J&L CONSULTING ltd.

Land North of Solent Road, Havant

Flood Risk Assessment

Chancerygate (Erdington) Limited

21-012_Land North of Solent Road, Havant

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Quality Control

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Final	14.04.2021	Submission for Full Planning	IL	Ismail Laher	Director

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1. Introduction

I&L Consulting Limited (I&L) was commissioned by the Applicant, Chancerygate (Erdington) Limited, to undertake a Flood Risk Assessment (FRA) for a new headquarter for Portsmouth Water along with new industrial/warehouse units off Solent Road in Havant. The site lies within the authority of Havant Borough Council (HBC).

The relevant national planning guidance is set out by the National Planning Policy Framework (NPPF, updated in 2019). A FRA is required because the proposed development is over 1 ha. The FRA must assess all aspects of flood risk both to the proposed development itself and also the potential impact on people and property elsewhere within the catchment.

1.1 Study Aims and Objectives

The overall objective of this study was to carry out a FRA that meets the requirements of the NPPF and HBC flood risk policies. These consider surface water runoff management and the specific needs of the Environment Agency (EA), HBC and Southern Water. The study is required to assess all aspects of flood risk to the proposed development, the potential impacts of the development on people and property elsewhere within the catchment and identify possible mitigation measures to ensure that the development is safe in the event of a flood. To achieve this aim, the following key actions were undertaken:

- Obtain flood data from the EA and HBC;
- Review topographical and flood risk data to identify the existing flood risk posed to the site from all sources;
- Assess the residual flood risk post-development;
- Consider the vulnerability of the users and the development, taking account of the vulnerability classification;
- Assess the safety of the route of access/egress from the site in a flood event;
- Identify suitable mitigation measures to protect the development site against flooding; and
- The production of a conceptual surface water drainage strategy for the proposed development.

1.2 Scope of Works

In order to meet the above objectives, the following scope of work and tasks were undertaken:

- **Task 1: Data Collection.** I&L Consulting collected relevant available information on the nature of the flooding at the site. The Applicant and their consultant team have provided information about the site and proposed development layout and design.
- **Task 2: Identification of Current and Post-Development Flood Risk.** The existing and post-development flood risk posed to the site was assessed from the data that was collected in Task 1. The assessment identifies the flood risk from all potential sources of flooding and includes consideration of the impact of climate change on flood risk.
- **Task 3: Assessment of Site Safety**. I&L Consulting considered whether flood resilience measures needed to be undertaken and the safety of the route of access/egress from the site.

1.3 Data Collected

Table 1 lists the data that has been collected as part of this assessment. Comments on the source and the nature of the data are also provided.

Table 1: Collected Data

Purpose	Data and Source	Comments
Identification of site location	Ordnance Survey Map	Identifies the position of the site and local hydrological features
Identification of flood risk	Environment Agency Flood Map	Risk of flood from tidal and fluvial sources
	Topographical Survey	Existing site levels and topography
	Development details (drawings for existing site and proposed development)	Information on the layout of the proposed development
	Strategic Flood Risk Assessment (SFRA)	Reports that identify existing flood risk information within the area and considerations for development.
	Portsmouth Water / Ardent Consulting Engineers (Flood Alleviation works to adjoining watercourse)	Flood modelling along with flood alleviation works are in the process of being completed to the adjoining watercourse. These works have a material impact on the flood risk to the site, reducing the risk from the site from high to low/medium.
Identification of the existing drainage network	Sitewide Drainage Plan	Asset plans and drainage drawings identify public and private sewers nearest to the site.
Identification of ground conditions	British Geological Society (BGS) borehole logs and site investigation reports.	Identifies the type of aquifer, groundwater level, permeability and geotechnical information

2. Planning Policy and Evidence

2.1 National Planning Policy Framework

The NPPF sets out what needs to be taken into account by developers to assess whether a proposed development is likely to be at risk of flooding or has the potential to increase flood risk elsewhere. Within the recently published updated NPPF (February 2019), the principles relating to flood risk management remain mostly unchanged from the 2012 version.

The overall objective of the NPPF is to steer development towards areas of lowest flood risk. NPPF policy aims to ensure flood risks have been taken into account and appropriate measures put in place to ensure that:

- The development is safe;
- Where possible, the flood risk overall is reduced;
- Increased flood risk does not occur elsewhere; and
- Appropriate mitigation measures are employed to deal with these effects and risks.

Paragraph 163 and footnote 50 of the NPPF outlines that a site-specific flood risk assessment is required for proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

The current EA Flood Map shows that a large part of the site is located in land designated as Flood Zone 3 (high probability of fluvial flooding) and is shown as undefended. The north eastern corner is shown to be in Flood Zone 1 (low probability of flooding). The site is greater than 1 ha.

Portsmouth Water along with their consultant Ardent have submitted flood modelling and are undertaking flood alleviation works to the adjoining watercourse. This work is being undertaken under **Environmental Permit licence number EPR/PB3294JJ. The works are underway and when completed the site will remain flood free during the 1 in 100 year plus climate change scenario.** See **Appendix A** for relevant information.

The NPPF considers the vulnerability of different forms of development to flooding; and classifies the proposed development as ‘Less Vulnerable’.

2.2 Havant Borough Council – Core Strategy

Policy CS15 Flood and Coastal Erosion Risk

Development in areas at risk of flooding now and in the future as identified on the latest Environment Agency flood risk maps and Strategic Flood Risk Assessment climate change maps will only be permitted where:

1. It meets the sequential and exception test (where required) in relation to PPS25.

2. The site is located in a low hazard area as defined in the Strategic Flood Risk Assessment.

3. A site-specific flood risk assessment demonstrates that the development will be safe, including the access, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

4. The scheme incorporates flood protection, flood resilience and resistance measures appropriate to the character and biodiversity of the area and the specific requirements of the site.

5. Appropriate flood warning and evacuation plans are in place.

6. New site drainage systems are designed taking account of events which exceed the normal design standard.

All development will be required to ensure that there is no net increase in surface water run off. Priority should be given to incorporating Sustainable Drainage Systems (SuDS) to manage surface water drainage, unless it is proven that SuDS are not appropriate. Where SuDs are provided arrangements must be put in place for their whole life management and maintenance.

The council will work with partners to implement the Coastal Policy Zones in the North Solent Shoreline Management Plan to ensure that development avoids areas at risk from coastal erosion and coastal flooding and that areas required to offset coastal squeeze and prevent habitat fragmentation, to allow species to adapt to climate change, are identified and protected from development.

2.3 Strategic Flood Risk Assessment (Local Plan Sites), November 2018

The proposed site has been assessed to show that flood risk has been fully taken into account when allocating this site. The SFRA assessment has been appended to this report as **Appendix B**. Extract from the report as follows:

Conclusion on prospect of safe development in light of flood risk

The EA have indicated that the key issue on this site is the offsite implications of flooding from development of the site i.e. floodplain compensation. Previous work has given confidence that an employment use can be safely delivered. On that basis, there is a prospect of safe delivery, although a detailed assessment of this would be required at application stage, in particular in relation to flood storage compensation, so any allocation policy would need to be heavily caveated with assessment requirements

Portsmouth Water along with their consultant Ardent are undertaking flood alleviation works to the adjoining watercourse. This work is being undertaken under **Environmental Permit licence number EPR/PB3294JJ. The works are underway and when completed the site will remain flood free during the 1 in 100 year plus climate change scenario.**

This flood alleviation works will therefore satisfy the concerns raised in the SFRA and therefore the proposed commercial use for the site is acceptable.

2.4 Climate Change

The Flood risk assessments: Climate Change Allowances Guidance published in February 2016 indicates that climate change is currently expected to result in increased rainfall and rising sea levels. Table 2 below shows anticipated changes in extreme rainfall intensity in small and urban catchments.

Table 2: Peak rainfall intensity allowance in small and urban catchments (Ref: Flood risk assessments: climate change allowances Guidance by EA, February 2016)

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

3. Site Description

The proposed development site which is the subject of this Flood Risk Assessment (FRA) is situated in a strategic location north of Solent Road in Havant. The development will be accessed via the existing access road off Solent road which currently serves the existing medical centre.

The proposed development will consist of a new headquarter for Portsmouth Water along with a terrace of new industrial/warehouse units with associated parking, soft landscaping and HGV turning areas. The total development site rises gently from west to east with a total site area of 1.4983Ha.

The existing site is undeveloped. The proposal would be to drain the developed site by gravity and discharge at a Greenfield restricted rate using a flow control into either the existing private surface water sewer crossing the site or direct to the adjoining watercourse, see **Appendix E**.

The site location plan is shown in Figure 1 below.

Figure 1: Site Location Plan

3.1 Topography and Hydrological Setting

Environment Agency (EA) river mapping shows that the nearest watercourse is the Brockhampton Stream, which is located to the north and west of the site.

The topographic survey (**Appendix C**) indicates that the site levels fall from west to east. Spot levels taken from topographical survey as follows east (5.75m AOD) to west (5.00m AOD).

Existing site survey and utility plan shows a potential surface water private sewer crossing the site from the north east to the south west where this connects into the Watercourse. The proposal would be to either connect the new drainage from the development to this sewer or make a new connection via a headwall to the adjoining watercourse. Surface water will be restricted to a Greenfield discharge rate.

The existing public Foul Water sewer crossing the site will be diverted prior to undertaking any works on site. This proposed diversion works has been agreed with Southern Water.

Please see Appendix D.

3.2 Geology and Hydrogeology

British Geological Survey (BGS) mapping indicates the site is located on permeable chalk geology with impermeable London Clay Formation bedrock to the north.

An intrusive site investigation has been undertaken by Delta-Simons. The investigations found the site to consist of a variable thickness of topsoil and Made Ground, which is in turn underlain by superficial deposits comprising of Alluvium, Head Deposits and River Terrace Deposits, followed by Chalk bedrock. Monitoring of standpipes identified shallow groundwater at the Site.

4. Existing Flood Risk

This section of the report identifies the existing risks from the different forms of flooding identified in NPPF.

4.1 Fluvial & Tidal Flooding

The EA has produced Flood Zone maps for much of England and Wales. The current displayed map for the site shows that a large part of the site is located in land designated as Flood Zone 3 (high probability of fluvial flooding) and is shown as undefended. The north eastern corner is shown to be in Flood Zone 1 (low probability of flooding).

Portsmouth Water along with their consultant Ardent have submitted flood modelling and are undertaking flood alleviation works to the adjoining watercourse. This work is being undertaken under **Environmental Permit licence number EPR/PB3294JJ. The works are underway and when completed the site will remain flood free during the 1 in 100 year plus climate change scenario.** See **Appendix A** for relevant information.

Figure 2 below has been extracted from the approved revised flood model assessment which shows that following completion of the flood alleviation works the site will lie within Flood Zone 1 (low risk).

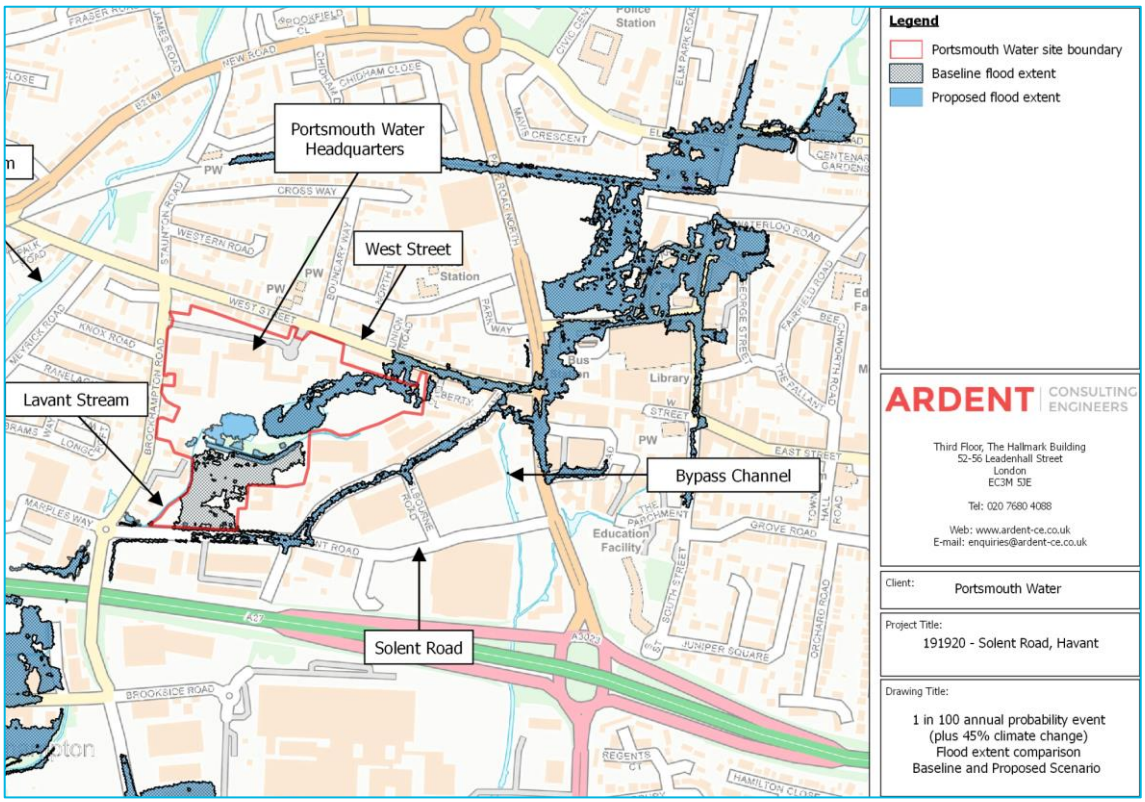


Figure 2: See Appendix A for full Ardent flood model details

On the coast storm surges and high tides can threaten low lying coastal areas and can be sometimes large and rapid enough to overtop defence works, causing significantly more damage than river flooding. Tidal flooding is not considered a risk to the site due to the inland location of the development.

Therefore, flood risk from fluvial and tidal sources to the site is considered to be low.

4.2 Surface Water Flooding

Surface water flooding occurs when rainfall is unable to infiltrate into the ground and/or engineered drainage networks and accumulates on the surface.

The risk of flooding from surface water is presented in the GOV.UK online map at a strategic scale. It can be seen from the surface water flood map in Figure 3 that the site is shown to have a medium risk of flooding

but this surface water flooding is associated with the adjoining watercourse and network of drainage in the area. Following the flood alleviation works the risk from surface water flooding from the site will be low level and unlikely to cause any risk to the site.

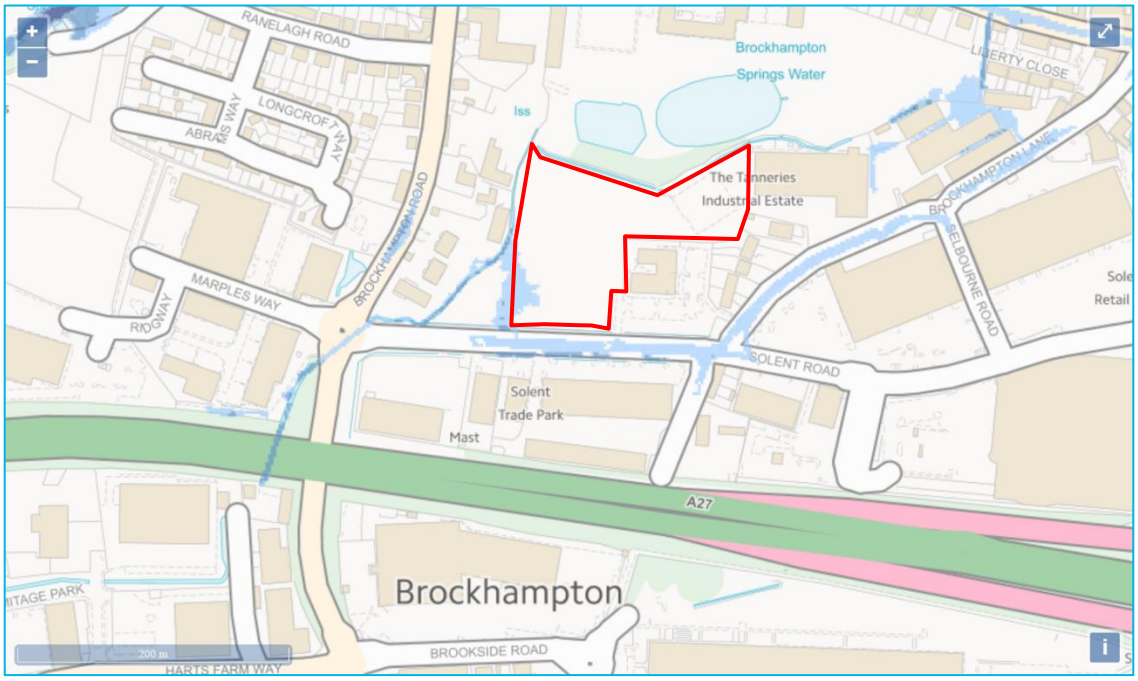


Figure 3: Surface Water Flood Risk Map (Source: https://flood-warning-information.service.gov.uk)

Given the topography, existing drainage system and surface water flood map information, the site is understood to be at a low risk from surface water flooding.

4.3 Groundwater Flooding

The site geology is expected to consist of a Made Ground, which is in turn underlain by superficial deposits comprising of Alluvium, Head Deposits and River Terrace Deposits, followed by Chalk bedrock. Shallow groundwater has been recorded at the Site. The proposed finished surface and finished floor levels will be raised from current ground levels. The impact of water level rises in the adjoining watercourse and subsequent groundwater levels rising would therefore have limited impact on the proposed development.

The existing flood risk from groundwater is therefore considered to be medium risk.

4.4 Sewer Flooding

A sewer flood is often caused by surface water drains discharging into the combined sewer systems; sewer capacity is exceeded in large rainfall events causing the backing up of floodwaters within properties or discharging through manholes. Most adopted surface water drainage networks are designed to the criteria set out in Sewers for Adoption. One of the design parameters is that sewer systems be designed such that no flooding of any part of the site occurs in a 1 in 30-year rainfall event. By definition a 1 in 100-year event would exceed the capacity of the surrounding sewer network as well as any proposed drainage.

To ensure that sewer and surface water flooding is not exacerbated; surface water must be considered within the design of the site. This ensures that any additional surface water and overland flows are managed correctly, to minimise flood risk to the site and the surrounding area.

As mentioned in section 3.1 above, the site is will have new surface and foul water connection points. The discharge from the site will be restricted to Greenfield runoff rates therefore not increasing flows from the site.

Therefore, the risk of sewer flooding to the site is considered low.

4.5 Artificial Sources of Flooding

The EA Flood Risk from Reservoirs mapping indicates that the site is located outside of an area of potential risk from flooding. There has been no loss of life in the UK from reservoir flooding since 1925.

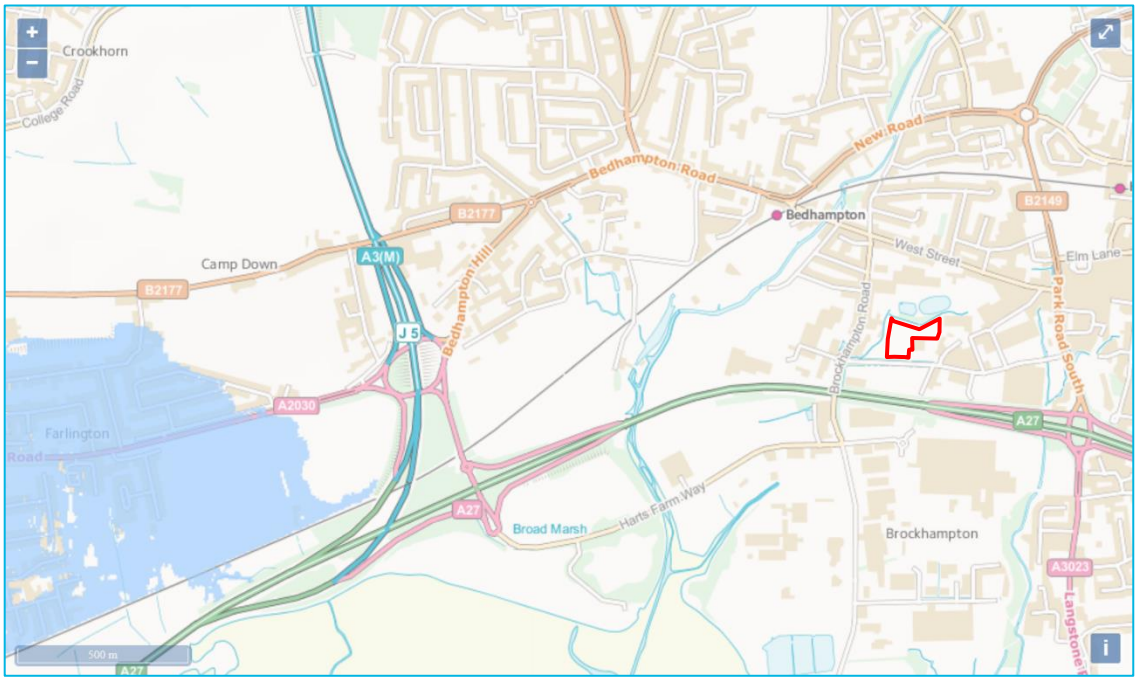


Figure 4: Reservoir Flood Risk Map. (Source: https://flood-warning-information.service.gov.uk)

Therefore, the risk from this type of flooding can be considered low.

4.6 Summary of Existing Flood Risk

The flood risk from fluvial & tidal flooding, surface water flooding, sewer flooding and groundwater is assessed to be low.

The flood risk to the site is summarised in Table 3.

Table 3: Summary of flood risk to the Site

Type of Flooding	Source of Flooding	Existing Flood Risk
Fluvial and Tidal	Brockhampton Stream (flood alleviation works underway **Environmental Permit licence number EPR/PB3294JJ**)	Low
Surface Water	Runoff from the site and surrounding land	Low
Sewers	Surrounding public foul drainage systems	Low
Ground Water	Underlying geology and groundwater levels	Medium
Artificial Sources	none	n/a

5. Flood Risk from the Proposed Development

The proposal aims to provide new headquarter office/water testing premises for Portsmouth Water, new industrial/warehouse units together with access, servicing, parking and landscaping on a site of circa 1.498 hectares to the North of Solent Road, Havant.

The proposed development drawing is included in **Appendix D**.

5.1 Fluvial and Tidal Flooding

The current EA Flood Map shows that a large part of the site is located in land designated as Flood Zone 3 (high probability of fluvial flooding) and is shown as undefended. The north eastern corner is shown to be in Flood Zone 1 (low probability of flooding).

Portsmouth Water along with their consultant Ardent have submitted flood modelling and are undertaking flood alleviation works to the adjoining watercourse. This work is being undertaken under **Environmental Permit licence number EPR/PB3294JJ. The works are underway and when completed the site will remain flood free during the 1 in 100 year plus climate change scenario.** See **Appendix A** for relevant information.

The proposed development work would not have any impact on the fluvial or tidal flooding once the flood alleviation works are complete.

Therefore, the risk of flooding from fluvial and tidal sources has therefore been assessed as low.

5.2 Surface Water Flooding and Proposed Drainage Strategy

Recommendation provided in Strategic Flood Risk Assessment for new developments is that surface water is restricted to Greenfield runoff rates where possible for new developments.

Equivalent GREENFIELD Site Peak Flows – ICP SUDS

The existing greenfield run-off for the original site has been calculated using ICP SUDS. This is based on the IH 124 method which is suitable for all catchments up to 200ha. For catchments smaller than 50ha the equivalent runoff from a 50ha site must be calculated using IH124, it is then possible to pro-rata this value to give the peak run-off for the smaller site. ICP SUDS calculation automatically carries out the pro rata conversion reducing the possibility of human error.

Taking into account the sites characteristics SAAR 725, soil figure of 0.4 and area of 1.498ha the Greenfield run-off rate has been calculated for the site at 5.3 l/s (rural)

Calculations can be seen in **Appendix F**.

As mentioned under section 3.2 the existing site geology consists of a variable thickness of topsoil and Made Ground, which is in turn underlain by superficial deposits comprising of Alluvium. A high groundwater levels has also been recorded. Infiltration will therefore not be possible at this site and the initial design provided as part of this report has therefore allowed for no infiltration.

The surface water drainage network for the proposed development is in line with the principles of integrated Construction Industry Research and Information Association (CIRIA) Sustainable Drainage System SuDS and source control methods to convey surface water runoff flows from the site as well as national and local standard.

- Runoff from the site to be restricted at the Greenfield rate of 5.3L/s for all the events from 1 in 1 year to 1 in 100 year return periods, including climate change allowances;
- Appropriate attenuation to be provided onsite;
- The onsite surface water drainage design will follow the principles listed in the Approved Document Part H of the Building Regulations and Sewers for Adoption 7th Edition. The Building Regulations established a hierarchy for surface water disposal which encourages a SuDS approach;
- No surcharge for the 1:1year rainfall event except for the outfall pipe which may surcharge due to restriction

- Onsite surface water sewers shall be designed to a 1 in 30 year no flooding standard in accordance with BS EN 752: 2017. There will be no flooding of buildings or off-site areas during a 1 in 100-year return period storm event including climate change allowance;
- Any onsite flooding in the 1:100+20% event, will be directed into a safe place or mitigation measures to be provided on site for any flooding over $5m^3$.

The proposed drainage network and attenuation requirements are modelled using industry standard hydraulic modelling software and included in **Appendix F**. The controlled discharge will be to either the existing private onsite surface water drainage crossing the site or via a new headwall to the adjoining watercourse, **Appendix E**.

Therefore, the risk of surface water flooding from the proposed development will remain low.

Assessment of Surface Water Management Options

For sustainable management of surface water run-off from a new development, the use of SuDS is recommended. Table 6 provides a comparison of the different kinds of SuDS systems and their suitability for use at the development site.

5.3 Water Quality

Table 26.2 of the CIRIA C753 SuDS Manual identifies that the pollution hazard level associated with the land uses within the Proposed Development as being 'Medium'. On a scale from 0 – 1, 'Commercial Yard & delivery areas' are deemed to have the following pollution hazard indices:

- Total suspended solids = 0.7
- Metals = 0.6
- Hydrocarbons = 0.7

The SuDS Manual confirms that in England and Wales, where the destination of runoff is to a watercourse then surface water indices should be used for the surface water discharge (Table 26.3 of The SuDS Manual).

The proposed surface water drainage strategy discharges via a new headwall into a watercourse. Therefore, the use of the surface water indices approach is deemed to be appropriate.

In terms of pollution control the car parking for the Portsmouth Water office building discharges via porous paving prior to connecting to the new drainage system. The industrial unit's commercial yard and delivery areas are to be protected by Class 1 bypass petrol interceptor. The pollution mitigation assessment is summarised in Tables 5 below. The pollution removal characteristics of the pollution control features are based on data in CIRIA C753 and data provided by the product manufacturers.

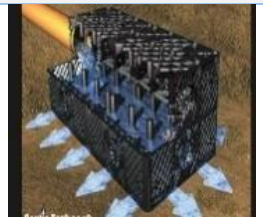
Table 5: Pollution Mitigation Assessment for the site

Type of SuDS component	Total suspended solids (TSS)	Metals	Hydrocarbons
Class 1 Bypass Petrol Interceptor (Kingspan or similar)	0.4*	0.6*	0.8*
Total	**0.4**	**0.6**	**0.8**

*subject to manufactures details

The results in Table 5 show that there is a minor residual impact associated with the Total Suspended Solids. However, whilst Pollution Mitigation Index data is not provided in CIRIA C753 for gullies/catch pit manholes, it is anticipated that sumps at the base of the gullies and catch pits will provide a positive improvement that would mitigate the residual impact for the Total Suspended Solids.

Table 6: Assessment of Suitability of SuDS at the site as the drainage hierarchy

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site
Retention	Balancing Pond		Provides both storm water attenuation and treatment. Run-off from each rain event is detained and treated in the pool. The retention time promotes pollutant removal through sedimentation.	Good removal of pollutants, can be used where groundwater is vulnerable, good community acceptability, high ecological, and amenity benefits.	No reduction in run-off volume, land take may limit use in high density sites.	× Not suitable for the type of development
	Sub-surface Storage		Oversized pipes, tank systems and modular geocellular systems that can be used to create a below ground storage structure.	Modular and flexible, dual usage (infiltration/storage, high void ratios), can be installed beneath trafficked and soft landscaped areas.	No water quality treatment.	✓ Sub-surface storage is recommended.
Wetland	Shallow wetland Extended detention wetland Pond wetland Pocket wetland Submerged gravel wetland Wetland channel		Wetlands provide storm water attenuation and treatment. They comprise shallow ponds and marshy areas, covered in aquatic vegetation. Wetlands detail flows for an extended period to allow sediments to settle and to remove contaminants. They can provide significant ecological benefits.	Good pollutant removal and if lined can be used where groundwater I vulnerable. Good community acceptability, ecological and amenity benefits.	Land take is high, requires base flow, little reduction in run-off volume, not suitable for steep sites.	× Wetlands are not possible due to the high land take required
Infiltration	Infiltration trench Infiltration basin Soakaway		Surface water run-off can be discharged directly to ground for infiltration by soakaways, basins, or trenches. A prerequisite is that both groundwater and ground conditions are appropriate to receive the quality and quantity of water generated.	Reduces the volume of run-off, effective at pollutant removal, contributes to groundwater recharge, simple and cost-effective, easy performance observation.	Requires appropriate pre-treatment, basins require a large flat area, offset from foundations.	× Infiltration unlikely with the alluvium soils and high-water table identified on site.

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site
	Porous paving Permeable paving		Block or porous paving allows run-off to infiltrate through to subbase layer. Water can then be infiltrated into ground or conveyed into storage or drainage systems.	Reduces the volume of run-off and if designed for infiltration contributes towards groundwater recharge. East to install and retrofit. Simple to manage. If lined can be used where groundwater is sensitive.	Not suitable for heavily trafficked areas or adoptable roads. Requires regular sweeping to prevent clogging with dirt.	✓ Porous paving to the car parking areas has been proposed.
Filtration	Surface sand filter Sub-surface sand filter Perimeter sand filter		Structures designed to treat surface water run-off through filtration using a sand bed filter medium. The filters can be designed with or without infiltration. Temporary storage of run-off is achieved through ponding above the filter layer. They are used where particularly high pollutant removal is required.	Flexibility of design, efficient in removing pollutants, suitable for retrofits and in tightly constrained urban locations.	Not for high sediment content, detention times can support algae growth, minimum hydraulic head of 1.2m required, possible odour problems, high capital and maintenance cost.	× There is no requirement for high pollution reduction at this site
	Bioretention/filter swale		Vegetated strips of land designed to accept run-off as overland sheet flow between a hard-surfaced area and a receiving system.	Landscaping features, effective in removing pollutants, flexible layout to fit into landscape, suited for highly impervious areas, good retrofit, capability, effective pre-treatment option.	Requires landscaping and management, large land required, not suitable for steep sites; no significant attenuation or reduction of flows.	× No requirement for high pollution reduction; large land areas not available.
	Filter trench/drain		Shallow excavations filled with rubble or stone that create temporary subsurface storage for filtration of storm water run-off.	Hydraulic benefits achieved with filter trenches, trenches can be incorporated into site landscaping and fit	High clogging potential without effective pre-treatment, limited to small catchments,	× Not feasible for the proposed development

SUDS Group	Technique	Image	Description	Advantages	Disadvantages	Suitable for Use at Site
			Receive lateral inflow from an adjacent impermeable surface.	well beside roads and car parks.	high cost of replacing filter material.	
Detention	Detention basin		Surface storage basins that provide flow control through attenuation. Normally dry and in certain situations the land may also function as a recreational facility	Cater for a wide range of rainfall events, can be used where groundwater is vulnerable, potential for dual land use, easy to maintain.	Land take, little reduction in run-off volume, detention depths constrained by levels.	× Not suitable and not required for this site
	Enhanced dry swale Enhanced wet swale		Swales are linear vegetated drainage features in which surface water can be stored or conveyed. They can be designed to allow infiltration, where appropriate.	Incorporate into landscaping, good removal of pollutants, reduces run-off rates and volumes, low cost.	Not suitable for steep areas, significant land take, not suitable in areas with roadside parking.	× Not suitable and not required for this site
Conveyance	Conveyance swales Rills		Formal linear drainage features in which surface water can be stored or conveyed. They can be incorporated with water features such as ponds or waterfalls where appropriate.	Negate the need for underground pipework. Can provide some attenuation. Possible reduction in run-off volume via plant uptake and infiltration.	Potential trip/wheel hazard, disable access issues.	× Not suitable and not required for this site
Source control	Green/brown roof		Multi-layered system that covers the roof of a building with vegetation cover/landscaping over a drainage layer. Designed to intercept and retain precipitation, reducing the volume of run-off and attenuating peak flows.	Mimics greenfield state of building footprint for high density developments, good removal of pollutants, ecological benefits, insulates buildings, sound absorption.	Additional weight, not appropriate for steep roofs, maintenance of roof vegetation.	× Not suitable for the proposed structure at this site

5.3.1 Maintenance of SuDS

The on-site drainage will be managed by the site management company who will be responsible to maintain any on-site services including drainage. The off-site private drainage is managed by a management company managing the business park.

Table 7: Management and Maintenance Strategy

Drainage Feature	Regular Maintenance	Occasional/Remedial Maintenance	Monitoring
Drainage channels/Gullies	• Inspections will include gratings; covers including their locking bolts; sumps and sump buckets; exposed concrete surround and adjacent surfacing. • Check for accumulation of debris and silt and cleaned as necessary • Gratings, frames and all associated locking parts to be checked for damage. • Exposed concrete and adjacent surfacing to be checked for cracking and general damage. • Check condition of inlet and outlet pipes, flow controls, baffles and isolation structures	• Channel/Slot cleaning will be by flushing with water or high-pressure jetting (no boiling water or cleaning agent will be used). All silt buckets and sumps will be cleaned out replaced back into the units ensuring they are correctly fitted. • All channel surfaces and joints will be checked and repaired as necessary. • Repair/rehabilitation of inlets, outlet, as required.	• Inspect every 4 months or after large storm.
Manholes/Inspection Chambers	• Check for accumulation of debris and silt and clean as necessary. • Covers and frames to be checked for damage. • Exposed concrete and adjacent surfacing to be checked for cracking and general damage. • Check condition of inlet and outlet pipes, flap valves, baffles etc.	• Clean as necessary. • All manhole and inspection chamber covers and frames to be replaced as necessary. • Repair exposed concrete and surfacing as necessary • Repair/rehabilitation of inlets, outlet, overflows and vents, as required.	• Inspect every 6 months or after large storm.
Attenuation Tank	• Check for accumulation of debris and silt and clean as necessary. • Check condition of inlet and outlet pipes and ventilation structures	• Clean as necessary. • Repair/rehabilitation of inlets and outlet, as required.	• Inspect every 6 months or after large storm.
Pumping Station	• Check for accumulation of debris and silt and clean as necessary. • Check condition of inlet and outlet pipes and ventilation structures	• Clean as necessary. • Repair/rehabilitation of inlets and outlet, as required.	• Inspect every 6 months or after large storm.

5.4 Sewer Flooding

The site will form a new foul water connection point to the public Southern Water manhole formed on the diverted public sewer crossing the site. The peak discharge rate from the industrial development will be minimal and have limited impact on wider infrastructure.

Therefore, the risk of sewer flooding to the site post development work would remain unchanged.

5.5 Groundwater Flooding

The proposed development is likely to be constructed using CMC piled foundations and unlikely to impact the groundwater below the site.

Therefore, the risk from groundwater flooding will be remain as low.

5.6 Artificial Sources of Flooding

The proposed development work will not have an impact on artificial sources of flood risk.

5.7 Summary of Flood Risk from the Proposed Development

The flood risk to and from the proposed development has been assessed to remain low from all sources.

The flood risk to the development is summarised in Table 8.

Table 8: Summary of flood risk to the development

Type of Flooding	Source of Flooding	Flood Risk	Proposed Mitigation
Fluvial and Tidal	Brockhampton Stream	Low	Flood alleviation works underway **Environmental Permit licence number EPR/PB3294JJ**
Surface Water	Runoff from the site and surrounding land	Low	Discharge into the private surface water network or watercourse at a restricted Greenfield runoff rate and onsite attenuation.
Sewers	Surrounding public foul drainage systems	Low	Diversion and discharge into the existing drainage network
Ground Water	Underlying geology and groundwater levels	Low	Development levels raised.
Artificial Sources	none	Not applicable	

6. Conclusion

The existing flood risk to the development area from all sources has been assessed from a review of all available data. Future climate change has also been considered. Using the proposed development plan, the extent of the flood risk has been determined for the site as well as the effect that the development might have on flood risk elsewhere.

The assessment can be summarised as follows:

- The Strategic Flood Risk Assessment (Local Plan Sites) completed in November 2018 for this site (Land North of Solent Road – Site Ref: HB36), has shown this site is suitable for commercial use.
- Portsmouth Water along with their consultant Ardent are undertaking flood alleviation works to the adjoining watercourse. This work is being undertaken under **Environmental Permit licence number EPR/PB3294JJ.** The site will remain flood free during the 1 in 100 year plus climate change scenario and provide necessary flood alleviation to address concerns raised in the SFRA.
- Following completion of flood alleviation works the site will be located in Flood Zone 1.
- The site is at low risk of flooding from all sources.
- The proposed development is classified as ‘Less Vulnerable’ and suitable for this location.
- The proposed development work would not increase the risk of flooding from any sources;
- A drainage strategy is proposed in consideration with the local and national standard and would not increase the flood risk;
- Recommendation provided in the Strategic Flood Risk Assessment for new developments is that surface water runoff is restricted to Greenfield runoff rate. ICP SUDS Greenfield calculation has been undertaken giving a discharge rate of 5.3L/s for the 1.49ha site which has been adopted for this site.
- The development site has a high-water table which limits the use of infiltration systems on site. The proposal includes SuDS measure in the form of attenuation tank and porous paving for parking areas.
- In conclusion, the proposed development work will not increase the risk of flooding to the site or surrounding areas in accordance with the provisions of relevant national and local planning policies.

Appendix A Ardent flood modelling + EA permit (EPR/PB3294JJ)

Permit with introductory note

The Environmental Permitting (England & Wales) Regulations 2016

Portsmouth Water Limited

The removal of a 2.5m length of 450mm diameter cast iron culvert and associated groundworks on the Brockhampton Stream

National Grid Reference[s]: SU7115206195

Located on the Brockhampton Stream approximately 120m south of the Portsmouth Water ltd. compound at West Street, Havant, PO9 1LG and approximately 420m south west from the bifurcation of the Brockhampton Stream from the Lavant Stream.

Permit number

EPR/PB3294JJ

Introductory note

This introductory note does not form a part of the permit

The main features of the permit are as follows.

Flood risk activity comprising of the removal of in-channel structures, namely the removal of a 2.5m length of 450mm diameter cast iron culvert and associated groundworks on the Brockhampton Stream.

The status log of the permit does not form part of the permit. It sets out the permitting history, including changes to the permit or permit reference number.

Status log of the permit		
Description	**Date**	**Comments**
Application EPR/PB3294JJ	Duly made 11 November 2020	Application for the removal of a 2.5m length of 450mm diameter cast iron culvert on the Brockhampton Stream
Permit determined EPR/PB3294JJ	14 January 2021	Permit issued to Portsmouth Water Limited

End of introductory note

Permit

The Environmental Permitting (England and Wales) Regulations 2016

Permit number

EPR/PB3294JJ

The Environment Agency hereby authorises, under regulation 13 of the Environmental Permitting (England and Wales) Regulations 2016

Portsmouth Water Limited ("the operator")

whose registered office is

Po Box No8
West Street
Havant
Hampshire
PO9 1LG

company registration number [02536455]

to operate the following flood risk activities:

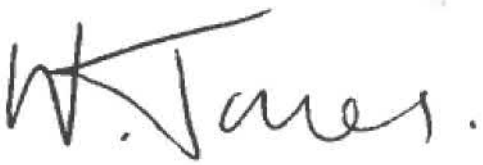
The removal of in-channel structures, namely the removal of a 2.5m length of 450mm diameter cast iron culvert and associated groundworks on the Brockhampton Stream.

at

the Brockhampton Stream approximately 120m south of the Portsmouth Water ltd. compound at West Street, Havant, PO9 1LG and approximately 420m south west from the bifurcation of the Brockhampton Stream from the Lavant Stream.

National Grid Reference(s) SU7115206195

to the extent authorised by and subject to the conditions of this permit.

Name	Date
 **Wesley Jones** **Partnership and Strategic Overview Team Leader** **East Hampshire and Isle of Wight – Solent and South Downs**	14/01/2021

Authorised on behalf of the Environment Agency

Conditions

1 Management

1.1 General management

1.1.1 The operator shall manage and operate the activities:

(a) in accordance with a written management system that identifies and minimises risks of flooding, impact on drainage and environmental harm so far as is reasonably practicable, including those risks arising from operations, maintenance, accidents, incidents, non-conformances and those drawn to the attention of the operator as a result of complaints; and

(b) using sufficient competent persons and resources.

1.1.2 Records demonstrating compliance with condition 1.1.1 shall be maintained.

1.1.3 Any person having duties that are or may be affected by the matters set out in this permit shall have convenient access to a copy of the permit.

2 Operations

2.1 Permitted activities

2.1.1 The operator is only authorised to carry out the activities specified in schedule 1 table S1.1 (the "activities").

2.2 The site

2.2.1 The activities shall not extend beyond the site, being the land shown edged in blue on the site plan at schedule 2 to this permit and showing National Grid Reference SU7115206195.

2.3 Operating techniques

2.3.1 The operator shall use appropriate measures, including but not limited to those in the approved Method of Work.

(a) to minimise sediment mobilisation

(b) to minimise impact on biodiversity

(c) to ensure there is no increase to flood risk or detrimental impact on drainage;

(d) for the storage and disposal or waste produced; and

(e) to prevent and minimise environmental harm.

2.3.2 All liquids in containers, whose emission to water or land could cause pollution, shall be provided with secondary containment, unless the operator has used other appropriate measures to prevent or where that is not practicable, to minimise, leakage and spillage from the primary container.

2.3.3 Measures shall be taken to ensure that the activities do not cause the spread of invasive non-native species or plant or animal diseases.

2.3.4 No vegetation clearance or site clearance shall be take place during nesting season (1 March-31 July inclusive each year).

2.3.5 No works shall take place until a fish screen (maximum 2mm mesh spacing) is installed on the pump or a fish friendly pump is used to prevent the entrapment, entrainment or impingement of fish and eel

(including elver) during over pumping. The fish/eel screen shall be maintained in accordance with the manufacturer's specifications and records kept of such maintenance available for inspection by the Environment Agency.

2.3.6 The fish rescue will be undertaken in line with the methodology provided by Pisces Conservation Ltd. dated 15 Dec 2020. Records of species caught to be provided to the Environment Agency within 1 month of capture.

2.3.7 Nothing shall be done or permitted to occur during the works which would materially reduce the capacity of the floodplain.

2.3.8 The operator shall sign up to receive flood warnings from the Environment Agency. Upon receipt of the warning the works shall cease and temporary works removed as directed by the Environment Agency. An emergency 24 hour contact has been supplied in case of any flood warnings: - Portsmouth Water Operations Centre: 02392449091

2.3.9 The activities shall, subject to the conditions of this permit, be operated using the techniques and in the manner described in the documentation specified in schedule 1, table S1.2, unless otherwise agreed in writing by the Environment Agency.

3 Information

3.1 Records

3.1.1 All records required to be made by this permit shall:

(a) be legible;

(b) be made as soon as reasonably practicable;

(c) if amended, be amended in such a way that the original and any subsequent amendments remain legible, or are capable of retrieval; and

(d) be retained, unless otherwise agreed in writing by the Environment Agency, for at least 6 years from the date when the records were made

3.1.2 The operator shall keep on site all records, plans and the management system required to be maintained by this permit, unless otherwise agreed in writing by the Environment Agency.

3.2 Reporting

3.2.1 The operator shall send all reports and notifications required by the permit to the Environment Agency using the contact details supplied in writing by the Environment Agency.

3.3 Notifications

3.3.1 The Environment Agency shall be notified no less than 7 days before the commencement of the activities.

3.3.2 The Environment Agency shall be notified no less than 7 days after the activities are completed.

3.3.3 The Environment Agency shall be notified without delay following the detection of any breach of a limit specified in the permit or any significant environmental effects resulting from the activities or of any breach of the permit.

3.3.4 Written confirmation of actual or potential incidents or effects and breaches referred to in 3.3.3 shall be submitted within 24 hours.

3.3.5 The Environment Agency shall be notified within 14 days of the occurrence of the following matters, except where such disclosure is prohibited by Stock Exchange rules:

Where the operator is a registered company:

(a) any change in the operator's trading name, registered name or registered office address; and

(b) any steps taken with a view to the operator going into administration, entering into a company voluntary arrangement or being wound up.

Where the operator is a corporate body other than a registered company:

(a) any change in the operator's name or address; and

(b) any steps taken with a view to the dissolution of the operator.

In any other case:

(a) the death of any of the named operators (where the operator consists of more than one named individual);

(b) any change in the operator's name(s) or address(es); and

(c) any steps taken with a view to the operator, or any one of them, going into bankruptcy, entering into a composition or arrangement with creditors, or, in the case of them being in a partnership, dissolving the partnership.

3.3.6 Where the operator proposes to make a change in the nature or functioning, or an extension of the activities, which may have consequences for flood risk, drainage or the environment and the change is not otherwise the subject of an application for approval under the Regulations or this permit:

(a) the Environment Agency shall be notified at least 14 days before making the change; and

(b) the notification shall contain a description of the proposed change in operation.

3.4 Interpretation

3.4.1 In this permit the expressions listed in schedule 3 shall have the meaning given in that schedule.

3.4.2 In this permit references to reports and notifications mean written reports and notifications, except where reference is made to notification being made "without delay", in which case it may be provided by telephone.

3.4.3 Any reference to a distance of a number of metres from a flood defence structure, drainage work, remote defence or sea defence is a reference to that distance as measured from the foot of the foregoing as the case may be.

3.4.4 Any reference to a distance of a number of metres from a river control work is a reference to that distance as measured from the nearest part of the river control work.

3.4.5 Any reference to a distance of a number of metres from a watercourse is a reference to that distance as measured horizontally from the foot of the bank on the landward side of the watercourse

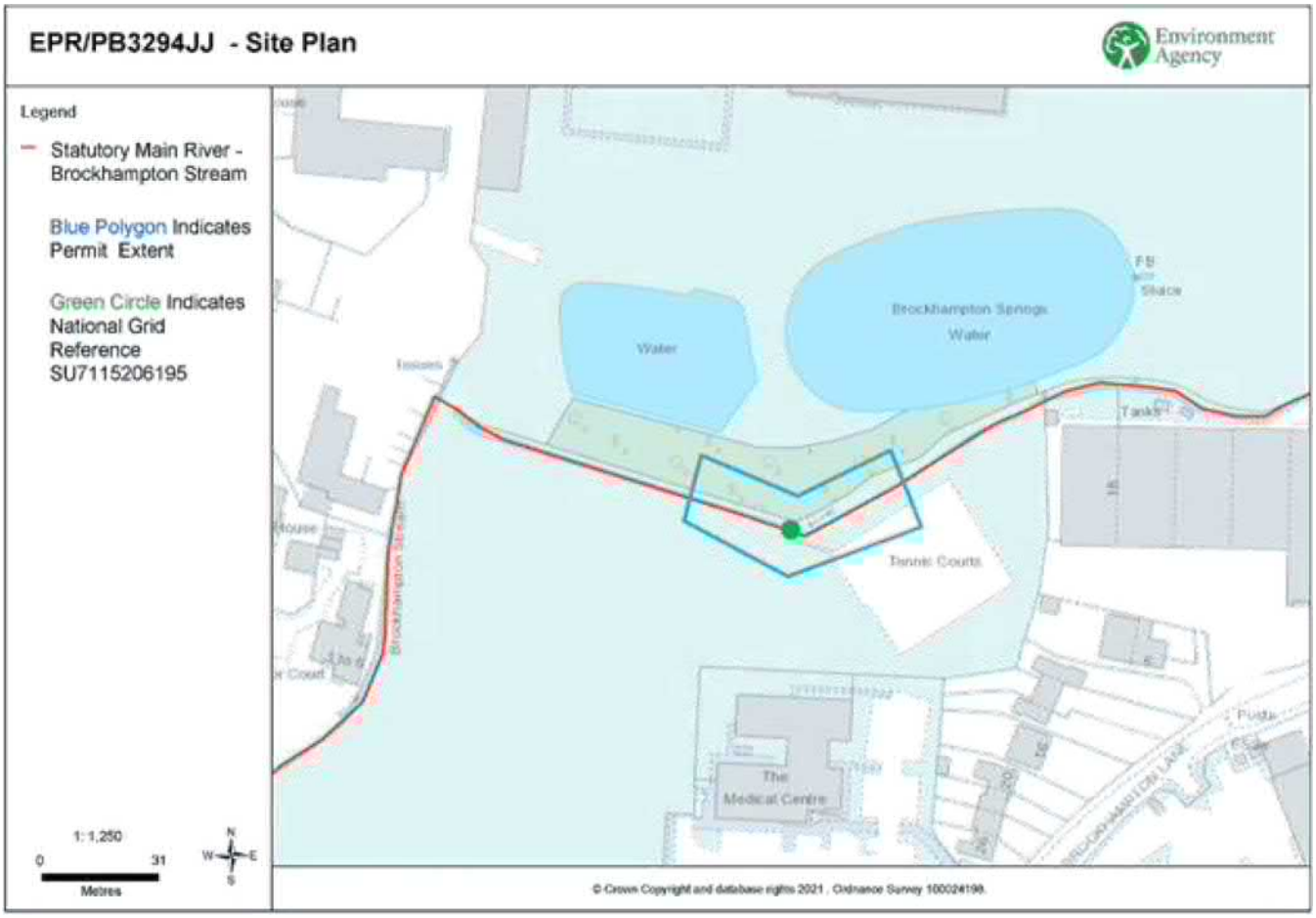
Schedule 1 – Operations

Table S1.1 activities		
Activity reference	**Description of activities**	**Limits of activities**
	Permanent Works	
P1	The removal of in-channel structures, namely the removal of a 2.5m length of 450mm diameter cast iron culvert and associated groundworks on the Brockhampton Stream.	The activity shall be commenced within 3 years of the date of the grant of the permit and completed within 4 months of commencement. The activities shall be carried out in accordance with the application form dated 04 November 2019 and Method Statement with Subject "Removal of 2.5m x 450mm Cast iron pipe work from stream and re-instate stream to natural habitat." Authored by Steve Brown and dated 06/09/2019. and Risk Assessment with Reference RA- 01 dated 01/10/2019 Authored by Steve Brown and Flood Risk Assessment titled "Flood Risk Assessment – Culvert Removal" report reference number 191920-07 and dated July 2020 authored by Ardent Consulting Engineers. and Plan and cross-sectional drawing titled "Proposed Flood Alleviation Works Plan and Details" with drawing number 191921-002 revision A and dated October 2020. and Plan and cross-sectional drawing titled "Proposed flood alleviation Earthworks" with drawing number 191921-003 revision A and dated October 2020. and Document titled "Schedule 5 Notice – Solent Road" presented by Simon Deacon. and Fish Rescue Plan titled "Method statement – electric fishing at Lavant stream, Havant" dated 15/12/2020 and produced by Pices Conservation Ltd. The activities shall only be carried out on the Brockhampton Stream main river.

Table S1.2 Operating techniques			
Requirement	**Measures (if measures are specified)**	**Document reference**	**Date Received**
Condition 2.3.1	Approved Method of Work	Method Statement with Subject "Removal of 2.5m x 450mm Cast iron pipe work from stream and re-instate stream to natural habitat." Authored by Steve Brown and dated 06/09/2019.	04/11/2019
Condition 2.3.4	No vegetation clearance or site clearance shall be take place during nesting season (1 March-31 July inclusive each year).	Email with Reference: "EPR/PB3294JJ Confirmation of Conditions"	13/01/2021
Condition 2.3.5	No works shall take place until a fish screen (maximum 2mm mesh spacing) is installed on the pump or a fish friendly pump is used to prevent the entrapment, entrainment or impingement of fish and eel (including elver) during over pumping. The fish/eel screen shall be maintained in accordance with the manufacturer's specifications and records kept of such maintenance available for inspection by the Environment Agency.	Fish Rescue Plan titled "Method statement – electric fishing at Lavant stream, Havant" dated 15/12/2020 and produced by Pices Conservation Ltd. And Email with Reference: "EPR/PB3294JJ Confirmation of Conditions"	21/12/2020 13/01/2021
Condition 2.3.6	The fish rescue will be undertaken in line with the methodology provided by Pisces Conservation Ltd. dated 15 Dec 2020. Records of species caught to be provided to the Environment Agency within 1 month of capture.	Fish Rescue Plan titled "Method statement – electric fishing at Lavant stream, Havant" dated 15/12/2020 and produced by Pices Conservation Ltd. And Email with Reference: "EPR/PB3294JJ Confirmation of Conditions"	21/12/2020 13/01/2021
Condition 2.3.7	Nothing shall be done or permitted to occur during the works which would materially reduce the capacity of the floodplain.	Plan and cross-sectional drawing titled "Proposed flood alleviation Earthworks" with drawing number 191921-003 revision A and dated October 2020. And Email with Reference: "EPR/PB3294JJ Confirmation of Conditions" And Flood Risk Assessment titled "Flood Risk Assessment – Culvert Removal" report reference number 191920-07 and dated July 2020 authored by Ardent Consulting Engineers.	21/12/2020 13/01/2021 22/07/2020

Table S1.2 Operating techniques			
Requirement	**Measures (if measures are specified)**	**Document reference**	**Date Received**
Condition 2.3.8	The operator shall sign up to receive flood warnings from the Environment Agency. Upon receipt of the warning the works shall cease and temporary works removed as directed by the Environment Agency. An emergency 24 hour contact has been supplied in case of any flood warnings: - Portsmouth Water Operations Centre: 02392449091	Email with Reference: "EPR/PB3294JJ Confirmation of Conditions"	13/01/2021

Schedule 2 – Site Plan



Schedule 3 – Interpretation

"application" means the application for this permit, together with any additional information supplied by the operator as part of the application and any response to a notice served under Schedule 5 to the EP Regulations.

"authorised officer" means any person authorised by the Environment Agency under section 108(1) of The Environment Act 1995 to exercise, in accordance with the terms of any such authorisation, any power specified in section 108(4) of that Act.

"EP Regulations" means The Environmental Permitting (England and Wales) Regulations SI 2016 No.1154 and words and expressions used in this permit which are also used in the Regulations have the same meanings as in those Regulations.

"main river" means a watercourse or part of a watercourse designated as main river on the statutory main river map held by the Environment Agency.

"Method of Work" means a document forming part of the operator's management system, setting out the working methods for carrying out the activity and what measures will be taken to avoid or minimise the risks of environmental effects.

"approved Method of Work" means the operator's Method of Work approved by the Environment Agency

"environmental effects" means:

(a) flooding or risk of flooding;

(b) harm to the environment or risk of harm to the environment; and

(c) detrimental impact on drainage or risk of detrimental impact on drainage.

"environmental harm" means a result of human activity which may:

(a) cause harm to the conservation, protection and enhancement of any species and habitats designated under any enactment as having special protection or priority;

(b) prevent the achievement of environmental objectives within the meaning of the Water Framework Directive 2000/60/EC;

(c) cause pollution; or

(d) otherwise adversely affect the protection and enhancement of the environment.

END OF PERMIT

ARDENT CONSULTING ENGINEERS

PORTSMOUTH WATER

SOLENT ROAD

FLOOD RISK ASSESSMENT – CULVERT REMOVAL
(Flood Risk Activities Permit Application)

Report Ref NO. 191920-07
Project No. 191920
JULY 2020

PORTSMOUTH WATER

SOLENT ROAD

FLOOD RISK ASSESSMENT – CULVERT REMOVAL
(Flood Risk Activities Permit Application)

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EC3M 5JE
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REPORT REF NO. 191920-07
PROJECT NO. 191920
JULY 2020

CONTENTS

FIGURES

TABLES

APPENDICES

DOCUMENT CONTROL SHEET

REV	ISSUE PURPOSE	AUTHOR	CHECKED	APPROVED	DATE
-	Final	JE	JE	BC	22-07-20

1. INTRODUCTION

1.1. Ardent Consulting Engineers (hereafter referred to as "Ardent") has been commissioned by Portsmouth Water to undertake Flood Risk Assessment (FRA) in support of a Flood Risk Activities Permit (FRAP) application to the Environment Agency (EA) in order to facilitate the removal of a small culvert on the Lavant Stream where it flows through the centre of a proposed development site located on Portsmouth Water owned land at Solent Road, Havant (hereafter referred to as 'the site').

1.2. Ardent have undertaken a hydraulic modelling study of the watercourse in order to assess the risk of flooding to the development site. The conclusion of the modelling study identified that the site is at risk of flooding during the 1 in 100 year event however this is due in large part due to the throttling effect of a 600 mm dia culvert on the Lavant Stream that acts as the main hydraulic control along this reach resulting in out of bank flows and a shallow flow path being formed across the site. Consequently, it has been proposed that by removing the culvert the risk of flooding to the site can be mitigated. Ardent have carried out modelling runs with the culvert removed to demonstrate this. An interim hydraulic modelling note (report ref **191920-03**) was submitted to the EA Partnership and Strategic Overview (PSO) team as part of a Flood Risk Activities Permit application to remove the culvert and demonstrate that the modelling methodology was sound and that removal of the culvert did not result in an increase in flood risk offsite.

1.3. As part of the FRAP review process the EA have provided several iterations of comments and Ardent have responded accordingly to answer these queries. The outcome of which is that on the 26th June 2020 the EA confirmed that the hydraulic model was fit for the purpose of the FRAP application (refer to **Appendix A**). However, the EA also requested that a Flood Risk Assessment (FFRA) was prepared to appraise the baseline flood risk and determine the risk of flooding both on and off site as a result of the culvert removal.

1.4. This FRA has been prepared to specifically address the EA's request and satisfy the requirements of the FRAP application. The scope is therefore limited and is not intended to support any proposed planning application.

2. SITE DESCRIPTION

Site Location

2.1. The Site is approximately 1.6 ha and is centred at Ordnance Survey grid reference SU 71106 06165 on Solent Road, Havant with the nearest post code being PO9 1LX. The Site is located within Portsmouth Water owned land to the rear of Portsmouth Water headquarters at West Street, Havant, PO9 1LG. The Lavant Stream (EA 'main river') flows through the centre of the Portsmouth Water owned land and marks the boundary along the northern edge of the site. Refer to **Figure 2-1** below for site Location Plan.

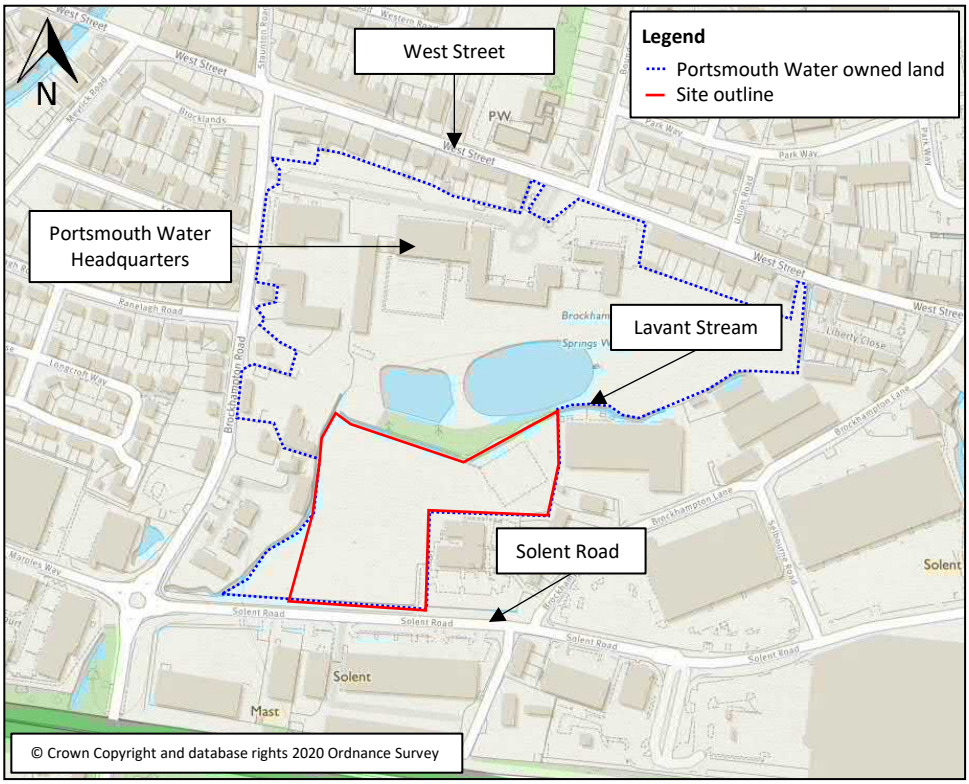


Figure 2-1: Site location plan

Waterbodies in the Vicinity of the Site

2.2. There are several waterbodies within the vicinity of the site (refer to **Figure 2-2**). The Lavant Stream flows from east to west along the northern boundary of the Site and southwards along the western boundary. The Lavant Stream is classified as 'main river'. The upper catchment of the Lavant Stream is situated on chalk bedrock before flowing through the urban area of Havant through multiple culverted sections. The channel is artificially diverged approximately 400 m

upstream of the Site for the creation of a flood bypass channel which flows southwards through the urban area.

2.3. The Site lies adjacent to a boundary between permeable chalk bedrock an impermeable London Clay Formation to the north. Consequently, several springs are present in the area including the Brockhampton Springs on the Portsmouth Water site which give rise to the two ponds to the north of the site. A spring is also present in the south west corner of the Portsmouth Water owned land which joins the Lavant Stream adjacent to Solent Road. Also adjacent to the south of the development site are two ditches in open and culverted section which are understood to be fed by the urban drainage network to the east and north. These are understood to discharge into the Lavant Stream south of the site.

2.4. Approximately 350 m to the north west of the Site, the Hermitage Stream flows from north to south. A flood relief culvert is present on the Lavant Stream approximately 1.5 km upstream of the Site which is designed to transfer flows from the Lavant Stream catchment into the Hermitage Stream during extreme rainfall events. Both the Hermitage Stream and the Lavant Stream discharge to the estuary approximately 1.0 km to the south of the Site.

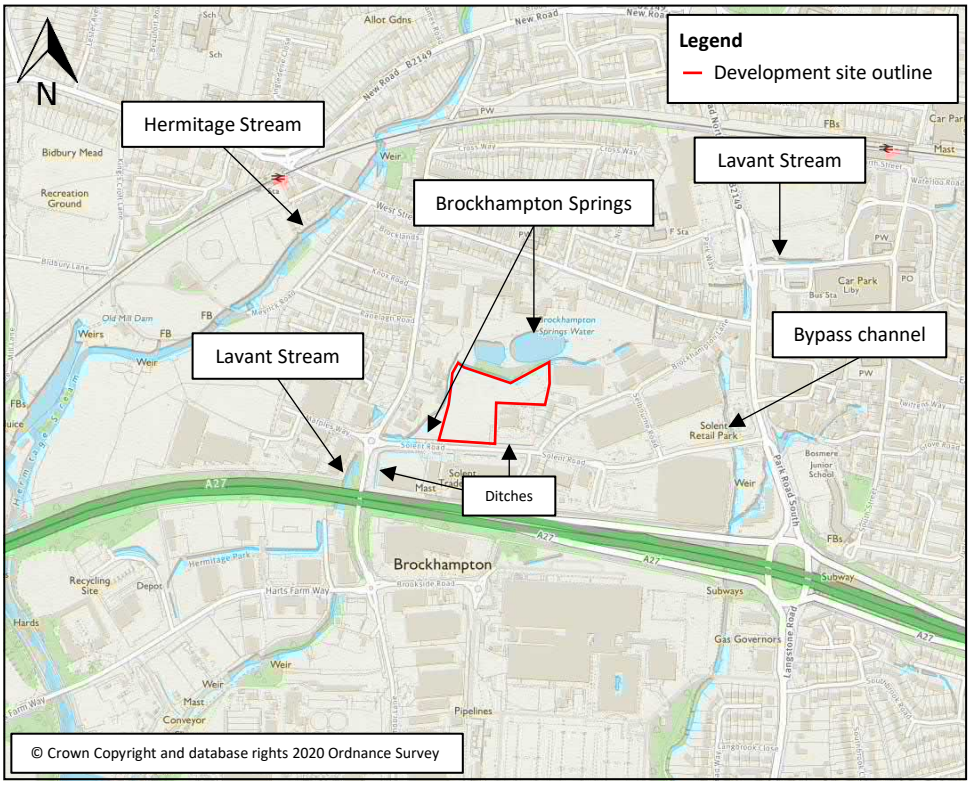


Figure 2-2: Waterbodies in the vicinity of the site

Existing Development

2.5. The existing site is currently formed of undeveloped Greenfield land with the exception of a disused former tennis court in the western part of the Site.

Topography

2.6. Ardent have obtained EA 1 metre resolution LiDAR data of the study area. The LiDAR data shows that elevations on the site fall from approximately 5.8 m AOD in the north west corner of the Site adjacent to the Lavant Stream down to 4.8 m AOD in the south western corner (refer to **Figure 2-3** below). This is a gradient of approximately 1:120.

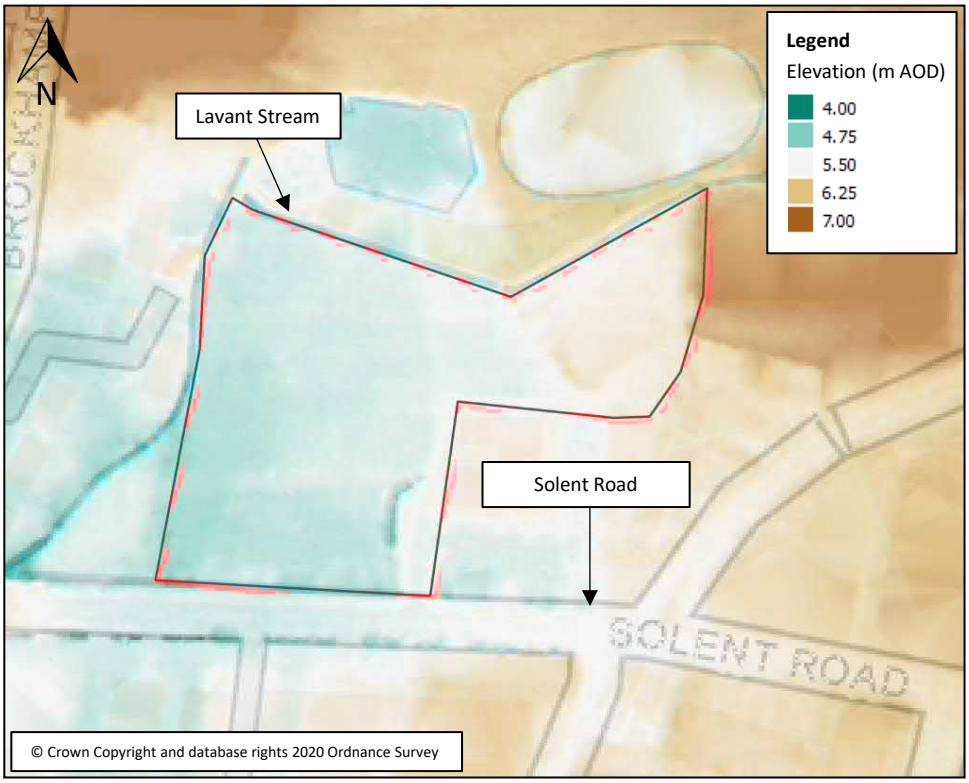


Figure 2-3: 1m resolution LiDAR data

Ground Conditions

2.7. As mentioned in **Section 2.2** above, the geology of the local area is quite complex. British Geological Survey data (refer to **Figure 2-4**) shows that the Site is located on permeable chalk geology with impermeable London Clay Formation bedrock to the north. This change in permeability results in the emergence of several springs in the vicinity of the Site.

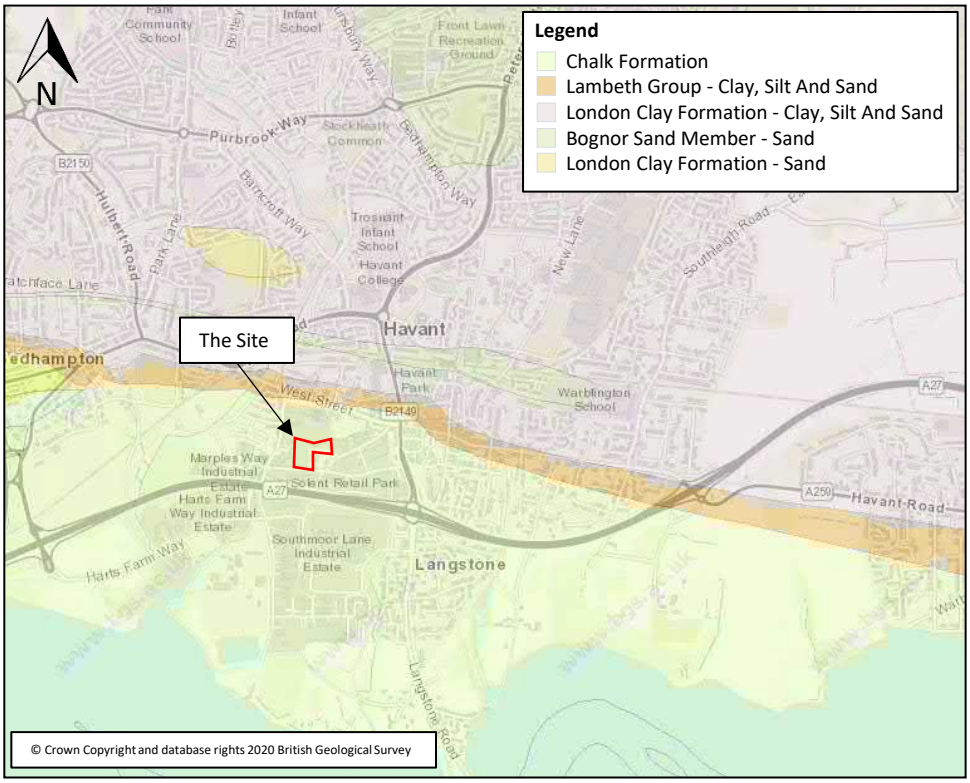


Figure 2-4: British Geological Survey data

3. BASELINE FLOOD RISK

Flood Zone Designation

3.1. Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences. The National Planning Policy Framework (NPPF) Planning Practice Guidance defines Flood Zones as follows:

- **Flood Zone 1: Low Probability**. Land having a less than 1 in 1,000 annual probability of river or sea flooding.
- **Flood 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.
- **Flood 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.
- **Flood 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.

3.2. The Flood Zones are shown on the EA Flood Map for Planning (Rivers and Sea). The Planning Practice Guidance states that the Zones shown on the EA Flood Map do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding.

Environment Agency Flood Map for Planning

3.3. According to the EA Flood Map for Planning (**Figure 4-1**) a large part of the site is located in land designated as Flood Zone 3 (high probability of fluvial flooding) and is shown as undefended. The north eastern corner is shown to be in Flood Zone 1 (low probability of flooding). However, the flood outlines have been derived from a hydraulic model constructed in 2008 using hydraulic modelling software InfoWorks CS and RS. Through consultation with the Environment Agency (EA) it became apparent that the hydrology associated with the model was outdated and would need revising and that also, several structures within the model were not accurately

represented or were not included. Therefore, confidence in the modelling outputs and flood outlines was reduced but this represented the best available information. As part of the assessment of flood risk to the Site it was therefore decided to update the hydrology and make an assessment based on the latest climate change guidance and update the hydraulic model with new survey data.

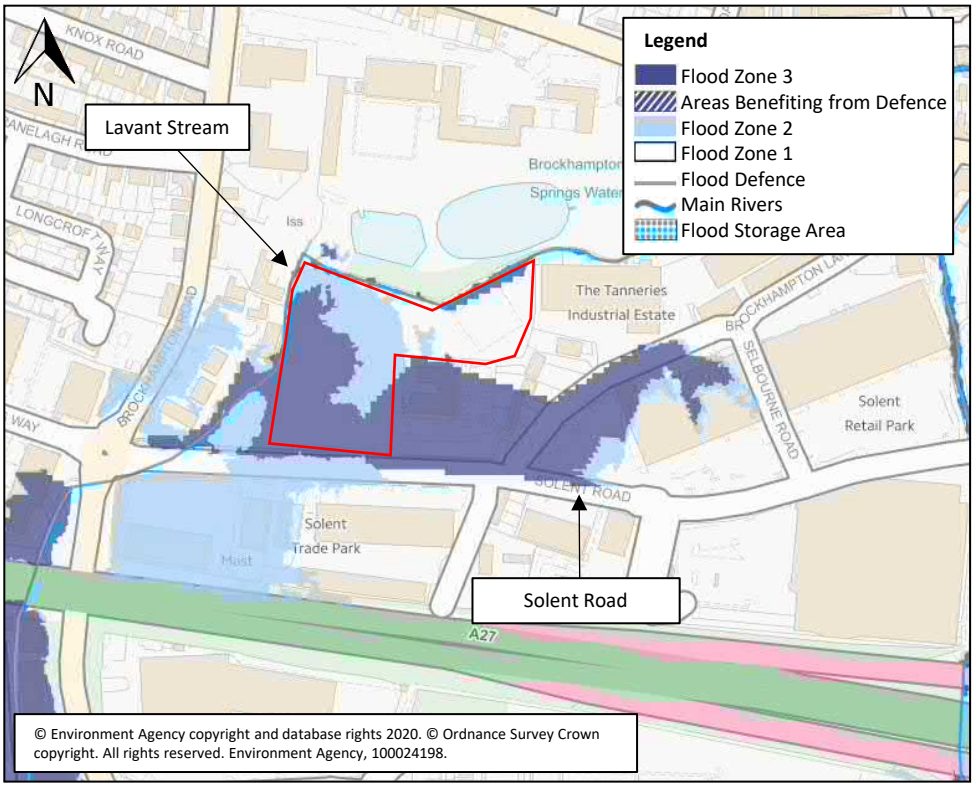


Figure 4-1: EA Flood Map for Planning (Rivers and Sea)

Hydraulic Model Build

3.4. The original EA hydraulic model of the Lavant Stream was constructed in 2008 by Atkins using Infoworks CS and RS as part of the Havant Flood Mapping Study.

3.5. InfoWorks CS allows for modelling of the urban drainage network or sewer system. InfoWorks RS allows the modelling of the river network. These are legacy software packages and are no longer supported.

3.6. Therefore in order to adequately appraise flood risk to the Site it was decided to construct a dynamically linked 1D-2D model of the Lavant

Stream and floodplain using FMP (1D) and Tuflow (2D) software packages based on new cross sectional channel survey data as well as utilising data, river sections and sewer sections taken from the original Infoworks models where appropriate.

Hydrology

Fluvial Inflows

3.7. As part of this study, the EA advised that the hydrology of the model would likely need updating to include more recent data and would also require an assessment of the latest climate change scenarios.

3.8. A hydrology report was prepared by consultant hydrologist Dr Paul Garrad and is included in **Appendix B**. The report identifies that the catchment of the Lavant Stream is divided into the upper, rural, chalk dominated catchment and the lower, urban, clay catchment (approximately 56 km² and 1.5 km² respectively) and that these two distinct catchments influence the hydrology of the system significantly.

3.9. Flows for the larger, predominantly rural, chalk catchment were derived using the Flood Estimation Handbook statistical method. Flows for the smaller, urban, clay catchment were derived using the ReFH method. Peak flows are included within the hydrology report in **Appendix B**.

3.10. The hydrology of the Lavant Stream is complex within the urban area of Havant. As with most urban catchments, runoff is contributed to the stream at multiple points along its reach from the surrounding urban sewer system and surface water network. The Lavant Stream is also characterised by the presence of several long culverts as it flows through the town centre. In addition, the main channel divides into two separate watercourses upstream of the Site adjacent to Park Road North. The bypass channel, as it's known, flows south adjacent to Park Road South and towards the estuary. The other channel flows westwards and southwards in culverted section towards the Site where it is fed by a series of springs at a boundary between clay and

chalk geology. At this location the Lavant Stream is sometimes referred to as "Brockhampton Springs".

3.11. Upstream of the urban area, a flood relief culvert known as the Lavant Link Pipe is present. This structure is designed to transfer flows from the Lavant Stream to the neighbouring Hermitage Stream during peak flows.

3.12. Due to the complex nature of the urban hydrology outlined above, it was considered that it would not be appropriate to apply the urban hydrology to the model as a single inflow at the upstream of the model reach. Instead, the urban hydrology has been divided and applied incrementally along the urban reach based on the urban subcatchments as defined in the original EA Infoworks CS model.

3.13. In accordance with the EA's latest guidance, an assessment of the impact of climate change has been taken into consideration by increasing fluvial and sewer flows as well as the tidal boundary levels. Suitable allowance for increased river flow due to climate change were considered based on the EA's February 2016 guidance.

3.14. The current Site is located in the South East Region and is allocated for commercial development. The central allowance is therefore appropriate in this instance, however as a conservative assessment the higher central allowance has been used in this study i.e. the 1 in 100 year plus 45% event.

Tidal Boundary

3.15. The Tidal boundary was updated based on the East Solent Tidal Model built by JBA in July 2018. The model domain covering the area of interest is that of the Hayling Island model and the closest node to the Site of interest is BNDRY_5. The remaining nodes are located further east and south away from the Site of interest.

3.16. The 1 in 2 year climate change tidal curve was used in the model. The 2 year present day tidal peak level, according to the East Solent Modelling study undertaken by JBA in July 2018, is 2.91 m AOD.

Guidance from the EA states[1] that the anticipated rise in sea level for the south east of England up to the year 2115 is expected to be 1.21 m. Therefore, this value was used for the Climate Change adjustment. Based on the above the 2 year climate change tidal peak level is 4.11m AOD.

Data sources

1D Domain

3.17. The 1D model has been constructed using a mixture of different data sources.

3.18. The primary data source that has informed the 1D domain is channel survey cross sections collected by Terrain Geomatics in May 2019 of the Lavant Stream. The surveyed reach extends from Farringdon Road down to the estuary but did not include the Bypass Channel and also, due to access restrictions, did not include details of the Lavant Link Pipe.

3.19. The modelled reach was supplemented with data from the original EA InfoWorks RS model. Cross sectional data was extracted and incorporated to the FMP model extending the reach approximately 600 m upstream of Farringdon Road as well as at other selected locations.

3.20. Cross sections for the Bypass Channel adjacent to Park Road North were also extracted from the RS Model and incorporated into the FMP model. Details of the Lavant Link Pipe were extracted from the CS model. The total 1D model extent therefore extends from north of Bartons Road approximately 3.0 km upstream of the Site down towards the estuary 700 m downstream of the Site where the tidal boundary is applied. These extents are considered appropriate for the scope of the study. Full 1D and 2D model extents are provided in **Appendix C**.

[1] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#future-flood-risk-management

3.21. Observations and measurements of additional structures and features were also made during a walkover of the Site and modelled reach.

3.22. Manning's 'n' values have been applied to the 1D domain based on Manning's 'n' for Channels from Chow, 1959 and a review of photographic data provided by the surveyor as well as observations made on Site. Where EA cross sections have been utilised the Manning's 'n' values have only been adjusted where information to the contrary is available. For in channel, Manning's 'n' values are typically in the range between 0.03-0.04 but are as low as 0.025 for some stretches of concrete lined channel and 0.015 for a short section of brick lined channel between nodes S31-S30. Manning's 'n' values of between 0.025-0.035 have been adopted for concrete structures and culverts throughout the 1D domain. The values for the 1D domain are within the range of typical Manning's 'n' values for in channel and are industry standard practice. They are therefore considered to be appropriate to the study.

3.23. Further details regarding the control structure immediately downstream of the inlet to the Lavant Link Pipe at Crossland Drive were obtained through consultation with the EA (refer to **Appendix D**). The consultation established that a penstock is present downstream of the inlet which restricts flows during peak events and elevates the upstream water level. This enables flow to enter the Lavant Link Pipe which is subsequently transferred to the Hermitage Stream catchment to the west.

3.24. Due to access restrictions, the surveyors were unable to collect data of this structure directly. Therefore, the details supplied by the EA represent the best available information of this structure. The penstock was represented in the model using two orifice units with assumptions made on the dimensions of the structure based on the photograph provided by the EA in **Figure 4-2** below.

Figure 4-2: Penstock control structure downstream of Lavant Link Pipe

2D domain

3.25. The floodplain has been represented within the 2D domain of the model using LiDAR data. 1m resolution LiDAR data of the study area was obtained from the EA and incorporated into the hydraulic model. The hydraulic model has been run with a 2m cell size to represent the 2D domain. This provides sufficient resolution to accurately model flood flow paths whilst also ensuring model run times are not excessive.

3.26. OS OpenMap Local shapefile data was obtained from Ordnance Survey. This was then used to inform the 'materials' file within Tuflow. The 'materials' file allows for a Manning's 'n' roughness value to be applied to the floodplain.

3.27. Together, the LiDAR data and 'materials' file allow for an accurate representation of over land flow paths throughout the 2D model domain.

3.28. Manning's 'n' values for the 2D domain are presented in **Table 4-1** below. These are within the range of typical Manning's 'n' values for floodplain and are industry standard practice. They are therefore considered to be appropriate to the study.

Table 4-1: Manning's 'n' values for 2D domain

Land use	Manning's 'n' value
Open Water	0.02
Roads/Tarmac	0.025
Default Grassed Areas / Car parks	0.035
Railway Tracks	0.04
Pasture / light vegetation	0.055
Urban areas/ Fenced Gardens	0.06
Dense vegetation / Wooded areas	0.08
Warehouse type Buildings	0.1
Masonry / Concrete Buildings	0.3
Stability Patch	0.9

Baseline Modelling Results

3.29. The Ardent baseline hydraulic model has been run for the following events:

- 1 in 100 year
- 1 in 100 year plus 45% climate change
- 1 in 1000 year
- 1 in 1000 year plus 45% climate change

3.30. The hydraulic model was run in the following software versions:

- Tuflow; 2018-03-AE-iDP-w64
- Flood Modeller Pro; 4.5.1

3.31. The model was run with a 1 second timestep for both the 1D and 2D domains. It is usual modelling practice to model the 1D domain with a timestep that is half that of the 2D domain if possible, however due to the inclusion of multiple structures in the urban reach a reduced 1D timestep was not possible due to instabilities.

3.32. Model plots for all baseline events are included in **Appendix E**. **Figure 4-3** below shows the maximum flood depths on Site during the 1 in 100 year plus 45% climate change baseline scenario overlain with the EA model flood extents for the 1 in 100 year plus 20% climate change scenario.

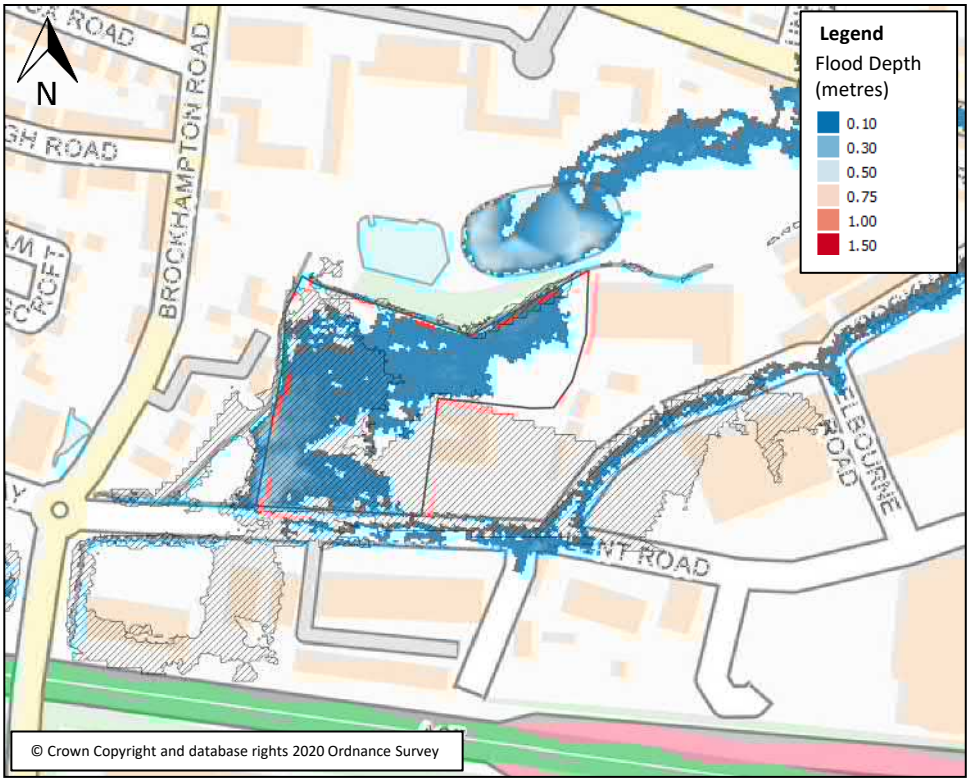


Figure 4-3: 1 in 100 year plus 45% climate change baseline scenario maximum flood depth

3.33. The EA flood outline covers the majority of the western and southern portions of the Site. However, the Ardent flood extent impacts the majority of the Site. The EA outline suggests that flood water is coming out of bank on the Lavant Stream on the western boundary of the Site as the watercourse flows southwards. However, analysis of aerial photography and site visits have confirmed that the presence of a 2.0 m high wall running the length of the channel at this location (**Figure 4-4**) prohibits any water from coming out of bank. Further interrogation of the EA model indicates that this wall has not been included within the model. The EA outputs are therefore misrepresentative.

3.34. The EA were consulted regarding their modelled outputs who stated that the wall has not been included in their model as the Flood Map for Planning does not take into account the presence of flood defences (despite the wall not being a formal flood defence).

Figure 4-4: 2.0 m high wall curtailing western boundary of the Site

3.35. In the Ardent outputs, the 2.0 m wall is included which prevents any out of bank flow occurring at this location. The Site however becomes flooded as a result of the limiting capacity of a 600 mm diameter culvert on the northern boundary of the Site. This constriction results in water levels becoming elevated upstream of the culvert and spilling over the left bank of the watercourse. This forms a shallow flow path across the Site (less than 100 mm depth) with water propagating westward. Water is unable to re-enter the watercourse in the Ardent model as the 2.0 m high wall is included. Instead, flood water flows south where a drainage ditch is present along the southern boundary of the Site adjacent to Solent Road. This ditch, and a series of

culverts, serve to convey flood flows away from the Site and back into the Lavant Stream downstream of the Site.

3.36. This flooding mechanism was also observed for the other modelled baseline events (refer to model plots in **Appendix E**).

3.37. In order to alleviate the flood risk to the Site, it was proposed to remove the 600 mm culvert in order to remove the hydraulic control. This is discussed in the following section.

Mitigation Modelling

3.38. In order to mitigate the risk of flooding to the Site, Ardent undertook an iterative process firstly be removing the 600 mm culvert on the Lavant Stream on the northern boundary of the Site from the 1D model domain. Elevations along the northern bank of the watercourse were also lowered in order to provide a degree of attenuation in order to reduce the potential risk in flooding downstream as a result of the increase in flows. In total a 145 m length of the northern bank was lowered to an elevation of 5.2 m AOD (average 750 mm depth of material). This served to alleviate the risk of flooding to the Site without impacting flood risk downstream. However, following an ecological assessment of the Site, it was confirmed that several trees had Tree Preservation Order (TPO) status and that it would not be possible to excavate the full 145 m reach. Therefore, targeted locations for excavation were established and it was proposed to also include a low level bund along the southern edge of the Lavant Stream.

3.39. The bund is to be set 5.0 m back from the watercourse with additional minor excavations carried out to provide additional attenuation. The bund is intended to tie in with brick arch culvert headwall at the north west corner of the Site. The bund has been designed to be typically 500 mm – 600 mm in height above adjacent ground levels. The proposed bund and excavation works are shown on drawing number **191920-001** in **Appendix F**.

3.40. In order to represent the bund and proposed excavation works within the 2D domain of the model, a series of 'z_shapes' were used that

allow the ground model utilised within Tuflow to be manipulated by either lowering or raising elevations. This in addition to the culvert removal from the 1D domain were the only changes made between the baseline and mitigation modelling scenarios.

Mitigation Model Results

3.41. **Figure 4-5** below shows the post development maximum flood depths for the 1 in 100 year plus 45% climate change mitigation scenario in comparison to the baseline flood extents. Model plots and comparison plots for all modelled events are included in **Appendix G**. It can be seen that the proposed mitigation measures of removing the culvert and the associated bund and excavation works have served to completely mitigate the risk of flooding to the Site. In addition, there is a de minimis impact on flood extents offsite as a result of the proposed works.

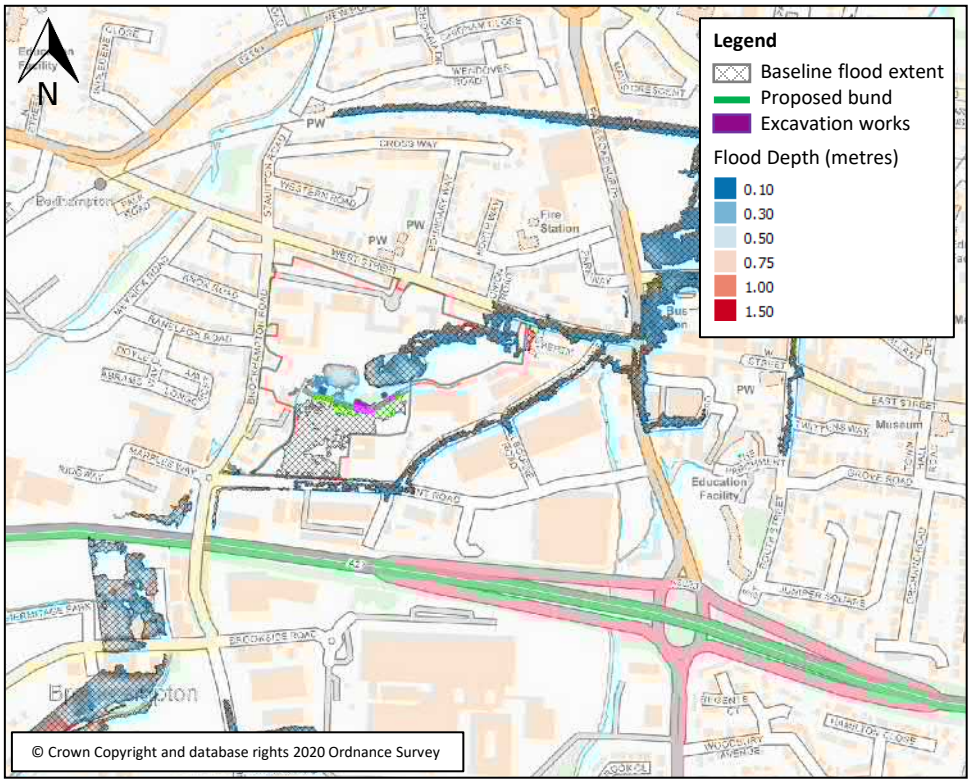


Figure 4-5: 1 in 100 year plus 45% climate change, mitigation scenario maximum flood depths

Sensitivity Testing

3.42. In order to test the accuracy of the model, it would be desirable to compare the modelled outputs against observed data and flood extents in order to calibrate and validate the model. However, there is currently no calibration data available which to test the model against. As a compromise, Ardent have modelled a range of return period events for both the baseline and proposed scenario as well as undertaken a series of sensitivity tests to determine the robustness and suitability of the model as well as to determine the impact of the proposed works offsite. This is considered to be wholly adequate given the scale of the proposed works and the nature of the FRAP application.

3.43. Standard modelling practice typically involves sensitivity testing of the following parameters:

- Boundary Conditions
  - Inflows
  - Downstream *boundary (+/- gradient 20%)*
- Manning's 'n' roughness (+/- 20%)

3.44. In testing the climate change scenario of the study area, the boundary conditions have been adjusted with an uplift in flows against the present day conditions but also at the downstream boundary. As discussed in **Section 3.16**, the study site is located within 1 km of the estuary and there is therefore a tidal influence at the downstream boundary. In the baseline scenario this has been accounted for by applying the 1 in 2 year maximum tidal curve taken from the JBA East Solent Tidal Model (2018). The 2 year present day tidal peak level, according to the East Solent Modelling study undertaken by JBA in July 2018, is 2.91m AOD. Guidance from the EA (December 2019) states that the anticipated rise in sea level for the south east of England (higher central allowance) up to the year 2115 is expected to be 1.21 m. Therefore, this value was used for the Climate Change adjustment. Based on the above the 2 year climate change tidal peak level is 4.11m AOD.

3.45. The results show that as expected with the uplift in inflows, there is an increase in maximum stage within the 1D results as well as an

increase in flood extents in the 2D where flood water is coming out of bank. With respect to the downstream boundary, the additional application of 1.21 m due to climate change elevates maximum water level downstream of the Site (see **Appendix H**). It is this which is the dominant hydraulic control influencing flood level at this location as opposed to the gradient of the bed level in this downstream reach. The results show that the Site, and the culvert are sufficiently elevated above this maximum tidal level so as not to be influenced by the impact of tide locking.

3.46. With regard to the Manning's 'n' roughness value sensitivity test, Ardent initially attempted to test this during the 1 in 100 year plus climate change event in the culvert removed scenario. However, due to the urbanised nature of the watercourse which flows through multiple culverts and structures, the 1D component of the model is quite sensitive when these structures become surcharged. During the climate change scenario, the steepness or 'flashy' nature of the urban hydrographs is amplified due to the significant uplift of 45% in peak flows (refer to example below) and exacerbates these instabilities. While testing Manning's 'n' in the 1 in 100 year plus climate change scenario, the 1D component of the model routinely crashed before the peak flood level was reached due to the factors mentioned above. Therefore, in order to ensure a complete test of Manning's 'n' could be assessed, the sensitivity test was carried out on the 1 in 100 year scenario without the application of climate change instead.

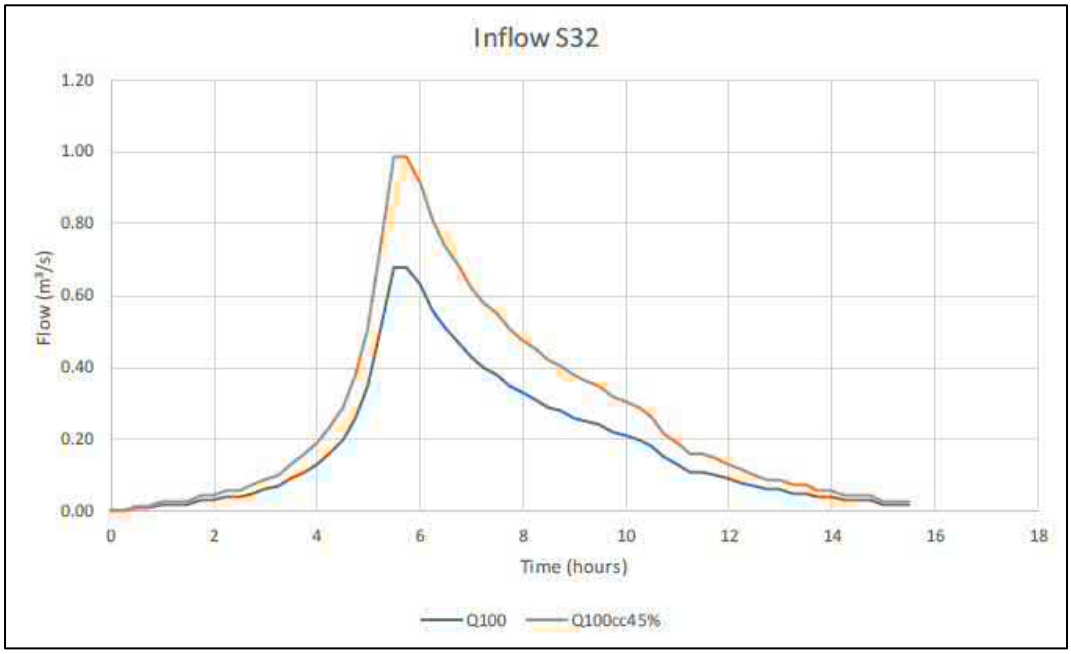


Figure 4-6: Comparison of baseline vs climate change hydrograph

3.47. The 1D, 1 in 100 year Manning's 'n' sensitivity results are presented in **Appendix H**. The results show that as expected, an increase in maximum stage within the 1D model associated with increase in Manning's 'n' and a decrease in maximum stage associated with a reduction in Manning's 'n'.

3.48. This is also broadly reflected in the 2D results (**Appendix H**) with an increase in flooding associated with an increase in Manning's 'n' and vice versa with a reduction. However, there are a couple of exceptions where the flood the +20% flood extent is less than the baseline scenario where flooding forms an overland flow path across roads and tarmacked areas. In the baseline scenario these areas have a Manning's 'n' value of 0.025. In the +20% scenario this increases to 0.030. This increase in resistance reduces velocities and prevents the flood flow path propagating further. In the –20% scenario, despite there being even less resistance in these areas, there is less volume coming out of bank to cause an increase in flood extent. The model is therefore considered to be robust to changes in Manning's 'n' with no significant changes as a result to changes in this parameter.

4. CONCLUSIONS

4.1. This FRA has been produced to support the Flood Risk Activities Permit (FRAP) application for the removal of a 600 mm diameter culvert on the Lavant Stream where it flows through Portsmouth Water owned land at Solent Road, Havant.

4.2. In constructing a new hydraulic model of the Lavant Stream based on new survey data and updated hydrological inputs, Ardent have been able to make a more robust, accurate and up to date assessment of baseline flood risk at the Site when compared to the EA outputs shown on the Flood Map for Planning. The Ardent baseline modelling outputs established that the Site was at risk of flooding due to the insufficient capacity of the 600 mm diameter culvert which acts as the main hydraulic control along this reach. The culvert has a throttling effect thereby elevating the upstream water level resulting in flows coming out of bank and propagating across the Site.

4.3. Ardent have undertaken proposed mitigation modelling scenarios to determine the potential impact of removing the culvert to alleviate flood risk at the Site. There was a risk that by removing the culvert flood risk downstream of the Site could be increased as a result of the additional flow volumes being conveyed within the channel. Consequently, earthworks were proposed along the north bank of the Lavant Stream to provide a degree of attenuation and reduce any potential offsite impacts. However, due to the presence of Tree Protection Orders, opportunities to excavate here would be limited. A 145 m bund was therefore also proposed on the left bank of the watercourse set back by a distance of 5 metres. This would allow for further attenuation whilst also ensuring the Site remains flood free during the 1 in 100 year plus climate change scenario.

4.4. The results of the mitigation modelling simulations showed that there was de minimis impact on flood risk offsite with the culvert removed when compared to the baseline modelling results. Sensitivity testing of key parameters has demonstrated that the model is fit for purpose.

4.5. In conclusion then this FRA has demonstrated that the FRAP application for removal of the culvert is acceptable in terms of not increasing flood risk offsite.

Appendix A

EA PSO Team Modelling Methodology Consultation

John Easton

From: Partnership and Strategic Overview team, HIOW <psohiow@environment-agency.gov.uk>
Sent: 26 June 2020 15:06
To: John Easton
Cc: Chris Hardyman; Jenna Dewhurst; 'Tony Chalkley'; Simon Deacon; Steve Cross; Brian Cafferkey; Georgia Athanasia
Subject: RE: EPR/PB3294JJ Ardent Flood Risk Report - Solent Road Havant [Filed 02 Jul 2020 11:28]
Attachments: EPR_PB3294JJ Schedule 5 Notice of request for more information.pdf

Hi John,

Thank you for your comments.

Our response is as follows:

Thank you for submitting the extra clarification and justification behind some of the modelling techniques. We can confirm that we deem that the model is fit for the purpose of this Flood Risk Activity Permit, we caveat this statement with the fact that if this was to come in as part of a planning application the model may be scrutinised further.

As part of the FRAP we ask that you now produce a flood risk assessment using the model and the scenarios you have produced to clearly conclude an assessment of flood risk both on site and off site. Any FRA should be clear on the methodology used and this justified where appropriate. If the FRA finds that flood risk is increased as part of the proposal, mitigation measures should be outlined to tackle this. We should note that this does not have to be a lengthy document, but needs to assess the baseline and proposed flood risk of the works and clearly conclude this alongside any potential mitigation measures.

Chris, as Agent for this FRAP I attach the Schedule 5 request for information. When we have seen the updated FRA this will likely satisfy schedule 1 regarding addressing the flood risk. We still await a response to schedule 2-9 regarding the environmental concerns.

Thank you for your patience in reviewing this Flood Risk Report.

I would like to stress that as per our policy on culverts, we hope to facilitate the removal of culverts where possible through our role as regulator.

As such we are more than keen to help these works proceed. If you have any questions please do let me know.

We look forward to receiving your FRA as per above.

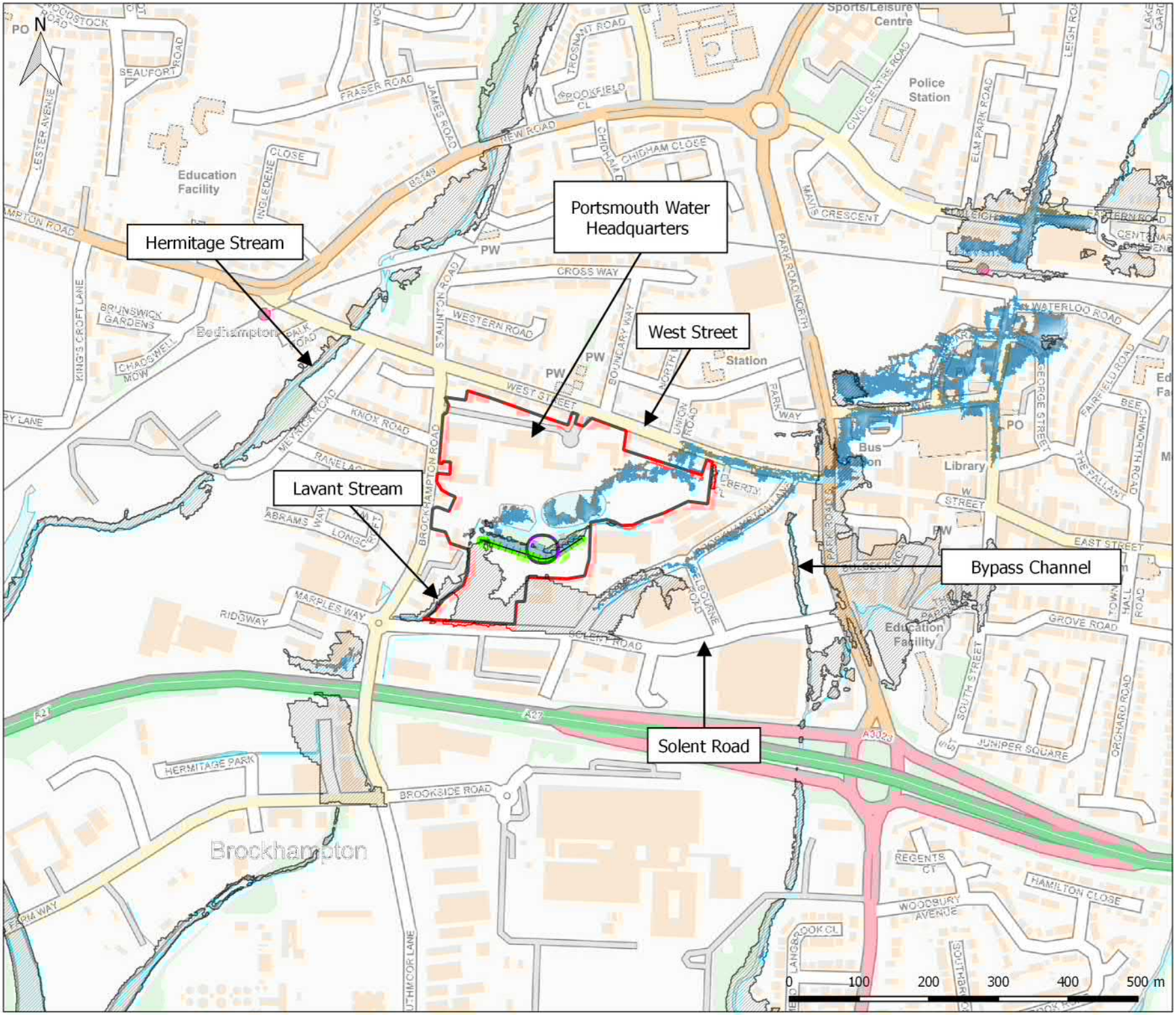
Kindly,

Nathan Bayley

Flood and Coastal Risk Management Officer – New Forest, Test & Itchen
Environment Agency
Partnership & Strategic Overview Team
Environment Agency | Romsey Depot, Canal Walk, Romsey. SO51 7LP
020 7714 1072
psohiow@environment-agency.gov.uk

Appendix G

Mitigation Modelling Results



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Legend

- Portsmouth Water site boundary
- Culvert location
- EA 1 in 100 year flood outline
- Proposed bund

Ardent flood depth (metres)

- 0.10
- 0.30
- 0.50
- 0.75
- 1.00
- 1.50

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Client: Portsmouth Water

Project Title: 191920 - Solent Road, Havant

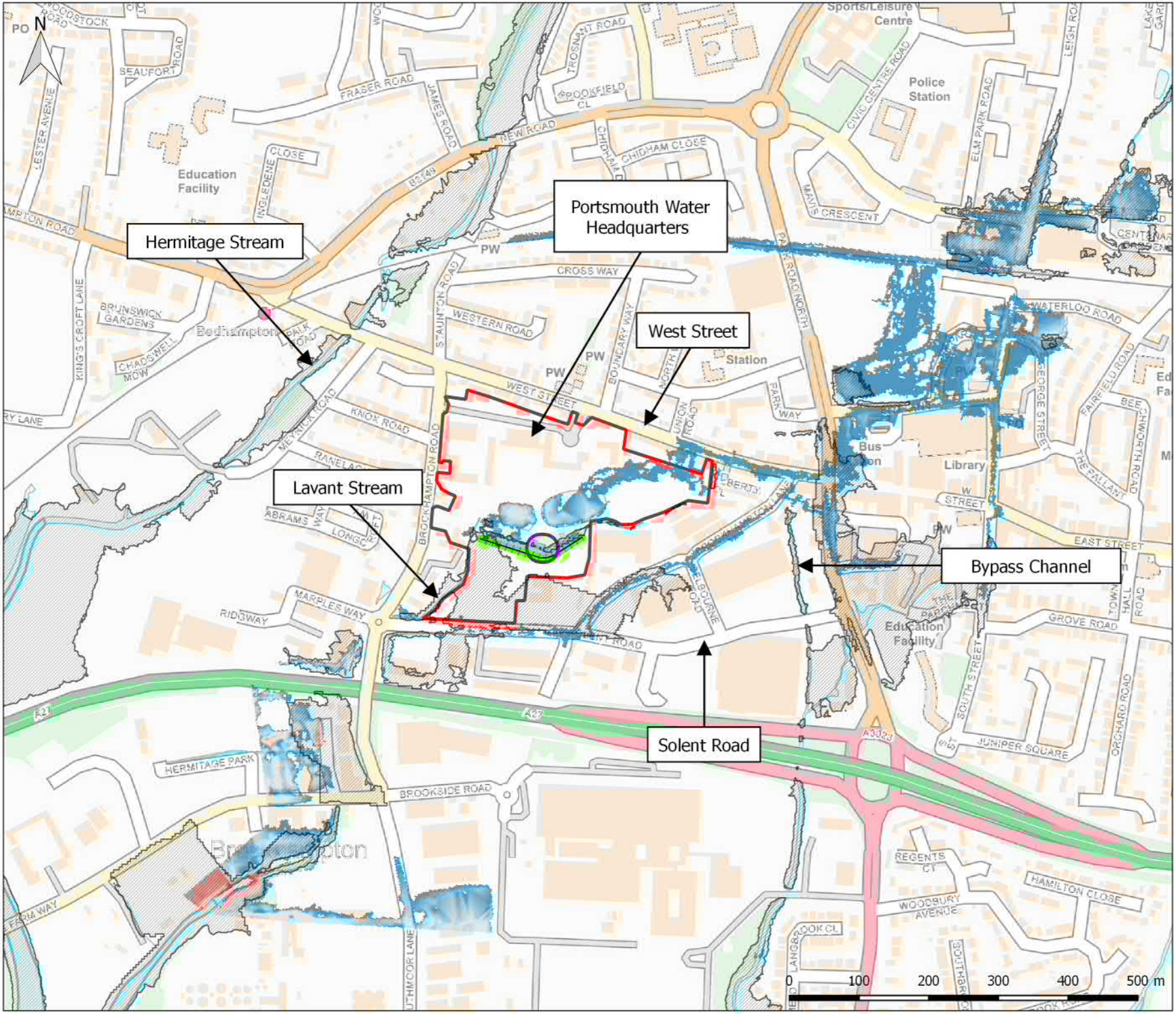
Drawing Title:

1 in 100 annual probability event
Maximum Flood Depth
Proposed Scenario - Culvert Removed

Drawn:	Checked:	Approved:	Rev:
JE	CC	BC	-

Drawing Ref: 191920_SolentRoad_018_DEV_Q100_CLA_d_Max

Date: 05/02/2020



Legend

- Portsmouth Water site boundary
- Culvert location
- EA 1 in 100 year flood outline (+20% CC)
- Proposed bund

Ardent flood depth (metres)

- 0.10
- 0.30
- 0.50
- 0.75
- 1.00
- 1.50

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Client: Portsmouth Water

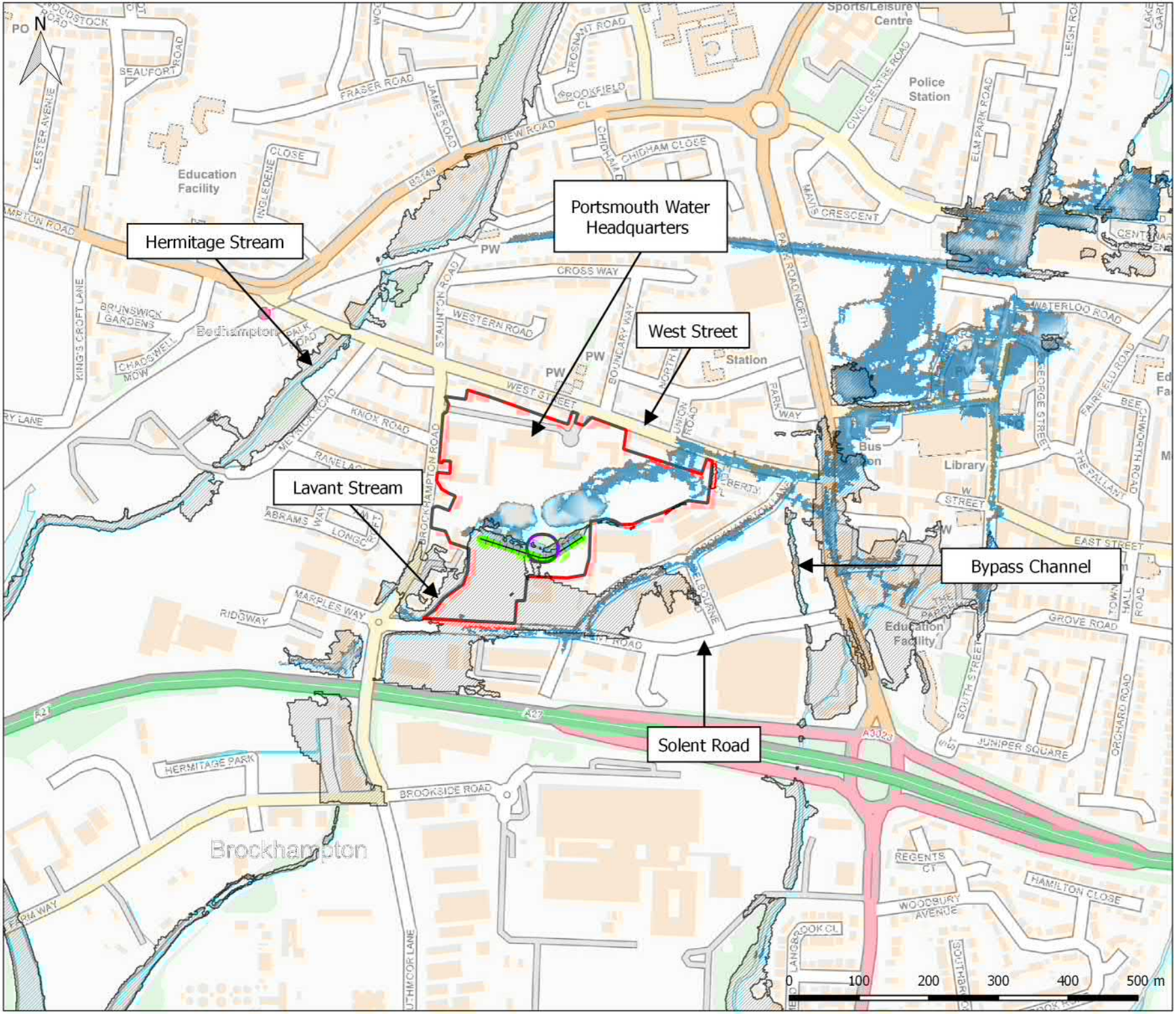
Project Title: 191920 - Solent Road, Havant

Drawing Title:
1 in 100 annual probability event
(plus 45% climate change)
Maximum Flood Depth
Proposed Scenario - Culvert Removed

Drawn:	Checked:	Approved:	Rev:
JE	CC	BC	-

Drawing Ref: 191920_SolentRoad_018_DEV_Q100cc45_CLA_d_Max

Date: 05/02/2020



Legend

- Portsmouth Water site boundary
- Culvert location
- EA 1 in 1000 year flood outline
- Proposed bund

Ardent flood depth (metres)

- 0.10
- 0.30
- 0.50
- 0.75
- 1.00
- 1.50

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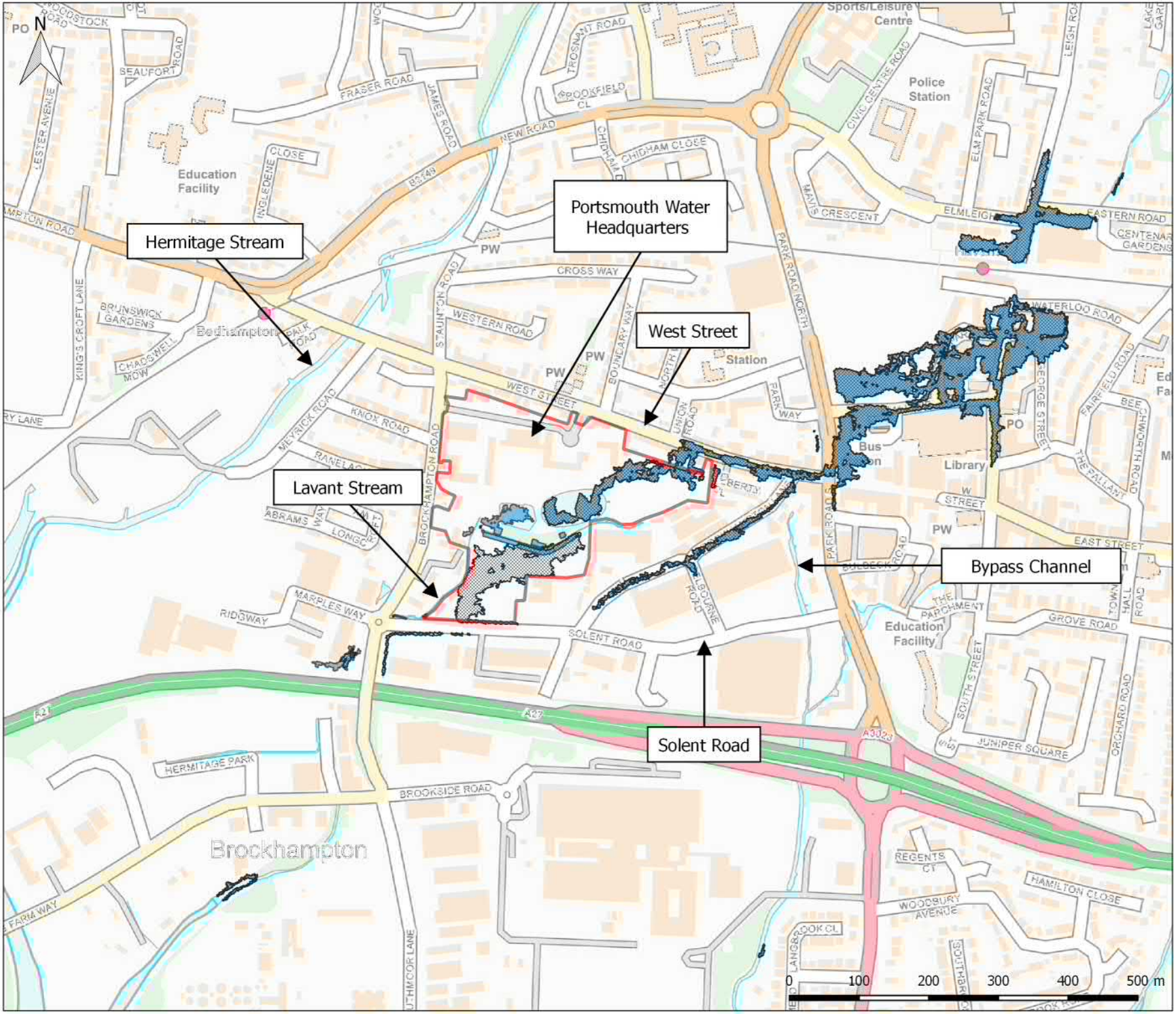
Drawing Ref: 191920_SolentRoad_018_DEV_Q1000_CLA_d_Max

Date: 05/02/2020



Legend

- Portsmouth Water site boundary
- Baseline flood extent
- Proposed flood extent

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Client: Portsmouth Water

Project Title: 191920 - Solent Road, Havant

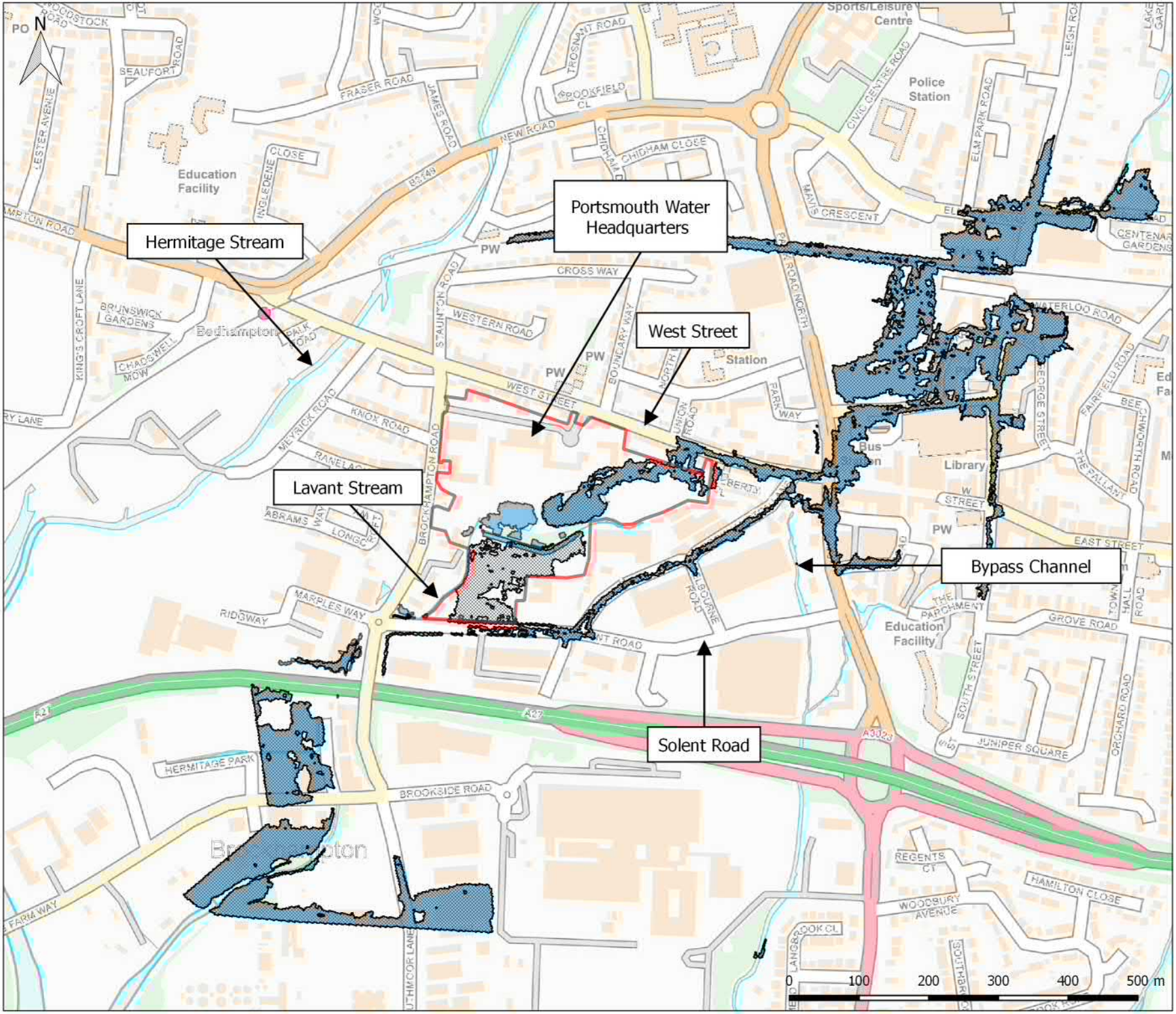
Drawing Title:

1 in 100 annual probability event
Flood extent comparison
Baseline and Proposed Scenario

Drawn:	Checked:	Approved:	Rev:
JE	CC	BC	-

Drawing Ref: 191920_SolentRoad_018_Q100_Comparison

Date: 05/02/2020



Legend

- Portsmouth Water site boundary
- Baseline flood extent
- Proposed flood extent

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Client: Portsmouth Water

Project Title: 191920 - Solent Road, Havant

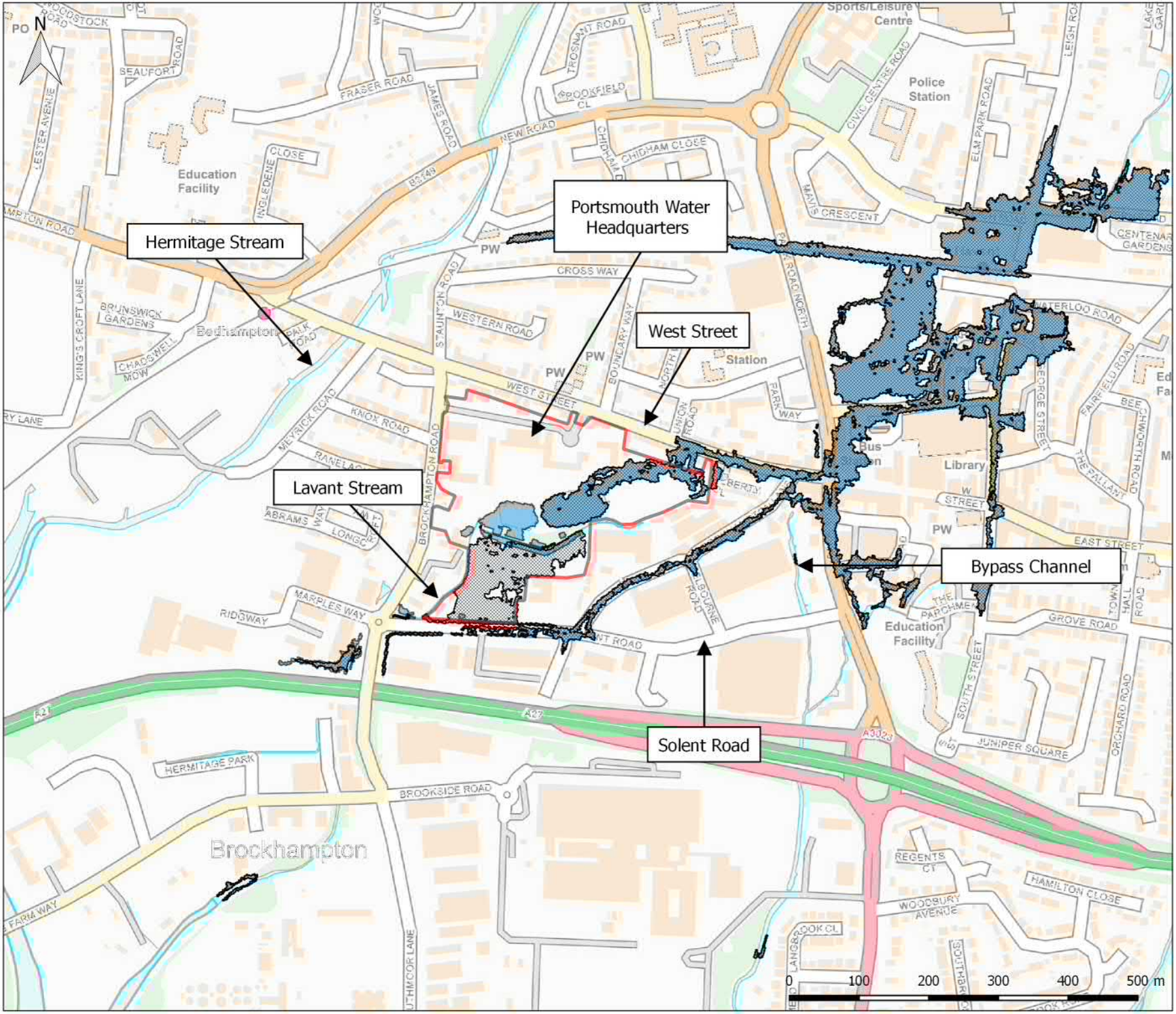
Drawing Title:

1 in 100 annual probability event
(plus 45% climate change)
Flood extent comparison
Baseline and Proposed Scenario

Drawn:	Checked:	Approved:	Rev:
JE	CC	BC	-

Drawing Ref: 191920_SolentRoad_018_Q100cc45_Comparison

Date: 05/02/2020



Legend

- Portsmouth Water site boundary
- Baseline flood extent
- Proposed flood extent

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Client: Portsmouth Water

Project Title: 191920 - Solent Road, Havant

Drawing Title:

1 in 1000 annual probability event
Flood extent comparison
Baseline and Proposed Scenario

Drawn:	Checked:	Approved:	Rev:
JE	CC	BC	-

Drawing Ref: 191920_SolentRoad_018_Q1000_Comparison

Date: 05/02/2020

Appendix B SFRA assessment of site ref HB36

Land North of Solent Road – Site Ref: HB36

Basic Information

The Site: The site is located north of Solent Road, east of Brockhampton Road and directly south of the current headquarters of Portsmouth Water.

Site Area: 1.68 ha

Allocation Proposal: Commercial ('less vulnerable')

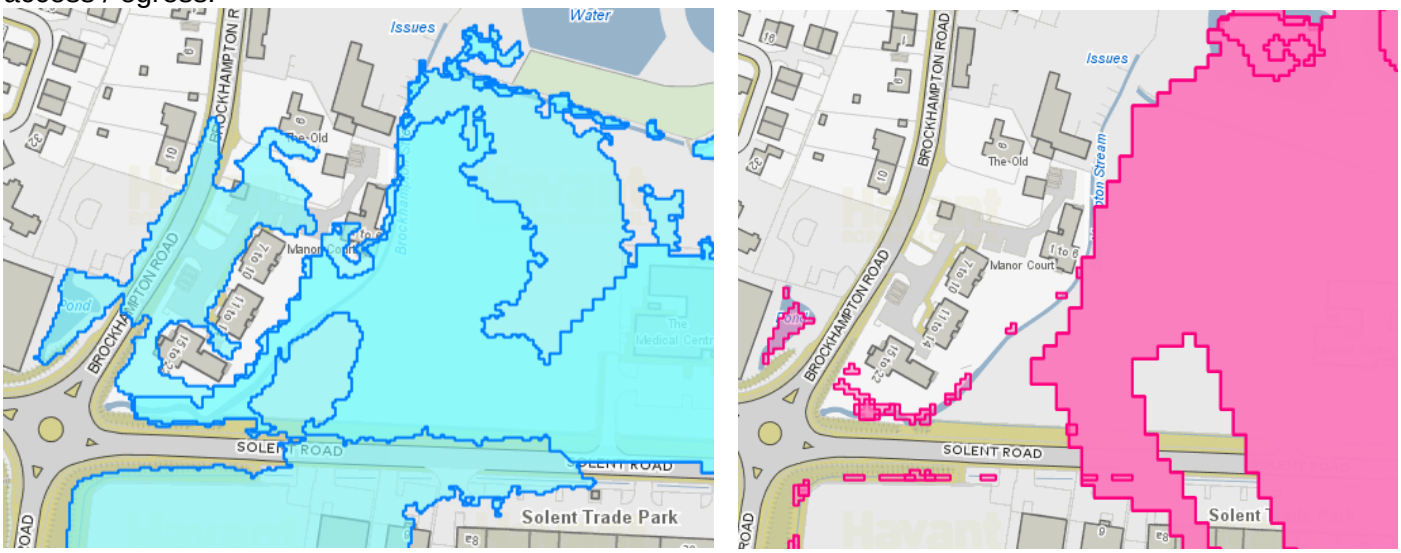
Flood Risk Information

Source / Pathway: Fluvial from Brockhampton Stream

Level of Flood Risk: A large part of the site is in FZ2 and 3, both in the present day and with climate change. As the vast majority of the site is shown to be in the area at risk of flooding, it cannot be avoided within the site.

The site benefits from defences along the Brockhampton Stream for the 1 in 40 year scenario. The defences consist of high ground and a wall and most of them are in good condition based on the last inspection undertaken in 2018;The 1D model results for the 1 in 100 year event (Flood Zone 2) indicate that the levels on the Brockhampton Stream range from 5.90 m AOD1 at the eastern (upstream) end of the watercourse site to 5.15 m AOD at the western (downstream) end of the watercourse.The 1D model results for the 1 in 1000 year event (Flood Zone 1) indicate that the levels on the Brockhampton Stream range from 5.93 m AOD in the eastern (upstream) end to 5.41 mAOD in the western (downstream) end of the watercourse.

Access / egress to the site is via Solent Road. However, the Environment Agency's flood risk mapping indicates that Solent Road to the south of the site is in Flood Zone 3 and therefore at high risk of flooding. It is recommended that site-specific hydraulic modelling should be undertaken to refine the flood zone extents at the site and consequently determine if any mitigation measures are required to facilitate safe access / egress.



Current Day Zones 2 & 3 vs Climate Change 2115. Source: EA Flood Map and PUSH SFRA

Sequential Approach - Can areas of flood risk be avoided?

No – the vast majority of the site is in FZ2 and 3, both in the present day and with climate change. The access is also on FZ3.

If flood risk cannot be avoided, what is the preferred approach?

It may be possible to modify the shape of a fluvial floodplain to generate a more favourable flood outline that allows the development area of a site to be maximised. If that is to be pursued, it would be necessary to demonstrate that compensatory storage can be provided on a level for level basis for any floodplain displaced by a development. If it is proposed to develop areas in fluvial Flood Zone 3, compensatory

Land North of Solent Road – Site Ref: HB36
storage would be required. The feasibility of providing compensation at the site depends on ground conditions and groundwater levels below the site. It would also be necessary to demonstrate through hydraulic modelling that the proposed compensatory storage is effective at mitigating the loss of floodplain and effective at maintaining the current level of flood risk to neighbouring property.
Conclusion on prospect of safe development in light of flood risk
The EA have indicated that the key issue on this site is the offsite implications of flooding from development of the site i.e. floodplain compensation. Previous work has given confidence that an employment use can be safely delivered. On that basis, there is a prospect of safe delivery, although a detailed assessment of this would be required at application stage, in particular in relation to flood storage compensation, so any allocation policy would need to be heavily caveated with assessment requirements
Implications for Local Plan 2036
It is acknowledged that the site was allocated in the previous Local Plan for a new Portsmouth Water HQ. The sequential test at that time was passed on the basis that the HQ had to be in this location for operational reasons, being close to a water source. The company has since decided to locate their HQ elsewhere and is promoting this site for general B1 or B8 (trade counter) use. The council considers that there are other sequentially preferable sites in the Borough for general employment use, and the exception made for the HQ use therefore falls away. Therefore, although it had been accepted in the past that there may be a prospect of safe delivery, this question does not arise, as the sequential test is not passed. An allocation for general employment use is not supported.

Appendix C Topographical Survey & Utility Maps

N

OS Note:

Some services may have been omitted due to parked vehicles. The Ordnance Survey tile is to be used as a guide only.

OS Buildings *Surveyed Buildings*

This survey has been orientated to the Ordnance Survey (O.S) National Grid OSGB36(15) via Global Navigation Satellite Systems (GNSS) and the O.S. Active Network (OS Net).

A true OSGB36 coordinate has been established near to the site centre via a transformation using the OSTN15GB & OSGM15GB transformation models.

The survey has been correlated to this point and a further one or more OSGB36 (15) points established to create a true O.S. bearing for angle orientation.

No scale factor has been applied to the survey therefore the coordinates shown are arbitrary & not true O.S. Coordinates which have a scale factor applied.

Please refer to Survey Station Table to enable establishment of the on-site grid and datum.

Legend:

Boundaries: Wall, Kerb line, Drop kerb, Centre line, Top of bank, Overhead Cable, Concrete edge, Tarmac edge, Gable verge, Overground Wiring, Cable, Bottom of bank, Station and Name, Station Level, Tree / Bush / Sapling, Area of Undergrowth, Woodland, Ridge Level, Eaves Level, Flat Roof Level, Gate

Fence types: IW Interwoven, IR Iron Railings, WM Wire Mesh, PR Post & Rail, PW Post & Wire, CL Chain Link, WP Wooden Panels, CB Close Boarded, SP Steel Palisade

IC	Inspection chamber	Bo	Bollard
Pinv	Pipe invert	IB	Illuminated bollard
Gy	Gully	Bin	Rubbish bin
Bg	Back gully	Vp	Vent pipe
Dp	Down pipe	Gri	Ground light
Pipe	Pipe above ground	Lbox	Letter box
MH	Manhole	Stmp	Tree Stump
WL	Water level	Sty	Stile
Fl	Flood light	IFL	Internal floor level
Lp	Lamp post	THL	Threshold level
Tp	Telegraph post	Sp	Sign post
Ep	Electricity post	TH	Trashcan
Ti	Traffic light	BH	Borehole
Bus	Bus stop	ELC	Electric
Sv	Stop valve	BT	British Telecom
St	Stop tap	Cbox	Control box
Er	Earth rod	TT	Tactile
Wm	Water meter	BP	Brick paved
Gas	Gas valve	CPS	Concrete paving slabs
Av	Air valve	CVR	Cover
ICU	Unidentified inspection	Rwall	Retaining wall
Wo	Wash out	TWL	Top of Wall Level
Re	Rodding eye	TCL	Tree canopy level
BB	Bollelna beacon	G	Girth
CTV	Cable tv	MG	Multi girth
Mkr	Marker post	IC	Inspection chamber
Gmkr	Gas marker post	CL	Cover level
So	SUR	IL	Invert level
Fh	Fire hydrant	UTL	Unable to lift

Rev	Date	Description	Drawn	Q. Ref

greenhatch group

- Topographical Surveys
- Site Engineering
- Utility / CCTV Surveys
- Measured Building Surveys
- 3D Laser Scanning
- Revit & BIM Models

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CLIENT
Chancerygate Group Ltd

PROJECT
Solent Road, Havant, PO9 1DQ

TITLE
Topographical Survey

SCALE	DATE
A2@ 1: 500	July 2019
DRAWN	QUALITY REF
LP	GH5411

Level datum	See note
Grid orientation	See note
Job number	34028
Drawing No.	Rev.
34028_T	0

Comments
This plan should only be used for its original purpose. Greenhatch Group accepts no responsibility for this plan if supplied to any party other than the original client.

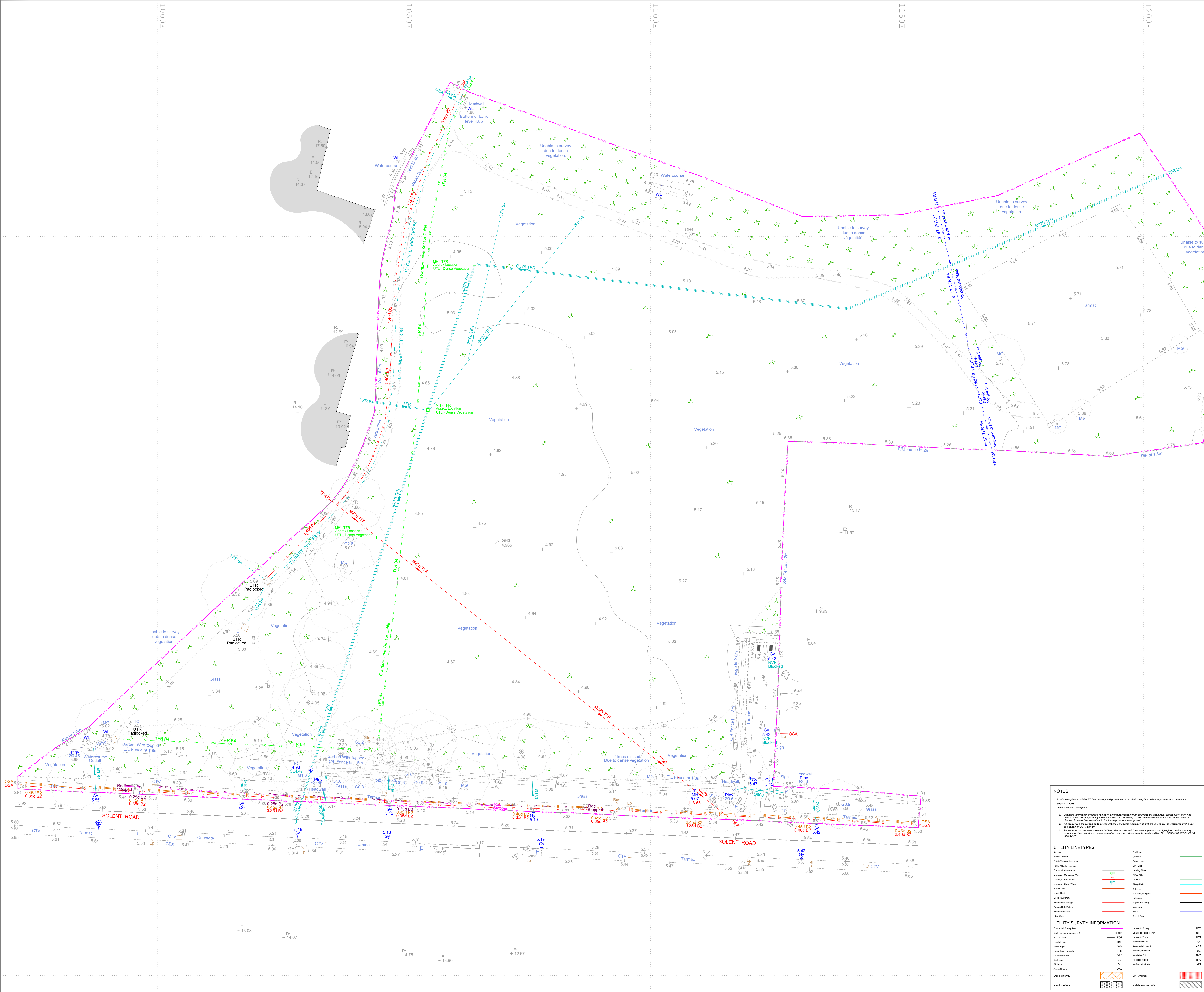
All dimensions should be checked on site prior to design and construction.

Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

Notes:

Station Information:

Station	Easting (m)	Northing (m)	Level (m)
GH1	471027.717	106076.764	5.324
GH2	471118.766	106072.894	5.529
GH3	471068.998	106137.864	4.965
GH4	471106.783	106198.564	5.395



PAS 128 : 2014

	QL-B3	POSITION OF THE UTILITY DETECTED BY ONE OF THE GEOPHYSICAL TECHNIQUES. **(EML OR GPR DETECTION WITH LIMITED CONFIDENCE IN DEPTH)**
	QL-B2	POSITION AND DEPTH OF THE UTILITY DETECTED BY ONE OF THE GEOPHYSICAL TECHNIQUES. **(EML OR GPR DETECTION WITH CONFIDENCE IN DEPTH)**
	QL-B1	POSITION AND DEPTH OF THE UTILITY DETECTED BY MULTIPLE GEOPHYSICAL TECHNIQUES. **(EML + GPR DETECTION)**

DISCLAIMER

Whilst every effort has been taken in the preparation of this drawing, the original land marks/apparatus configuration may have been altered since the survey/drawing was produced. The user shall make further enquiries and investigations to satisfy himself as to the accuracy of this drawing and position of the apparatus. The exact positions of the apparatus should be verified by the use of suitable detection devices and safe digging practices in accordance with HSG47, further advice on the location of apparatus should be recommended by the owner. No representation is made by Greenhatch Group, its agents or servants as to the accuracy, completeness, and sufficiency or otherwise of this drawing and the position of the apparatus.

All apparatus shall be treated as live unless proved otherwise by the owner. It is the users responsibility to ensure that the information on the location of apparatus is provided to all persons (either direct labour or contractors) working in proximity to the apparatus.

Rev	Date	Description	Drawn	Q. Ref.

greenhatch group

- Topographical Surveys
- Site Engineering
- Utility / CCTV Surveys
- Measured Building Surveys
- 3D Laser Scanning
- Revit & BIM Models

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CLIENT
Chancerygate Group Ltd

PROJECT
Solent Road, Havant, PO9 1DQ

TITLE
Utility Survey

SCALE	DATE
A2@ 1: 500	**July 2019**
DRAWN	QUALITY REF
RW	**GH5411**

Level datum	See note
Grid orientation	See note
Job number	34028

Drawing No.	Rev.
34028_T_UG	0

Comments
This plan should only be used for its original purpose. Greenhatch Group accepts no responsibility for this plan if supplied to any party other than the original client.

All dimensions should be checked on site prior to design and construction.

Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

Notes:

Appendix D Proposed Development Plan

NOTES

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Subject to Statutory Approvals.

Landscaping is indicative, please refer to Landscape Architect's drawing(s) for details of trees & planting

KEY

- 2M HIGH BLACK WELDMESH FENCE WITH MATCHING GATES
- CHARCOAL BLOCK PAVING
- BUFF BLOCK PAVING
- CONCRETE
- TARMAC
- EXISTING TREES TO BE RETAINED
- PROPOSED TREES

Rev	Description	Chk	Date

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tel +44(0)20 7400 2120

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www.cornisharchitects.com

RIBA Chartered Practice

cornisharchitects

Project Title.

SOLENT ROAD
HAVANT

Drawing Title.

SITE PLAN
AS PROPOSED

WORK IN PROGRESS

Drawing Status.

TOWN PLANNING

0 5 metres 40

Drawn By.	Scale.	Date.	Chk'd By.
R P	1:500 @ A2	14/10/2020	E D

Chancerygate
DEVELOPMENT AND ASSET MANAGEMENT

Drawing No.	Rev.
19003 - TP - 003	-

Appendix E Proposed Drainage Strategy Layout

POROUS PARKING -2
Contributing area = 1,100m²
Subbase storage area = 1,040m²
Permeable block to the parking bays only and subbase storage max.320mm to the carpark areas. outfall restricted by Ø100 pipe

POROUS PARKING -1
Contributing area = 1,570m²
Subbase storage area = 1,420m²
Permeable block to the parking bays only and subbase storage max.320mm to the carpark areas. outfall restricted by Ø100 pipe.

UNIT FFL= 5.70

UNIT FFL= 5.20

L.6.0m Ø375 @1: XXX(TBC)

L.27.0m Ø375 @1: XXX(TBC)

EXISTING Ø375 SW SEWER TO BE DIVERTED

BUILD NEW MANHOLE ON EXISTING Ø375 SW SEWER, IL TO BE CONFIRMED

BUILD NEW MANHOLE ON EXISTING Ø375 SW SEWER, IL TO BE CONFIRMED

8m BUFFER ZONE TO THE EDGE OF WATERCOURSE

Surface water to drain to watercourse with new Headwall

SW rising main

Flow Control (pump) restricted to 5.3 l/s (Greenfield rate)

Flood volume for 100yr+40%cc
Total Volume = 60.0 m³
accommodated within site at max. depth at 120mm, max. flood level = 5.14m

ATTENUATION TANK
Surface Water Attenuation Tank
650m² x 0.8m x 95% Porosity
Water Volume = 494 m³
Drained Area = 8,830 m²
(Designed for 30yr)

PROPOSED BUND
TOTAL VOLUME = 1,120m³
SIDE SLOPE = 1:3
MAX. HEIGHT = 1.5m

EXISTING Ø225 FW SEWER TO BE DIVERTED

Service yard and other vehicular accessed areas (3,430m²) to pass through petrol interceptor before draining to the tank.

6m EASEMENT

BUILD NEW MANHOLE ON EXISTING Ø225 FW SEWER

EXISTING WATER MAIN TO BE DIVERTED SUBJECT TO FURTHER INVESTIGATION

OFFICE

A1 A2 A3 A4

The Bosmere Medical Centre

Bibby Lampwick Stream

LEGEND

- EXISTING PUBLIC FOUL WATER PIPE
- NEW FOUL WATER PIPE
- NEW FOUL WATER INSPECTION CHAMBER
- NEW FOUL WATER MANHOLE
- EXISTING PRIVATE/PUBLIC STORM WATER PIPE
- ABANDONED EXISTING STORM WATER PIPE
- NEW DIVERTED STORM WATER PIPE
- NEW STORM WATER PIPE
- NEW STORM WATER INSPECTION CHAMBER
- NEW STORM WATER MANHOLE
- NEW PUMP
- PETROL INTERCEPTOR
- LINEAR DRAINAGE CHANNEL
- ROAD GULLY
- PROPOSED CELLULAR STORAGE
- POROUS SUBBASE
- 8m BUFFER ZONE TO THE EDGE OF WATERCOURSE
- SITE BOUNDARY

N

Rev.	Date	Description	Technician	Reviewer
P1	12.04.21	FOR PLANNING APPROVAL	RM	IL

J&L CONSULTING ltd.
E: projects@jl-consultants.com

Drawing: DRAINAGE LAYOUT

Project	Scale	Project Number	Drawing Number	Revision
SOLENT ROAD, HAVANT	1:250 @ A1 1:500 @ A3	21-012-CHA	D00	P1

Appendix F Hydraulic Calculation

ICP SUDS Mean Annual Flood

Input

Return Period (years)	2	Soil	0.400
Area (ha)	1.500	Urban	0.000
SAAR (mm)	725	Region Number	Region 7

Results l/s

QBAR Rural	5.3
QBAR Urban	5.3
Q2 years	4.7
Q1 year	4.5
Q30 years	12.1
Q100 years	17.0

Cascade Summary of Results for PP-1 for 30yr.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Tank for 30yr.SRCX	(None)

Half Drain Time : 169 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.101	0.031	0.0	0.4	0.4	13.0	O K
30 min Summer	5.115	0.045	0.0	0.9	0.9	19.2	O K
60 min Summer	5.129	0.059	0.0	1.7	1.7	25.0	O K
120 min Summer	5.138	0.068	0.0	2.0	2.0	28.9	O K
180 min Summer	5.142	0.072	0.0	2.2	2.2	30.5	O K
240 min Summer	5.144	0.074	0.0	2.3	2.3	31.5	O K
360 min Summer	5.146	0.076	0.0	2.4	2.4	32.5	O K
480 min Summer	5.147	0.077	0.0	2.4	2.4	32.8	O K
600 min Summer	5.147	0.077	0.0	2.4	2.4	32.8	O K
720 min Summer	5.146	0.076	0.0	2.4	2.4	32.5	O K
960 min Summer	5.144	0.074	0.0	2.3	2.3	31.6	O K
1440 min Summer	5.139	0.069	0.0	2.1	2.1	29.6	O K
2160 min Summer	5.133	0.063	0.0	1.9	1.9	26.9	O K
2880 min Summer	5.129	0.059	0.0	1.7	1.7	24.9	O K
4320 min Summer	5.122	0.052	0.0	1.3	1.3	22.3	O K
5760 min Summer	5.118	0.048	0.0	1.1	1.1	20.5	O K
7200 min Summer	5.115	0.045	0.0	0.9	0.9	19.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	69.220	0.0	10.2	19
30 min Summer	46.082	0.0	16.5	33
60 min Summer	29.395	0.0	25.4	62
120 min Summer	18.205	0.0	33.5	114
180 min Summer	13.601	0.0	38.4	140
240 min Summer	11.003	0.0	42.0	170
360 min Summer	8.144	0.0	47.3	238
480 min Summer	6.575	0.0	51.2	304
600 min Summer	5.565	0.0	54.4	370
720 min Summer	4.855	0.0	57.0	436
960 min Summer	3.911	0.0	61.2	566
1440 min Summer	2.880	0.0	67.0	812
2160 min Summer	2.117	0.0	74.9	1172
2880 min Summer	1.701	0.0	78.9	1532
4320 min Summer	1.247	0.0	83.5	2252
5760 min Summer	1.000	0.0	88.2	3000
7200 min Summer	0.843	0.0	89.7	3744

Cascade Summary of Results for PP-1 for 30yr.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	5.112	0.042	0.0	0.8	0.8	17.7	O K
10080 min Summer	5.109	0.039	0.0	0.7	0.7	16.6	O K
15 min Winter	5.106	0.036	0.0	0.6	0.6	15.4	O K
30 min Winter	5.122	0.052	0.0	1.3	1.3	22.3	O K
60 min Winter	5.137	0.067	0.0	2.0	2.0	28.6	O K
120 min Winter	5.148	0.078	0.0	2.5	2.5	33.1	O K
180 min Winter	5.151	0.081	0.0	2.6	2.6	34.7	O K
240 min Winter	5.153	0.083	0.0	2.8	2.8	35.4	O K
360 min Winter	5.154	0.084	0.0	2.8	2.8	35.7	O K
480 min Winter	5.153	0.083	0.0	2.7	2.7	35.3	O K
600 min Winter	5.151	0.081	0.0	2.6	2.6	34.6	O K
720 min Winter	5.149	0.079	0.0	2.5	2.5	33.7	O K
960 min Winter	5.145	0.075	0.0	2.3	2.3	31.9	O K
1440 min Winter	5.137	0.067	0.0	2.0	2.0	28.7	O K
2160 min Winter	5.129	0.059	0.0	1.7	1.7	25.2	O K
2880 min Winter	5.124	0.054	0.0	1.4	1.4	23.1	O K
4320 min Winter	5.118	0.048	0.0	1.0	1.0	20.4	O K
5760 min Winter	5.113	0.043	0.0	0.8	0.8	18.1	O K
7200 min Winter	5.109	0.039	0.0	0.7	0.7	16.5	O K
8640 min Winter	5.106	0.036	0.0	0.6	0.6	15.3	O K
10080 min Winter	5.104	0.034	0.0	0.5	0.5	14.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.733	0.0	90.4	4488
10080 min Summer	0.651	0.0	90.2	5152
15 min Winter	69.220	0.0	12.5	19
30 min Winter	46.082	0.0	19.7	32
60 min Winter	29.395	0.0	29.6	60
120 min Winter	18.205	0.0	38.6	114
180 min Winter	13.601	0.0	44.1	142
240 min Winter	11.003	0.0	48.2	178
360 min Winter	8.144	0.0	54.1	252
480 min Winter	6.575	0.0	58.6	324
600 min Winter	5.565	0.0	62.2	392
720 min Winter	4.855	0.0	65.2	462
960 min Winter	3.911	0.0	70.0	596
1440 min Winter	2.880	0.0	76.8	850
2160 min Winter	2.117	0.0	85.7	1208
2880 min Winter	1.701	0.0	90.5	1560
4320 min Winter	1.247	0.0	96.3	2332
5760 min Winter	1.000	0.0	102.0	3056
7200 min Winter	0.843	0.0	104.4	3816
8640 min Winter	0.733	0.0	105.8	4560
10080 min Winter	0.651	0.0	106.4	5248

Cascade Rainfall Details for PP-1 for 30yr.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.157

Time (mins) From:	To:	Area (ha)
0	4	0.157

Cascade Model Details for PP-1 for 30yr.SRCX

Storage is Online Cover Level (m) 5.520

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	32.0
Membrane Percolation (mm/hr)	1000	Length (m)	44.4
Max Percolation (l/s)	394.7	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	5.070	Membrane Depth (m)	0

Pipe Outflow Control

Diameter (m)	0.100	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	10.000	Upstream Invert Level (m)	5.070
Roughness k (mm)	0.600		

Cascade Summary of Results for PP-2 for 30yr.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Tank for 30yr.SRCX	(None)

Half Drain Time : 137 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	4.829	0.029	0.0	0.4	0.4	8.9	O K
30 min Summer	4.842	0.042	0.0	0.8	0.8	13.1	O K
60 min Summer	4.854	0.054	0.0	1.4	1.4	16.9	O K
120 min Summer	4.862	0.062	0.0	1.8	1.8	19.2	O K
180 min Summer	4.865	0.065	0.0	1.9	1.9	20.2	O K
240 min Summer	4.867	0.067	0.0	2.0	2.0	20.8	O K
360 min Summer	4.868	0.068	0.0	2.1	2.1	21.3	O K
480 min Summer	4.868	0.068	0.0	2.1	2.1	21.3	O K
600 min Summer	4.868	0.068	0.0	2.0	2.0	21.1	O K
720 min Summer	4.867	0.067	0.0	2.0	2.0	20.8	O K
960 min Summer	4.864	0.064	0.0	1.9	1.9	20.0	O K
1440 min Summer	4.860	0.060	0.0	1.7	1.7	18.6	O K
2160 min Summer	4.854	0.054	0.0	1.4	1.4	17.0	O K
2880 min Summer	4.851	0.051	0.0	1.2	1.2	15.8	O K
4320 min Summer	4.845	0.045	0.0	0.9	0.9	14.0	O K
5760 min Summer	4.840	0.040	0.0	0.8	0.8	12.6	O K
7200 min Summer	4.837	0.037	0.0	0.7	0.7	11.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	69.220	0.0	7.3	19
30 min Summer	46.082	0.0	11.9	33
60 min Summer	29.395	0.0	17.9	62
120 min Summer	18.205	0.0	23.5	100
180 min Summer	13.601	0.0	27.0	130
240 min Summer	11.003	0.0	29.5	162
360 min Summer	8.144	0.0	33.2	230
480 min Summer	6.575	0.0	36.0	296
600 min Summer	5.565	0.0	38.2	362
720 min Summer	4.855	0.0	40.1	426
960 min Summer	3.911	0.0	43.0	550
1440 min Summer	2.880	0.0	47.1	794
2160 min Summer	2.117	0.0	52.3	1164
2880 min Summer	1.701	0.0	55.1	1528
4320 min Summer	1.247	0.0	58.2	2252
5760 min Summer	1.000	0.0	61.2	3000
7200 min Summer	0.843	0.0	62.2	3744

Cascade Summary of Results for PP-2 for 30yr.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	4.835	0.035	0.0	0.6	0.6	10.8	O K
10080 min Summer	4.833	0.033	0.0	0.5	0.5	10.3	O K
15 min Winter	4.834	0.034	0.0	0.5	0.5	10.5	O K
30 min Winter	4.849	0.049	0.0	1.1	1.1	15.3	O K
60 min Winter	4.862	0.062	0.0	1.8	1.8	19.3	O K
120 min Winter	4.870	0.070	0.0	2.1	2.1	21.8	O K
180 min Winter	4.873	0.073	0.0	2.3	2.3	22.9	O K
240 min Winter	4.875	0.075	0.0	2.3	2.3	23.2	O K
360 min Winter	4.874	0.074	0.0	2.3	2.3	23.0	O K
480 min Winter	4.872	0.072	0.0	2.2	2.2	22.5	O K
600 min Winter	4.870	0.070	0.0	2.1	2.1	21.8	O K
720 min Winter	4.868	0.068	0.0	2.0	2.0	21.1	O K
960 min Winter	4.863	0.063	0.0	1.9	1.9	19.7	O K
1440 min Winter	4.857	0.057	0.0	1.5	1.5	17.7	O K
2160 min Winter	4.851	0.051	0.0	1.2	1.2	15.8	O K
2880 min Winter	4.847	0.047	0.0	1.0	1.0	14.5	O K
4320 min Winter	4.840	0.040	0.0	0.7	0.7	12.3	O K
5760 min Winter	4.835	0.035	0.0	0.6	0.6	11.0	O K
7200 min Winter	4.833	0.033	0.0	0.5	0.5	10.1	O K
8640 min Winter	4.830	0.030	0.0	0.4	0.4	9.4	O K
10080 min Winter	4.828	0.028	0.0	0.4	0.4	8.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.733	0.0	62.5	4416
10080 min Summer	0.651	0.0	62.3	5152
15 min Winter	69.220	0.0	9.0	18
30 min Winter	46.082	0.0	14.1	32
60 min Winter	29.395	0.0	20.8	60
120 min Winter	18.205	0.0	27.1	100
180 min Winter	13.601	0.0	31.0	136
240 min Winter	11.003	0.0	33.9	172
360 min Winter	8.144	0.0	38.0	244
480 min Winter	6.575	0.0	41.2	314
600 min Winter	5.565	0.0	43.7	380
720 min Winter	4.855	0.0	45.8	446
960 min Winter	3.911	0.0	49.2	572
1440 min Winter	2.880	0.0	53.9	822
2160 min Winter	2.117	0.0	59.9	1188
2880 min Winter	1.701	0.0	63.2	1560
4320 min Winter	1.247	0.0	67.2	2292
5760 min Winter	1.000	0.0	70.9	3056
7200 min Winter	0.843	0.0	72.5	3712
8640 min Winter	0.733	0.0	73.4	4504
10080 min Winter	0.651	0.0	73.7	5240

Cascade Rainfall Details for PP-2 for 30yr.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.110

Time (mins) From:	To:	Area (ha)
0	4	0.110

Cascade Model Details for PP-2 for 30yr.SRCX

Storage is Online Cover Level (m) 5.250

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	17.6
Membrane Percolation (mm/hr)	1000	Length (m)	59.0
Max Percolation (l/s)	288.4	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	4.800	Membrane Depth (m)	0

Pipe Outflow Control

Diameter (m)	0.100	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	10.000	Upstream Invert Level (m)	4.800
Roughness k (mm)	0.600		

Cascade Summary of Results for Tank for 30yr.SRCX

	Upstream Structures	Outflow To	Overflow To
PP-1 for 30yr.SRCX		(None)	(None)
PP-2 for 30yr.SRCX			

Half Drain Time : 393 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.127	0.127	0.0	3.4	3.4	78.5	O K
30 min Summer	3.167	0.167	0.0	4.4	4.4	103.4	O K
60 min Summer	3.210	0.210	0.0	5.3	5.3	129.9	O K
120 min Summer	3.257	0.257	0.0	5.3	5.3	158.7	O K
180 min Summer	3.284	0.284	0.0	5.3	5.3	175.4	O K
240 min Summer	3.302	0.302	0.0	5.3	5.3	186.2	O K
360 min Summer	3.321	0.321	0.0	5.3	5.3	198.5	O K
480 min Summer	3.329	0.329	0.0	5.3	5.3	203.2	O K
600 min Summer	3.332	0.332	0.0	5.3	5.3	205.2	O K
720 min Summer	3.334	0.334	0.0	5.3	5.3	206.1	O K
960 min Summer	3.333	0.333	0.0	5.3	5.3	205.7	O K
1440 min Summer	3.324	0.324	0.0	5.3	5.3	199.8	O K
2160 min Summer	3.299	0.299	0.0	5.3	5.3	184.8	O K
2880 min Summer	3.271	0.271	0.0	5.3	5.3	167.6	O K
4320 min Summer	3.221	0.221	0.0	5.3	5.3	136.7	O K
5760 min Summer	3.191	0.191	0.0	5.1	5.1	117.7	O K
7200 min Summer	3.171	0.171	0.0	4.5	4.5	105.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	69.220	0.0	93.5	19
30 min Summer	46.082	0.0	129.4	33
60 min Summer	29.395	0.0	178.7	64
120 min Summer	18.205	0.0	224.7	124
180 min Summer	13.601	0.0	253.3	182
240 min Summer	11.003	0.0	274.2	242
360 min Summer	8.144	0.0	305.4	362
480 min Summer	6.575	0.0	329.3	466
600 min Summer	5.565	0.0	348.5	522
720 min Summer	4.855	0.0	364.7	586
960 min Summer	3.911	0.0	391.1	712
1440 min Summer	2.880	0.0	428.7	972
2160 min Summer	2.117	0.0	479.5	1364
2880 min Summer	1.701	0.0	511.3	1756
4320 min Summer	1.247	0.0	555.9	2464
5760 min Summer	1.000	0.0	593.5	3168
7200 min Summer	0.843	0.0	619.4	3896

Cascade Summary of Results for Tank for 30yr.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	3.155	0.155	0.0	4.1	4.1	95.8	O K
10080 min Summer	3.143	0.143	0.0	3.8	3.8	88.0	O K
15 min Winter	3.143	0.143	0.0	3.8	3.8	88.0	O K
30 min Winter	3.188	0.188	0.0	5.0	5.0	116.2	O K
60 min Winter	3.238	0.238	0.0	5.3	5.3	146.9	O K
120 min Winter	3.292	0.292	0.0	5.3	5.3	180.6	O K
180 min Winter	3.325	0.325	0.0	5.3	5.3	200.7	O K
240 min Winter	3.347	0.347	0.0	5.3	5.3	214.1	O K
360 min Winter	3.373	0.373	0.0	5.3	5.3	230.6	O K
480 min Winter	3.386	0.386	0.0	5.3	5.3	238.6	O K
600 min Winter	3.390	0.390	0.0	5.3	5.3	241.1	O K
720 min Winter	3.389	0.389	0.0	5.3	5.3	240.3	O K
960 min Winter	3.384	0.384	0.0	5.3	5.3	236.9	O K
1440 min Winter	3.363	0.363	0.0	5.3	5.3	224.1	O K
2160 min Winter	3.317	0.317	0.0	5.3	5.3	196.0	O K
2880 min Winter	3.270	0.270	0.0	5.3	5.3	166.8	O K
4320 min Winter	3.200	0.200	0.0	5.3	5.3	123.4	O K
5760 min Winter	3.170	0.170	0.0	4.5	4.5	104.7	O K
7200 min Winter	3.147	0.147	0.0	3.9	3.9	91.0	O K
8640 min Winter	3.131	0.131	0.0	3.5	3.5	80.6	O K
10080 min Winter	3.118	0.118	0.0	3.1	3.1	72.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	0.733	0.0	640.8	4616
10080 min Summer	0.651	0.0	658.3	5344
15 min Winter	69.220	0.0	106.5	19
30 min Winter	46.082	0.0	146.9	33
60 min Winter	29.395	0.0	202.0	62
120 min Winter	18.205	0.0	253.6	122
180 min Winter	13.601	0.0	285.7	182
240 min Winter	11.003	0.0	309.1	240
360 min Winter	8.144	0.0	344.1	356
480 min Winter	6.575	0.0	370.9	468
600 min Winter	5.565	0.0	392.5	572
720 min Winter	4.855	0.0	410.7	660
960 min Winter	3.911	0.0	440.2	762
1440 min Winter	2.880	0.0	482.3	1052
2160 min Winter	2.117	0.0	540.3	1468
2880 min Winter	1.701	0.0	576.4	1848
4320 min Winter	1.247	0.0	627.5	2508
5760 min Winter	1.000	0.0	670.4	3232
7200 min Winter	0.843	0.0	700.6	3968
8640 min Winter	0.733	0.0	725.8	4736
10080 min Winter	0.651	0.0	746.6	5440

Cascade Rainfall Details for Tank for 30yr.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.617

Time (mins) From:	To:	Area (ha)
0	4	0.617

Cascade Model Details for Tank for 30yr.SRCX

Storage is Online Cover Level (m) 5.000

Cellular Storage Structure

Invert Level (m) 3.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	650.0	0.0	0.801	0.0	0.0
0.800	650.0	0.0			

Pump Outflow Control

Invert Level (m) 3.000

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.200	5.3000	0.400	5.3000	0.600	5.3000	0.800	5.3000

Cascade Summary of Results for PP-1 for 100yr+40%cc.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Tank for 100yr+40%cc.SRCX	(None)

Half Drain Time : 140 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	5.138	0.068	0.0	2.0	2.0	28.8	O K
30 min Summer	5.163	0.093	0.0	3.3	3.3	39.7	O K
60 min Summer	5.185	0.115	0.0	4.5	4.5	48.9	O K
120 min Summer	5.199	0.129	0.0	4.9	4.9	55.1	O K
180 min Summer	5.206	0.136	0.0	5.1	5.1	57.8	O K
240 min Summer	5.208	0.138	0.0	5.1	5.1	58.8	O K
360 min Summer	5.209	0.139	0.0	5.1	5.1	59.1	O K
480 min Summer	5.207	0.137	0.0	5.1	5.1	58.3	O K
600 min Summer	5.203	0.133	0.0	5.0	5.0	56.9	O K
720 min Summer	5.200	0.130	0.0	4.9	4.9	55.3	O K
960 min Summer	5.192	0.122	0.0	4.7	4.7	52.0	O K
1440 min Summer	5.179	0.109	0.0	4.3	4.3	46.4	O K
2160 min Summer	5.166	0.096	0.0	3.5	3.5	41.0	O K
2880 min Summer	5.157	0.087	0.0	3.0	3.0	37.1	O K
4320 min Summer	5.144	0.074	0.0	2.3	2.3	31.4	O K
5760 min Summer	5.135	0.065	0.0	1.9	1.9	27.7	O K
7200 min Summer	5.129	0.059	0.0	1.7	1.7	25.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	125.353	0.0	26.1	18
30 min Summer	84.267	0.0	38.6	33
60 min Summer	54.074	0.0	54.4	60
120 min Summer	33.506	0.0	69.4	98
180 min Summer	24.949	0.0	78.4	130
240 min Summer	20.093	0.0	84.7	164
360 min Summer	14.773	0.0	94.0	232
480 min Summer	11.871	0.0	101.0	298
600 min Summer	10.010	0.0	106.6	364
720 min Summer	8.703	0.0	111.3	428
960 min Summer	6.973	0.0	118.8	556
1440 min Summer	5.093	0.0	129.3	794
2160 min Summer	3.711	0.0	142.4	1168
2880 min Summer	2.961	0.0	150.1	1528
4320 min Summer	2.150	0.0	159.7	2252
5760 min Summer	1.711	0.0	168.5	2992
7200 min Summer	1.432	0.0	172.9	3680

Cascade Summary of Results for PP-1 for 100yr+40%cc.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	5.125	0.055	0.0	1.5	1.5	23.6	O K
10080 min Summer	5.123	0.053	0.0	1.3	1.3	22.4	O K
15 min Winter	5.148	0.078	0.0	2.5	2.5	33.1	O K
30 min Winter	5.176	0.106	0.0	4.1	4.1	45.2	O K
60 min Winter	5.201	0.131	0.0	4.9	4.9	55.9	O K
120 min Winter	5.217	0.147	0.0	5.3	5.3	62.7	O K
180 min Winter	5.223	0.153	0.0	5.5	5.5	65.1	Flood Risk
240 min Winter	5.223	0.153	0.0	5.5	5.5	65.4	Flood Risk
360 min Winter	5.220	0.150	0.0	5.4	5.4	64.0	Flood Risk
480 min Winter	5.214	0.144	0.0	5.3	5.3	61.5	O K
600 min Winter	5.208	0.138	0.0	5.1	5.1	58.6	O K
720 min Winter	5.201	0.131	0.0	4.9	4.9	55.8	O K
960 min Winter	5.189	0.119	0.0	4.6	4.6	50.6	O K
1440 min Winter	5.173	0.103	0.0	3.9	3.9	43.7	O K
2160 min Winter	5.158	0.088	0.0	3.0	3.0	37.4	O K
2880 min Winter	5.148	0.078	0.0	2.5	2.5	33.1	O K
4320 min Winter	5.133	0.063	0.0	1.9	1.9	27.0	O K
5760 min Winter	5.126	0.056	0.0	1.5	1.5	23.9	O K
7200 min Winter	5.122	0.052	0.0	1.3	1.3	22.0	O K
8640 min Winter	5.119	0.049	0.0	1.1	1.1	20.7	O K
10080 min Winter	5.116	0.046	0.0	1.0	1.0	19.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.240	0.0	176.1	4408
10080 min Summer	1.098	0.0	178.0	5144
15 min Winter	125.353	0.0	30.5	18
30 min Winter	84.267	0.0	44.4	32
60 min Winter	54.074	0.0	62.0	60
120 min Winter	33.506	0.0	78.8	110
180 min Winter	24.949	0.0	89.0	138
240 min Winter	20.093	0.0	96.0	176
360 min Winter	14.773	0.0	106.5	250
480 min Winter	11.871	0.0	114.4	320
600 min Winter	10.010	0.0	120.8	388
720 min Winter	8.703	0.0	126.1	454
960 min Winter	6.973	0.0	134.6	578
1440 min Winter	5.093	0.0	146.6	822
2160 min Winter	3.711	0.0	161.3	1192
2880 min Winter	2.961	0.0	170.2	1560
4320 min Winter	2.150	0.0	181.7	2292
5760 min Winter	1.711	0.0	191.9	2976
7200 min Winter	1.432	0.0	197.5	3680
8640 min Winter	1.240	0.0	201.8	4408
10080 min Winter	1.098	0.0	204.6	5240

Cascade Rainfall Details for PP-1 for 100yr+40%cc.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.157

Time (mins) From:	To:	Area (ha)
0	4	0.157

Cascade Model Details for PP-1 for 100yr+40%cc.SRCX

Storage is Online Cover Level (m) 5.520

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	32.0
Membrane Percolation (mm/hr)	1000	Length (m)	44.4
Max Percolation (l/s)	394.7	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	5.070	Membrane Depth (m)	0

Pipe Outflow Control

Diameter (m)	0.100	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	10.000	Upstream Invert Level (m)	5.070
Roughness k (mm)	0.600		

Cascade Summary of Results for PP-2 for 100yr+40%cc.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	Tank for 100yr+40%cc.SRCX	(None)

Half Drain Time : 103 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	4.864	0.064	0.0	1.9	1.9	19.8	O K
30 min Summer	4.887	0.087	0.0	3.0	3.0	27.1	O K
60 min Summer	4.905	0.105	0.0	4.0	4.0	32.7	O K
120 min Summer	4.917	0.117	0.0	4.6	4.6	36.4	O K
180 min Summer	4.921	0.121	0.0	4.7	4.7	37.8	O K
240 min Summer	4.923	0.123	0.0	4.7	4.7	38.2	O K
360 min Summer	4.921	0.121	0.0	4.7	4.7	37.7	O K
480 min Summer	4.917	0.117	0.0	4.6	4.6	36.6	O K
600 min Summer	4.913	0.113	0.0	4.5	4.5	35.3	O K
720 min Summer	4.909	0.109	0.0	4.3	4.3	34.1	O K
960 min Summer	4.903	0.103	0.0	3.9	3.9	32.0	O K
1440 min Summer	4.892	0.092	0.0	3.3	3.3	28.6	O K
2160 min Summer	4.880	0.080	0.0	2.6	2.6	25.0	O K
2880 min Summer	4.871	0.071	0.0	2.2	2.2	22.2	O K
4320 min Summer	4.860	0.060	0.0	1.7	1.7	18.7	O K
5760 min Summer	4.854	0.054	0.0	1.4	1.4	17.0	O K
7200 min Summer	4.851	0.051	0.0	1.2	1.2	15.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	125.353	0.0	18.7	18
30 min Summer	84.267	0.0	27.5	32
60 min Summer	54.074	0.0	38.2	60
120 min Summer	33.506	0.0	48.8	88
180 min Summer	24.949	0.0	55.1	122
240 min Summer	20.093	0.0	59.5	156
360 min Summer	14.773	0.0	66.0	222
480 min Summer	11.871	0.0	70.9	288
600 min Summer	10.010	0.0	74.8	350
720 min Summer	8.703	0.0	78.1	412
960 min Summer	6.973	0.0	83.4	538
1440 min Summer	5.093	0.0	90.8	780
2160 min Summer	3.711	0.0	99.6	1148
2880 min Summer	2.961	0.0	104.9	1504
4320 min Summer	2.150	0.0	111.7	2244
5760 min Summer	1.711	0.0	117.5	2944
7200 min Summer	1.432	0.0	120.5	3672

Cascade Summary of Results for PP-2 for 100yr+40%cc.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	4.848	0.048	0.0	1.0	1.0	14.8	O K
10080 min Summer	4.845	0.045	0.0	0.9	0.9	13.9	O K
15 min Winter	4.873	0.073	0.0	2.3	2.3	22.8	O K
30 min Winter	4.899	0.099	0.0	3.7	3.7	30.8	O K
60 min Winter	4.919	0.119	0.0	4.6	4.6	37.2	O K
120 min Winter	4.932	0.132	0.0	5.0	5.0	41.1	O K
180 min Winter	4.935	0.135	0.0	5.0	5.0	42.0	O K
240 min Winter	4.933	0.133	0.0	5.0	5.0	41.6	O K
360 min Winter	4.927	0.127	0.0	4.8	4.8	39.6	O K
480 min Winter	4.920	0.120	0.0	4.6	4.6	37.3	O K
600 min Winter	4.913	0.113	0.0	4.4	4.4	35.1	O K
720 min Winter	4.907	0.107	0.0	4.2	4.2	33.4	O K
960 min Winter	4.898	0.098	0.0	3.6	3.6	30.5	O K
1440 min Winter	4.885	0.085	0.0	2.9	2.9	26.4	O K
2160 min Winter	4.871	0.071	0.0	2.2	2.2	22.1	O K
2880 min Winter	4.862	0.062	0.0	1.8	1.8	19.3	O K
4320 min Winter	4.853	0.053	0.0	1.3	1.3	16.5	O K
5760 min Winter	4.848	0.048	0.0	1.1	1.1	15.0	O K
7200 min Winter	4.844	0.044	0.0	0.9	0.9	13.7	O K
8640 min Winter	4.840	0.040	0.0	0.8	0.8	12.6	O K
10080 min Winter	4.838	0.038	0.0	0.7	0.7	11.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.240	0.0	122.7	4408
10080 min Summer	1.098	0.0	123.9	5144
15 min Winter	125.353	0.0	21.8	18
30 min Winter	84.267	0.0	31.6	32
60 min Winter	54.074	0.0	43.6	58
120 min Winter	33.506	0.0	55.4	94
180 min Winter	24.949	0.0	62.5	132
240 min Winter	20.093	0.0	67.4	168
360 min Winter	14.773	0.0	74.8	238
480 min Winter	11.871	0.0	80.3	304
600 min Winter	10.010	0.0	84.7	368
720 min Winter	8.703	0.0	88.4	428
960 min Winter	6.973	0.0	94.4	558
1440 min Winter	5.093	0.0	102.9	808
2160 min Winter	3.711	0.0	112.9	1172
2880 min Winter	2.961	0.0	119.1	1532
4320 min Winter	2.150	0.0	127.1	2252
5760 min Winter	1.711	0.0	133.9	2944
7200 min Winter	1.432	0.0	137.7	3752
8640 min Winter	1.240	0.0	140.6	4496
10080 min Winter	1.098	0.0	142.6	5144

Cascade Rainfall Details for PP-2 for 100yr+40%cc.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.110

Time (mins) From:	To:	Area (ha)
0	4	0.110

Cascade Model Details for PP-2 for 100yr+40%cc.SRCX

Storage is Online Cover Level (m) 5.250

Porous Car Park Structure

Infiltration Coefficient Base (m/hr)	0.00000	Width (m)	17.6
Membrane Percolation (mm/hr)	1000	Length (m)	59.0
Max Percolation (l/s)	288.4	Slope (1:X)	0.0
Safety Factor	2.0	Depression Storage (mm)	5
Porosity	0.30	Evaporation (mm/day)	3
Invert Level (m)	4.800	Membrane Depth (m)	0

Pipe Outflow Control

Diameter (m)	0.100	Entry Loss Coefficient	0.500
Slope (1:X)	150.0	Coefficient of Contraction	0.600
Length (m)	10.000	Upstream Invert Level (m)	4.800
Roughness k (mm)	0.600		

Cascade Summary of Results for Tank for 100yr+40%cc.SRCX

	Upstream Structures	Outflow To	Overflow To
PP-1 for 100yr+40%cc.SRCX		(None)	(None)
PP-2 for 100yr+40%cc.SRCX			

Half Drain Time : 874 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	3.232	0.232	0.0	5.3	5.3	143.5	O K
30 min Summer	3.315	0.315	0.0	5.3	5.3	194.5	O K
60 min Summer	3.416	0.416	0.0	5.3	5.3	256.7	O K
120 min Summer	3.527	0.527	0.0	5.3	5.3	325.2	O K
180 min Summer	3.592	0.592	0.0	5.3	5.3	365.3	O K
240 min Summer	3.635	0.635	0.0	5.3	5.3	392.2	O K
360 min Summer	3.695	0.695	0.0	5.3	5.3	429.3	O K
480 min Summer	3.734	0.734	0.0	5.3	5.3	453.4	O K
600 min Summer	3.757	0.757	0.0	5.3	5.3	467.2	O K
720 min Summer	3.767	0.767	0.0	5.3	5.3	473.9	O K
960 min Summer	3.768	0.768	0.0	5.3	5.3	474.1	O K
1440 min Summer	3.751	0.751	0.0	5.3	5.3	463.9	O K
2160 min Summer	3.714	0.714	0.0	5.3	5.3	440.9	O K
2880 min Summer	3.670	0.670	0.0	5.3	5.3	413.6	O K
4320 min Summer	3.577	0.577	0.0	5.3	5.3	356.1	O K
5760 min Summer	3.488	0.488	0.0	5.3	5.3	301.4	O K
7200 min Summer	3.409	0.409	0.0	5.3	5.3	252.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	125.353	0.0	182.3	19
30 min Summer	84.267	0.0	249.5	52
60 min Summer	54.074	0.0	341.8	114
120 min Summer	33.506	0.0	426.7	186
180 min Summer	24.949	0.0	477.7	240
240 min Summer	20.093	0.0	513.3	288
360 min Summer	14.773	0.0	565.9	376
480 min Summer	11.871	0.0	605.2	484
600 min Summer	10.010	0.0	636.1	602
720 min Summer	8.703	0.0	661.2	722
960 min Summer	6.973	0.0	698.9	914
1440 min Summer	5.093	0.0	737.9	1144
2160 min Summer	3.711	0.0	860.0	1528
2880 min Summer	2.961	0.0	912.1	1928
4320 min Summer	2.150	0.0	984.6	2720
5760 min Summer	1.711	0.0	1045.8	3464
7200 min Summer	1.432	0.0	1088.4	4184

Cascade Summary of Results for Tank for 100yr+40%cc.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	3.343	0.343	0.0	5.3	5.3	211.7	O K
10080 min Summer	3.289	0.289	0.0	5.3	5.3	178.4	O K
15 min Winter	3.261	0.261	0.0	5.3	5.3	161.2	O K
30 min Winter	3.358	0.358	0.0	5.3	5.3	220.9	O K
60 min Winter	3.474	0.474	0.0	5.3	5.3	292.7	O K
120 min Winter	3.600	0.600	0.0	5.3	5.3	370.4	O K
180 min Winter	3.674	0.674	0.0	5.3	5.3	416.1	O K
240 min Winter	3.724	0.724	0.0	5.3	5.3	447.0	O K
360 min Winter	3.793	0.793	0.0	5.3	5.3	489.9	O K
480 min Winter	5.024	2.024	0.0	5.3	5.3	519.1	FLOOD
600 min Winter	5.042	2.042	0.0	5.3	5.3	537.6	FLOOD
720 min Winter	5.053	2.053	0.0	5.3	5.3	548.0	FLOOD
960 min Winter	5.058	2.058	0.0	5.3	5.3	553.8	FLOOD
1440 min Winter	5.041	2.041	0.0	5.3	5.3	536.3	FLOOD
2160 min Winter	5.006	2.006	0.0	5.3	5.3	501.4	FLOOD
2880 min Winter	3.743	0.743	0.0	5.3	5.3	458.8	O K
4320 min Winter	3.596	0.596	0.0	5.3	5.3	368.0	O K
5760 min Winter	3.459	0.459	0.0	5.3	5.3	283.4	O K
7200 min Winter	3.343	0.343	0.0	5.3	5.3	211.8	O K
8640 min Winter	3.255	0.255	0.0	5.3	5.3	157.4	O K
10080 min Winter	3.201	0.201	0.0	5.3	5.3	124.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.240	0.0	1124.8	4920
10080 min Summer	1.098	0.0	1154.3	5552
15 min Winter	125.353	0.0	206.0	19
30 min Winter	84.267	0.0	280.1	73
60 min Winter	54.074	0.0	384.6	136
120 min Winter	33.506	0.0	479.5	208
180 min Winter	24.949	0.0	536.3	264
240 min Winter	20.093	0.0	575.9	310
360 min Winter	14.773	0.0	633.8	396
480 min Winter	11.871	24.9	676.5	484
600 min Winter	10.010	43.4	709.3	596
720 min Winter	8.703	53.8	735.1	708
960 min Winter	6.973	59.6	770.8	926
1440 min Winter	5.093	42.1	790.8	1256
2160 min Winter	3.711	7.2	966.2	1644
2880 min Winter	2.961	0.0	1025.1	2076
4320 min Winter	2.150	0.0	1106.9	2900
5760 min Winter	1.711	0.0	1176.9	3688
7200 min Winter	1.432	0.0	1225.8	4392
8640 min Winter	1.240	0.0	1267.5	4984
10080 min Winter	1.098	0.0	1302.0	5448

Cascade Rainfall Details for Tank for 100yr+40%cc.SRCX

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.100	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.617

Time (mins) From:	To:	Area (ha)
0	4	0.617

Cascade Model Details for Tank for 100yr+40%cc.SRCX

Storage is Online Cover Level (m) 5.000

Cellular Storage Structure

Invert Level (m) 3.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	650.0	0.0	0.801	0.0	0.0
0.800	650.0	0.0			

Pump Outflow Control

Invert Level (m) 3.000

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.200	5.3000	0.400	5.3000	0.600	5.3000	0.800	5.3000