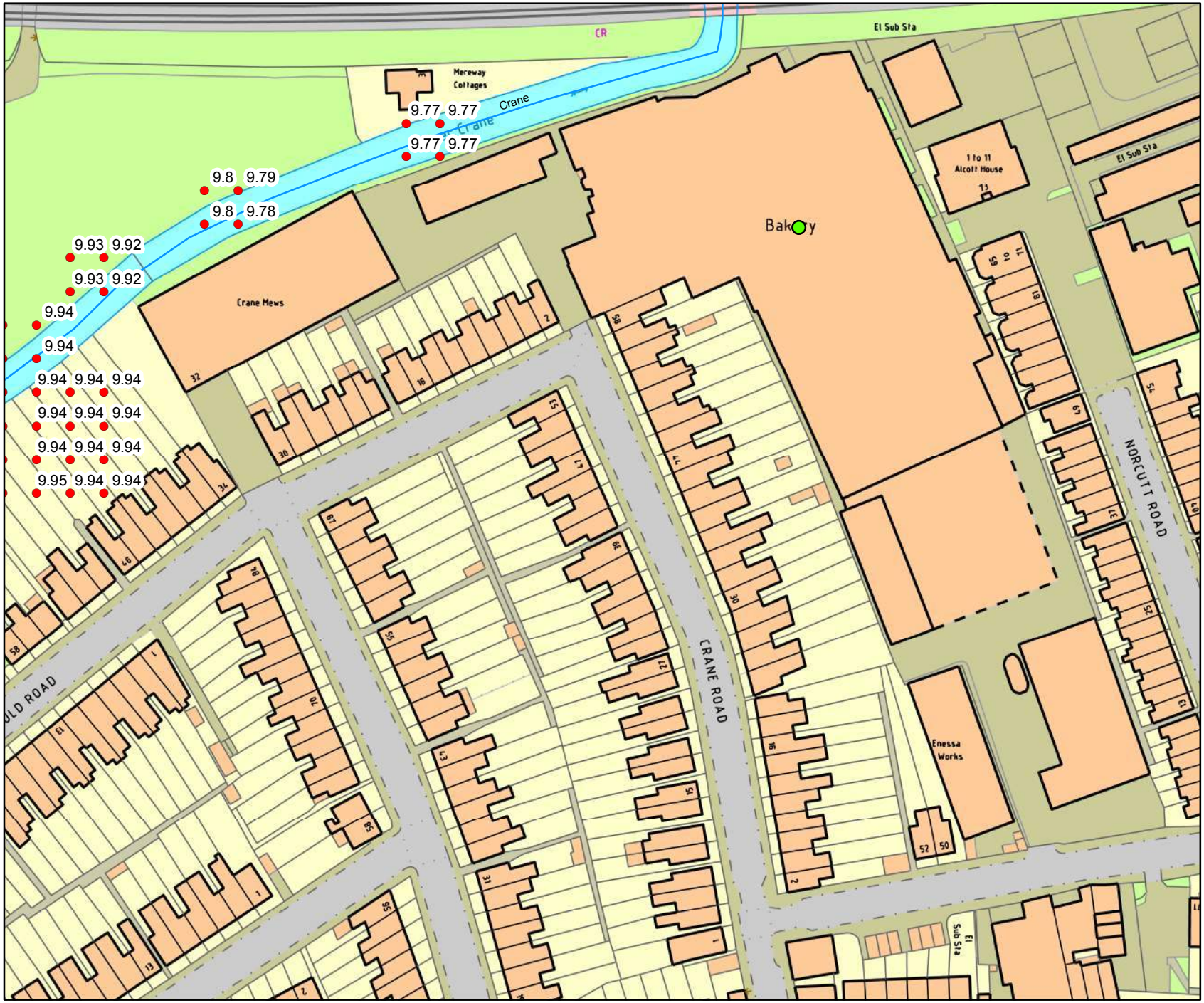

Environment Agency
Alchemy,
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Welwyn Garden City,
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N

0 15 30 60
Metres

Legend

Main Rivers

Site location

2D Node Results: Heights

1 in 100+70% (*CC) Defended

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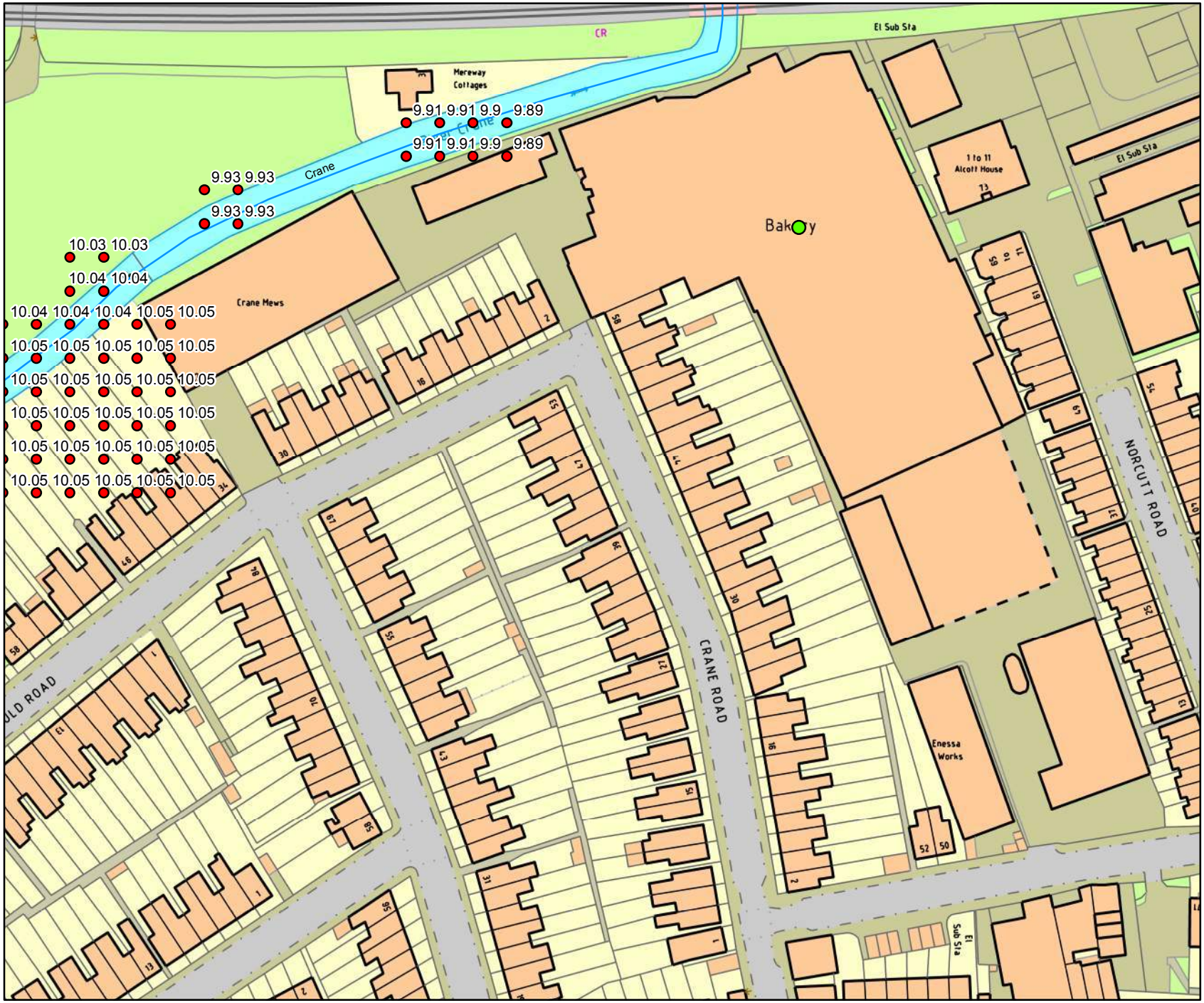

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

N

0 15 30 60
Metres

Legend

Main Rivers

Site location

2D Node Results: Heights

1 in 1000 (0.1%) Defended

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