



STUDIO11
architecture

PROPOSED RESIDENTIAL DEVELOPMENT, LAND OFF BROADGATE,
WESTON HILLS

DRAINAGE STRATEGY 622

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00	S11	KB	29.08.2024	Information	Initial Issue

Introduction

This drainage strategy report has been produced to accompany a planning application to South Holland District Council (SHDC) for a residential development on land off Broadgate, Weston Hills. This document should be read in conjunction with the Concept Drainage Strategy drawing – 622-S11-00-SI-SK-C-9000, and also the Flood Risk Assessment (FRA) undertaken by S M Hemmings.

Site Description

The proposed site covers an area of approximately 1.40 hectares, and is a greenfield site. The proposal is to erect 24 dwellings on the site. The indicative site layout and location is shown in the figure below.



Figure 1 - Proposed Site Layout

Drainage

For developments of 10 or more dwellings there is a requirement to apply sustainable drainage principles (SuDS) to the disposal of surface water from the site. Generally, the aim should be to discharge surface water as high up the following hierarchy of drainage options as reasonably practicable:

1. Into the ground (infiltration);
2. To a surface water body;
3. To a surface water sewer or highway drain;
4. To a combined sewer.

Infiltration

At this stage of the project a phase 2 ground investigation report has not been undertaken, and therefore a desktop study is being undertaken to understand the prospect of infiltration. BGS mapping shows that the bedrock of the area is 'Oxford Clay Formation - Mudstone', This natural indicates that infiltration into the bedrock is unlikely to be feasible.

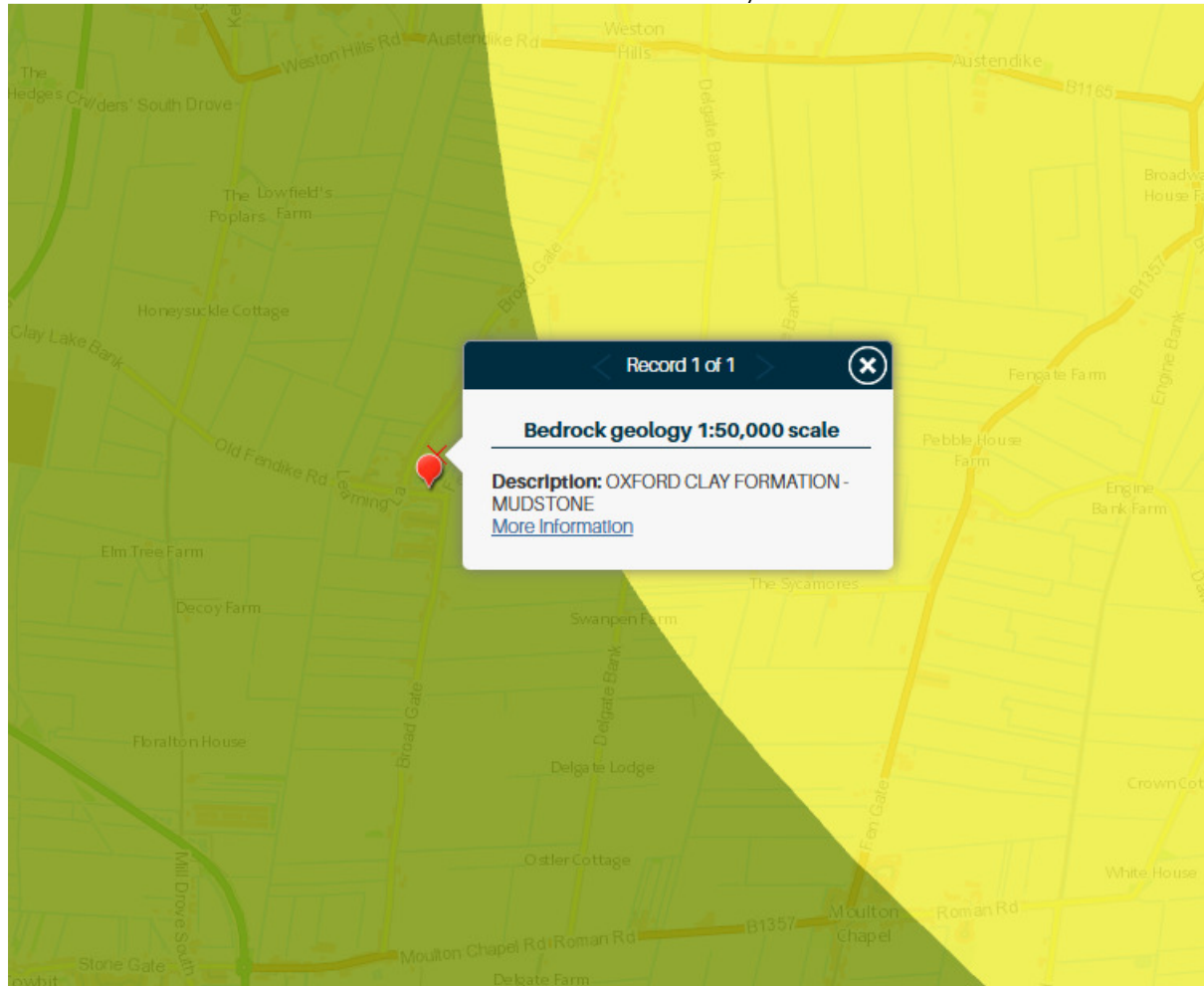


Figure 2 - Bedrock

The superficial deposits, as shown in the figure below, is shown as 'Tidal Flat Deposits – Clay and Silt'. The prospect of infiltration in this type of soil is also likely to be very limited, and is highly unlikely to be viable.

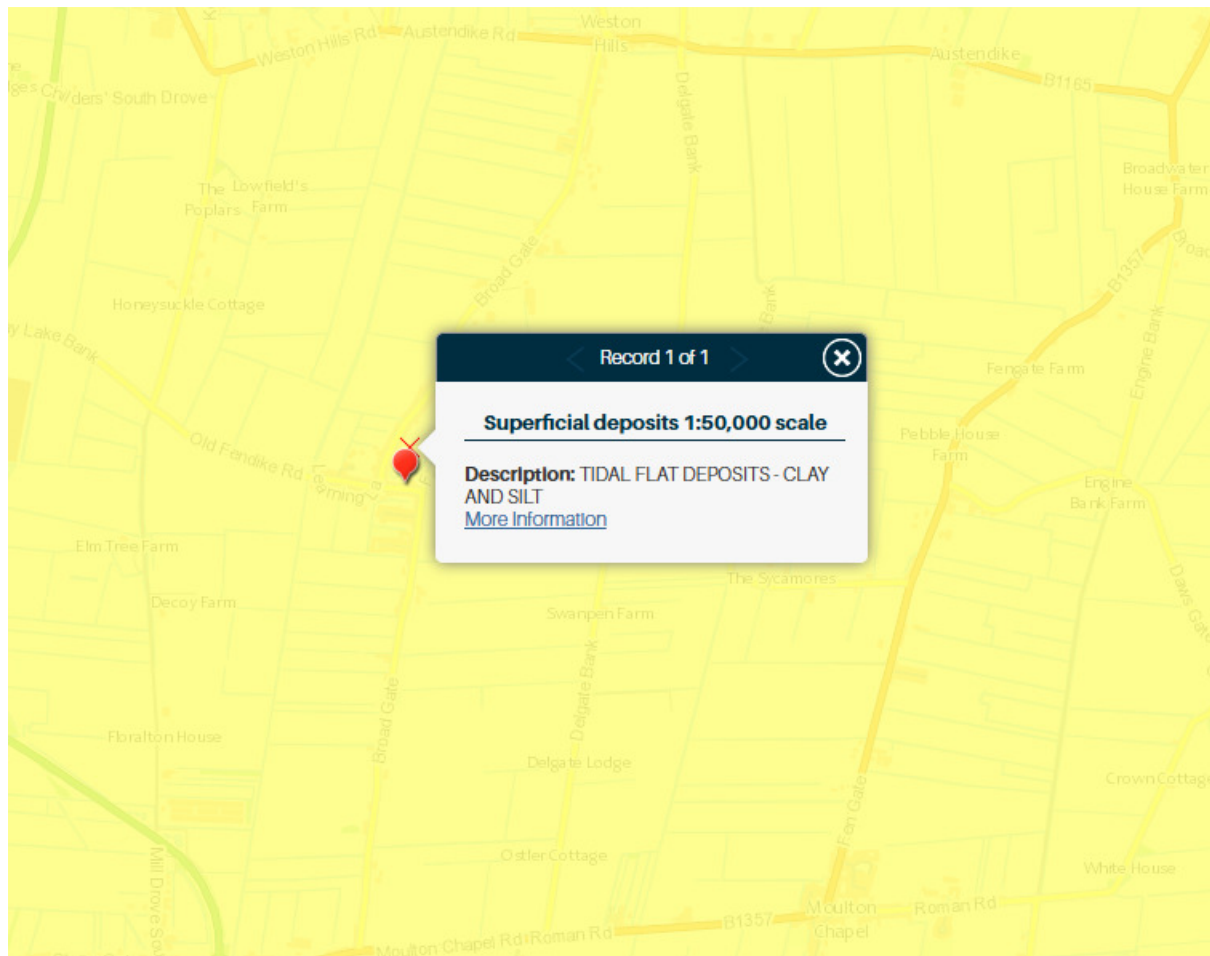


Figure 3 - Superficial Deposits

There is a publicly available borehole in proximity to the site. This confirms the superficial observations as above. The highest recorded ground water level to this area was approximately 3m below ground levels, but this was not a monitored station, just an open excavation which was sealed quickly. It is expected that the water table will be higher than this, but this will need to be investigated through the phase 2 ground investigation.

With the above factors considered, although infiltration will be tested during a phase 2 ground investigation, given local knowledge of the site and the findings of the desktop study, it is highly unlikely that infiltration will be viable for the scheme, and an alternative disposal method is being sought.

Watercourses

The site is bounded by ditches, assumed riparian, but at present there is no survey information available to these. These appear to connect into a relatively deep ditch along Fengate Drove, which appears to flow towards and connect into Delgate Drain – an IDB drain.

The site falls within the catchment of 'South Holland IDB', as shown in the figure below. The riparian (assumed) ditch, flows into the IDB drain to the east.

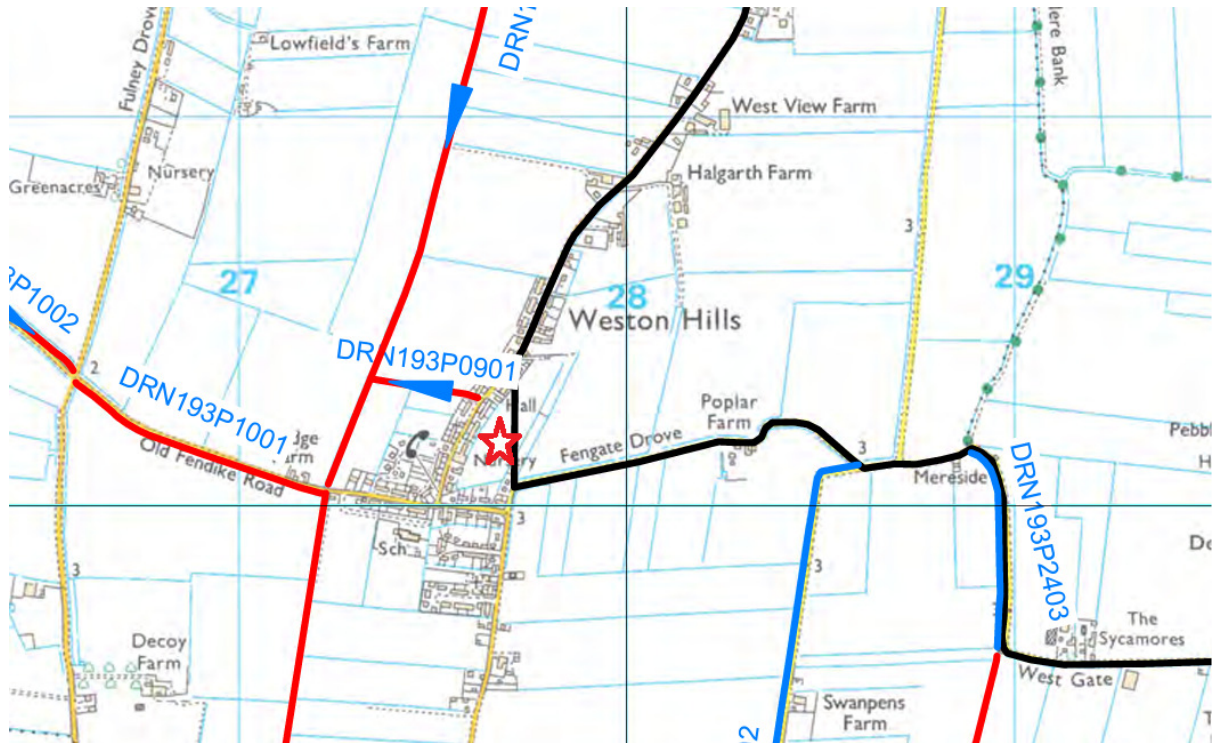


Figure 4 - IDB Map

The site will require byelaw consent for the surface water discharge and ordinary watercourse consent, both from the IDB. This will be applied for upon detailed design.

Run-off Rates

In line with current guidelines, the developed site shall not exceed the pre-development greenfield run-off rate for the Q_{BAR} event - post development. The greenfield run-off for the site has been calculated in accordance with HR Wallingford's 'Greenfield runoff rate estimation', and their guidance has been followed when entering the data. The proposed run-off from the site will therefore be restricted to a maximum of 1.0l/s. An extract of the existing greenfield runoff is shown below.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	1.02	1.02
1 in 1 year (l/s):	0.89	0.89
1 in 30 years (l/s):	2.51	2.51
1 in 100 year (l/s):	3.64	3.64
1 in 200 years (l/s):	4.3	4.3

Figure 5 - Greenfield Runoff Rates

As the actual greenfield run-off from the site and the IDB rates for contribution differs, there will be the need to apply to the IDB for a consent to discharge surface water and pay for a development contribution.

Proposed Surface Water Drainage Design

The proposed drainage layout is shown on S11 drawing 0622-S11-00-SI-SK-C-9000, which has been provided as part of the overall planning submission.

All drainage models has been simulated for the 1 in 1, 30, 100 and 100 + 40% climate change events using FSR data, with a Cv value set to 1.

A full copy of the preliminary drainage calculations can be found in appendix A of this document, and a graphical representation of the model is shown in the figure below. Please note, that some of the drainage model has been simplified for this stage of the design. The final model will be fully represented and fine-tuned.

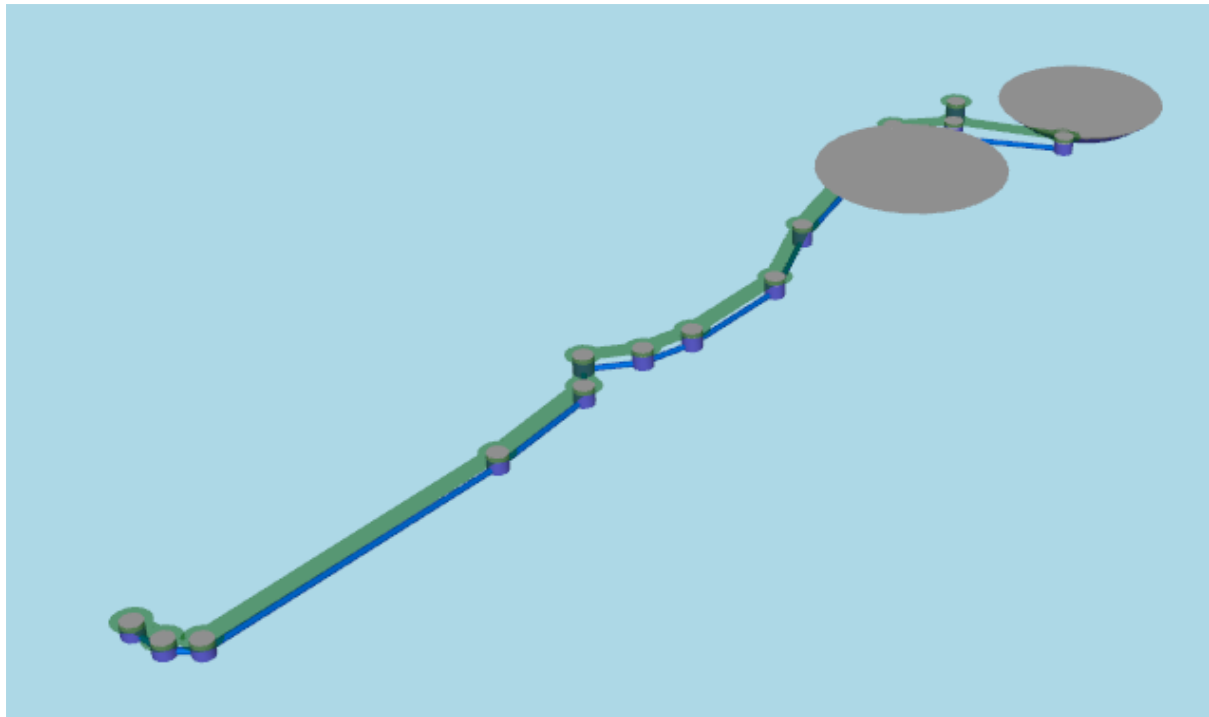


Figure 6 – Drainage Model

As outlined previously, it is assumed that infiltration is not feasible for this site, therefore the SuDS strategy for the surface water highway drainage will be achieved using the provision of surface water conveyance, cleansing and attenuation. The site layout has generally been designed to utilise a swale to collect highway and domestic water – leading into an attenuation basin, and eventual discharge into the existing ditch – although the levels will need to be established.

It is proposed the carriageway will generally be laid to a single crossfall, which will discharge into a filter strip before discharging into the swale. The filter drain will likely contain both road and domestic water, and therefore will be put forward for adoption to Anglian Water. To meet CIRIA C753's mitigation indices, the swale will undergo pre-treatment via a 'filter strip' – this is also a detail requirement of LCC. It will be proposed that the swale and filter drain is adopted by AW, although dependant on levels it may be that they solely serve highways drainage.

At a minimum the house drainage will discharge into the attenuation basin, this will provide the water quality and attenuation required for the site.

Once a full phase 2 ground investigation has been undertaken, more will be known regarding the water table for the site. If the site has a high-water table, or at least if this is within or close to the base of the filter drain, it will be proposed that below the swale will be lined with an impermeable membrane to stop below ground lateral flow of the ground water – in essence acting as a land drain. Additionally, if the filter drain is within 5m of a foundation should also be lined. Similarly, the same rules would apply with the attenuation basin.

Given the use of the filter strip, swale and attenuation basin, it is proposed that sufficient suds features are being used, and as a result the drainage from the dwellings are to discharge into traditional pipework before entering the SUDs features as mentioned above. For the purpose of the preliminary drainage strategy, only the key, typically adoptable drainage features are being shown.

The discharge into the drain – subject to byelaw consent, will be via. a new insitu headwall.

The attenuation basin has been designed to store all storms, up to and including the 1 in 100 year + 40% climate change storm events. All storms up to and including the 1 in 100 year + 40% climate change event will be stored below ground. This design ethos is in accordance with DEFRA guidance and LCC's requirements.

Given the elevation of the ditch and natural falls, it is not expected that surcharging will be an issue and therefore has not been included in the calculations. This will need to be established at detailed design, and surcharging can readily be added to the calculations.

Surface Water Drainage Summary

In summary, the surface water drainage will be to the following.

- Domestic roofwater will discharge into a piped system before discharging into the swale and attenuation basin, or alternatively just the attenuation basin.
- Domestic drives will discharge into a piped system before discharging into the swale and attenuation basin, or alternatively just the attenuation basin.
- The highways will drain into filter strip and swale to the side of the roads before discharging into the attenuation basin.
- There is a very small section of highways which cannot drain via swales, and will need to have gullies to discharge this element. This will still eventually pass through the basin so achieves a compliant SUDS scheme.
- The basin will discharge into the ordinary watercourse to the north of the site which eventually flows into the IDB drain to the west.

Urban Creep

In this instance, as the site is residential, an Urban Creep of 10% additional impermeable area has been included into the calculations. At present this has been included as a global factor, but at detailed design will be limited to private curtilages (as per CIRIA 753).

Flood Routing

The scheme has been designed so that no above ground flooding is created in the 1 in 100 year + 40% climate change + 10% urban creep storm, and therefore a plan is not required to represent the volumes, depths, velocities or extents of flooding. The design compliments the natural ground levels, and any flood water will either be cut off by the swale, free board in the attenuation basin, or rear gardens. Indicative exceedance flow routes have been provided on the strategy drawing.

Water Quality

The methods of surface water disposal mentioned above have included provisions for water quality. In accordance with CIRIA C753, the pollution hazard features for the drainage areas are;

Residential roofs	- Very low
Individual property driveways	- Low
Private access	- Low
Adoptable cul-de-sac	- Low

To remove the pollution risks, CIRIA have developed 'Pollution hazard indices' and the 'mitigation indices' that the SuDS components provide, further details of these are found in the tables below.

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydrocarbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/Industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways ¹	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways ¹	High	0.8 ²	0.8 ²	0.9 ²

TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

Type of SuDS component	Mitigation indices ¹		
	TSS	Metals	Hydrocarbons
Filter strip	0.4	0.4	0.5
Filter drain	0.4 ²	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond ⁴	0.7 ³	0.7	0.5
Wetland	0.8 ³	0.8	0.8
Proprietary treatment systems ^{5,6}	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

To deliver adequate treatment, the selected SuDS components should have a total pollution mitigation index (for each containment type) that equals or exceeds the pollution hazard index (for each contaminant type):

$$\text{Total SuDS mitigation index} \geq \text{pollution hazard index} \\ (\text{for each contaminant type}) \quad (\text{for each contaminant type})$$

Where the mitigation index of an individual component is insufficient, two components (or more) in series will be required where:

$$\text{Total SuDS mitigation index} = \text{mitigation index}_1 + 0.5 (\text{mitigation index}_2)$$

Where:

Mitigation index_n = mitigation index for component n

Provided the total SuDS mitigation index exceeds the pollution hazard indices, then sufficient water quality will be provided.

For the calculations below the hazards are represented by;

Total suspended solids	= Red
Metals	= Blue
Hydrocarbons	= Green

Roofs

0.2 0.2 0.05 = Attenuation Basin 0.5 0.5 0.6

The mitigation provided by the SUDs features exceeds all the pollution indices, therefore sufficient treatment has been provided.

Individual property driveways

0.5 0.4 0.4 = Attenuation Basin 0.5 0.5 0.6

The mitigation provided by the SUDs features exceeds all the pollution indices, therefore sufficient treatment has been provided.

Adopted Cul-de-sacs

0.5 0.4 0.4 = Filter strip 0.4 0.4 0.5 + ½ Swale 0.25 0.3 0.3 + ½ Attenuation Basin 0.25 0.25 0.3 (Total 0.9 0.95 1.1)

The mitigation provided by the SUDs features exceeds all the pollution indices, therefore sufficient treatment has been provided.

Adopted Cul-de-sacs (Gullies only)

0.5 0.4 0.4 = Attenuation Basin 0.5 0.5 0.6

The mitigation provided by the SUDs features exceeds all the pollution indices, therefore sufficient treatment has been provided.

All the methods above provide enough water quality in accordance with CIRIA's C753 document. Further evidence will need to be provided at detailed design stage.

Finished Floor Levels

The FRA has recommended that the floor levels are set a minimum of 300mm above existing ground levels. Proposed levels will be reworked to ensure part M compliance can be achieved. Additionally, it is likely that some of the FFL's will be raised beyond this to support the drainage strategy.

Foul Water

We have identified the closest Anglian Water foul water sewer which close to the entrance of the site, running down Broad Gate, the closest manhole reference is 5102. An extract of the asset map is shown below.



Figure 7 - AW Asset Map

The depth of the manhole is approximately 2.6m, and therefore a gravity connection should be possible, although this is dependant on final confirmed levels.

The connection will be subject to a section 106 agreement, although given the relatively low flow increase, it is unlikely that this will be rejected.

Conclusion

- The above drainage strategy demonstrates that the site can be drained appropriately including the use of a Sustainable Drainage System.
- The run-off rate from the developed site will be no higher than 1.0l/s for all storm events, although this is subject to detailed design of the pumping station and may need to be higher to accommodate the device.
- Discharge from the site will ultimately be to a South Holland IDB maintained drain via an ordinary watercourse (possible riparian drain).
- The landowner will need to seek clarity of the ownership of the drain to the north, and if it is outside of riparian ownership then permission will be required from the owner.
- A full maintenance strategy will be developed at the detailed design stage.
- A drainage sketch can be found on Studio 11's Concept Drainage Strategy drawing: 622-S11-00-SI-SK-C-9000.
- As the run-off from the site is being restricted to greenfield run-off the risk of flooding as a result of the site's development will not increase.
- No flooding is currently anticipated for the 1 in 100 year + 40% climate change event.
- Finished floor levels will be set at a minimum of 300mm above the existing highest ground levels, in accordance with the FRA.

Appendices

Appendix A - Calculations

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	1	Maximum Rainfall (mm/hr)	50.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.400	Preferred Cover Depth (m)	1.200
CV	1.000	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
S1	0.048	5.00	3.000	1200	527386.204	329277.954	1.100
S2	0.019	5.00	3.000	1200	527401.808	329270.893	1.171
S3	0.019	5.00	3.000	1200	527409.266	329262.014	1.219
S4			3.000	1200	527414.331	329248.047	1.281
S5	0.091	5.00	3.000	1200	527412.822	329240.224	1.314
S6	0.056	5.00	3.000	1200	527363.186	329231.220	1.100
S7	0.047	5.00	3.000	1200	527384.879	329232.476	1.191
S9	0.055	5.00	3.000	1200	527396.965	329230.272	1.265
S10	0.076	5.00	3.000	1350	527408.115	329233.520	1.423
Hydrobrake			3.000	1350	527424.257	329207.851	1.551
Headwall 1			3.000	1350	527413.706	329225.471	1.464
Headwall 2	0.044	5.00	3.000	1200	527418.936	329213.303	1.500
Headwall 3			3.000	1350	527427.000	329204.218	1.581
S8	0.064	5.00	3.000	1200	527397.176	329190.734	1.100

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	S1	S2	17.127	0.600	1.900	1.829	0.071	240.0	300	5.28	50.0
1.001	S2	S3	11.596	0.600	1.829	1.781	0.048	240.0	300	5.47	50.0
1.002	S3	S4	14.857	0.600	1.781	1.719	0.062	240.0	300	5.72	50.0
1.003	S4	S5	7.967	0.600	1.719	1.686	0.033	240.0	300	5.85	50.0
3.000	S6	S7	21.729	0.600	1.900	1.809	0.091	240.0	300	5.36	50.0
3.001	S7	S9	12.285	0.600	1.809	1.758	0.051	240.0	300	5.56	50.0
2.001	S9	S10	11.613	0.600	1.735	1.687	0.048	240.0	300	5.84	50.0
1.004	S5	S10	8.191	0.600	1.686	1.652	0.034	240.0	300	5.99	50.0
1.005	S10	Headwall 1	9.800	0.600	1.577	1.536	0.041	239.0	375	6.13	49.9

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	1.010	71.4	8.7	0.800	0.871	0.048	0.0	70	0.688
1.001	1.010	71.4	12.1	0.871	0.919	0.067	0.0	83	0.756
1.002	1.010	71.4	15.5	0.919	0.981	0.086	0.0	95	0.812
1.003	1.010	71.4	15.5	0.981	1.014	0.086	0.0	95	0.812
3.000	1.010	71.4	10.1	0.800	0.891	0.056	0.0	76	0.720
3.001	1.010	71.4	18.6	0.891	0.942	0.103	0.0	104	0.853
2.001	1.010	71.4	40.1	0.965	1.013	0.222	0.0	161	1.038
1.004	1.010	71.4	32.0	1.014	1.048	0.177	0.0	140	0.982
1.005	1.167	128.9	85.6	1.048	1.089	0.475	0.0	224	1.245

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
4.000	Headwall 2	Hydrobrake	7.618	0.600	1.500	1.449	0.051	150.0	150	5.16	50.0
4.001	Hydrobrake	Headwall 3	4.552	0.600	1.449	1.419	0.030	150.0	150	5.25	50.0
2.000	S8	S9	39.539	0.600	1.900	1.735	0.165	240.0	300	5.65	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
4.000	0.818	14.5	8.0	1.350	1.401	0.044	0.0	79	0.837
4.001	0.818	14.5	8.0	1.401	1.431	0.044	0.0	79	0.837
2.000	1.010	71.4	11.6	0.800	0.965	0.064	0.0	81	0.747

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	17.127	240.0	300	Circular	3.000	1.900	0.800	3.000	1.829	0.871
1.001	11.596	240.0	300	Circular	3.000	1.829	0.871	3.000	1.781	0.919
1.002	14.857	240.0	300	Circular	3.000	1.781	0.919	3.000	1.719	0.981
1.003	7.967	240.0	300	Circular	3.000	1.719	0.981	3.000	1.686	1.014
3.000	21.729	240.0	300	Circular	3.000	1.900	0.800	3.000	1.809	0.891
3.001	12.285	240.0	300	Circular	3.000	1.809	0.891	3.000	1.758	0.942
2.001	11.613	240.0	300	Circular	3.000	1.735	0.965	3.000	1.687	1.013
1.004	8.191	240.0	300	Circular	3.000	1.686	1.014	3.000	1.652	1.048
1.005	9.800	239.0	375	Circular	3.000	1.577	1.048	3.000	1.536	1.089
4.000	7.618	150.0	150	Circular	3.000	1.500	1.350	3.000	1.449	1.401
4.001	4.552	150.0	150	Circular	3.000	1.449	1.401	3.000	1.419	1.431
2.000	39.539	240.0	300	Circular	3.000	1.900	0.800	3.000	1.735	0.965

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	S1	1200	Manhole	1 Adoptable	S2	1200	Manhole	1 Adoptable
1.001	S2	1200	Manhole	1 Adoptable	S3	1200	Manhole	1 Adoptable
1.002	S3	1200	Manhole	1 Adoptable	S4	1200	Manhole	1 Adoptable
1.003	S4	1200	Manhole	1 Adoptable	S5	1200	Manhole	1 Adoptable
3.000	S6	1200	Manhole	1 Adoptable	S7	1200	Manhole	1 Adoptable
3.001	S7	1200	Manhole	1 Adoptable	S9	1200	Manhole	1 Adoptable
2.001	S9	1200	Manhole	1 Adoptable	S10	1350	Manhole	1 Adoptable
1.004	S5	1200	Manhole	1 Adoptable	S10	1350	Manhole	1 Adoptable
1.005	S10	1350	Manhole	1 Adoptable	Headwall 1	1350	Manhole	1 Adoptable
4.000	Headwall 2	1200	Manhole	1 Adoptable	Hydrobrake	1350	Manhole	1 Adoptable
4.001	Hydrobrake	1350	Manhole	1 Adoptable	Headwall 3	1350	Manhole	1 Adoptable
2.000	S8	1200	Manhole	1 Adoptable	S9	1200	Manhole	1 Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
S1	527386.204	329277.954	3.000	1.100	1200		0 1.000	1.900	300

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)	
S2	527401.808	329270.893	3.000	1.171	1200		1	1.000	1.829	300
							0	1.001	1.829	300
S3	527409.266	329262.014	3.000	1.219	1200		1	1.001	1.781	300
							0	1.002	1.781	300
S4	527414.331	329248.047	3.000	1.281	1200		1	1.002	1.719	300
							0	1.003	1.719	300
S5	527412.822	329240.224	3.000	1.314	1200		1	1.003	1.686	300
							0	1.004	1.686	300
S6	527363.186	329231.220	3.000	1.100	1200		0	3.000	1.900	300
S7	527384.879	329232.476	3.000	1.191	1200		1	3.000	1.809	300
							0	3.001	1.809	300
S9	527396.965	329230.272	3.000	1.265	1200		1	3.001	1.758	300
							2	2.000	1.735	300
							0	2.001	1.735	300
S10	527408.115	329233.520	3.000	1.423	1350		1	2.001	1.687	300
							2	1.004	1.652	300
							0	1.005	1.577	375
Hydrobrake	527424.257	329207.851	3.000	1.551	1350		1	4.000	1.449	150
							0	4.001	1.449	150
Headwall 1	527413.706	329225.471	3.000	1.464	1350		1	1.005	1.536	375
Headwall 2	527418.936	329213.303	3.000	1.500	1200		0	4.000	1.500	150
Headwall 3	527427.000	329204.218	3.000	1.581	1350		1	4.001	1.419	150
S8	527397.176	329190.734	3.000	1.100	1200		0	2.000	1.900	300

Simulation Settings

Rainfall Methodology	FSR	Analysis Speed	Normal
Rainfall Events	Singular	Skip Steady State	x
FSR Region	England and Wales	Drain Down Time (mins)	240
M5-60 (mm)	20.000	Additional Storage (m ³ /ha)	0.0
Ratio-R	0.400	Starting Level (m)	
Summer CV	1.000	Check Discharge Rate(s)	x
Winter CV	1.000	Check Discharge Volume	x

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
1	0	0	0
2	0	0	0
30	0	0	0
100	0	0	0
100	40	10	0

Node Hydrobrake Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	1.449	Product Number	CTL-SHE-0045-1000-1200-1000
Design Depth (m)	1.200	Min Outlet Diameter (m)	0.075
Design Flow (l/s)	1.0	Min Node Diameter (mm)	1200

Node Headwall 2 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	14.000
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	1.500	Main Channel Slope (1:X)	200.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.035

Inlets

Headwall 1

Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)
0.000	162.0	0.0	1.500	442.0	0.0

Node S6 Depth/Area Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Safety Factor	2.0	Invert Level (m)	1.900
Side Inf Coefficient (m/hr)	0.00000	Porosity	0.95	Time to half empty (mins)	

Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)
0.000	350.0	0.0	0.800	350.0	0.0	0.801	0.0	0.0

Results for 1 year Critical Storm Duration. Lowest mass balance: 99.62%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S1	10	1.970	0.070	8.6	0.0796	0.0000	OK
1440 minute winter	S2	1380	1.950	0.121	0.6	0.1374	0.0000	OK
1440 minute winter	S3	1380	1.950	0.169	0.8	0.1917	0.0000	OK
1440 minute winter	S4	1380	1.950	0.231	0.8	0.2618	0.0000	OK
1440 minute winter	S5	1380	1.950	0.264	1.6	0.2991	0.0000	OK
1440 minute winter	S6	1380	1.950	0.050	1.3	16.8385	0.0000	OK
1440 minute winter	S7	1380	1.950	0.141	1.0	0.1600	0.0000	OK
1440 minute winter	S9	1380	1.950	0.215	1.9	0.2437	0.0000	OK
1440 minute winter	S10	1380	1.950	0.373	4.0	0.5344	0.0000	OK
1440 minute winter	Hydrobrake	1380	1.950	0.501	0.8	0.7174	0.0000	SURCHARGED
1440 minute winter	Headwall 1	1380	1.950	0.414	3.9	0.5931	0.0000	OK
1440 minute winter	Headwall 2	1380	1.950	0.450	2.6	0.5095	0.0000	SURCHARGED
15 minute summer	Headwall 3	1	1.419	0.000	0.7	0.0000	0.0000	OK
15 minute summer	S8	10	1.979	0.079	11.4	0.0897	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	S1	1.000	S2	8.5	0.572	0.119	0.2559	
1440 minute winter	S2	1.001	S3	0.6	0.281	0.008	0.3928	
1440 minute winter	S3	1.002	S4	0.8	0.337	0.011	0.7381	
1440 minute winter	S4	1.003	S5	0.8	0.262	0.011	0.4943	
1440 minute winter	S5	1.004	S10	1.6	0.386	0.022	0.5574	
1440 minute winter	S6	3.000	S7	-1.0	0.214	-0.014	0.4396	
1440 minute winter	S7	3.001	S9	0.8	0.356	0.011	0.4939	
1440 minute winter	S9	2.001	S10	1.8	0.433	0.025	0.6952	
1440 minute winter	S10	1.005	Headwall 1	3.9	0.342	0.030	1.0803	
1440 minute winter	Hydrobrake	Hydro-Brake®	Headwall 3	0.7				64.5
1440 minute winter	Headwall 1	Flow through pond	Headwall 2	2.2	0.008	0.000	83.6578	
1440 minute winter	Headwall 2	4.000	Hydrobrake	0.8	0.170	0.053	0.1341	
15 minute summer	S8	2.000	S9	11.2	0.480	0.156	0.9439	

Results for 2 year Critical Storm Duration. Lowest mass balance: 99.62%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
1440 minute winter	S1	1380	1.997	0.097	0.5	0.1095	0.0000	OK
960 minute winter	S2	915	1.997	0.168	1.0	0.1895	0.0000	OK
1440 minute winter	S3	1410	1.996	0.215	0.9	0.2437	0.0000	OK
960 minute winter	S4	930	1.998	0.279	1.3	0.3151	0.0000	OK
960 minute winter	S5	930	1.997	0.311	2.5	0.3518	0.0000	SURCHARGED
960 minute winter	S6	945	1.996	0.096	3.1	32.1438	0.0000	OK
960 minute winter	S7	945	1.996	0.187	2.5	0.2119	0.0000	OK
960 minute winter	S9	930	1.997	0.262	3.0	0.2959	0.0000	OK
960 minute winter	S10	930	1.996	0.419	6.2	0.6003	0.0000	SURCHARGED
960 minute winter	Hydrobrake	945	1.996	0.547	0.8	0.7827	0.0000	SURCHARGED
960 minute winter	Headwall 1	945	1.996	0.460	6.0	0.6584	0.0000	OK
960 minute winter	Headwall 2	945	1.996	0.496	3.7	0.5611	0.0000	SURCHARGED
15 minute summer	Headwall 3	1	1.419	0.000	0.7	0.0000	0.0000	OK
1440 minute winter	S8	1380	1.997	0.097	0.7	0.1094	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
1440 minute winter	S1	1.000	S2	0.5	0.262	0.007	0.5129	
960 minute winter	S2	1.001	S3	1.0	0.334	0.014	0.5485	
1440 minute winter	S3	1.002	S4	0.9	0.337	0.013	0.9079	
960 minute winter	S4	1.003	S5	1.2	0.273	0.017	0.5522	
960 minute winter	S5	1.004	S10	2.4	0.440	0.034	0.5768	
960 minute winter	S6	3.000	S7	-2.5	0.213	-0.035	0.7146	
960 minute winter	S7	3.001	S9	-2.0	0.376	-0.029	0.6524	
960 minute winter	S9	2.001	S10	2.7	0.459	0.038	0.7874	
960 minute winter	S10	1.005	Headwall 1	6.0	0.319	0.047	1.0809	
960 minute winter	Hydrobrake	Hydro-Brake®	Headwall 3	0.7				47.8
960 minute winter	Headwall 1	Flow through pond	Headwall 2	3.1	0.013	0.000	94.7942	
960 minute winter	Headwall 2	4.000	Hydrobrake	0.8	0.227	0.054	0.1341	
1440 minute winter	S8	2.000	S9	0.7	0.202	0.010	1.6719	

Results for 30 year Critical Storm Duration. Lowest mass balance: 99.62%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
1440 minute winter	S1	1410	2.219	0.319	0.9	0.3611	0.0000	SURCHARGED
1440 minute winter	S2	1410	2.219	0.390	1.5	0.4411	0.0000	SURCHARGED
1440 minute winter	S3	1410	2.219	0.438	2.0	0.4957	0.0000	SURCHARGED
1440 minute winter	S4	1410	2.220	0.501	1.6	0.5668	0.0000	SURCHARGED
1440 minute winter	S5	1440	2.218	0.532	4.2	0.6018	0.0000	SURCHARGED
1440 minute winter	S6	1410	2.219	0.319	5.4	106.3102	0.0000	SURCHARGED
1440 minute winter	S7	1410	2.219	0.410	4.4	0.4640	0.0000	SURCHARGED
1440 minute winter	S9	1410	2.219	0.484	3.6	0.5474	0.0000	SURCHARGED
1440 minute winter	S10	1440	2.219	0.642	6.3	0.9187	0.0000	SURCHARGED
1440 minute winter	Hydrobrake	1410	2.219	0.770	0.8	1.1014	0.0000	SURCHARGED
1440 minute winter	Headwall 1	1410	2.219	0.683	6.2	0.9773	0.0000	OK
1440 minute winter	Headwall 2	1410	2.219	0.719	3.8	0.8131	0.0000	SURCHARGED
15 minute summer	Headwall 3	1	1.419	0.000	0.7	0.0000	0.0000	OK
1440 minute winter	S8	1410	2.219	0.319	1.2	0.3613	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
1440 minute winter	S1	1.000	S2	1.2	0.281	0.017	1.2061	
1440 minute winter	S2	1.001	S3	1.7	0.299	0.023	0.8166	
1440 minute winter	S3	1.002	S4	1.6	0.336	0.023	1.0462	
1440 minute winter	S4	1.003	S5	2.8	0.245	0.039	0.5610	
1440 minute winter	S5	1.004	S10	3.7	0.377	0.052	0.5768	
1440 minute winter	S6	3.000	S7	-4.4	0.201	-0.061	1.5301	
1440 minute winter	S7	3.001	S9	-3.5	0.358	-0.049	0.8651	
1440 minute winter	S9	2.001	S10	2.8	0.424	0.039	0.8178	
1440 minute winter	S10	1.005	Headwall 1	6.2	0.341	0.048	1.0809	
1440 minute winter	Hydrobrake	Hydro-Brake®	Headwall 3	0.8				73.3
1440 minute winter	Headwall 1	Flow through pond	Headwall 2	3.1	0.015	0.000	154.7640	
1440 minute winter	Headwall 2	4.000	Hydrobrake	0.8	0.216	0.057	0.1341	
1440 minute winter	S8	2.000	S9	1.1	0.198	0.016	2.7843	

Results for 100 year Critical Storm Duration. Lowest mass balance: 99.62%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
1440 minute summer	S1	1440	2.356	0.456	1.7	0.5156	0.0000	SURCHARGED
1440 minute summer	S2	1440	2.355	0.526	2.2	0.5949	0.0000	SURCHARGED
1440 minute summer	S3	1440	2.355	0.574	2.9	0.6495	0.0000	SURCHARGED
1440 minute summer	S4	1440	2.356	0.637	2.9	0.7205	0.0000	SURCHARGED
1440 minute summer	S5	1440	2.355	0.669	6.2	0.7566	0.0000	SURCHARGED
1440 minute summer	S6	1440	2.354	0.454	9.8	151.5939	0.0000	SURCHARGED
1440 minute summer	S7	1470	2.354	0.545	8.0	0.6168	0.0000	SURCHARGED
1440 minute summer	S9	1440	2.355	0.620	6.3	0.7011	0.0000	SURCHARGED
1440 minute summer	S10	1440	2.355	0.778	8.7	1.1132	0.0000	SURCHARGED
1440 minute summer	Hydrobrake	1440	2.354	0.905	0.9	1.2951	0.0000	SURCHARGED
1440 minute summer	Headwall 1	1440	2.354	0.818	6.7	1.1709	0.0000	OK
1440 minute summer	Headwall 2	1440	2.354	0.854	4.5	0.9661	0.0000	SURCHARGED
15 minute summer	Headwall 3	1	1.419	0.000	0.7	0.0000	0.0000	OK
1440 minute summer	S8	1470	2.354	0.454	2.3	0.5137	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
1440 minute summer	S1	1.000	S2	1.5	0.268	0.021	1.2061	78.2
1440 minute summer	S2	1.001	S3	2.2	0.298	0.031	0.8166	
1440 minute summer	S3	1.002	S4	2.9	0.292	0.040	1.0462	
1440 minute summer	S4	1.003	S5	2.9	0.228	0.040	0.5610	
1440 minute summer	S5	1.004	S10	6.0	0.360	0.084	0.5768	
1440 minute summer	S6	3.000	S7	-7.8	-0.251	-0.109	1.5301	
1440 minute summer	S7	3.001	S9	-6.3	0.348	-0.088	0.8651	
1440 minute summer	S9	2.001	S10	2.9	0.391	0.040	0.8178	
1440 minute summer	S10	1.005	Headwall 1	6.7	0.340	0.052	1.0809	
1440 minute summer	Hydrobrake	Hydro-Brake®	Headwall 3	0.9				
1440 minute summer	Headwall 1	Flow through pond	Headwall 2	3.2	0.010	0.000	195.7349	78.2
1440 minute summer	Headwall 2	4.000	Hydrobrake	0.9	0.190	0.062	0.1341	
1440 minute summer	S8	2.000	S9	2.1	0.194	0.030	2.7843	

Results for 100 year +40% CC +10% A Critical Storm Duration. Lowest mass balance: 99.62%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute summer	S1	11	2.760	0.860	42.1	0.9721	0.0000	FLOOD RISK
15 minute summer	S2	11	2.729	0.900	56.1	1.0175	0.0000	FLOOD RISK
15 minute summer	S3	11	2.682	0.901	71.8	1.0195	0.0000	SURCHARGED
1440 minute winter	S4	1440	2.678	0.959	3.2	1.0842	0.0000	SURCHARGED
1440 minute winter	S5	1440	2.677	0.991	7.0	1.1207	0.0000	SURCHARGED
1440 minute winter	S6	1440	2.677	0.777	9.6	259.1698	0.0000	SURCHARGED
1440 minute winter	S7	1440	2.677	0.868	7.6	0.9822	0.0000	SURCHARGED
1440 minute winter	S9	1440	2.678	0.943	6.1	1.0660	0.0000	SURCHARGED
1440 minute winter	S10	1410	2.677	1.100	9.6	1.5742	0.0000	SURCHARGED
1440 minute winter	Hydrobrake	1440	2.677	1.228	1.0	1.7567	0.0000	SURCHARGED
1440 minute winter	Headwall 1	1440	2.677	1.141	8.2	1.6327	0.0000	OK
1440 minute winter	Headwall 2	1440	2.677	1.177	5.4	1.3311	0.0000	SURCHARGED
15 minute summer	Headwall 3	1	1.419	0.000	0.8	0.0000	0.0000	OK
1440 minute winter	S8	1440	2.677	0.777	2.4	0.8788	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute summer	S1	1.000	S2	40.2	0.673	0.563	1.2061	
15 minute summer	S2	1.001	S3	55.9	0.794	0.783	0.8166	
15 minute summer	S3	1.002	S4	71.5	1.015	1.001	1.0462	
1440 minute winter	S4	1.003	S5	3.6	0.222	0.050	0.5610	
1440 minute winter	S5	1.004	S10	6.9	0.386	0.096	0.5768	
1440 minute winter	S6	3.000	S7	-7.5	0.205	-0.105	1.5301	
1440 minute winter	S7	3.001	S9	-5.9	0.350	-0.082	0.8651	
1440 minute winter	S9	2.001	S10	2.9	0.412	0.040	0.8178	
1440 minute winter	S10	1.005	Headwall 1	8.2	0.407	0.064	1.0809	
1440 minute winter	Hydrobrake	Hydro-Brake®	Headwall 3	1.0				84.9
1440 minute winter	Headwall 1	Flow through pond	Headwall 2	3.8	0.012	0.000	307.1479	
1440 minute winter	Headwall 2	4.000	Hydrobrake	1.0	0.203	0.071	0.1341	
1440 minute winter	S8	2.000	S9	2.4	0.202	0.034	2.7843	