

FRA & SuDS Strategy Report

FRA20197.1B



SGN Gasholders Site

Canal Rd

Gravesend

DA12 2PS

11-07-2025

Prepared for:

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1. Executive Summary

The PES has been commissioned to produce a Flood Risk Assessment (FRA) and Sustainable Urban Drainage System (SuDS) Strategy report for the proposed development at the SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS in support of a planning application for the proposed development. The proposed development is to create an external storage area that includes racking systems, an HGV servicing / Lorry holding zone and vehicular access with turning.

This FRA and SuDS report has been prepared as a desk top study based on the architectural drawings supplied and gathered data available within the public domain. It summarises the SuDS design process for the proposed development and demonstrates that the development complies with planning policy on flood risk – National Planning Policy Framework (NPPF) and supports Planning Practice Guidance (PPG) as well as the local Gravesham BC Policies and guidelines including associated Kent CC SuDS requirements.

The design process began with a review and analysis of the proposed development and the existing site conditions with respect to surface water drainage and flood risk. This included a study of both the hydrology and hydrogeology of the site.

The proposed SuDS design strategy provides for mainly source control techniques of, permeable paving. Surface water will be discharged into the adjacent existing drainage ditch / watercourse.

Associated hydraulic and attenuation calculations are based on greenfield runoff rates for both pre and post development along with impermeable areas and a description of the proposed surface water management, SuDS scheme for the site is prepared accordingly. Hydraulic design was an iterative process to provide for flow controls sized and used to allow a practicable maintenance regime to be incorporated within and to allow for attenuation drain down times. The multiple flow control system will control the discharge from site to greenfield Q1-Q100 runoff scenarios. The discharge of 6 l/s for the 1 in 100yr+45% cc requires a total of 888m³ attenuation for the 1 in 100yr +45%cc runoff scenarios. The required attenuation is provided within the permeable pavement and associated drainage network.

The SuDS provides a surface water management solution that reduces the surface water run off that leaves the site and shows that the proposed development does not result in an increase to the risk of flooding on or off site.

Permeable paving is provided on site for permeable conveyance and passive treatment techniques to collect, convey, attenuate and treat storm / surface water prior to discharge to the drainage ditch / watercourse next to the site. It will also take the first 5mm of rainfall.

This report provides a management and a maintenance regime statement for the SuDS surface water management of the new development.

A LLFA land drainage consent application is to be made.

2. Introduction

Brief

The PES has been commissioned to produce a FRA and SuDS Strategy report for the proposed development at the SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS in support of a planning application for the proposed development. The proposed development is to create an external storage area that includes racking systems, an HGV servicing / Lorry holding zone and vehicular turning.

This desk study report is produced to identify an appropriate FRA and SuDS for the proposed development that mirrors the natural drainage pattern of the development site and restricts flows to greenfield runoff conditions if possible, for the site. The SuDS will provide a surface water management solution to reduce the surface water run off that leaves the site and show that the proposed development will not result in an increase to the risk of flooding on or off site. Where required, it recommends mitigation to any potential flooding issues associated with the proposed development. The SuDS solution follows the requirements of the Environment Agency (EA), Kent CC and Gravesham BC and Southern Water.

The SuDS solution is developed using information supplied by others. The PES in good faith has used it as deemed accurate, without guarantee but as best information available at the time of completion of the SuDS design and associated report.

The purpose of this report is to summarise the SuDS strategy design process for the proposed development and demonstrate that the development complies with national planning policy on flood risk as well as the local Gravesham Council Policy and guidelines including Kent CC associated SuDS requirements.

Report Structure

These works are discussed in the following sections. The structure of this report is summarised as follows:

- Section 3: Describes site conditions with respect to topography, hydrology, hydrogeology, drainage and potential design proposals as well as identifying National and local planning Policies and guidance;
- Section 4: Provides a commentary on how flood risk from a range of potential sources may or may not constrain development proposals and influence the SuDS solution;
- Section 5: Describes how surface water from the development area can be drained in a sustainable manner, without increasing the risk of flooding elsewhere;
- Section 6: Provides a management and a maintenance regime statement for the SuDS surface water management for the new development. It also deals with the management of exceedance flows;
- Section 7: Presents a summary of the report and identifies the main conclusions that can be drawn.

3. Site Conditions and Planning Policy

Existing Conditions

The existing SGN Gasholder development site accessed off Canal Road is a rectangular plot previously occupied by two large gasholder structures with associated gas governor and other buildings and infrastructure. The gasholder structures have been demolished but the associated buildings and infrastructure remain in place.

There is an ordinary watercourse / ditch running immediately next to the eastern boundary next to the site running north. The watercourse emerges from a culvert immediately south of the site prior to turning northward along the drainage ditch.

There are no Southern Water surface water sewers located within or near the site.

The brownfield site benefits from EA flood defences at the interface with the River Thames.

Proposed development

The development proposal outlines the demolition of some out buildings and associated gasholder infrastructure. A gas governor and some of the existing buildings will remain in place. The proposed development will create an external storage area that includes racking systems, an HGV servicing / Lorry holding zone and vehicular turning.

The site location plan can be seen in Figure 1 below.

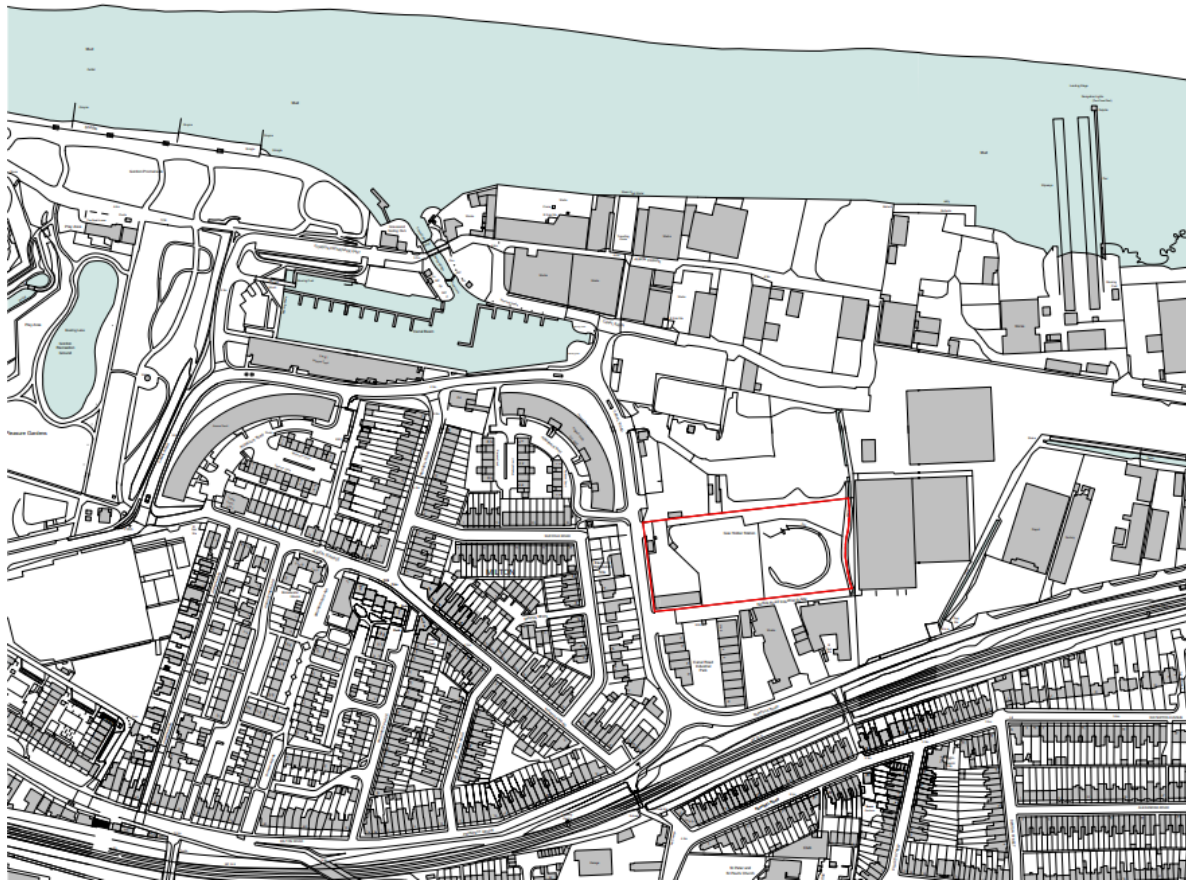


Figure 1 - Site Location Plan for Proposed Development at SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS

The Site Plan for the Proposed Development at SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS is shown in Figure 2 below.

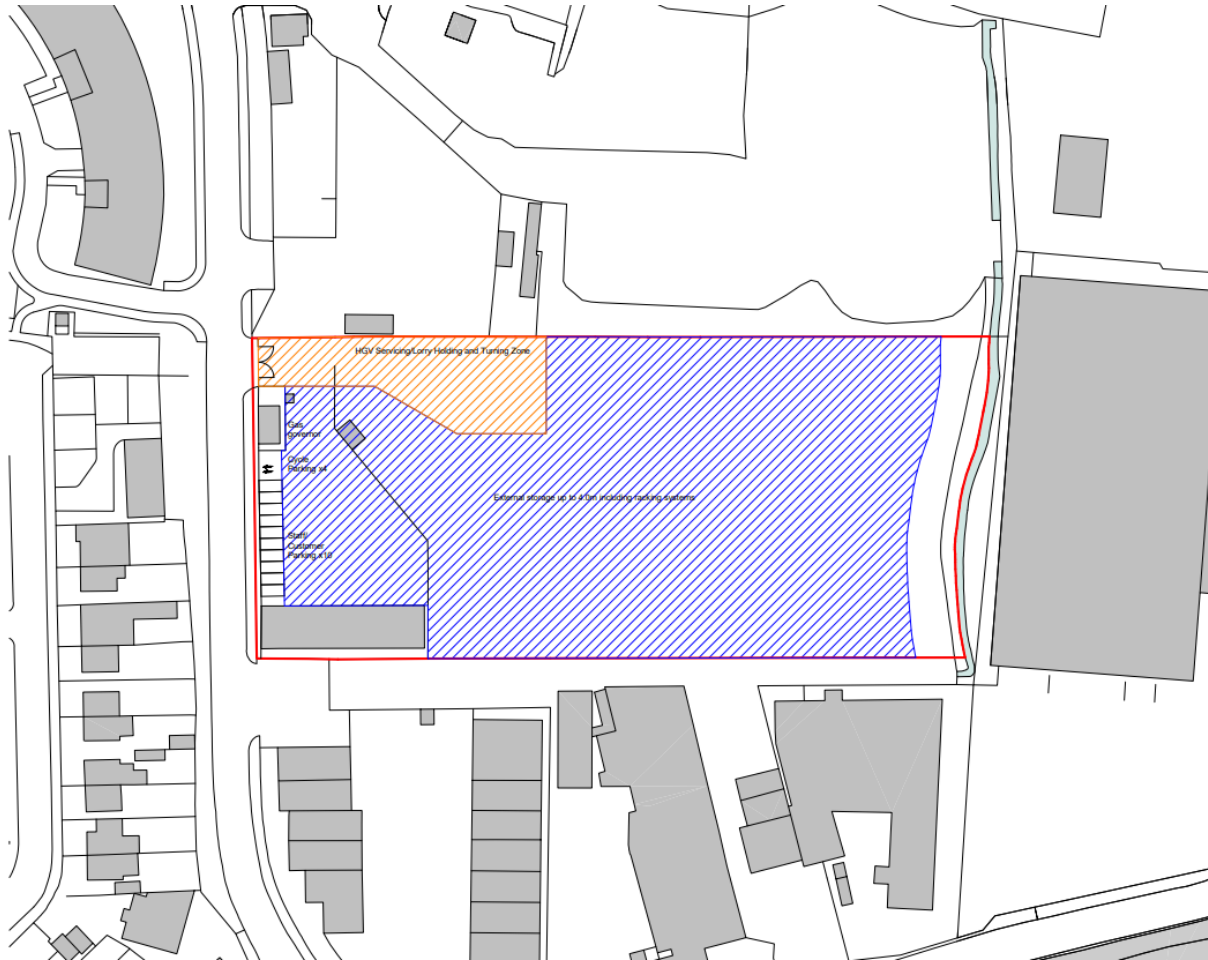


Figure 2 - Site Plan for the Proposed Development at SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS

Areas of Critical Drainage

According to Kent County Council Drainage and Planning Policy - a Local Flood Risk Management Strategy Document; no Critical Drainage Areas have yet been defined within Kent and will not require further consultation.

Topography

The site is reasonably flat but falls gently towards Canal Road highway in the west and to the north as well as eastward towards the offsite ordinary water course adjacent the east boundary. Low points on site are in the north east and south east corners. The removal of the eastern gasholder has also left a circular low area in the east side of the site.

Southern Water Sewers

There are no public surface water or foul sewers located on the development site.

Southern Water asset location plans are provided within Appendix A.

Hydrology

The application site lies within the EA's Thames River Basin district.

There is an ordinary watercourse / ditch running immediately next to the eastern boundary next to the site running north that turns west along the northern site boundary where it is culverted. The site is reasonably flat and falls towards the ordinary watercourse / ditch

There are no Southern Water surface water sewers located within or near the site.

Exceedance surface water runoff from the site flows to the watercourse / drainage ditches adjacent to the site and low lying areas infiltrate or evaporate.

Hydrogeology

The British Geological Survey site describes the site bedrock geology as Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation - Chalk. Sedimentary bedrock formed during the Cretaceous period. The chalk bedrock at the application site identified by the British Geological Survey site is shown in Figure 3 below.

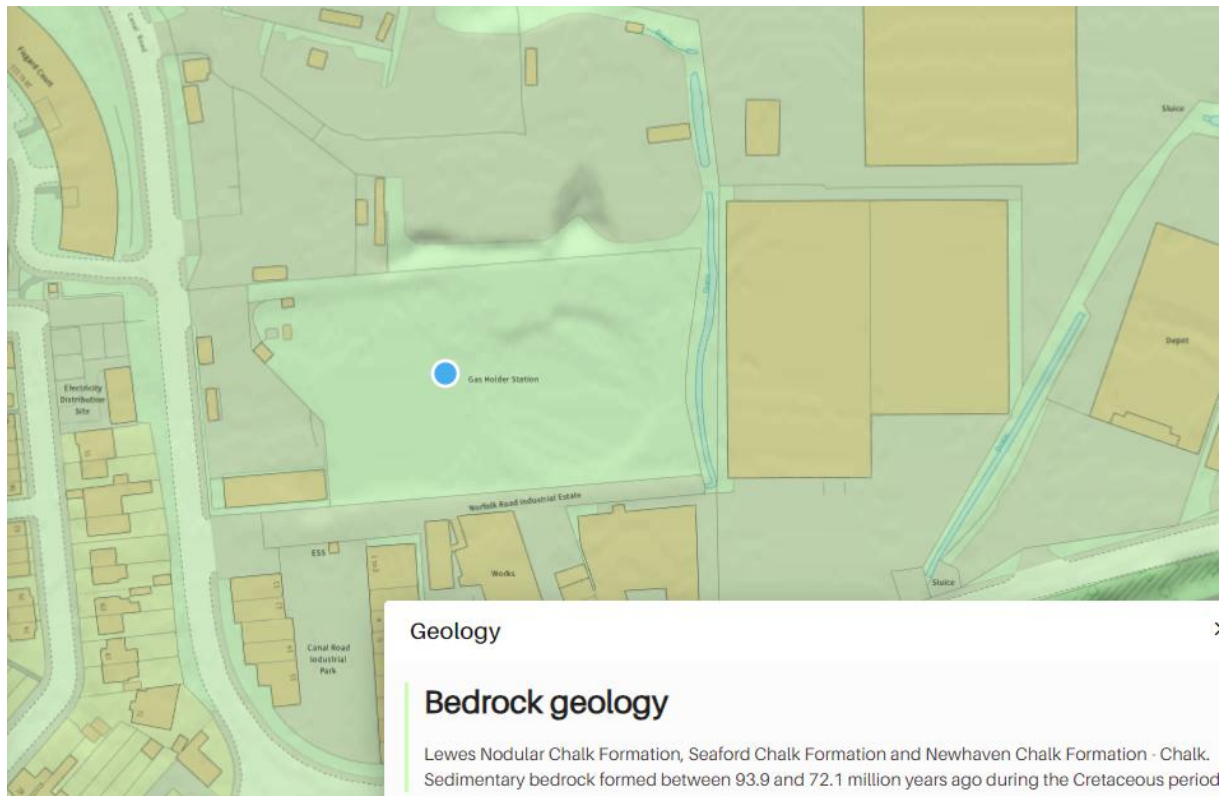


Figure 3 - BGS Bedrock Geology 1 in 50,000 (Source: British Geological Society Website (Contains British Geological Survey materials © URKI [2019]. Base mapping is provided by ESRI)).

The British Geological Survey site describes the site superficial deposit geology at the application site as Alluvium - Clay, silt, sand and peat. A Sedimentary superficial deposit formed during the Quaternary period. The alluvium superficial deposits at the application site identified by the British Geological Survey site is shown in Figure 4 below.

Borehole data available at the British Geological Survey website in the neighbourhood of the application site confirm the existence of the as described alluvium superficial deposits above chalk and clay bedrocks. An infiltration soakaway system is not considered appropriate for this site.

However a deep borehole infiltration system may be suitable dependent on the results of a ground investigation. The gasholder site ground conditions are potentially contaminated. A borehole

infiltration solution may provide a route to introduce contamination to the chalk aquifer. It would be expected that a future Geotechnical Investigation (GI) provide data for the detail design accordingly.

The suitability for infiltration in this area is uncertain.

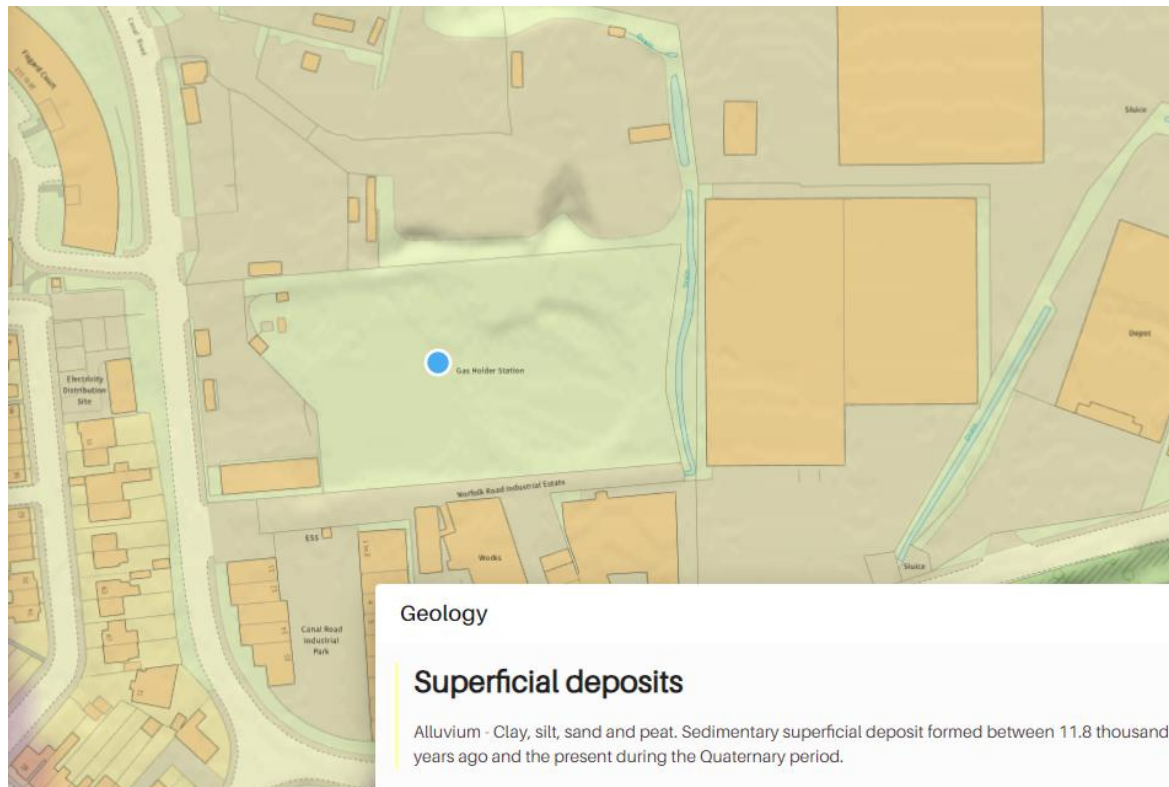
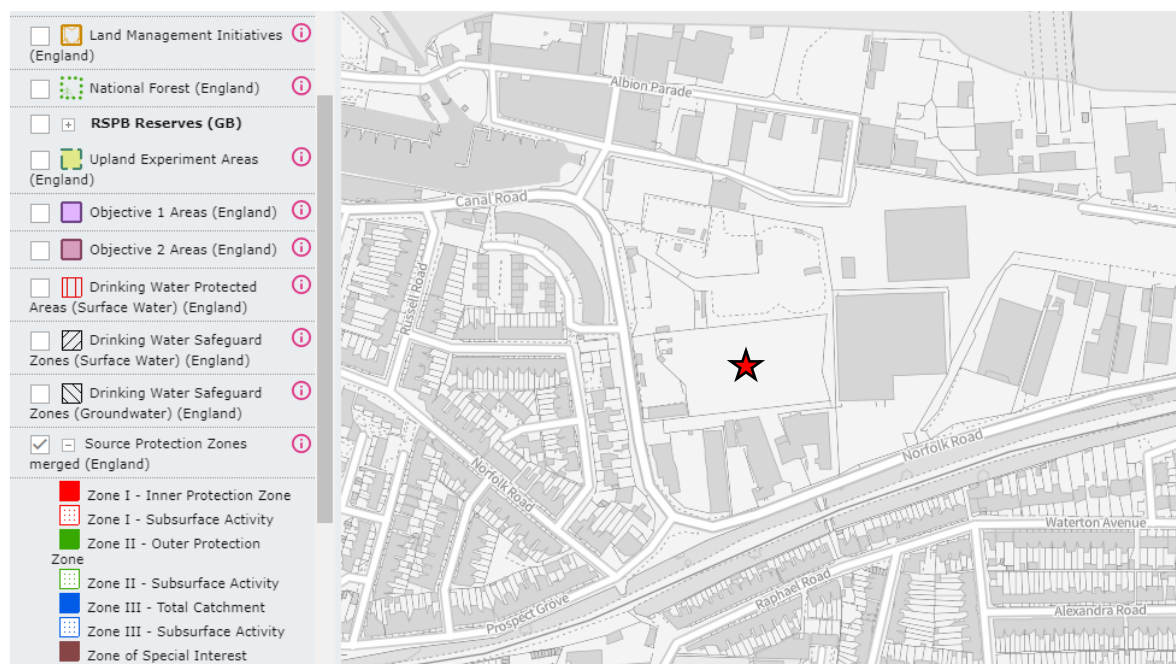


Figure 4 - BGS Superficial Geology 1 in 50,000 (Source: British Geological Society Website (Contains British Geological Survey materials © URKI [2019]. Base mapping is provided by ESRI)).

Groundwater

The site is not located within a groundwater source protection zone as shown in Figure 5 below.

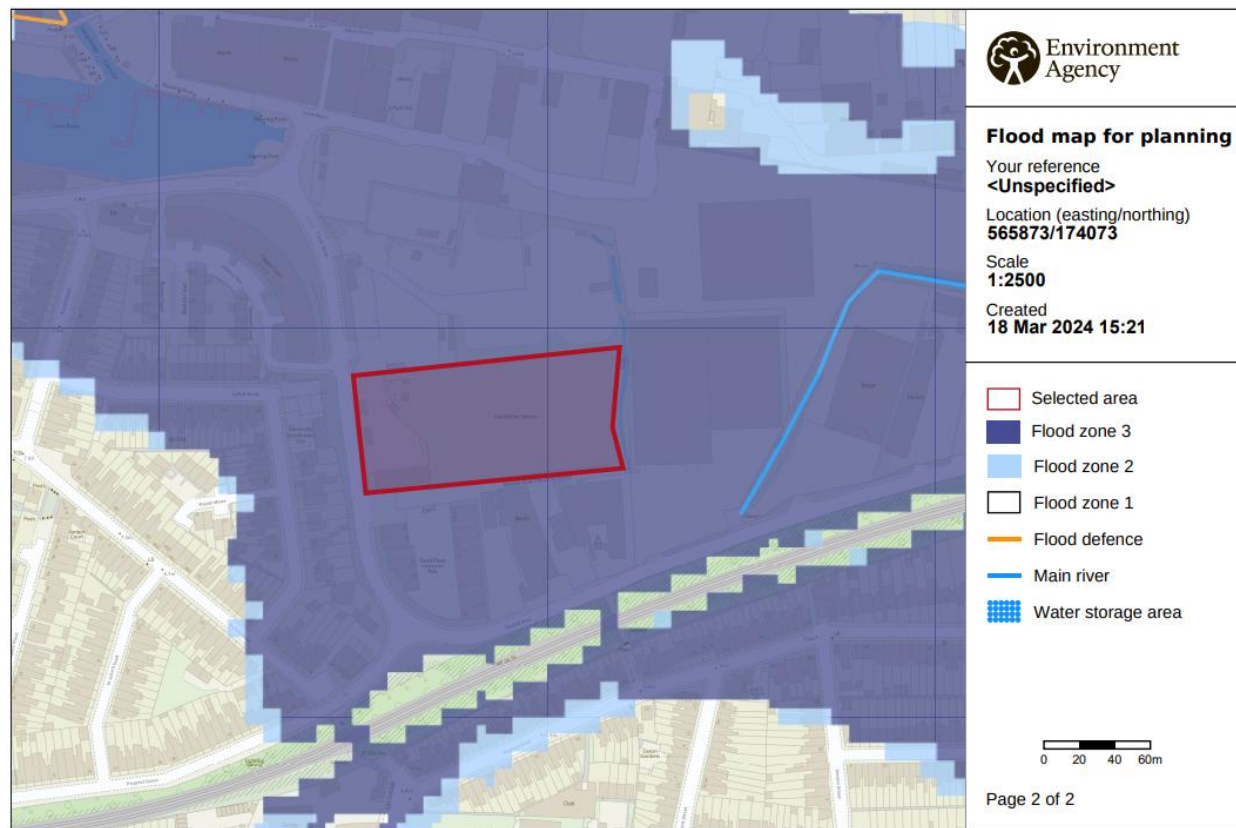


★ Location of the development.

Figure 5 - magic.defra.gov.uk - Source Protection Zones merged (England)

Flood Zone

EA flood mapping shows the application site within a Flood Zones 3 area that is protected by Flood Defences as seen in Figure 6 below.



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Figure 6 – EA Flood Map for Planning

Planning Policy

The National Planning Policy Framework (NPPF) currently sets out the Government’s planning policies for England and defines Flood Zones, Flood Risk vulnerability classification and their compatibility in the tables below.

Table 1: Flood Zones

These Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences. They are shown on the Environment Agency’s [Flood Map for Planning \(Rivers and Sea\)](#), available on the Environment Agency’s web site, as indicated in the table below.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as ‘clear’ on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)

Flood Zone	Definition
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

Note: The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

Table 1 – Table 1 from Planning Policy Guidance (Flood Risk and Coastal Change) 06 03 2014

Table 2: Flood risk vulnerability classification

Essential infrastructure • Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly vulnerable • Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').
More vulnerable • Hospitals • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill* and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Less vulnerable

- Police, ambulance and fire stations which are not required to be operational during flooding.
- Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure.
- Land and buildings used for agriculture and forestry.
- Waste treatment (except landfill* and hazardous waste facilities).
- Minerals working and processing (except for sand and gravel working).
- Water treatment works which do not need to remain operational during times of flood.
- Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.

Water-compatible development

- Flood control infrastructure.
- Water transmission infrastructure and pumping stations.
- Sewage transmission infrastructure and pumping stations.
- Sand and gravel working.
- Docks, marinas and wharves.
- Navigation facilities.
- Ministry of Defence defence installations.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation (excluding sleeping accommodation).
- Lifeguard and coastguard stations.
- Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 2 – Table 2 from Planning Policy Guidance (Flood Risk and Coastal Change) 06 03 2014

The proposed development classification at the application site is less vulnerable.

Table 3: Flood risk vulnerability and flood zone ‘compatibility’

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b functional floodplain	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
 × Development should not be permitted.

Table 3 - Table 3 from Planning Policy Guidance (Flood Risk and Coastal Change) 06 03 2014

Less vulnerable developments are acceptable within a Flood Zone 3a.

Reference

This FRA & SuDS Strategy takes into account and makes reference to the NPPF and the National Planning Practice Guidance (NPPG) as well as the local policies and guidance including the This FRA & SuDS Strategy takes into account and makes reference to the NPPF and the National Planning Practice Guidance (NPPG) as well as the local Gravesham BC policies and Local Plan Core Strategy & associated Maps; Kent CC Drainage and Planning Policy 2019; Kent CC Preliminary Flood Risk Assessment September 2011; Kent CC Local Flood Risk Management Strategy 2013; Kent CC Design Guide Making it Happen Sustainability Drainage Systems; Kent CC Local Flood Risk Management Strategy 2017-29=023; Thameside Stage 1 Surface water management Plan 2013; Thameside Strategic Flood Risk Assessment 2005.

It also makes reference to consultations with the Environment Agency and Anglian Water as well as CIRIA753 The SuDS Manual and Government Non-statutory technical standards for sustainable drainage systems – practice guidance and the design, maintenance and operation of SuDS, Susdrain – the community for sustainable drainage and BS8582 Code of practice for surface water management for development sites.

4. Flooding

Introduction

There are a wide range of potential mechanisms which can cause flooding. Each potential source of flooding is discussed individually below. This section refers to the LPA / LLFA Flood Risk Management Strategy and Strategic Flood Risk Assessments.

Tidal or River Flooding

The EA plan shows that the application site is within an area where the flood risk from rivers or the sea at this location is a low risk as shown in the Environment Agency flood risk map below in Figure 7 – Flood Risk from Rivers or the sea. Low risk means that this area has a chance of flooding of between 0.1% and 1% chance each year. These levels of flood risks align with the definition of a Flood Zone 3a. This takes into account the effect of any flood defences in the area. The site is located within an area that benefits from flood defences. Land and property benefitting from flood defences would have a high probability of flooding without the local flood defences.

These defences reduce but do not completely stop the chance of flooding as they can be overtopped or fail. If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

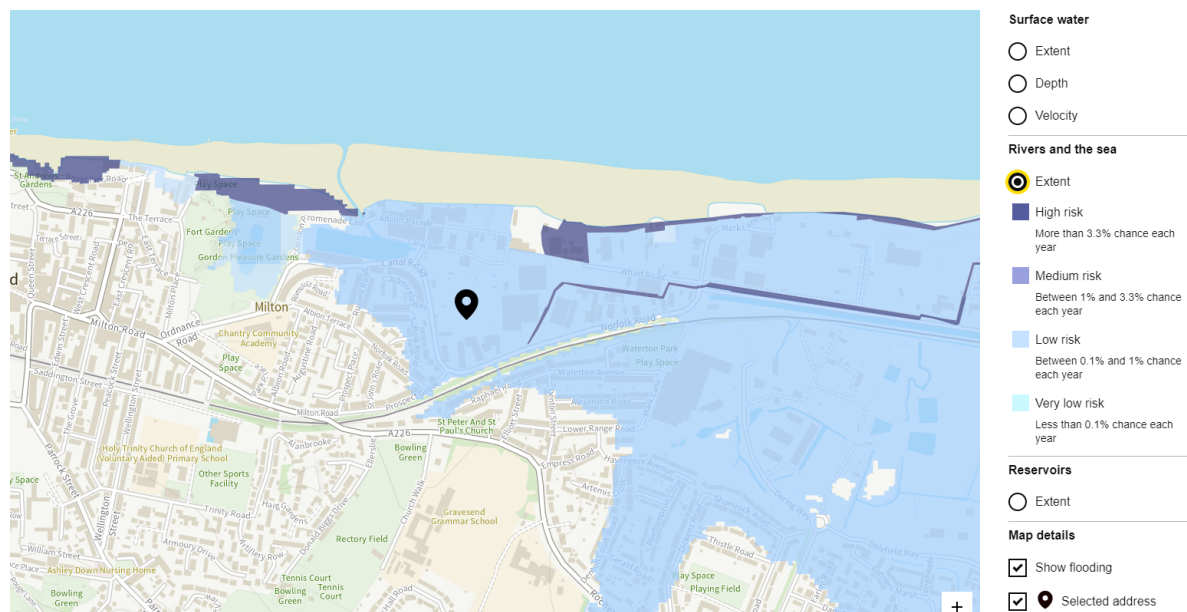


Figure 7 - Flood Risk from Rivers or the sea

The EA has provided locations of Flood Defences near the development site as shown below in Figure 8 - EA Flood Map for Planning with Flood Defence. The map also shows that the site is not a water storage area.

The EA and riparian owners are responsible for the structural integrity and maintenance of the flood defences that need to be undertaken timely. The Thames Estuary 2100 study notes that the standard of protection will be maintained for the current and future raising requirements of the system of defences. The EA inspect the flood defences twice a year to ensure that they remain fit for purpose.

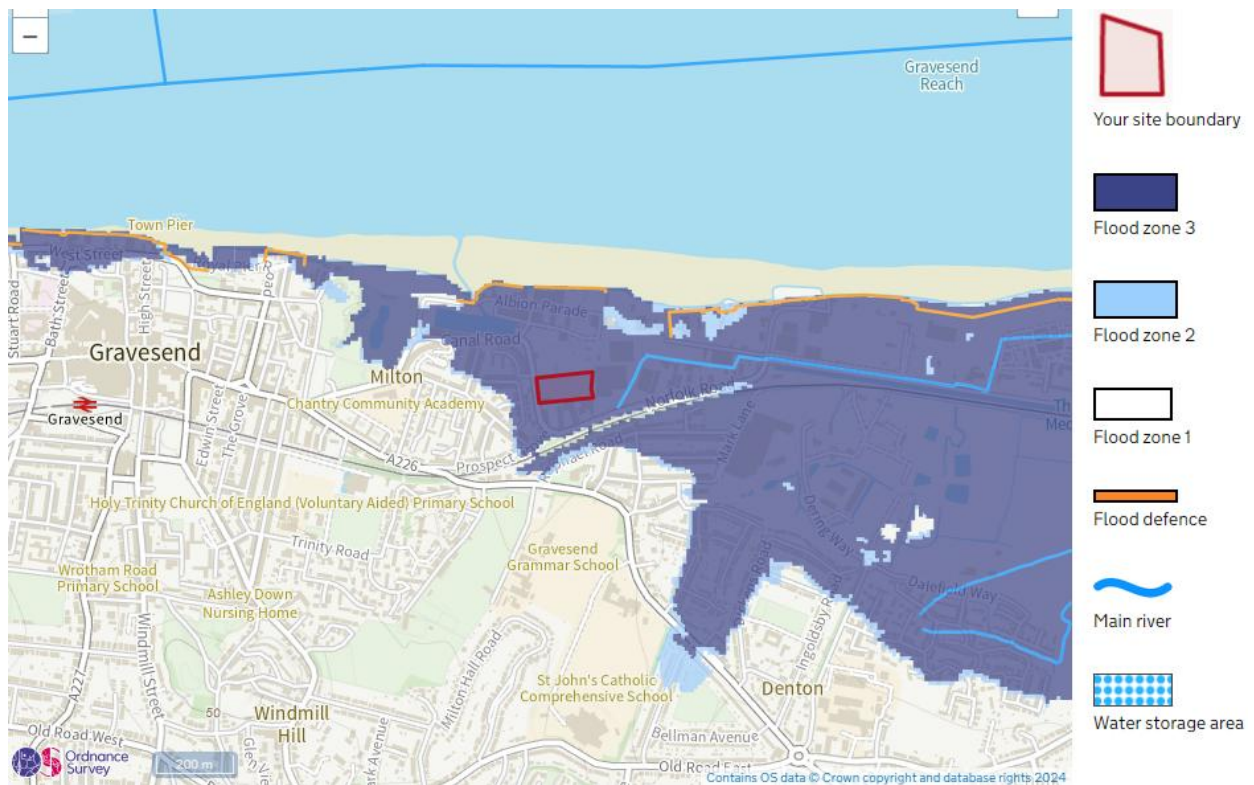
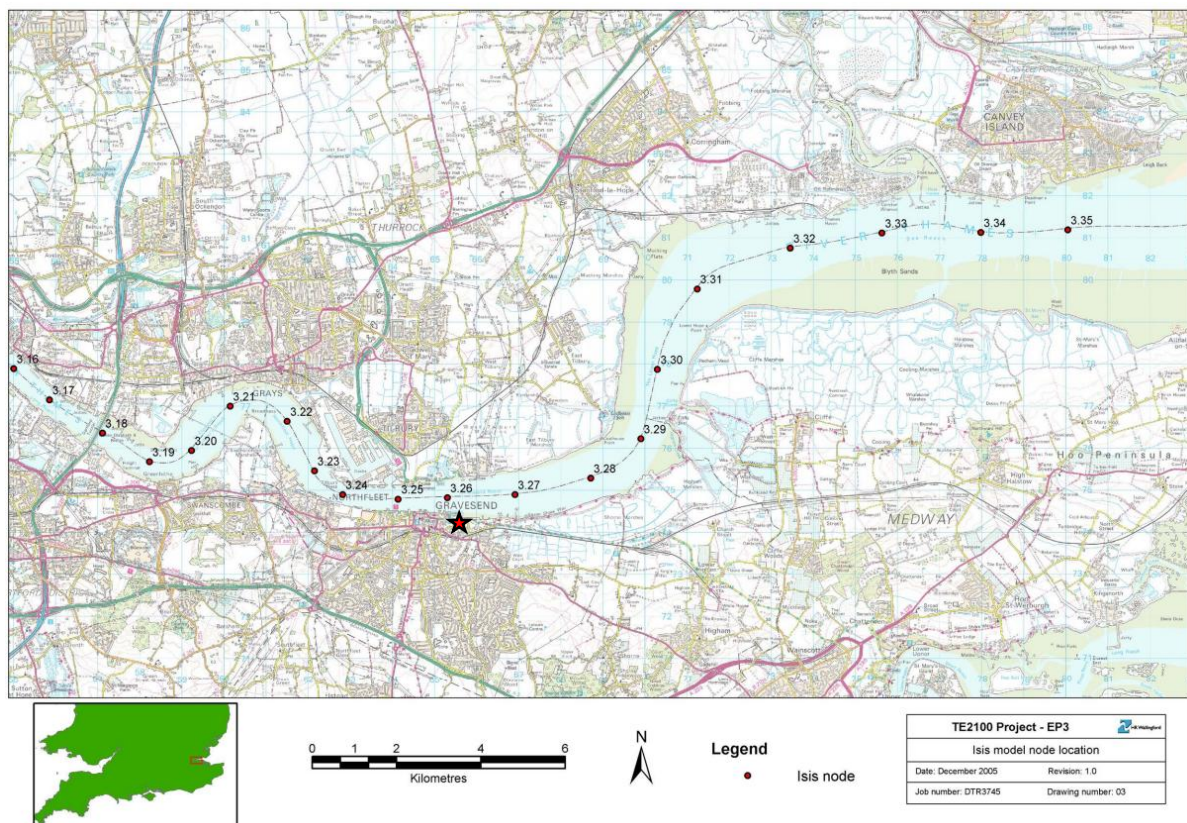


Figure 8 - EA Flood Map for Planning with Flood Defence Location

The EA also provided hydraulic model data of water levels within the River Thames at various design events at different model node locations along the river. Figure 9 below shows model node 3.26 as the nearest to the Canal Road site.



★ Site Location

Figure 9 - EA Thames (TE2100) Figure A.5 Model Estuary Node Locations: Greenhithe to Canvey Island

For the 2100 design scenario the EA 1000yr tidal water levels at node 3.26 nearest the site are 6.44mAOD. The EA TEAM2100 produced the Thames Estuary Modelling Doc No TEA-00-00.00-RP-HY-00-000005 Extreme Water Levels – Final Report Issue P03 dated 28 February 2022. Model results predict future Thames extreme water levels that the flood defences will need to cater for and therefore to be raised to suit in a timely fashion. The EA, partners and riparian owners are responsible for the raising of the flood defences and would complete the works accordingly.

The TE2100 plan has 3 phases of activity:

- Until 2035 – maintain and improve current defences, safeguard areas required for future improvements and monitor climate change indicators.
- 2035-2050 – raise existing walls, defences & smaller barriers whilst reshaping the riverside environment.
- 2050-2100 – determine and implement an option for the future of the Thames Barrier and adapt other defences as required to work alongside this to protect the estuary.

The Canal Road development site lies within the defended tidal floodplain of the River Thames Estuary and is at low residual risk of tidal flooding. In accordance with PPS25 an assessment of residual risk should be made and therefore hydrodynamic breach modelling data provided accordingly.

Breach Hazard Mapping “is based on computer modelling of simulated breaches at specific locations. Each breach has been modelled individually and the results combined to create the map. Multiple breaches, other combinations of breaches different sized tidal surges or flood flows may all give different results. A breach map only considers the consequences of a breach, it does not make any assumptions about the likelihood of a breach occurring. The likelihood of a breach occurring will depend on a number of different factors, including the construction and condition of the defences in the area.

The more recent EA Thames Tidal Upriver Breach Inundation modelling (2018) shows that the Canal Road site is at risk if there was to be a breach in the defences. The development site is shown within the extent of the 2100 Modelling: downriver breach modelling Map centred on the Canal Road site for 0.5% AEP outlines are shown below in in Figure 10. And, downriver breach modelling Map centred on the Canal Road site for 0.1% AEP outlines are shown below in in Figure 11.

The maps show that the site is partially inundated due to a flood defence breach for the 2014 (current year) epoch for both 0.5% AEP and 0.1% AEP and the totally inundated for the 2115 epoch in both the 0.5% AEP and 0.1% AEP.

Table 4 below provides breach Inundation model data flood levels at the SGN Gasholder site Canal Road. It displays site-specific modelled breach flood levels for epochs 2014 and 2115 at the SGN Gasholder site at nodes as indicated in the Node point location map in Figure 12 below. Figure 12 below shows the EA Node Points on the SGN Gasholder site location plan.

Downriver Breach Modelling Map centred on DA12 2PS created on 21 March 2024 [Ref: KSL 352215 JP]

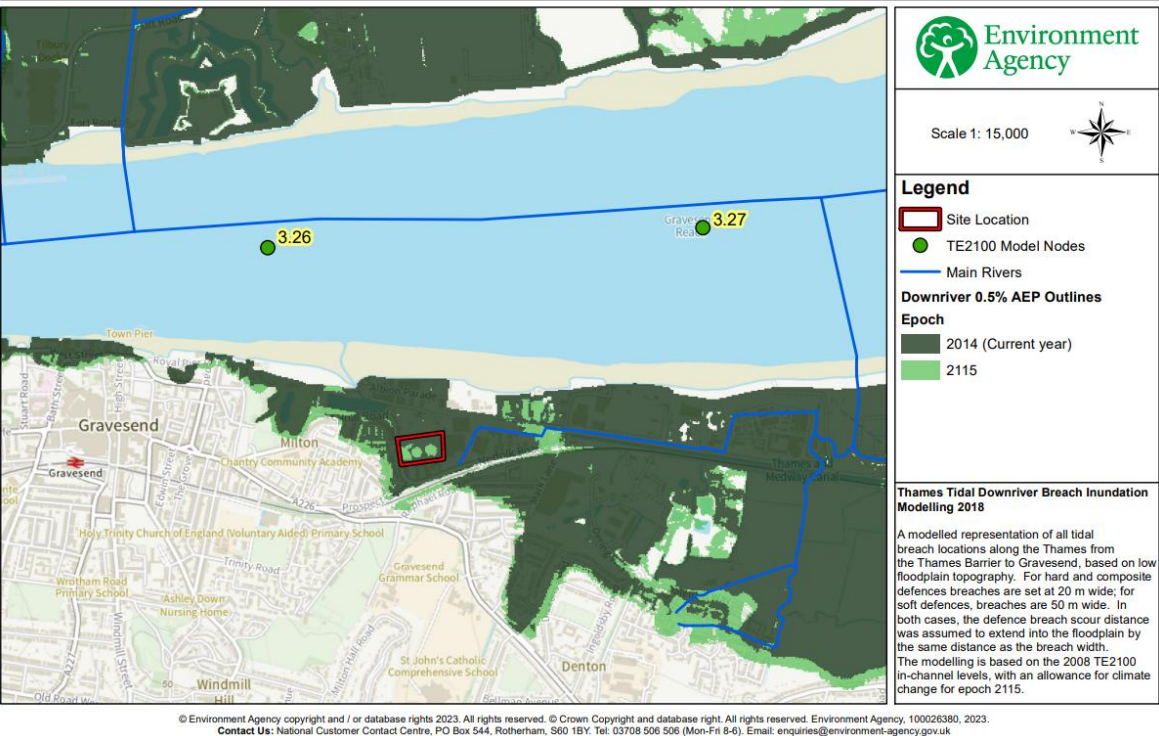


Figure10 - Downriver Breach Modelling Map centred on the Canal Road site for 0.5% AEP

Downriver Breach Modelling Map centred on DA12 2PS created on 21 March 2024 [Ref: KSL 352215 JP]

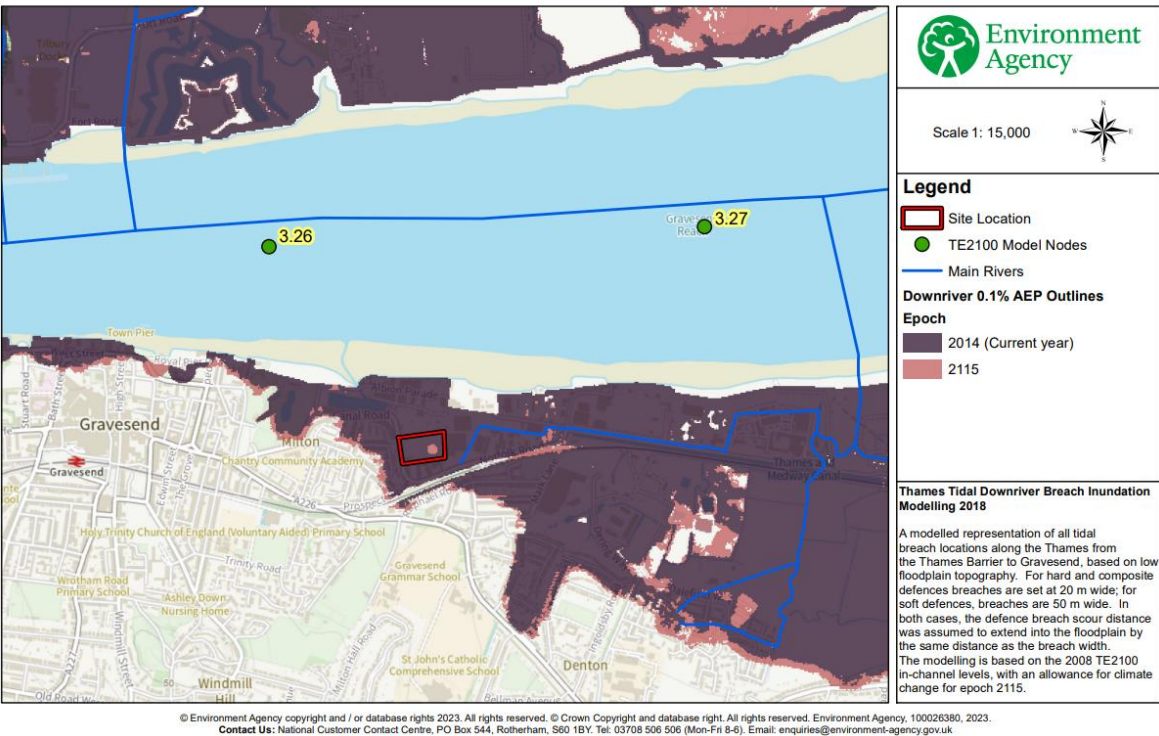
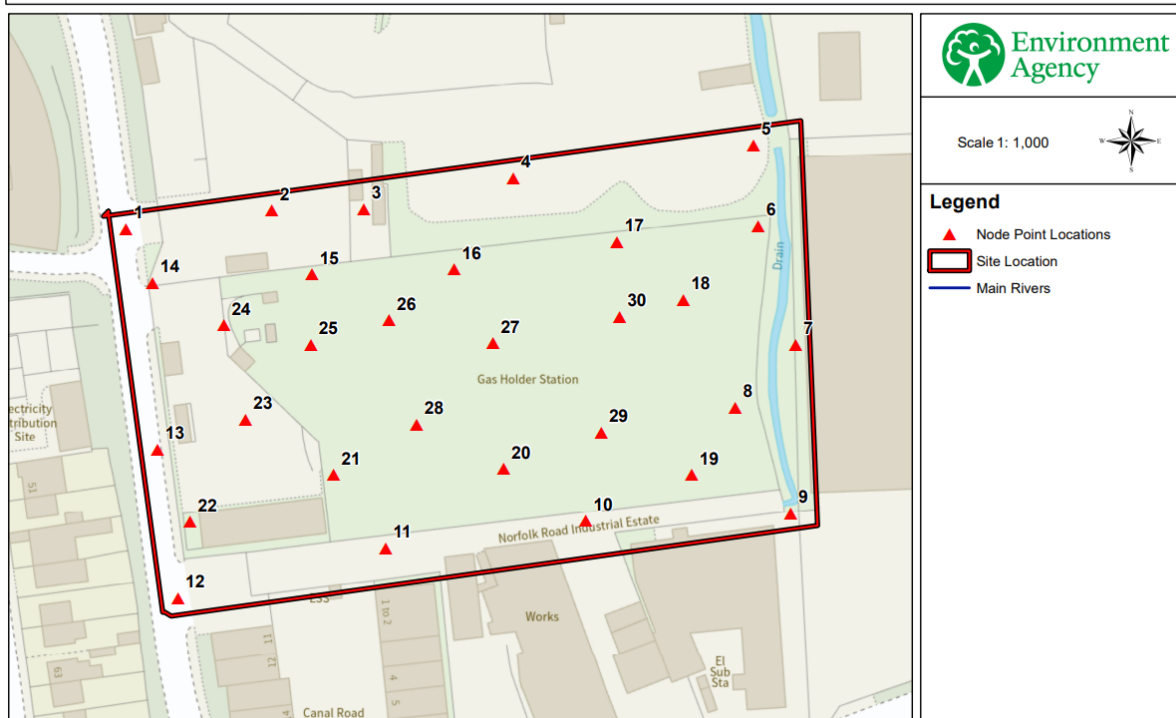


Figure 11 - Downriver Breach Modelling Map centred on the Canal Road site for 0.5% AEP

	Modelled levels in m AODN for 0.5% AEP		Modelled levels in m AODN for 0.1% AEP	
Node	2014	2115	2014	2115
1	4.727	5.844	5.304	6.228
2	4.693	5.843	5.304	6.228
3	4.676	5.842	5.303	6.227
4	4.675	5.836	5.301	6.221
5	4.675	5.837	5.302	6.222
6	4.675	5.837	5.301	6.210
7	4.675	5.832	5.300	6.211
8	4.676	5.817	5.295	6.182
9	4.675	5.796	5.292	6.168
10	4.675	5.829	5.299	6.200
11	4.675	5.833	5.300	6.213
12	4.676	5.836	5.301	6.222
13	4.675	5.841	5.303	6.226
14	4.722	5.843	5.304	6.230
15	4.690	5.845	5.305	6.231
16	4.675	5.841	5.304	6.228
17	4.675	5.841	5.303	6.224
18	4.675	5.833	5.301	6.223
19	4.675	5.822	5.296	6.204
20	4.675	5.831	5.300	6.206
21	4.675	5.841	5.303	6.221
22	Nil	5.836	5.302	6.220
23	Nil	5.843	5.304	6.230
24	4.676	5.844	5.304	6.232
25	Nil	5.844	5.303	6.229
26	4.675	5.840	5.302	6.231
27	4.675	5.841	5.303	6.226
28	Nil	5.838	5.301	6.221
29	Nil	5.830	Nil	6.208
30	Nil	5.838	5.302	6.219

Table 4 - Breach Inundation model data flood levels at the SGN Gasholder site Canal Road

Node Location Map centred on DA12 2PS created on 21 March 2024 [Ref: KSL 352215 JP]



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Figure 12 – EA Node Point Location Map

As part of the Kent Thameside Strategic Flood Risk Assessment (SFRA) breach analyses a number of scenarios were undertaken. The impact of the breaches modelled in these analyses includes the hard defences that are invariably protecting land that is built up (which often has been land raised over the years) and the simulated breach has a narrow opening and relatively high breach invert.

There are many gates in the tidal defences along the Kent Thameside tidal frontage. The gates vary in size. Large gates, which allow access to docks, are operated automatically in the event of a flood. Small gates, which give access to slipways and jetties or for works divided by the defences, are operated manually. An example of failure to operate a large gate (access to the Canal Basin in Gravesend) is modelled in scenario GR 7 as shown below in Figure 13 - Excerpt from Kent Thameside SFRA Figure 5.10 GR7 Breach Model (50 SLR Scenario) Maximum Depth.

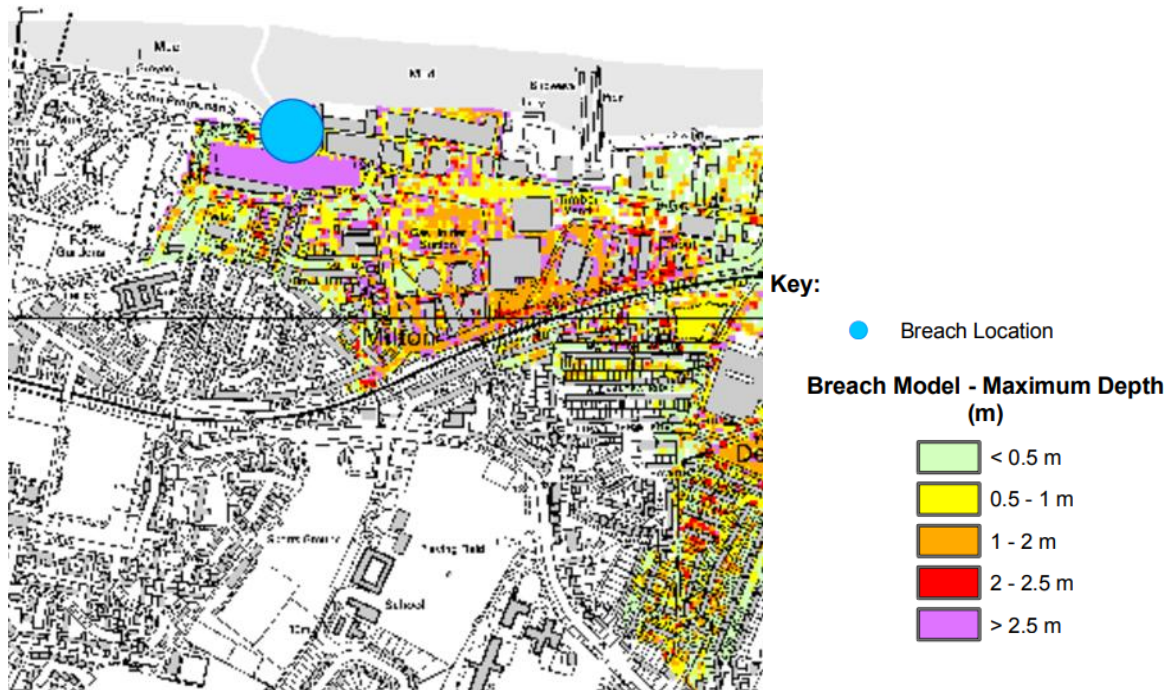


Figure 13 - Excerpt from Kent Thameside SFRA Figure 5.10 GR7 Breach Model (50 SLR Scenario) Maximum Depth

Breach scenario modelled maximum depths on the SGN site are mixed. Maximum depths of up to 0.5m are shown within the administrative building / car parking area close to the site entrance. Maximum depths of between 0.5 – 1m are shown at locations off site in Canal Road adjacent to the SGN site at the site entrance and within the main site itself. Maximum depths of between 1 – 2m are within the eastern end of the site and within the drainage ditch / watercourse.

A flood management plan should be in place in case of a flood defence breach residual risk at the proposed development site.

The detail design for the proposed development should demonstrate that it will provide a fit for purpose secondary flood defence in line with the raising epochs of the TE2100 Plan. Detailed design drawings in line with the flood plan should be provided to show the future on site secondary flood defences / barriers and heights / resilience measures. The detail design should incorporate suitable techniques and material choices for the flood protection / defence of the buildings, associated storage and storage racking systems. Onsite flood defences can be temporary or permanent. Flood defence / protection measures should take the necessary pressure of future heads of water in the event of flooding.

Resilience solutions should include waterproofing of walls & floors covering to air bricks etc.. All measures to include for the particular uses of locations within the development, flood resistant and resilience, safe escape or refuge procedures, flood response plans and clean-up operations. Flood waters conveyance routes / flow paths for flood waters should provide for the return of the flood waters to the River Thames via the local watercourse configurations / system as existing.

The flood management plan may accept the low risk of flooding due to a flood defence breach and allow flood waters onto site and manage them. The plan should then provide for an appropriate clean up strategy once flood waters have subsided.

Flood Management plan

The protection of life is paramount and an escape plan should be provided for all site users accordingly. The estate manager should coordinate and work with the EA flood alert / warning and

other associated community agencies. They should ensure that a programme of engagement on flood risk awareness is initiated within the estate. The estate manager should sign up to the EA floodline to provide flood warnings to site users of potential flooding at the Canal Road site. Thurrock Kent CC / Gravesham BC / North Kent Marshes Internal Drainage Board has Emergency Flood Plans specific to the risks and needs of their administrative areas. The Local Authorities and EA Floodline details should be integral to the specific Canal Road site Flood Management Plan to provide direction for people to safety during times of Flooding. Emergency services contact details and requirements should be included within the plan and provided for within the detail design process.

An access / egress evacuation plan should be provided within the flood plan.

Safe access/egress routes for predicted flood defence breach

When a breach of flood defences has occurred flood waters will approach the proposed development from the north and potentially the east.

The site access road should not be used for a refuge area or access during floods conditions. Safe evacuation and access / egress of the proposed development should be undertaken prior to a flood defence breach in accordance with the EA's flood warnings. A safe access / egress route to higher ground levels are via Canal Road southward to Norfolk Road heading west then south to higher level areas.

Safe escape and / or refuge procedures and a flood response plan should be made available to all building / property users for the predicted flood defence breach flood scenario.

Where possible the EA aims to give advanced warning of flooding using a system of flood warning codes. Flood warnings are provided on the EA website updated every 15 minutes, by their 24 hour Floodline service, flood warning messages and are also broadcast on TV and radio. The property owner / facilities manager should coordinate and work with the Environment Agency flood alert/warning and other associated community agencies. They should sign up to receive flood warnings from the EA's flood warning systems, understand the flood warning codes, develop a flood plan incorporating relevant procedures and have an evacuation plan in place. Safe escape and / or refuge procedure should be instigated through the flood and evacuation plan that is to be provided and displayed for residents and associated users.

Surface Water Flooding

Surface water flooding can occur during high intensity rainfall events as sheet run off from fields or hard paved areas.

The application site has varying flood risks within the site boundary. Much of the site has a very low risk of flooding from surface water as shown in the EA flood risk map below in Figure 14 - Flood Risk from Surface Water. However, there are also areas having low, medium and high risk of flooding.

Very low risk means that each year this area has a chance of flooding of less than 0.1%.

Low risk means that this area has a chance of flooding of between 0.1% and 1% each year.

Medium risk means that this area has a chance of flooding of between 1% and 3.3% each year.

High risk means that this area has a chance of flooding of greater than 3.3% each year.

Flooding from surface water is difficult to predict as rainfall location and volume are difficult to forecast. In addition, local features can greatly affect the chance and severity of flooding.

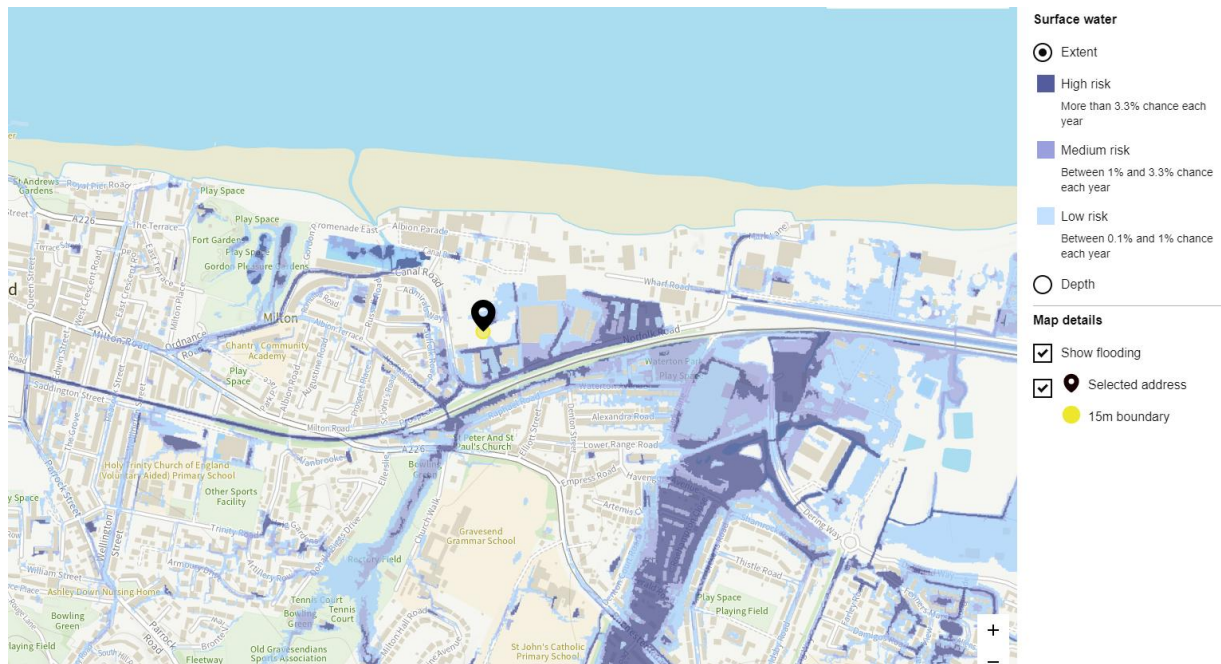


Figure 14 - Flood Risk from Surface Water

There are high risk areas within the adjacent watercourse outside the eastern boundary to the site and within the neighbouring property outside the southern boundary. EA mapping below in Figure 15 shows surface water flood risk: water depth in a low risk scenario. The majority of the site is free from flood waters, however, there are low risk flood depths within the plot of between 300mm and 900mm. As expected surface water flood depths of 300 - 900 and above are within the neighbouring eastern watercourse and southern property.

Surface water runoff on the site will be provided for by the proposed SuDS Strategy. Overland flow routes to the watercourses will be maintained.

There is no historical record of surface water flooding at the site.

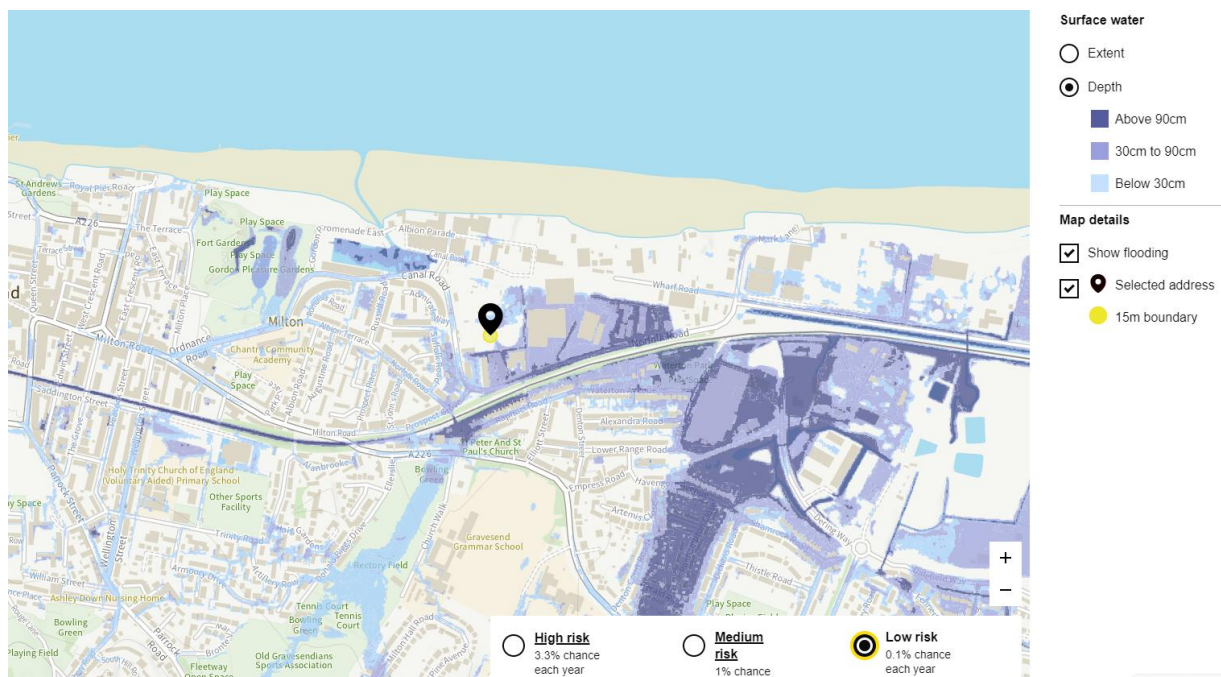


Figure 15 – Surface water flood risk: water depth in a low risk scenario

Groundwater Flooding

The Kent CC Local Flood Risk Management Strategy Report states that "Groundwater flooding occurs as a result of water rising up from the underlying aquifer, or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at a shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although it is also associated with more localised floodplain sands and gravels.

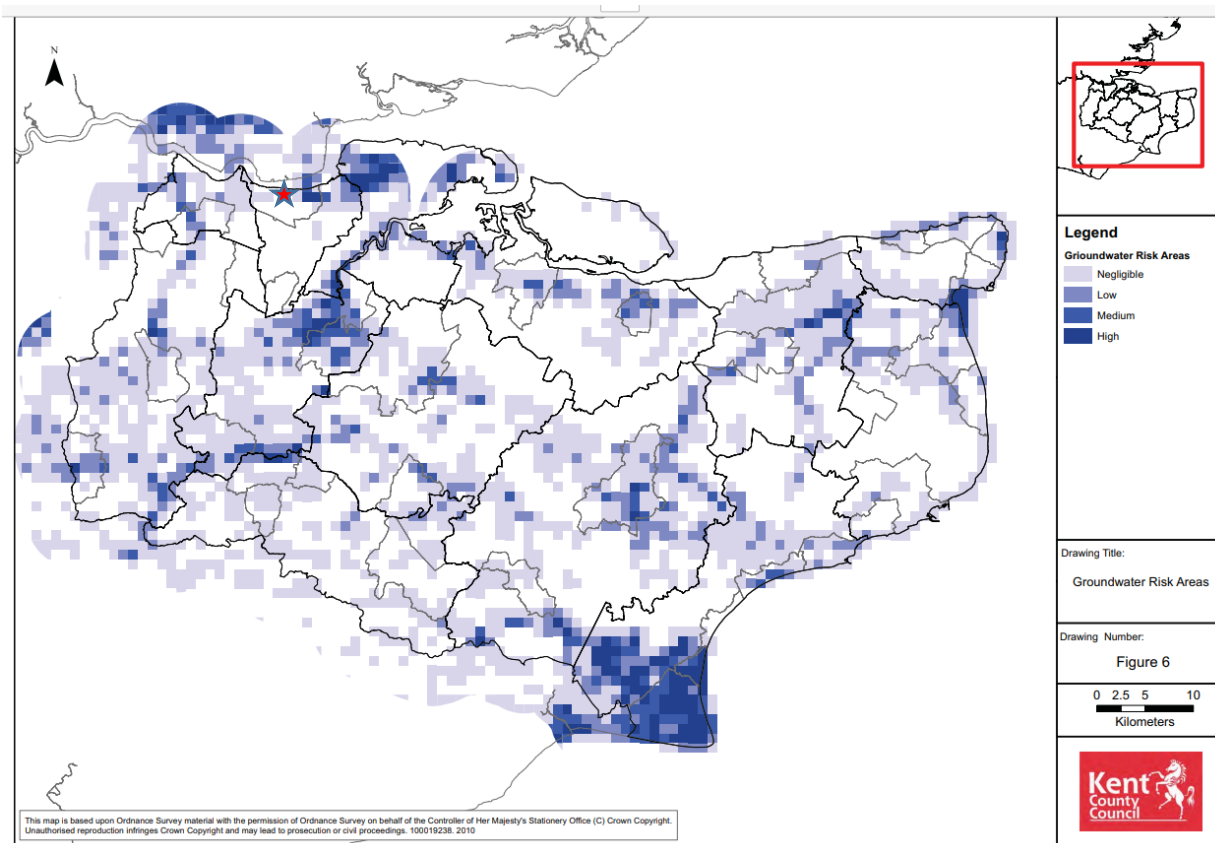
Groundwater flooding is very complex and is poorly understood. It is very difficult to assess the location, likelihood and volume of groundwater flooding. Consequently it is difficult to quantify the risk of groundwater flooding to Kent. The presence of major aquifers in Kent, the chalk of the North Downs and the sandstone of the High Weald, mean that there is a risk of groundwater flooding in some parts of Kent. Kent CC monitor events and to build a picture of areas prone to groundwater flooding and promote resistance and resilience measures in these areas.

Adjacent to the Thames Estuary, the bedrock geology is Chalk. The Chalk is the principle underlying aquifer in the area. Rainfall percolates into the aquifer and recharges it. The Drift deposit geology consists of Alluvium at this site close to the Thames Estuary. Alluvium consists of clays, silts, sands and gravels and the permeability can be highly variable depending on the exact composition of the material. Since this material has been deposited in riverbeds, it tends to be relatively impermeable.

An assessment of areas susceptible to groundwater flooding was undertaken as part of the Kent CC Preliminary Flood Risk Assessment (PFRA). The Areas at risk of groundwater flooding were identified and provided in Figure 6 Groundwater Risk Areas map included within the Kent CC PFRA. The Groundwater risk areas ranging from high to none are indicated on the map.

Figure 16 below shows the Canal Road site location marked on the Kent CC PFRA Figure 6 Groundwater Risk Areas map within an area that has none to negligible risk from groundwater flooding.

No incidences of groundwater flooding have been reported to the Council or the Environment Agency.



★ Location of the development.

Figure 16 - Kent PFRA Figure 6 Groundwater Risk Areas

Groundwater flooding at the proposed development site is very low risk.

Flood Risk From Sewers

Southern Water has no public sewerage networks within the vicinity of the proposed development that services the development site. There are no surface water sewers shown on the Southern Water asset plans within the site. Southern Water asset plans are shown in Appendix A.

Public Sewers are defined as those for which the Company holds statutory responsibility under the Water Industry Act 1991.

It is expected that the sewer networks in the vicinity of and on this site are well maintained as Southern Water is a highly professional company having planned operations and maintenance regimes for their sewerage, drainage and potable water main network systems.

The risk of flooding from sewers is low.

It should be noted that flooding can occur from private sewers and drains which are not the responsibility of the Southern Water.

Flood Risk from other Sources

In rare occasions, a development may be subject to flood risk from upstream features such as reservoirs, where there is a theoretical risk of failure. An area is considered at risk if people's lives could be threatened by an uncontrolled release of water from a reservoir.

The application site is not at risk of flooding from the failure of a reservoir as is shown in the EA flood risk map below in Figure 17 - Flood Risk from Reservoirs.

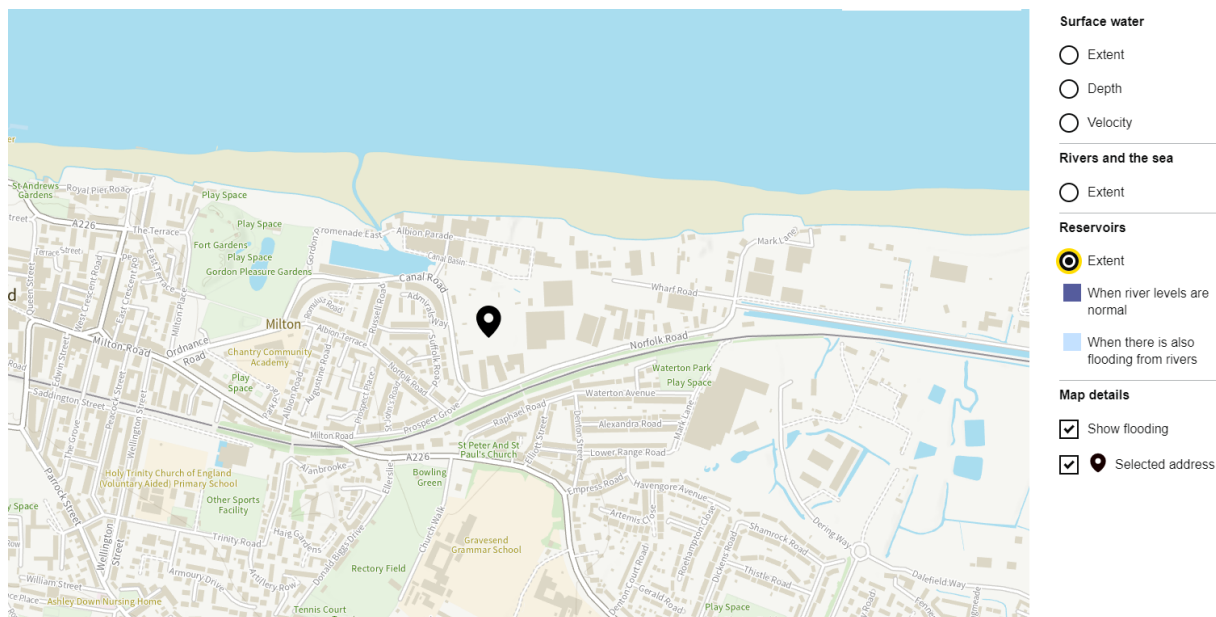


Figure 17 – Flood Risk from Reservoirs

Historical Flooding

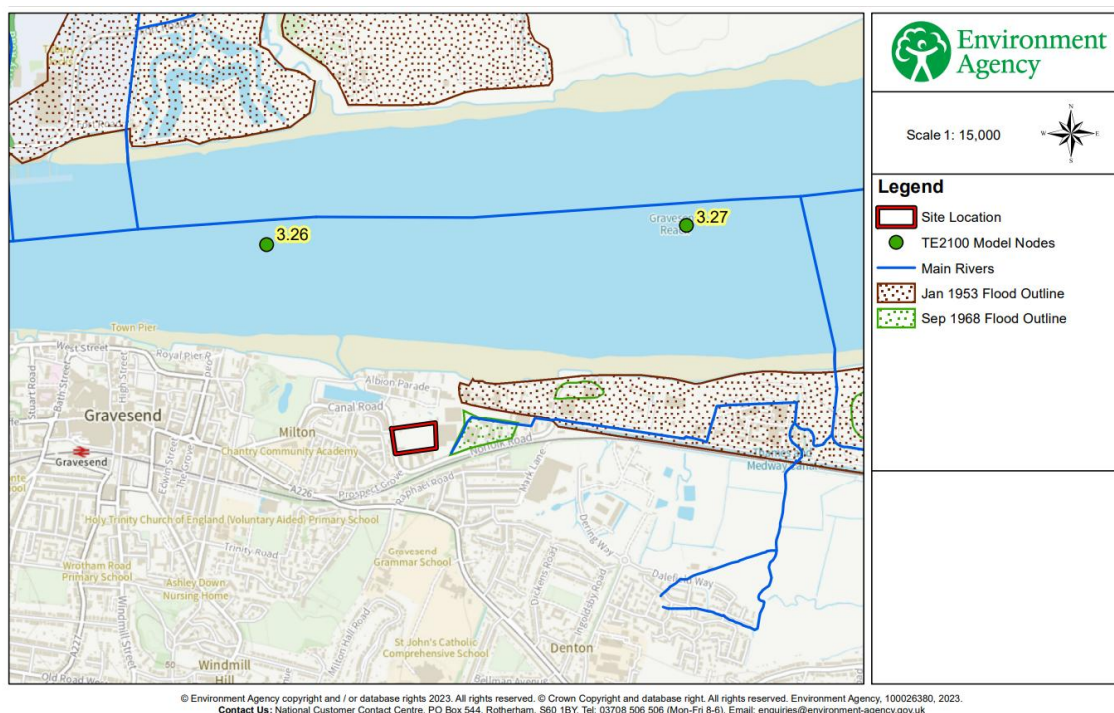
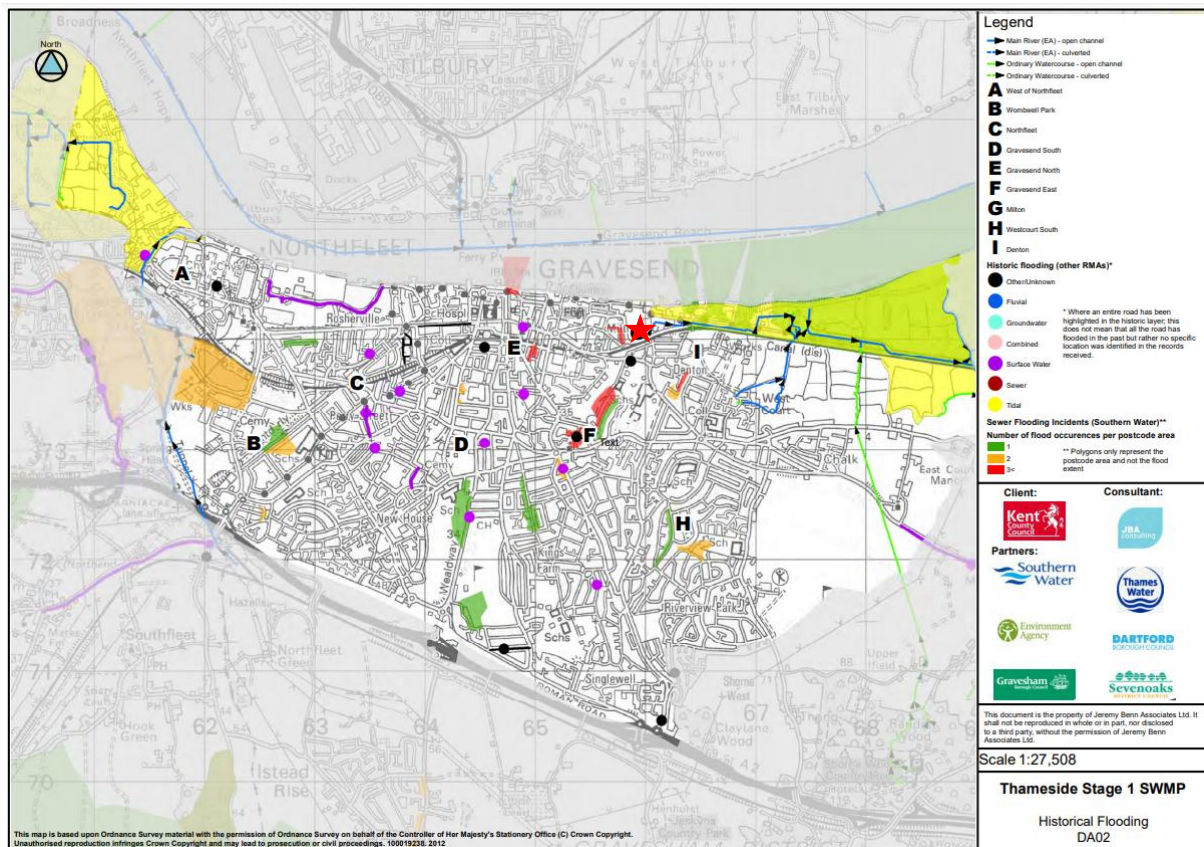


Figure 18 - EA Historic Flood Map centred on DA12 2PS created on 21 March 2024[Ref: KSL 352215 JP]

The EA holds records of historic flood events from rivers and the sea. The SGN Gasholder site was within 125m of the tidal flooding on the night of the 6th and morning of the 7th January 1928. An approximate level of the Thames at the time was 4.63m AODN. The site was within 61m of the tidal flooding due to a storm surge in the North Sea on the night of 31 January and the morning of 1st February 1953. An approximate level of the Thames at the time was 4.90m AODN. The EA produced a historical flood map centred on the SGN Gasholder site off Canal Road showing that they have no recorded flooding at the site. The January 1953 and September 1968 flood outlines did not affect the site as shown above in Figure 18.

The Thameside Stage 1 SWMP Historical Flooding DA02 plan below in Figure 19 also shows that the proposed Canal Road development site does not have any recorded historical flood.



★ Site Location

Figure 19 – Thameside Stage 1 SWMP Historical Flooding DA02

Flood Risk Summary

Data from the Environment Agency's flood maps and information provided by Kent CC show that the proposed Canal Road development site is generally at a low risk of flooding from all sources. However, the residual risk of a breach of the Flood defences remain.

5. Sustainable Drainage Systems Strategy

Philosophy

Sustainable drainage has moved away from the traditional thinking of designing to manage flood risk and where runoff is regarded as a nuisance to a philosophy of surface water being a valuable resource that should be managed for maximum benefit.

Sustainable Drainage systems (SuDS) can contribute to sustainable development overall by improving the places and spaces where we live, work and play as well as balancing the different opportunities and challenges that influence urban design and the development of communities.

The SuDS philosophy is to replicate, as closely as possible the natural drainage from a site before development. SuDS mimic nature and manage rainfall close to where it falls. They can be designed to convey surface water, slow / attenuate runoff before it enters watercourses, provide areas to store water in natural contours and can be used to allow water to infiltrate into the ground or evaporate from the surface and transpired from vegetation.

The "four pillars" of SuDS design philosophy is to meet design objective where surface water runoff is managed for water quantity, water quality, amenity and biodiversity benefits.

Management Train

Adopting a holistic approach towards surface water drainage provides the benefits of combined water quality and quantity control, biodiversity as well as increased amenity value. This is accomplished by managing the increased flows and pollution from surface water runoff that can arise from development

A fundamental concept used in the management / development of SuDS is the management train or treatment train, illustrated in Figure 20 below

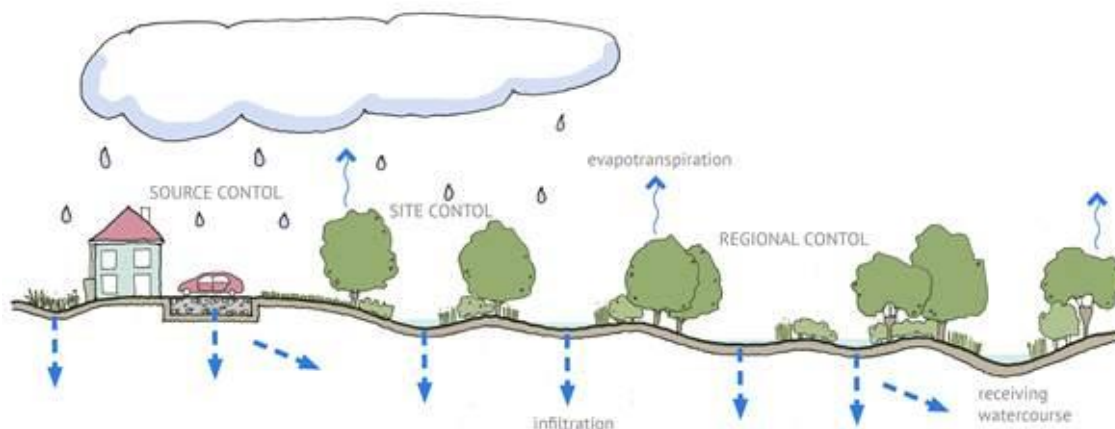


Figure 20 - SuDS Management Train (susdrain)

Just as in a natural catchment, drainage techniques can be used in series to change the flow and quality characteristics of the runoff in stages. The management train starts with prevention (prevent runoff by reducing impermeable areas), or good housekeeping measures for reducing pollution; and progresses through local source controls to larger downstream site and regional controls

They are regarded as a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies. Within the philosophy of the surface water management train each component adds to the performance of the whole drainage system.

Design Requirements

SuDS design proposals should consider the location of discharge as a hierarchy, Planning Practice Guidance states:

"Generally, the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

1. into the ground (infiltration);
2. to a surface water body;
3. to a surface water sewer, highway drain, or another drainage system;
4. to a combined sewer."

SuDS design:

- o Manage runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding
- o Provide opportunities for using runoff where it falls
- o Protect or enhance water quality (reducing pollution from runoff)
- o Protect natural flow regimes in watercourses
- o Are sympathetic to the environment and the needs of the local community
- o Provide an attractive habitat for wildlife in urban watercourses
- o Provide opportunities for evapotranspiration from vegetation and surface water
- o Encourage natural groundwater/aquifer recharge (where appropriate)
- o Create better places to live, work and play.

Summary of typical SuDS Components:

Source Control

- Good house keeping
- Green Roofs
- Infiltration Basins
- Infiltration trenches
- Permeable pavements / Grasscrete
- Rainwater Harvesting
- Soakaways

Permeable Conveyance Systems

- Filter (or French) Drains
- Swales

Passive Treatment

- Bioretention / Vegetated areas
- Filter Strips
- Detention Basins
- Retention ponds
- Wetlands

Pipes and accessories. A series of conduits and their accessories normally laid underground that convey surface water to a suitable location for treatment and/or disposal. (Although sustainable, these techniques should be considered where other SUDS techniques are not practicable).

Site Considerations

As well as to ensure that the users of the site are not at risk, another key objective is to ensure that the development does not increase the potential of flooding elsewhere. This objective can be achieved by designing a drainage / SuDS strategy for the development that will set the strict framework to be followed during the detailed drainage design.

Physical site conditions as described in Section 3 above are taken into account in order to develop a suitable SuDS Strategy for the proposed development. The SuDS strategy will be delivered as required in accordance with prevailing local and national planning policy and design standards including CIRIA Reports etc.

This FRA & drainage / SuDS Strategy takes into account and makes reference to the NPPF and the National Planning Practice Guidance (NPPG) as well as the local policies and guidance.

Currently, the most significant directives influencing the design of the SuDS strategy are the Flood and Water Management Act 2010, the NPPF and the National Planning Practice Guidance (NPPG) as well as the local Gravesham BC policies and Local Plan Core Strategy & associated Maps; Kent CC Drainage and Planning Policy 2019; Kent CC Preliminary Flood Risk Assessment September 2011; Kent CC Local Flood Risk Management Strategy 2013; Kent CC Design Guide Making it Happen Sustainability Drainage Systems; Kent CC Local Flood Risk Management Strategy 2017-29-023; Thameside Stage 1 Surface water management Plan 2013; Thameside Strategic Flood Risk Assessment 2005.

It also makes reference to consultations with the Environment Agency and Anglian Water as well as CIRIA753 The SuDS Manual and Government Non-statutory technical standards for sustainable drainage systems – practice guidance and the design, maintenance and operation of SuDS, Susdrain – the community for sustainable drainage and BS8582 Code of practice for surface water management for development sites and Susdrain – the community for sustainable drainage.

This drainage / SuDS strategy sets the guidelines for future detailed design, but more importantly, it demonstrates that a sustainable drainage solution is deliverable at this site, complying with all relevant planning and legislative criteria.

Outline SuDS Strategy Design

The aim of the outline SuDS strategy is to mimic the existing drainage system for the site and to restrict discharge rates from the site to as close to greenfield rates as is practicable.

A review of the British Geological Society data show that the existing brownfield site sits on a thick layer of alluvium superficial deposits directly overlying above chalk bedrock. There is currently no GI data available for the proposed development site. A high level source control infiltration / soak away system is not appropriate for this site. However a deep borehole infiltration system may be suitable dependent on the results of a ground investigation. The gasholder site ground conditions are potentially contaminated. A borehole infiltration solution may provide a route to introduce contamination to the chalk aquifer. A deep borehole infiltration system at this point is not considered appropriate. The site is not served by a surface water infiltration system.

A geotechnical investigation would provide data for the detail design accordingly.

Southern Water asset plans do not show any public / Southern Water sewers within the Canal Road development site.

There is an open drainage ditch / watercourse immediately adjacent to the site's eastern boundary to drain to. Surface runoff flows drain to the drainage ditch / watercourse.

Exceedance flows generally drain off site towards the adjacent watercourse and away from the site. At points of low level ground with no flow path to the adjacent watercourses exceedance flows pond on site until they evaporate. The flow route for exceedance surface water flows off site should be maintained as existing.

There are no historical records of flooding at the application site. The main flood risk to the development is therefore from surface water runoff from the new development itself. In addition to ensuring flood risk on site is not increased the SuDS design for the proposed redevelopment considers mitigation in order to protect the site and not to add to offsite flood risk.

Detail design of the works should provide for resistance and resilience materials and construction techniques to suit Building Regulation requirements and to the potential for a breach of the flood defences. Mitigation measures for this scenario has been dealt with above in Section 4 Flooding.

There are no historical records of flooding at the application site. A review of the EA flood maps, British Geological Society, Thames Water and Local Authority documents have identified that the site has a low risk of flooding from on or offsite sources. The main flood risk to the development is therefore from surface water runoff from the new development site itself

The proposed SuDS strategy will provide for the surface water runoff on the site itself.

It is the aim of this study to provide a SuDS strategy solution that aims for greenfield runoff rates and is pragmatic in both its specification and maintenance in accordance with site constraints.

The total area of the proposed brownfield development site is 9,840m².

Design optioning with associated hydraulic calculations was undertaken to ensure that surface water run-off is managed as close to its source as possible. The hydraulic calculation process was an iterative one to assess discharge with appropriate sized flow controls and attenuation drain down times based on greenfield runoff rates. Practicably maintainable flow controls are used to determine a suitable surface water discharge from the proposed development layout.

Runoff calculations for the proposed development site of total area of 9,840m² were calculated to establish greenfield runoff flows for 1 in 1yr of 2.1 l/s, Qbar of 2.5 l/s, 1 in 10yr of 4.1 l/s, 1 in 30yr of 4.9 l/s and 1 in 100yr of 6.3 l/s. These calculations are provided in Appendix B.

Brownfield runoff calculations for the proposed development site of total area of 9,840m² were calculated as 1 in 2yr of 57.6 l/s, 1 in 10yr of 86.1 l/s, 1 in 30yr of 107.7 l/s and 1 in 100yr of 139.3 l/s. These calculations are provided in Appendix B.

The proposed development has an impervious area of 9,840m². Runoff calculations for the proposed development site were calculated using the impermeable area of 9,840m². The climate change allowance for the site is 45%. The optimised design provides for a double Hydro Brake Flow Control system as appropriate for practicable maintenance within the SuDS System that allows for drain down times.

It provides a flow for 1 in 1yr discharge of 2.1 l/s, of 3.9 l/s for the 1 in 30yr, 5.1 l/s for the 1 in 100yr and 6 l/s for the 1 in 100yr + 45% cc. The proposed 1 in 100yr+45% cc discharge of 6 l/s is greater

than the 1 in 100yr greenfield runoff rate. However, this is a 95% reduction in the 1 in 100yr brownfield runoff discharge from the site. The proposed runoff for 1 in 100yr + 45% cc calculates that an attenuation of 888.2m³ is required. The required attenuation is provided within the permeable pavement / SuDS components and the drainage network itself. These calculations are also provided in Appendix B.

Surface water runoff from the grey roofs will be collected and drain via ducting and rainwater pipes to ground level to discharge into the adjacent permeable paved carparking, drive way / yard and main storage area. The permeable pavement is as Formpave / Aquaflo attenuation system or similar at 450mm thick. The surface water runoff from the permeable pavement discharges to a downstream Flow Control Chamber with a double Hydro Brake Flow Control flow control system within it.

Surface water runoff from the hard surfaced access and HGV Servicing/Lorry Holding and Turning Zone drains to an ACO drain located at the edge of the hard surface between the permeable paved areas. The ACO drain is connected to a downstream interceptor that also discharges to the Flow Control Chamber with the double Hydro Brake Flow Control flow control system. The flow from the Flow Control Chamber discharges via an outfall structure the adjacent water course at the eastern boundary.

The proposed SuDS Strategy system as described is shown on Drawing No FRA20197-DS-001A/B provided in Appendix C.

The proposed SuDS strategy will provide source control permeable paving incorporating Formpave / Aquaflo attenuation system or similar to collect, convey, attenuate and provide an element of passive treatment to storm / surface water prior to discharge into the existing adjacent drainage ditch / watercourse. The lined permeable pavement will provide for the first 5mm flush rainfall runoff.

Ground levels at the site will allow for exceedance flows to be directed to the Ravensbourne Park highway as existing.

An ordinary watercourse consent from Kent CC will be required for an outfall and works within an ordinary watercourse.

This strategy has been developed from a desk top study. Site surveys / investigations of the site drainage connections, public sewer network lines and levels should be undertaken to confirm the SuDS Strategy for detailed design.

6. Management and Maintenance

Management

All drainage works are to be completed prior to occupation.

The onsite surface water management system is not eligible for adoption and will remain in the private ownership of the developer estate manager. The Facilities Manager will be responsible for the long-term maintenance of the onsite drainage system.

All drainage works are to be completed prior to occupation.

On Site SuDS

Surface water runoff from the grey roofs will be collected and drain via ducting and rainwater pipes to ground level to discharge into the adjacent permeable paved carparking, drive way / yard and main storage area. The permeable pavement is as Formpave / Aquaflo attenuation system or similar at 450mm thick. The surface water runoff from the permeable pavement discharges to a downstream Flow Control Chamber with a double Hydro Brake Flow Control flow control system within it.

Surface water runoff from the hard surfaced access and HGV Servicing/Lorry Holding and Turning Zone drains to an ACO drain located at the edge of the hard surface between the permeable paved areas. The ACO drain is connected to a downstream interceptor that also discharges to the Flow Control Chamber with the double Hydro Brake Flow Control flow control system. The flow from the Flow Control Chamber discharges via an outfall structure the adjacent water course at the eastern boundary.

The proposed SuDS Strategy system as described is shown on Drawing No FRA20197-DS-001A/B provided in Appendix C.

Maintenance

The SuDS Maintenance Plan is to be read in conjunction with the whole of the FRA / SuDS Strategy Report. Section 5 above details the SuDS Strategy Philosophy, Site Considerations and Outline SuDS Strategy Design.

The maintenance strategy and regime are to continue in accordance with the existing established methods, procedures and specific manufacturers recommendations. They should include

- inspections required to identify performance issues and plan appropriate maintenance needs
- operation and maintenance of the overall drainage system
- landscape management
- waste management associated with contaminated silt and other waste materials resulting from maintenance.

An Operations & Management Manual for the SuDS should be completed and agreed with the estate manager / site operator on completion of the construction works. It should provide the surface water management strategy and SuDS overall philosophy as well as the function and operation of each component. Manufacturers technical details and maintenance procedures and requirements should be included within the Manual.

General

Regular good housekeeping management with inspections and cleansing should be employed at the whole of the site.

Regular inspection and cleansing of catchment, guttering, pipe inlets, channels, filters and inspection / orifice / Flow control chambers to reduce the likelihood of contamination is required to suit the prevailing operations, usage and circumstances of the development site.

Inspections after extreme rainstorms are essential to ensure that there are no blockages.

Regular inspections & removal of litter, debris and sediment intrusion or other items that represent blockage risks.

Contaminated silts / sediments etc to be disposed of at appropriately licenced tip.

Regular weeding and maintenance should be carried out and more intently during months of growth.

Permeable paving maintenance

Inspection routines are essential to maintain efficient performance of permeable paving and they should be carried out at frequent and regular intervals. An initial inspection of the system should be undertaken within 3 months of installation. Occasional but regular inspections to be undertaken over the lifetime as required.

Regular: The catch pit chamber and flow control for the permeable sub-base storage should be checked and emptied regularly to ensure there is no silting up of the system

Vacuum and sweep permeable paving surface to remove litter, debris and contamination as circumstances require. Minimum: seasonally during Spring and at leaf fall in Autumn.

Occasional: Management / removal and disposal of sediment intrusion.

Removal of weeds and invasive plants as circumstance require.

Washdown paving as required.

Remedial: Infiltration surface reconditioning / rehabilitate surface. Sweep in and reapplication of 2-4mm clean gritstone. As Required

Remediate areas of rutting and depressions - structure rehabilitation /rep

As required Replace broken / damaged blocks.

ACO Channel Drains

Inspection routines are essential to maintain efficient performance of drainage channels and they should be carried out at frequent and regular intervals. The frequency will be based on local knowledge and requirements, but inspections should be carried out at least once a year.

Regular: Sweep surface to remove debris and contamination as circumstances require.
Minimum: seasonally during Spring and at leaf fall in Autumn.

Occasional: Removal of weeds as circumstance requires.

Removal of silt, grit & vegetation. Remove grates with keys as required in accordance with manufacturers recommendations. Remove debris or empty silt bucket. Replace silt bucket and all grates.

Remedial: Gratings to be painted / treated or replaced if / as required

Kingspan NSBP010 Petrol Interceptor & Forecourt Separator or similar

Inspection routines are essential to maintain efficient drainage performance of a petrol interceptor and forecourt separator. They should be carried out at regular intervals as recommended by the manufacturer. Inspections and frequency of maintenance needed will be based on the interceptor & separator design and manufactured specific features, components and system connectivity.

Kingspan Environmental Services or similar manufacturers have dedicated service divisions that provides maintenance for their petrol interceptors and forecourt separators and associated alarm system.

Hydro Brake Flow Control TM

Inspection routines are essential to maintain efficient performance of a Hydro Brake Flow Control systems and they should be carried out at regular intervals. Normally, little maintenance is required as there are no moving parts within the Flow Control. Experience has shown that if blockages occur they do so at the intake. The Flow Control is fitted with a pivoting bypass door, which allows the manhole chamber to be drained down should blockage occur. Following installation of the Flow Control it is vitally important that any extraneous material ie. building materials are removed from the unit and the chamber. After the system is made live, and assuming that the chamber design is satisfactory, it is recommended that each unit be inspected monthly for three months and thereafter at six monthly intervals with hose down if required.

Regular (quarterly) inspections to be undertaken over the lifetime as required.

Inspection / control chambers are required to monitor and control the water level within the system. The control chamber provide access for inspection and maintenance for cleansing operations as required etc.

Regular: Each outlet, should be inspected and cleared of any build up or debris. Ensure connection drainage is clear and functioning, remove sediment, litter and other deposits from inspection chambers and check pipe inlets..

Occasional: Following any significant storm event, the outlets & flow controls should be visually inspected to ensure no blockage has occurred. Following any significant traffic or remedial works that take place on or around the tank, each of the outlets should be visually inspected to ensure all drainage holes are clear and free draining.

Remedial: Any vegetation which has encroached into drainage outlets, Inspection chambers and crates should be removed.

Structure rehabilitation / repair. Remediate drainage system and structure as required.

Outfall Structure

Inspection routines are essential to maintain efficient performance. They should be carried out at frequent and regular intervals. An initial inspection of the system should be undertaken following a

significant storm and / or within 3 months of installation. Regular (quarterly) inspections to be undertaken over the lifetime as required.

Regular: Check and remove any silt or obstructions. Cut back and remove vegetation or animal intrusions / nesting etc..

Occasional: Structural survey and assessment.

Remedial: Repair any structural damage and remove any flora or fauna intrusions as required.

7. Conclusions

The PES has been commissioned to produce a Flood Risk Assessment (FRA) and Sustainable Urban Drainage System (SuDS) Strategy report for the proposed development at the SGN Gasholders Site, Canal Rd, Gravesend DA12 2PS in support of a planning application for the proposed development. The proposed development is to create an external storage area that includes racking systems, an HGV servicing / Lorry holding zone and vehicular access with turning.

This FRA and SuDS report has been prepared as a desk top study based on the architectural drawings supplied and gathered data available within the public domain. It summarises the SuDS design process for the proposed development and demonstrates that the development complies with planning policy on flood risk – National Planning Policy Framework (NPPF) and supports Planning Practice Guidance (PPG) as well as the local Gravesham BC Policies and guidelines including associated Kent CC SuDS requirements.

The design process began with a review and analysis of the proposed development and the existing site conditions with respect to surface water drainage and flood risk. This included a study of both the hydrology and hydrogeology of the site.

The proposed SuDS design strategy provides for mainly source control techniques of, permeable paving. Surface water will be discharged into the adjacent existing drainage ditch / watercourse.

Associated hydraulic and attenuation calculations are based on greenfield runoff rates for both pre and post development along with impermeable areas and a description of the proposed surface water management, SuDS scheme for the site is prepared accordingly. Hydraulic design was an iterative process to provide for flow controls sized and used to allow a practicable maintenance regime to be incorporated within and to allow for attenuation drain down times. The multiple flow control system will control the discharge from site to greenfield Q1-Q100 runoff scenarios. The discharge of 6 l/s for the 1 in 100yr+45% cc requires a total of 888m³ attenuation for the 1 in 100yr +45%cc runoff scenarios. The required attenuation is provided within the permeable pavement and associated drainage network.

The SuDS provides a surface water management solution that reduces the surface water run off that leaves the site and shows that the proposed development does not result in an increase to the risk of flooding on or off site.

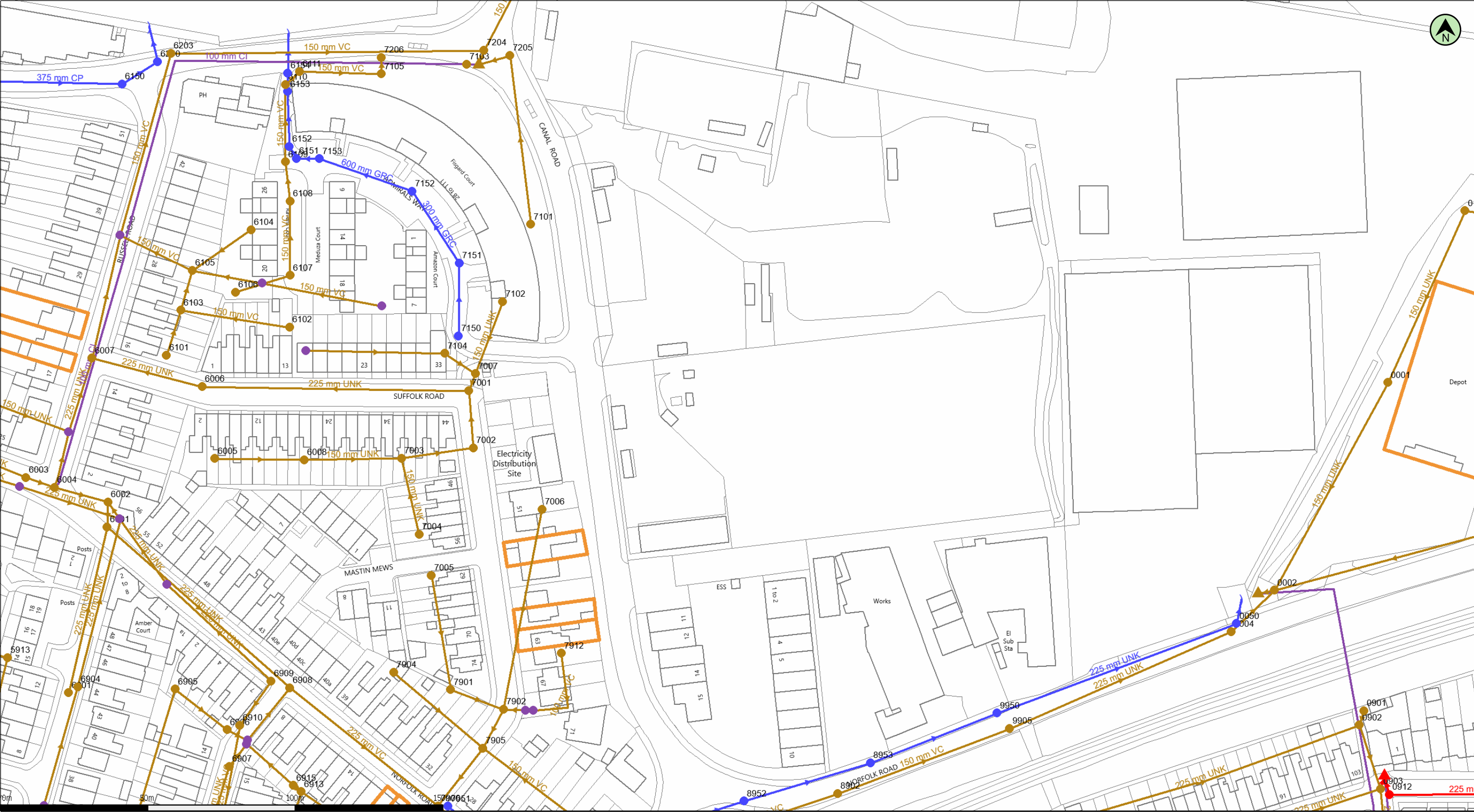
Permeable paving is provided on site for permeable conveyance and passive treatment techniques to collect, convey, attenuate and treat storm / surface water prior to discharge to the drainage ditch / watercourse next to the site. It will also take the first 5mm of rainfall.

This report provides a management and a maintenance regime statement for the SuDS surface water management of the new development.

A LLFA land drainage consent application is to be made.

Appendix A

Southern Water Asset Data



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Date: 19/03/24

Scale: 1:1250

Map Centre: 565843,174084

Data updated: 12/01/24

Our Ref: 1424907 - 1

Wastewater Plan A3

The positions of pipes shown on this plan are believed to be correct, but Southern Water Services Ltd accept no responsibility in the event of inaccuracy. The actual positions should be determined on site. This plan is produced by Southern Water Services Ltd (c) Crown copyright and database rights 2024 Ordnance Survey 100031673. This map is to be used for the purposes of viewing the location of Southern Water plant only. Any other uses of the map data or further copies is not permitted.

WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

Foul Gravity Sewer	Combined Gravity Sewer	Culverted Water Course or Treated Effluent	Surface Water Gravity Sewer
Rising Main, Vacuum or Syphon	Combined Outfall	Foul Outfall	Surface Water Outfall
Surface Water Inlet	Combined Pumping Station	Surface Water Pumping Station	Foul Pumping Station
Water Treatment Works	Section 104 Area	Building Over Agreement Area	Foul Manhole
Side Entry Manhole, Decarcation Chamber, Dummy Manhole or Surface Water Soakaway	Combined Manhole	Surface Water Manhole	

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SGN Gasholder site



Appendix B

Surface water drainage system Associated Hydraulic Calculations



Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	5	Maximum Rainfall (mm/hr)	50.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.400	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
PP	0.322	5.00	10.000	1350	565937.871	174057.993	1.000
Out			10.000	1350	565948.750	174057.800	1.109

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	PP	Out	10.881	0.600	9.000	8.891	0.109	100.0	300	5.12	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)
1.000	1.572	111.1	43.6	0.700	0.809	0.322	0.0

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	10.881	100.0	300	Circular	10.000	9.000	0.700	10.000	8.891	0.809

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	PP	1350	Manhole	Adoptable	Out	1350	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
PP	565937.871	174057.993	10.000	1.000	1350				
						0	1.000	9.000	300
Out	565948.750	174057.800	10.000	1.109	1350				
						1	1.000	8.891	300

Simulation Settings

Rainfall Methodology	FSR	Drain Down Time (mins)	240
FSR Region	England and Wales	Additional Storage (m³/ha)	20.0
M5-60 (mm)	20.000	Check Discharge Rate(s)	✓
Ratio-R	0.400	2 year (l/s)	69.3
Summer CV	0.750	10 year (l/s)	102.7
Winter CV	0.840	30 year (l/s)	127.5
Analysis Speed	Detailed	100 year (l/s)	161.6
Skip Steady State	x	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320
30	120	240	480	720	1440	2880	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0
10	0	0	0
30	0	0	0
100	0	0	0

Pre-development Discharge Rate

Site Makeup	Brownfield	Betterment (%)	0
Brownfield Method	MRM	Q 2 year (l/s)	69.3
Contributing Area (ha)	0.984	Q 10 year (l/s)	102.7
PIMP (%)	33	Q 30 year (l/s)	127.5
CV	0.840	Q 100 year (l/s)	161.6
Time of Concentration (mins)	5.00		



Results for 2 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	PP	10	9.173	0.173	58.7	1.3600	0.0000	OK
15 minute winter	Out	10	9.042	0.151	57.6	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	PP	1.000	Out	57.6	1.484	0.519	0.4224	27.0



Results for 10 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	PP	10	9.229	0.229	87.8	1.8019	0.0000	OK
15 minute winter	Out	10	9.086	0.195	86.1	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	PP	1.000	Out	86.1	1.617	0.775	0.5783	40.5



Results for 30 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	PP	11	9.289	0.289	111.3	2.2741	0.0000	OK
15 minute winter	Out	11	9.124	0.233	107.7	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	PP	1.000	Out	107.7	1.660	0.970	0.6986	51.3

Results for 100 year Critical Storm Duration. Lowest mass balance: 100.00%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	PP	11	9.448	0.448	144.6	3.5255	0.0000	SURCHARGED
15 minute winter	Out	11	9.168	0.277	139.3	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	PP	1.000	Out	139.3	1.979	1.254	0.7531	66.9

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	5	Maximum Rainfall (mm/hr)	50.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.400	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
INTERCEPTOR OUT	0.088	5.00	2.100	1200	565860.209	174079.357	0.600
PP	0.896	5.00	2.000	1200	565939.159	174058.038	0.700
FCC			2.000	1350	565944.473	174057.963	0.753
Out			2.000	1350	565948.750	174057.800	0.800

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	INTERCEPTOR OUT	PP	81.778	0.600	1.500	1.300	0.200	409.0	300	6.77	50.0
1.001	PP	FCC	5.315	0.600	1.300	1.247	0.053	100.0	150	6.86	50.0
1.002	FCC	Out	4.280	0.600	1.247	1.200	0.047	91.1	150	6.92	50.0

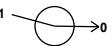
Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)
1.000	0.771	54.5	11.9	0.300	0.400	0.088	0.0
1.001	1.005	17.8	133.4	0.550	0.603	0.984	0.0
1.002	1.053	18.6	133.4	0.603	0.650	0.984	0.0

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	81.778	409.0	300	Circular	2.100	1.500	0.300	2.000	1.300	0.400
1.001	5.315	100.0	150	Circular	2.000	1.300	0.550	2.000	1.247	0.603
1.002	4.280	91.1	150	Circular	2.000	1.247	0.603	2.000	1.200	0.650

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	INTERCEPTOR OUT	1200	Manhole	Adoptable	PP	1200	Manhole	Adoptable
1.001	PP	1200	Manhole	Adoptable	FCC	1350	Manhole	Adoptable
1.002	FCC	1350	Manhole	Adoptable	Out	1350	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
INTERCEPTOR OUT	565860.209	174079.357	2.100	0.600	1200				
						0	1.000	1.500	300
PP	565939.159	174058.038	2.000	0.700	1200		1	1.000	1.300
						0	1.001	1.300	150
FCC	565944.473	174057.963	2.000	0.753	1350		1	1.001	1.247
						0	1.002	1.247	150
Out	565948.750	174057.800	2.000	0.800	1350		1	1.002	1.200
									150

Simulation Settings

Rainfall Methodology	FSR	Drain Down Time (mins)	1440
Rainfall Events	Singular	Additional Storage (m³/ha)	20.0
FSR Region	England and Wales	Starting Level (m)	
M5-60 (mm)	20.000	Check Discharge Rate(s)	✓
Ratio-R	0.400	1 year (l/s)	2.1
Summer CV	0.750	10 year (l/s)	4.1
Winter CV	1.000	30 year (l/s)	4.9
Analysis Speed	Detailed	100 year (l/s)	6.3
Skip Steady State	x	Check Discharge Volume	x

Storm Durations

15	60	180	360	600	960	2160	4320
30	120	240	480	720	1440	2880	

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
30	0	0	0
100	0	0	0
100	45	0	0

Pre-development Discharge Rate

Site Makeup	Greenfield	Growth Factor 30 year	1.95
Greenfield Method	IH124	Growth Factor 100 year	2.48
Positively Drained Area (ha)	0.984	Betterment (%)	0
SAAR (mm)	550	QBar	2.5
Soil Index	3	Q 1 year (l/s)	2.1
SPR	0.40	Q 10 year (l/s)	4.1
Region	7	Q 30 year (l/s)	4.9
Growth Factor 1 year	0.85	Q 100 year (l/s)	6.3
Growth Factor 10 year	1.62		

Node FCC Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Downstream Link	1.002	Sump Available	✓
Replaces Downstream Link	✓	Product Number	CTL-SHE-0080-2100-0200-2100
Invert Level (m)	1.247	Min Outlet Diameter (m)	0.100
Design Depth (m)	0.200	Min Node Diameter (mm)	1200
Design Flow (l/s)	2.1		

Node FCC Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	1.425	Product Number	CTL-SHE-0088-2600-0150-2600
Design Depth (m)	0.150	Min Outlet Diameter (m)	0.100
Design Flow (l/s)	2.6	Min Node Diameter (mm)	1200

Node PP Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	1.300
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.30	Time to half empty (mins)	1290

Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)	Depth (m)	Area (m²)	Inf Area (m²)
0.000	8022.0	0.0	0.450	8022.0	0.0	0.451	0.0	0.0

Results for 1 year Critical Storm Duration. Lowest mass balance: 99.98%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m ³)	Flood (m ³)	Status
15 minute winter	INTERCEPTOR OUT	11	1.621	0.121	14.8	0.4901	0.0000	OK
1440 minute winter	PP	1110	1.385	0.085	9.1	206.7189	0.0000	OK
720 minute winter	FCC	450	1.385	0.138	4.8	0.1973	0.0000	OK
15 minute summer	Out	1	1.200	0.000	0.9	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m ³)	Discharge Vol (m ³)
15 minute winter	INTERCEPTOR OUT	1.000	PP	14.3	1.157	0.263	1.1572	
1440 minute winter	PP	1.001	FCC	4.7	0.454	0.266	0.0723	
720 minute winter	FCC	Hydro-Brake®	Out	2.1				209.7
720 minute winter	FCC	Hydro-Brake®	Out	0.0				0.0

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.98%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	INTERCEPTOR OUT	10	1.691	0.191	36.2	0.7751	0.0000	OK
960 minute winter	PP	915	1.492	0.192	25.7	466.2599	0.0000	SURCHARGED
960 minute winter	FCC	915	1.488	0.241	3.9	0.3444	0.0000	SURCHARGED
15 minute summer	Out	1	1.200	0.000	2.1	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	INTERCEPTOR OUT	1.000	PP	35.9	1.405	0.659	2.1969	
960 minute winter	PP	1.001	FCC	3.9	0.315	0.217	0.0936	
960 minute winter	FCC	Hydro-Brake®	Out	2.3				273.6
960 minute winter	FCC	Hydro-Brake®	Out	1.6				60.2

Results for 100 year Critical Storm Duration. Lowest mass balance: 99.98%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	INTERCEPTOR OUT	10	1.722	0.222	47.0	0.9014	0.0000	OK
960 minute winter	PP	900	1.542	0.242	32.8	588.9102	0.0000	SURCHARGED
960 minute winter	FCC	900	1.535	0.288	5.1	0.4125	0.0000	SURCHARGED
15 minute summer	Out	1	1.200	0.000	2.1	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	INTERCEPTOR OUT	1.000	PP	46.6	1.463	0.856	2.6730	
960 minute winter	PP	1.001	FCC	5.1	0.458	0.286	0.0936	
960 minute winter	FCC	Hydro-Brake®	Out	2.5				293.4
960 minute winter	FCC	Hydro-Brake®	Out	2.6				150.6

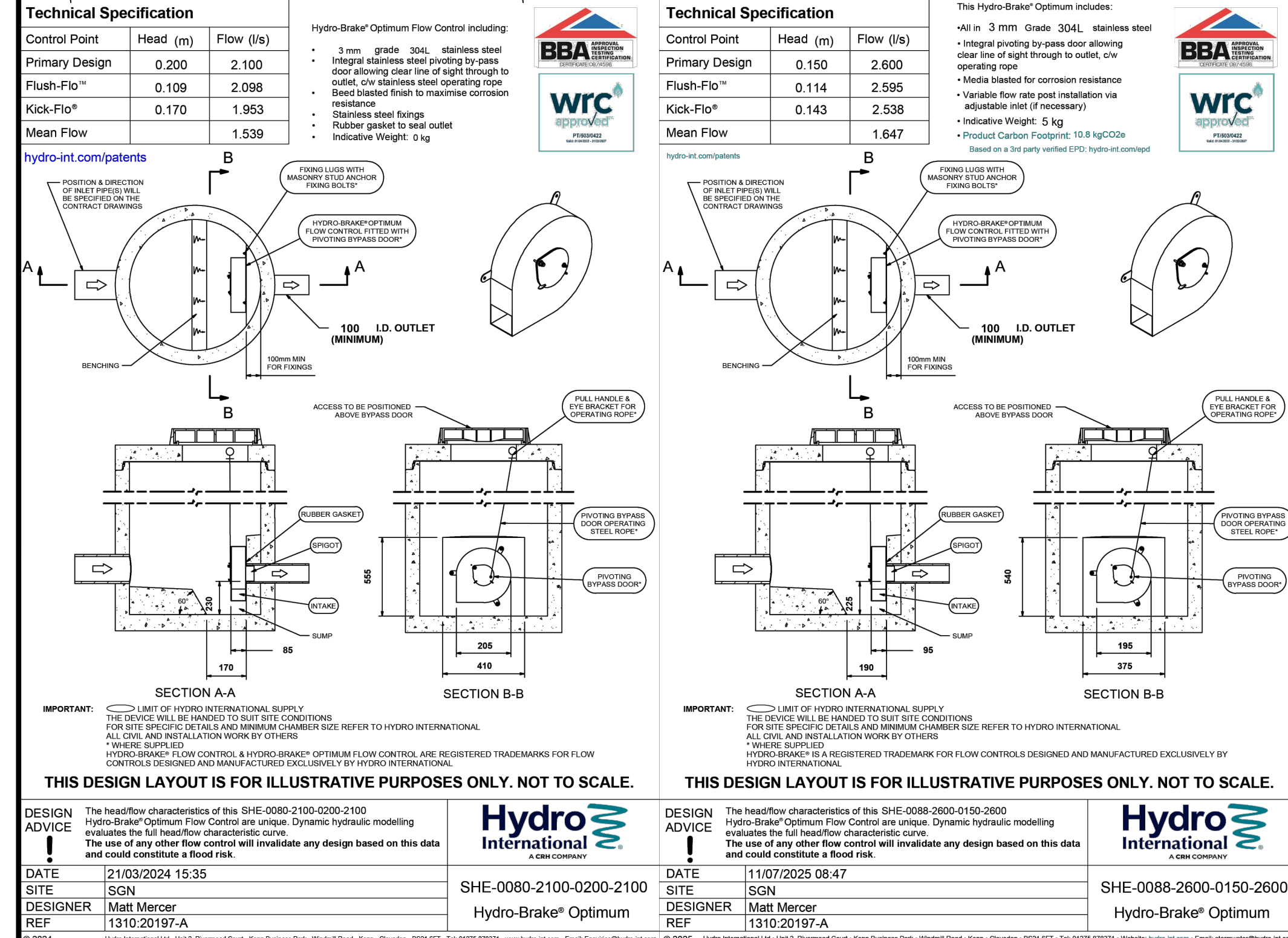
Results for 100 year +45% CC Critical Storm Duration. Lowest mass balance: 99.98%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	INTERCEPTOR OUT	11	1.816	0.316	68.2	1.2845	0.0000	FLOOD RISK
960 minute winter	PP	930	1.663	0.363	47.7	882.3762	0.0000	SURCHARGED
960 minute winter	FCC	930	1.653	0.406	6.0	0.5810	0.0000	SURCHARGED
15 minute summer	Out	1	1.200	0.000	2.1	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	INTERCEPTOR OUT	1.000	PP	62.6	1.471	1.149	3.7629	
960 minute winter	PP	1.001	FCC	6.0	0.436	0.341	0.0936	
960 minute winter	FCC	Hydro-Brake®	Out	2.9				341.8
960 minute winter	FCC	Hydro-Brake®	Out	3.1				303.1

Appendix C

Surface Water Drainage Strategy Drawing No FRA2197-DS-001A/B,



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