



Preliminary Drainage Strategy

Project:

Proposed Residential Development, Off Kesten Fields Development, Pinchbeck

Client:

D Brown Building Contractors Ltd

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Introduction

Jackson consulting engineers have been appointed by D Brown Building Contractors Ltd, to undertake a drainage strategy forming part of the supporting evidence for the planning submission of the proposed residential development to land off Mill Green Road, Pinchbeck, PE11 3PU. The site will be accessed off the larger 'Keston Field Development'. The following document is to assist the planners and Lead Local Flood Authority (LLFA) in demonstrating that the development is acceptable in terms of sustainable drainage strategy and post development flood risk as a result of the development.

Existing Site

The site lies to the east of Mill Green Road, Pinchbeck, Lincolnshire. An aerial location plan, with approximate site boundary (not the planning boundary) is shown in figure 1.



Figure 1 - Site Location

The site is currently greenfield, serving as an agricultural field. The proposed site has an approximate total site area of approximately 2.05 hectares. There is no impermeable or existing brownfield areas located on the site, although the north of the site had a historic rainwater reservoir to serve previous greenhouses.



A topographical survey was undertaken as part of the original site development. The north boundary connects onto the new development road. The road level at this point is approximately 3.3m AOD, with natural ground levels being similar. The west boundary generally abuts existing rear gardens (the rear gardens are ample, typically ranging from 30-95m), although towards the north there is an access track, extending to just under half the boundary length. Levels to the west boundary are typically 3.30m AOD. The southern boundary has a substantial hedge, and beyond the hedge is open field and industrial parking. The levels are slightly higher here – typically 3.4m AOD, although slightly raised at the base of the hedge. The east boundary abuts the rest of the Kesten Fields site, presumably to fencing. Levels are approximately 3.5m AOD, although it is likely that levels have been reworked. Finished floor levels to the proposed houses range from 3.3-4.0m AOD.

The entire site, is relatively flat although land levels would fall towards the north west – towards the existing development spur road and an existing ditch.

Flood Risk Assessment

As part of the planning permission, a flood risk assessment is being provided by a separate consultant, which was provided as part of the overall planning submission pack.

The drainage strategy is generally in accordance with this document, although the drainage strategy will be reassessed at detailed design and refined to suit final agreements, conditions and detailed levels.

Flood Risk Offsite

The scheme will be designed so that the risk of flooding to offsite properties will not be increased as a result of the development.



Development Proposals

The re-development involves the creation of 10 proposed executive dwellings, associated car parking and associated infrastructure. An indicative site layout is shown in the figure below. Each dwelling has a garage, either attached or detached.



Figure 2 - Indicative Site Layout



Proposed Drainage Strategy

The following section provides narrative on the principles behind the drainage strategy and has been carried out in general accordance with Lincolnshire County Councils SUDS Guidance, "CIRIA's C753 – the SUDS Manual", and national technical standards where appropriate.

Surface Water Drainage

For new developments there is a requirement to apply sustainable drainage principles (SuDS) to the disposal of surface water from the site where practicable. As required by Building Regulations and PPG, surface water must discharge to the following, listed in priority.

1. To ground – in an adequate soakaway or some other adequate infiltration system.
2. To a watercourse.
3. To a surface water sewer, highway drain or other drainage system.
4. To a combined sewer.

Infiltration

Infiltration testing is not available, but a desktop study has been undertaken by JCE to determine the viability of infiltration. The bedrock geology and superficial deposits are shown in the respective figures below. The bedrock has been described as 'Oxford Clay Formation - Mudstone' – this is unlikely to provide infiltration. The superficial deposits consist of 'Tidal Flat Deposits – Clay and Silt', this is unlikely to offer suitable infiltration as the silt content would tend to seal any pores that the clay may have. Both of these BGS map descriptions are shown in the figures below.

There are no borehole records in the direct vicinity of the site, although the closest records show that the boreholes match the descriptions.

Given the ground conditions mentioned above, and knowledge of the local area, and knowing that infiltration was discounted for the main development, it is highly unlikely that infiltration will provide sufficient surface water drainage, and although this will be confirmed by infiltration testing through a phase 2 geotechnical report, for the purpose of a drainage strategy it will be ruled out.

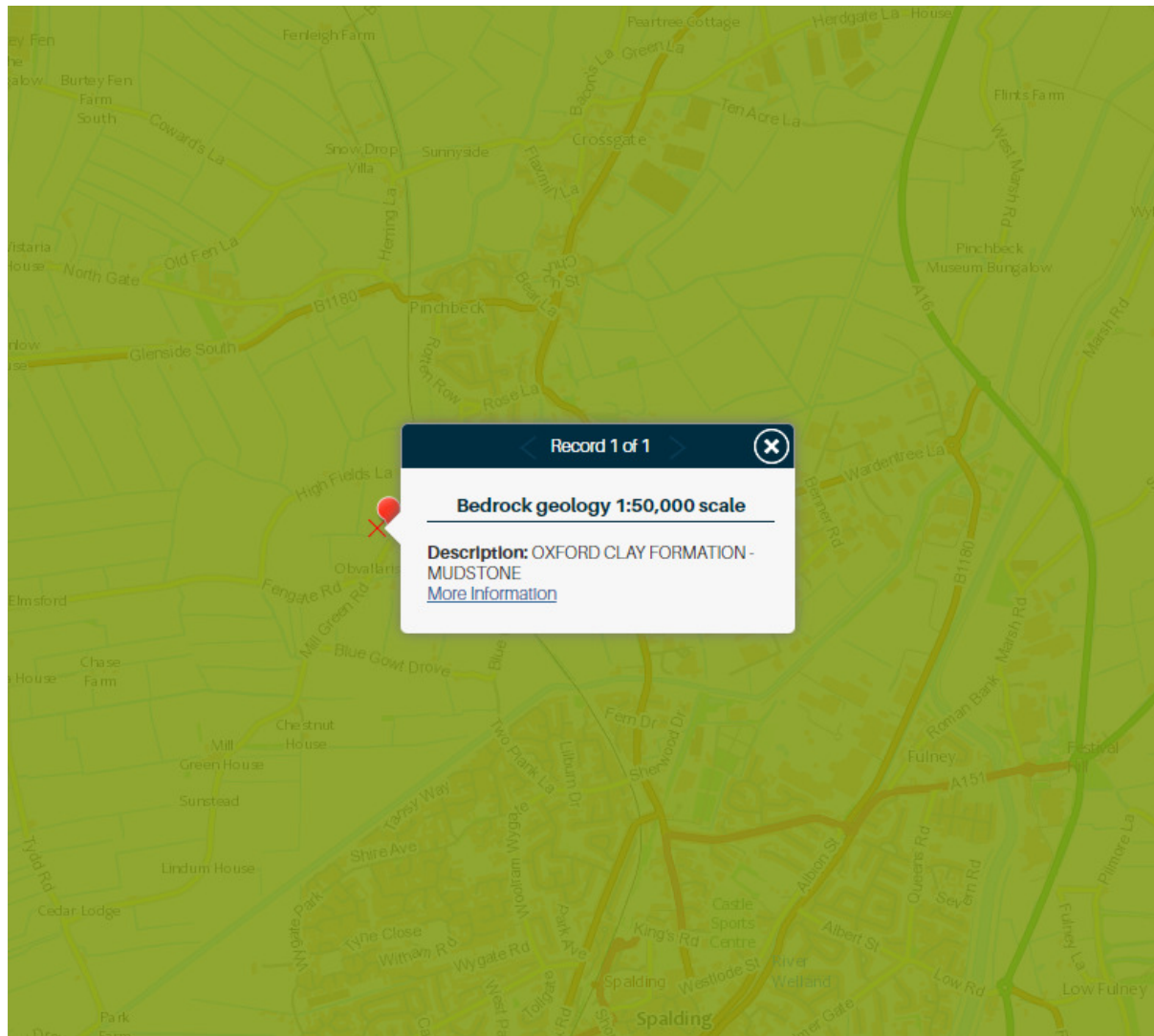


Figure 3 - Bedrock Geology

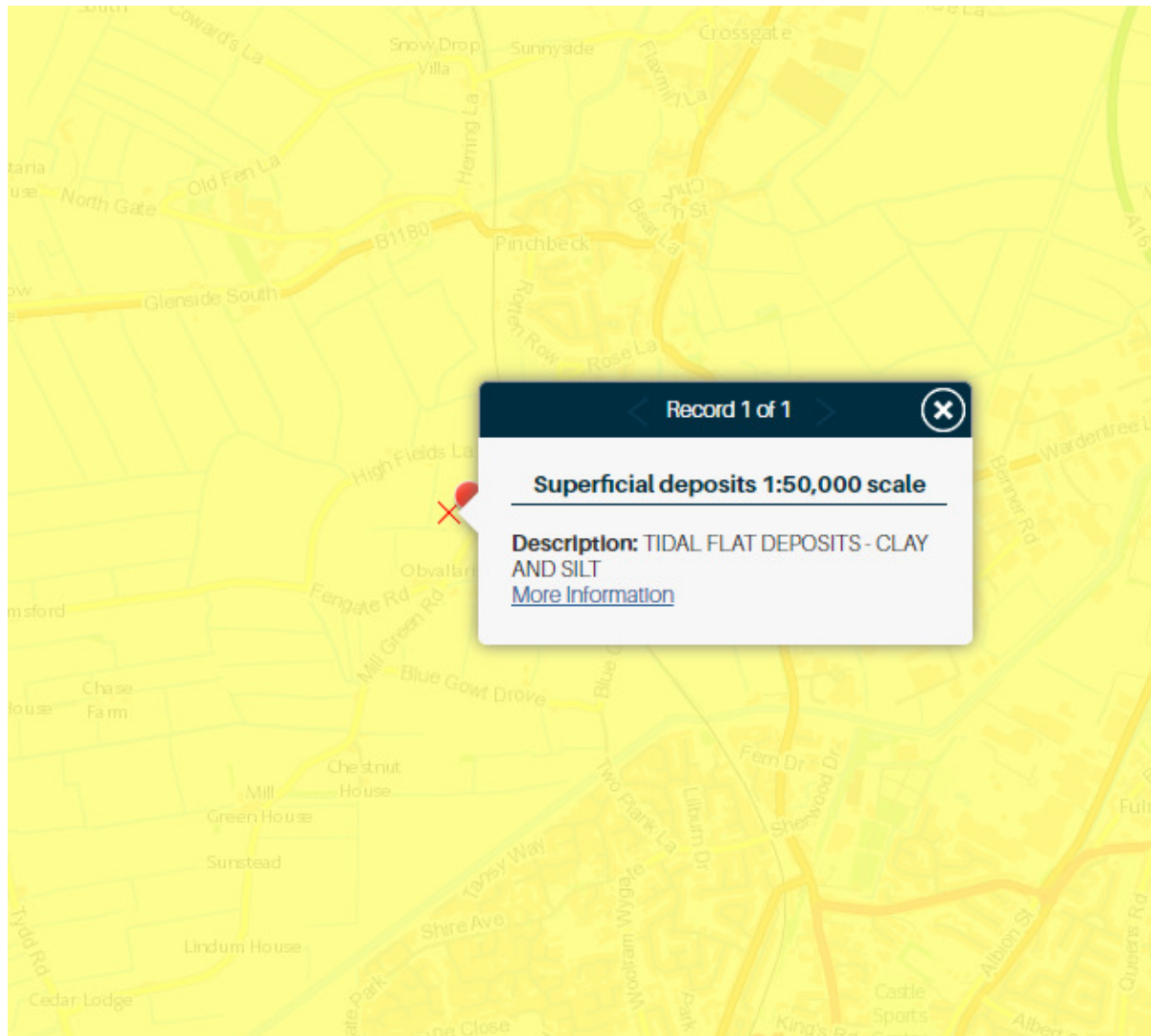


Figure 4 - Superficial Geology

Watercourse

The site falls within the catchment of Welland and Deepings Internal Drainage Board, falling in the overall catchment of the 'Fourth District', as shown in the figure below. The closest drain is to the north west corner of the site, with an unknown reference (likely to be riparian), although it heads towards the 'Reedy Graft Drain'. The private drain has levels which would create a northerly flow, and it is known that areas of the riparian ditch to the north has had improvements to cater for the overall development.

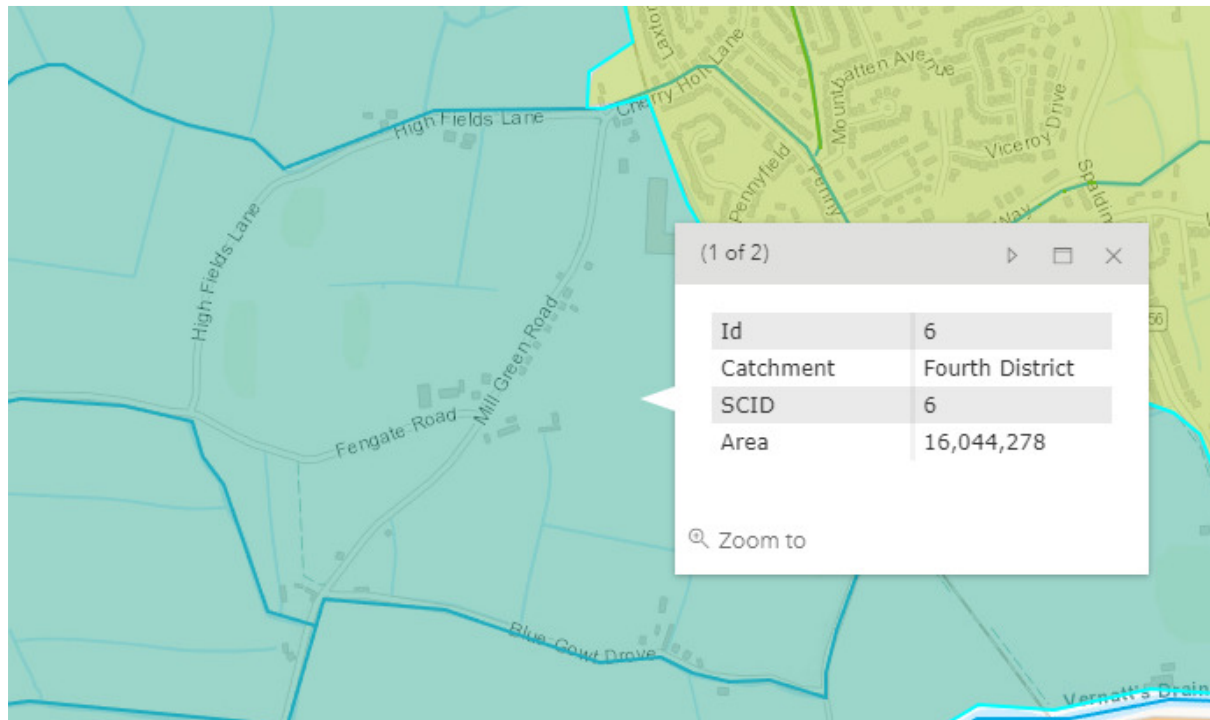


Figure 5 – W&DIDB: Catchment

The area of the aforementioned ditch has been included in the topographical survey, with an extract being shown in the figure below. The point of connection has an invert level of 2.380m AOD. The ditch has a fall of 380mm across its surveyed length of 138m, which is a substantial fall for an open watercourse.

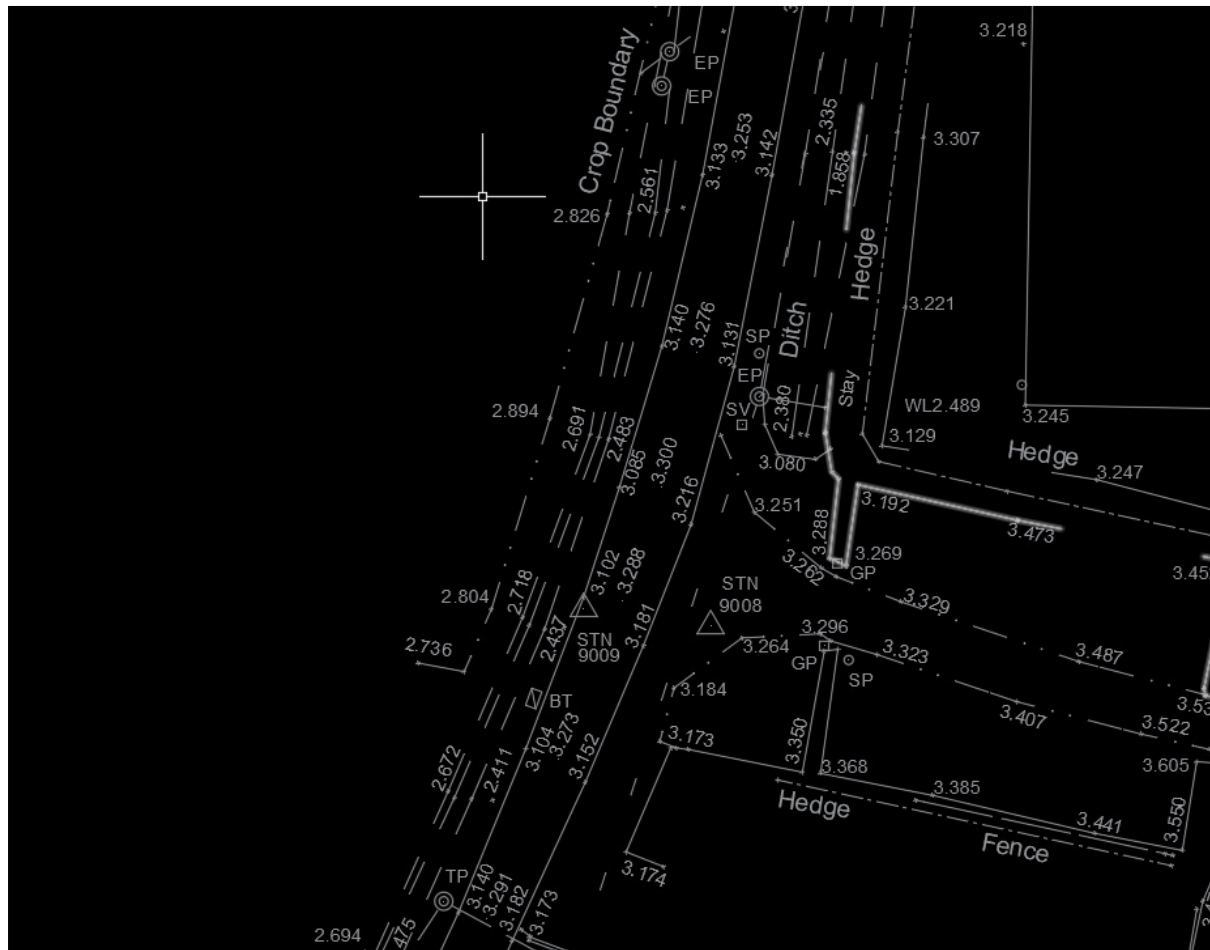


Figure 6 - Extract at Dyke Location

The Internal Drainage Board have a number of bylaws specific to this site, namely;

- Byelaw 3: Control of Introduction of Water and Increase in Flow or Volume of Water
- Byelaw 10: No Works within 9 metres of the Edge of Drainage/Flood Risk Management Infrastructure

Full details of these bylaws can be found on the IDB's website.

The site will need to apply for byelaw 3 consent. The IDB generally has an allowable 'pumped catchment' rate of 1.4l/s which does not necessarily relate to the greenfield run-off or flood risk. As the total area will be relatively small in comparison to the pumped catchment rate, the equivalent pumpable discharge rate will also be low, and not feasible for the development size. Therefore, subject to board approval, it will be proposed that the discharge rate from the site is increased above the pumped catchment rate, but in line with the requirements for Anglian Water adoption, Lincolnshire's Lead Local Flood Authorities sustainable drainage and DEFRA's non-technical standards.

The proposed dyke at the connection point appears to be in good condition, and of significant size. It is generally open watercourses. The downstream dykes appear to get larger and have recently been improved, and it is assumed that these interconnecting drains do not have capacity problems.



Surface Water Sewer

No surface water sewers have been identified in the proximity of the site, and as a connection into a watercourse is viable, no further consideration for a connection into a surface water sewer is needed.

Combined Water Sewer

No combined water sewers have been identified in the proximity of the site, and as a connection into a watercourse is viable, no further consideration for a connection into a surface water sewer is needed.

Run-off Rates

Existing greenfield run-off

The existing run-off rates for the site for the 1 in 1 year, Q_{BAR} , 1 in 30 year, 1 in 100 year and 1 in 200 year events are summarised in the figure below. The calculations consider the run-off for the entire development, minus large areas of public open space, given a contributing area of 1.78 hectares - this is in accordance with the methodology in CIRIA C753 and the HR Wallingford Methods. The full greenfield runoff report can be found in appendix A.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	2.5	2.5
1 in 1 year (l/s):	2.17	2.17
1 in 30 years (l/s):	6.12	6.12
1 in 100 year (l/s):	8.89	8.89
1 in 200 years (l/s):	10.52	10.52

Figure 7 - Existing Greenfield Runoff Rates

Proposed Run-off

To comply with the LLFA, the site should be returned to greenfield runoff as far as practical. There are two options to achieve this, to match the runoff to a maximum of Q_{BAR} , or to have a variable outflow, matching to the like for like predevelopment greenfield runoff. To keep the design straight forward at the planning stage, it is proposed that the sites discharge rate will be restricted to Q_{BAR} , although at detailed design, and through consultation with the IDB, the approach may be modified to suit the like-for-like storms.



The current approach means that although the discharge is higher than the pumpable catchment rate (this would equate to around 0.84l/s), the reality is that storms above the QBar event (roughly 1 in 2), the greenfield runoff will be reduced as a result of the development as it is being properly managed, for example predevelopment the runoff for the 1 in 30 year storm is 6.12l/s, but the post development will be 2.5l/s for all design storms.

Proposed Surface Water Drainage Design

The proposed drainage layout is shown on JCE drawing 0297-JCE-00-SI-SK-C-3000, which can be found in appendix B.

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

A full copy of the preliminary drainage calculations can be found in appendix C 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.

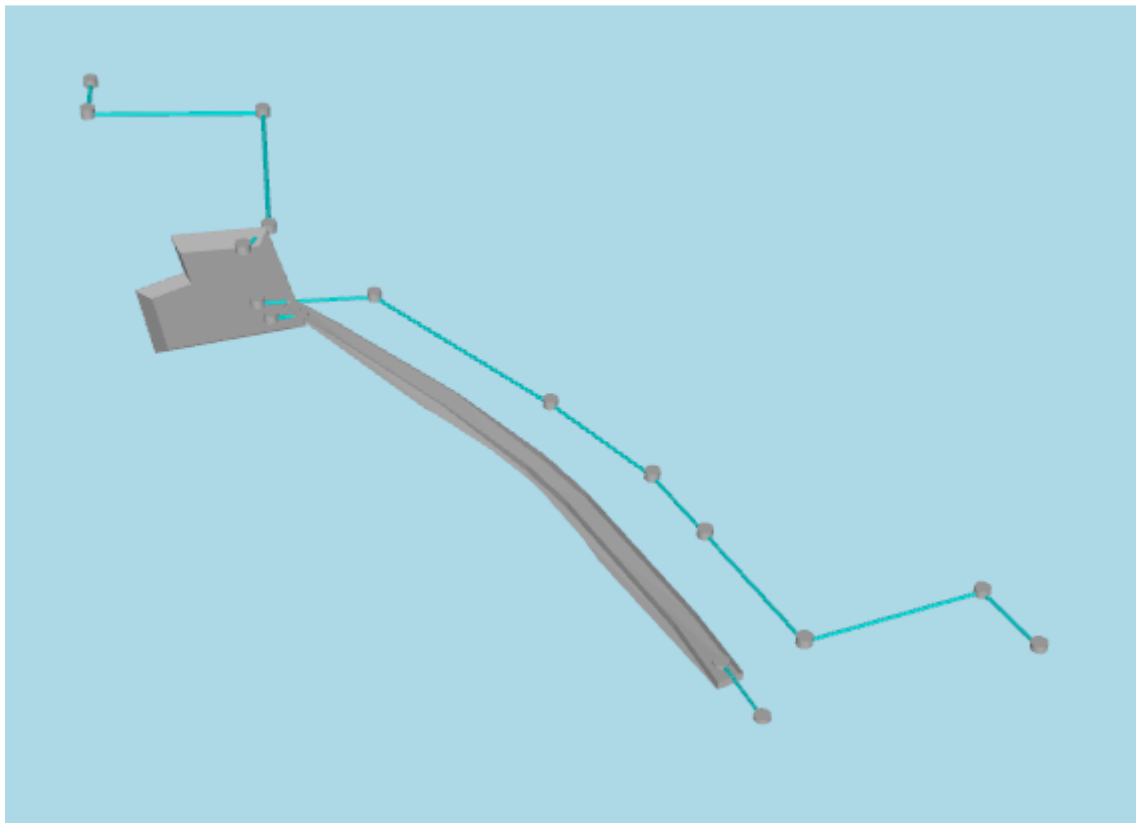


Figure 8 – Drainage Model

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 pond, before leading into an attenuation pond and eventual discharge into the existing ditch.



The site is relatively long and flat, with the intention to keep the drainage is intended to be kept as flat as possible. Standard design items such as dry swales still need to be laid to a fall of approximately 1 in 150, or with an underdrain. As a result of this, unless AW relax their approach at detailed design, the finished floor levels to the south of the site will need to be raised in order to offer a gravity solution.

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.

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 final discharge into the IDB 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.

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.
- The basins will discharge into the IDB drain to the north west of the site.

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 or free board in the attenuation basin, or rear gardens. This swale has a lot of spare capacity and would take a very extreme event to flood this, and event then it will discharge onto open spaces. Likewise, the basin has spare capacity, and the entire length to this boundary will have the levels designed to trap any flood water, with a lower level to overflow into the IDB drain. Indicative exceedance flow routes have been provided.

Finished Floor Levels + Finished Levels

In order to make the scheme work under gravity, the finished floor levels, especially the ones furthest away from the outfall point, will need to be raised. Some of these are insignificant, a minimum of 300mm, which is typically in line with current EA guidance for all development.

At the worst point, the finished floor level will be raised approximately 1.1m above the existing ground levels. Although this is a significant amount, the areas in which this happens are a significant distance away from existing buildings – this is due to the length of the existing gardens. The proposed gardens generally are significant in length, meaning that most of the buildings are set away from boundaries. It is noted that the levels on the overall development were picked up in a similar manor for similar reasons.

The road level, to allow the minimum fall of 1 in 150 for the swale, will have a similar slope towards the attenuation basin. This will give an approximate road level of 4.0m AOD at its highest point – roughly 600mm above existing ground levels.

The levels mentioned above are typically in line with development in flood risk elements, and should not cause concern to the planners, although it is being highlighted.

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, CIRA have developed 'Pollution hazard indices' and the 'mitigation indices' that the SuDS components provide, further details of these are found in the figures below.



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

Figure 9 - Pollution hazard indices for different land use classifications

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.		

Figure 10 - Indicative SuDS mitigation indices for discharging to a surface water

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

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

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

The figures are presented to show the actual achieved in the right-hand side column. The right-hand side's total must be higher than the left-hand side.

Roofs (swale = attenuation basin)

0.2 0.2 0.05 = Swale 0.5 0.6 0.6 + ½ Attenuation Basin 0.25 0.25 0.3 (Total 0.75 0.85 0.9)

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

Roofs (attenuation basin only)

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 (swale = attenuation basin)

0.5 0.4 0.4 = Swale 0.5 0.6 0.6 + ½ Attenuation Basin 0.25 0.25 0.3 (Total 0.75 0.85 0.9)

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

Individual property driveways (attenuation basin 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.

Adopted Roads

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.



All the methods above provide enough water quality in accordance with CIRIA's C753 mitigation indices.

Maintenance

It is crucial that the elements mentioned in the drainage elements and water quality are maintained to a sufficient standard to ensure that the devices can still function as designed. Generally, the maintenance requirements are either from CIRIA 753, or manufacturer guidance.

It is not possible to give full details of the proposed maintenance responsibilities as the project has not been developed enough, but it is expected that a full maintenance/management strategy will be put forward at detailed design and that this can be conditioned.

The maintenance for the devices outlined below are preliminary only and subject to detailed design.

Hydrobrake Maintenance

Maintenance

Normally, little maintenance is required as there are no moving parts within the Flow Control. Experience has shown that if blockages occur they do so at the intake, and the cause on such occasions has been due to a lack of attention to engineering detail such as approach velocities being too low, inadequate benching, or the use of units below the minimum recommended size. The Flow Control (where applicable) is fitted with a pivoting bypass door, which allows the manhole chamber to be drained down should blockage occur. The smaller conical units, below the minimum recommended size, are also supplied with rodding facilities or vortex suppressor pipes as standard.

Following installation of the Flow Control it is vitally important that any extraneous material i.e. building materials are removed from the unit and the chamber. After the system is made live, and assuming that the chamber design is satisfactory, it is recommended that each unit be inspected monthly for three months and thereafter at six monthly intervals with hose down if required. If problems are experienced, please do not hesitate to contact the company so that an investigation may be made.

All Flow Control units are typically manufactured from grade 304 Stainless Steel, and if required they can also be manufactured in grade 316 Stainless Steel. Both materials have an estimated life span in excess of the design life of drainage systems.



Attenuation Basin Maintenance

Operation and maintenance requirements for detention basins		
Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly
	Cut grass – for spillways and access routes	Monthly (during growing season), or as required
	Cut grass – meadow grass in and around basin	Half yearly (spring – before nesting season, and autumn)
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Inspect inlets, outlets and overflows for blockages, and clear if required.	Monthly
	Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly
	Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies.	Monthly (for first year), then annually or as required
	Check any penstocks and other mechanical devices	Annually
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from inlets, outlet and forebay	Annually (or as required)
	Manage wetland plants in outlet pool – where provided	Annually (as set out in Chapter 23)
Occasional maintenance	Reseed areas of poor vegetation growth	As required
	Prune and trim any trees and remove cuttings	Every 2 years, or as required
	Remove sediment from inlets, outlets, forebay and main basin when required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)
Remedial actions	Repair erosion or other damage by reseedling or re-turfing	As required
	Realignment of rip-rap	As required
	Repair/rehabilitation of inlets, outlets and overflows	As required
	Relevel uneven surfaces and reinstate design levels	As required



Filter Strip Maintenance

Operation and maintenance requirements for filter strips		
Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
	Inspect filter strip surface to identify evidence of erosion, poor vegetation growth, compaction, ponding, sedimentation and contamination (eg oils)	Monthly (at start, then half yearly)
	Check flow spreader and filter strip surface for even gradients	Monthly (at start, then half yearly)
	Inspect gravel flow spreader upstream of filter strip for clogging	Monthly (at start, then half yearly)
	Inspect silt accumulation rates and establish appropriate removal frequencies	Monthly (at start, then half yearly)
Occasional maintenance	Reseed areas of poor vegetation growth; alter plant types to better suit conditions, if required	As required or if bare soil is exposed over > 10% of the filter strip area.
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required



Swale Maintenance

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional maintenance	Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the swale treatment area
Remedial actions	Repair erosion or other damage by re-turfing or reseeded	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required

Catchpits

Catchpits are utilised to help prevent the ingress of heavy sediment and other debris from entering the system. Maintenance requirements are low, and it is recommended that catchpits are inspected every six months and any build-up of sediment removed.

Pipework

If sediment in the catchpits is above the incoming pipes, or if performance of the site is hampered, then the pipes are to be inspected and jetted as necessary. The condition of the pipes shall generally be checked at the catchpit inspection chambers.



Foul Proposals

Unlike the surface water disposal hierarchy, the preferred method of foul disposal is through sewers, rather than back into land or watercourses.

An extract of the original Keston Fields design shown in the figure below. As demonstrated, there are a couple of existing AW manholes outside to the western access track, referenced 4801 and 4802, although these manholes are relatively shallow in relation to the site – having a deepest invert level of 2.50m AOD. This generally appears to rule out a gravity drainage solution for the site, and therefore will require a pumping station. The existing overall development had the same issue, and a pumping station was included as part of that design.

As this part of the development is not currently adopted, a pre-development report was not possible, but it would be expected that the existing pumping station is capable of receiving an additional 10 plots, given that the current pumping station serves approximately 100 units. As this is not currently adopted, an agreement will need to be made with the current asset owner, which in this instance is the same as the proposed development, so rights will not be an issue.

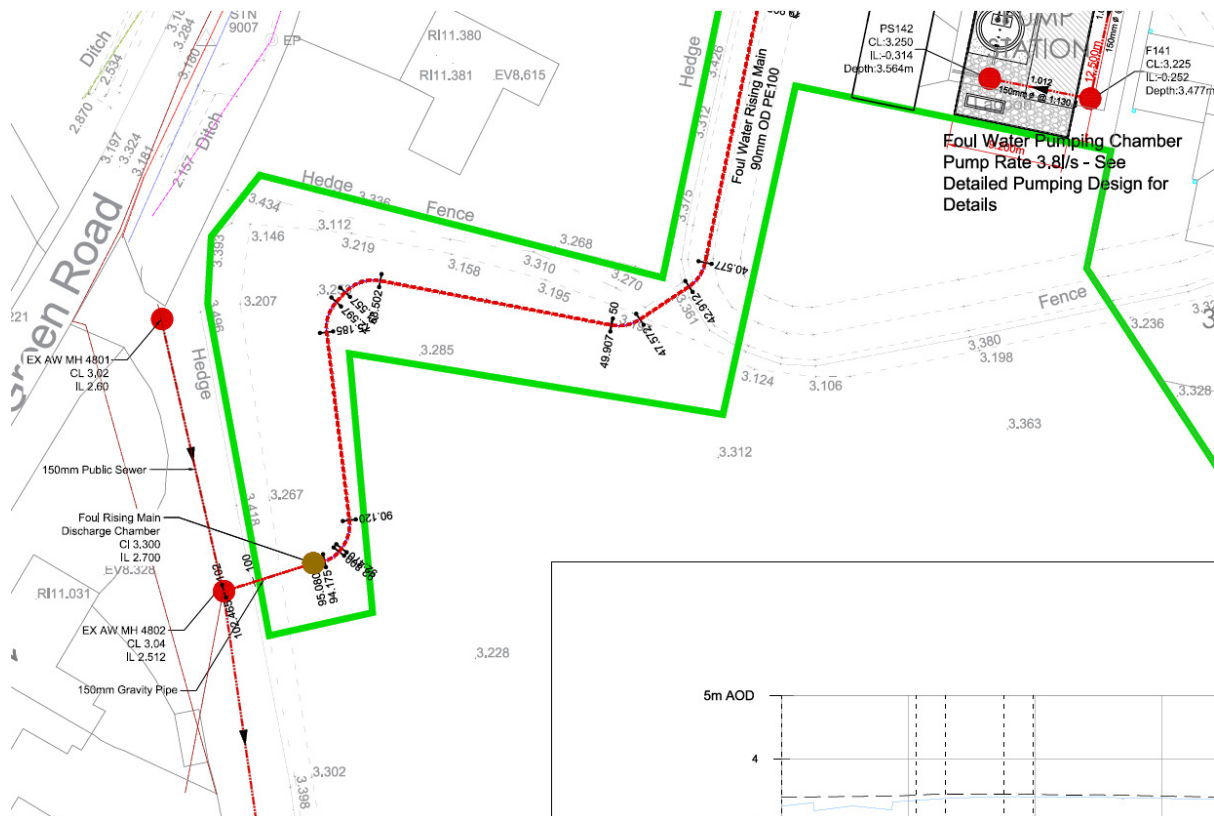


Figure 11 – Adoptable Anglian Water sewers in the proximity of the site

The proposed foul sewer will connect into an existing manhole, built as part of the overall development, this has a reference of F141, and has around 3.5m of depth – plenty to allow a gravity connection.

The foul drainage within the site will be put forward for adoption (other than in private areas) by Anglian Water and will be designed in full accordance with the 'Design and Construction Guidance for



foul and surface water sewers offered for adoption under the Code for Adoption agreements for water and sewerage companies operating wholly or mainly in England ("the Code")'.



Conclusion

- The above drainage strategy demonstrates that the site can be drained through the use of a Sustainable Drainage System at an appropriate level for the development.
- No above ground flooding is present for the 1 in 100 year + 40% climate change event + 10% urban creep, other than within the open basins.
- The proposed scheme does not increase the risk of flooding either on or off site as a result of the development, primarily as greenfield rates are not exceeded for the QBar event.
- A full maintenance strategy will be developed at the detailed design stage.
- Byelaw consent will be required from the IDB – which will be applied for at detailed design.
- A section 106 agreement for the AW foul connection is required and will be applied for at detailed design.
- A preliminary drainage layout can be found on JCE's Preliminary Drainage Strategy drawing 0297-JCE-00-SI-SK-C-3000.



Appendices

Appendix A – Greenfield Runoff Calculator

[Print](#)[Close Report](#)

Greenfield runoff rate estimation for sites

www.ukstds.com | Greenfield runoff tool

Calculated by: Ben Jackson

Site name: Keston Fields

Site location: Pinchbeck

Site Details

Latitude: 52.80679° N

Longitude: 0.16868° W

Reference: 153873831

Date: Jan 31 2023 18:51

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 1.78

Methodology

Q_{BAR} estimation method: Calculate from SPR and SAAR

SPR estimation method: Calculate from SOIL type

Soil characteristics

Default

Edited

SOIL type: 2 2

HOST class: N/A N/A

SPR/SPRHOST: 0.3 0.3

Hydrological characteristics

Default

Edited

SAAR (mm): 560 560

Hydrological region: 5 5

Growth curve factor 1 year: 0.87 0.87

Growth curve factor 30 years: 2.45 2.45

Growth curve factor 100 years: 3.56 3.56

Growth curve factor 200 years: 4.21 4.21

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

Default

Edited

Q_{BAR} (l/s): 2.5 2.5

1 in 1 year (l/s): 2.17 2.17

1 in 30 years (l/s): 6.12 6.12

1 in 100 year (l/s): 8.89 8.89

1 in 200 years (l/s): 10.12 10.12

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Appendix B – Proposed Drainage Plan

Drainage Key

- Proposed adoptable surface drainage
- Proposed adoptable foul drainage
- Proposed private surface drainage

FFL
7.700
(7.55)

Finished Floor Level
Proposed Level
(Existing Level)

Attenuation Basin

The main method of attenuation, restricting the run-off rates is via, a Hydrobrake which slows the flow and is stored within this basin.

It is intended that this basins will be online, and as the site is generally design in accordance with a SuDS treatment train it will be adopted by Anglian Water - to be determined at the detailed design phase.

Swale

It is provisionally proposed that this feature will be adopted by Anglian Water, subject to detail S104 submission and CIRIA evidence.

The swale will be installed with filter strip to act as pre-treatment.

Swale to be laid at a minimum gradient of 1 in 150, unless an underdrain is provided.

Main surface exceedence flow routes

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Drawing must be printed in colour. This text will be red if a coloured drawing.

Notes:

- All drawings to be read in conjunction with Structural Engineers Drawings.
- If in doubt - ASK!
- Any discrepancies are to be reported back to the engineer immediately.
- All dimensions are in metres unless noted otherwise (pipe diameters are generally shown in millimetres, unless noted otherwise).
- Drawings marked Preliminary, Information or Tender are for guidance/ approval only, i.e. NOT for construction.
- It is likely that existing services will be present within the existing site. Contractor to ensure all necessary precautions have been taken before any excavation takes place.
- It is the contractors responsibility to locate existing services where they may be affected by proposed works and protect them as necessary and agreed by the utility provider.
- Drawings to be read in conjunction with all relevant drawings.
- Setting out to be in accordance with the Architectural plans.
- All proprietary items to be installed in strict accordance with the manufacturers instructions and recommendations.
- All works to be carried out in accordance with the current British Standards, Codes for practice and Building Regulations.
- Manhole covers are to be D400 in adoptable areas and the main access way, C250 for shared parking areas, B125 for private domestic car parking and A15 for soft landscaped and non-vehicle areas.
- For private drainage, the pipework does not need concrete pipe protection if the following depths are exceeded:
 - 13.1. For PVC - 0.9m in vehicular areas or 0.6m in soft landscaping.
 - 13.2. For clayware or concrete - 1.2m in vehicular areas or 0.6m in soft landscaping.
- Pipe materials to be the following:
 - 14.1. Clayware to be Class 120
 - 14.2. Concrete to be Class M.
 - 14.3. Thermoplastic to have a nominal ring stiffness of SN4.
- PPIC's deeper than 1.2m are to be fitted with a non-access cover.
- Unused PPIC connections are to be installed with caps.
- Excavations near foundations need to be carefully considered. Refer to building regulations, and consult with the structural engineer where appropriate.
- No work is to be started until all necessary approvals have been obtained.
- Drainage has been design to store all storms up to and including the 1 in 100 year + 40% climate change within the site.
- The junctions from RWP's, fin drains, SVP's and similar connections into main runs are to be determined on site, and in accordance with building regulations.
- All RWP's, SVP's, etc. to be fitted with rodding access.
- For PPIC's the orientation of the main channel is to generally connect upstream and downstream pipes with stated inverts. Non stated inverts such as RE's, R's and F's to generally connect into side inlets.
- Drainage generally designed to incorporate a side step in preformed bases down into the main channel invert of of 100mm. Details vary dependant on the preformed base and manufacturer selected.
- Backdrops might be required to ensure that building drainage above foundations are able to enter the PPIC - refer to details.
- Unless noted, rain water pipes (R's) and below ground foul drainage pipes (F's) to be 100mmØ. R's to have a minimum fall of 1:100, and F's to have a minimum fall of 1:40, unless a WC is connected when the minimum fall shall be 1:80.
- All RWP's and below ground foul drainage to be set out from the architectural drawings.
- Where drainage gradients have been stated, these represent the minimum gradients, and can be steeper - subject to a maximum gradient of 1:10.
- If the contractor is unsure which manhole/PPIC reference is being used for the actual manhole/PPIC, ask!
- Cover levels are approximate only and must suit the finished external levels.
- All tie in levels with existing items are to be confirmed prior to construction.
- RWP positions have currently been assumed and must be confirmed by the architect.
- Above ground foul drainage has currently been assumed and must be confirmed by the architect.
- Discharge into the existing ditch must be agreed by LCC/LFA and IDB.
- This drawing represents an intent only and along with the calcs has been simplified accordingly. Final sizes and locations are subject to detailed design.

PLANNING

For planning authority approval

Rev	Description	Dn	Ck'd	Date
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Client:
D Brown Building Contractors Ltd



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Red Lion Street,
Spalding,
Lincolnshire
PE11 1SX

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Project Title:
Proposed Residential Development,
Keston Fields,
Pinchbeck

Drawing Title:
Proposed Drainage Strategy

Drawing Status:

Preliminary

Scale: 1:500	Paper size: A1	Date: 31/01/2023
Drawn: BJ	Checked: JCE	Approved: JCE

Drawing Number: 0297-JCE-00-SI-SK-C-3000	Rev -
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Appendix C – Proposed Drainage Calculations

Design Settings

Rainfall Methodology	FSR	Maximum Time of Concentration (mins)	30.00
Return Period (years)	1	Maximum Rainfall (mm/hr)	1.0
Additional Flow (%)	0	Minimum Velocity (m/s)	1.00
FSR Region	England and Wales	Connection Type	Level Soffits
M5-60 (mm)	20.000	Minimum Backdrop Height (m)	0.200
Ratio-R	0.400	Preferred Cover Depth (m)	1.200
CV	0.750	Include Intermediate Ground	✓
Time of Entry (mins)	5.00	Enforce best practice design rules	✓

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
S1	0.068	5.00	3.900	1200	553750.093	371769.757	0.359
HW1	0.288		3.750	1200	553748.653	371781.294	0.287
PS1	0.050	5.00	3.900	1200	553791.783	371772.822	0.600
PS2	0.000		3.900	1200	553789.197	371785.358	0.643
PS3			3.900	1200	553761.332	371782.632	0.736
PS4	0.032	5.00	3.800	1200	553756.260	371808.255	0.723
PS5	0.030	5.00	3.800	1200	553753.334	371823.073	0.773
PS6			3.700	1200	553744.119	371844.506	0.751
PS7	0.036	5.00	3.600	1200	553724.990	371880.831	0.788
HW2		5.00	3.300	1200	553712.286	371879.044	0.510
HW3			3.500	1200	553707.252	371879.521	0.750
HW4			3.500	1200	553706.074	371884.455	0.767
HW5	0.098	5.00	3.500	1350	553707.075	371901.175	0.860
S2			3.500	1350	553712.673	371906.372	0.879
S3			3.500	1350	553719.862	371945.318	0.977
S4			3.500	1350	553688.664	371953.892	1.057
HW6			3.300	1350	553690.965	371965.355	0.886

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	PS1	PS2	12.800	0.600	3.300	3.257	0.043	300.0	300	5.24	1.0
1.001	PS2	PS3	27.998	0.600	3.257	3.164	0.093	300.0	300	5.75	1.0
1.002	PS3	PS4	26.120	0.600	3.164	3.077	0.087	300.0	300	6.24	1.0
1.003	PS4	PS5	15.104	0.600	3.077	3.027	0.050	300.0	300	6.52	1.0
1.004	PS5	PS6	23.330	0.600	3.027	2.949	0.078	300.0	300	6.95	1.0
1.005	PS6	PS7	41.054	0.600	2.949	2.812	0.137	300.0	300	7.70	1.0
1.006	PS7	HW4	19.260	0.600	2.812	2.733	0.079	243.8	300	8.02	1.0

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)
1.000	0.902	63.8	0.1	0.300	0.343	0.050	0.0	10	0.175
1.001	0.902	63.8	0.1	0.343	0.436	0.050	0.0	10	0.175
1.002	0.902	63.8	0.1	0.436	0.423	0.050	0.0	10	0.175
1.003	0.902	63.8	0.2	0.423	0.473	0.082	0.0	13	0.209
1.004	0.902	63.8	0.3	0.473	0.451	0.112	0.0	15	0.228
1.005	0.902	63.8	0.3	0.451	0.488	0.112	0.0	15	0.228
1.006	1.002	70.8	0.4	0.488	0.467	0.148	0.0	16	0.268

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	HW2	HW3	5.057	0.600	2.790	2.755	0.035	144.5	300	5.06	1.0
3.000	S1	HW1	11.627	0.600	3.541	3.473	0.068	170.0	225	5.19	1.0
2.000	HW5	S2	7.638	0.600	2.640	2.621	0.019	405.0	450	5.13	1.0
2.001	S2	S3	39.604	0.600	2.621	2.523	0.098	405.0	450	5.78	1.0
2.002	S3	S4	32.355	0.600	2.523	2.443	0.080	405.0	450	6.32	1.0
2.003	S4	HW6	11.692	0.600	2.443	2.414	0.029	405.0	450	6.52	1.0

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	1.306	92.3	0.0	0.210	0.445	0.000	0.0	0	0.000
3.000	1.000	39.7	0.2	0.134	0.052	0.068	0.0	11	0.246
2.000	1.004	159.6	0.3	0.410	0.429	0.098	0.0	14	0.184
2.001	1.004	159.6	0.3	0.429	0.527	0.098	0.0	14	0.184
2.002	1.004	159.6	0.3	0.527	0.607	0.098	0.0	14	0.184
2.003	1.004	159.6	0.3	0.607	0.436	0.098	0.0	14	0.184

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	12.800	300.0	300	Circular	3.900	3.300	0.300	3.900	3.257	0.343
1.001	27.998	300.0	300	Circular	3.900	3.257	0.343	3.900	3.164	0.436
1.002	26.120	300.0	300	Circular	3.900	3.164	0.436	3.800	3.077	0.423
1.003	15.104	300.0	300	Circular	3.800	3.077	0.423	3.800	3.027	0.473
1.004	23.330	300.0	300	Circular	3.800	3.027	0.473	3.700	2.949	0.451
1.005	41.054	300.0	300	Circular	3.700	2.949	0.451	3.600	2.812	0.488
1.006	19.260	243.8	300	Circular	3.600	2.812	0.488	3.500	2.733	0.467
4.000	5.057	144.5	300	Circular	3.300	2.790	0.210	3.500	2.755	0.445
3.000	11.627	170.0	225	Circular	3.900	3.541	0.134	3.750	3.473	0.052
2.000	7.638	405.0	450	Circular	3.500	2.640	0.410	3.500	2.621	0.429
2.001	39.604	405.0	450	Circular	3.500	2.621	0.429	3.500	2.523	0.527
2.002	32.355	405.0	450	Circular	3.500	2.523	0.527	3.500	2.443	0.607

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	PS1	1200	Manhole	1 Adoptable	PS2	1200	Manhole	1 Adoptable
1.001	PS2	1200	Manhole	1 Adoptable	PS3	1200	Manhole	1 Adoptable
1.002	PS3	1200	Manhole	1 Adoptable	PS4	1200	Manhole	1 Adoptable
1.003	PS4	1200	Manhole	1 Adoptable	PS5	1200	Manhole	1 Adoptable
1.004	PS5	1200	Manhole	1 Adoptable	PS6	1200	Manhole	1 Adoptable
1.005	PS6	1200	Manhole	1 Adoptable	PS7	1200	Manhole	1 Adoptable
1.006	PS7	1200	Manhole	1 Adoptable	HW4	1200	Manhole	1 Adoptable
4.000	HW2	1200	Manhole	1 Adoptable	HW3	1200	Manhole	1 Adoptable
3.000	S1	1200	Manhole	1 Adoptable	HW1	1200	Manhole	1 Adoptable
2.000	HW5	1350	Manhole	1 Adoptable	S2	1350	Manhole	1 Adoptable
2.001	S2	1350	Manhole	1 Adoptable	S3	1350	Manhole	1 Adoptable
2.002	S3	1350	Manhole	1 Adoptable	S4	1350	Manhole	1 Adoptable

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)
2.003	11.692	405.0	450	Circular	3.500	2.443	0.607	3.300	2.414	0.436

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
2.003	S4	1350	Manhole	1 Adoptable	HW6	1350	Manhole	1 Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)	
S1	553750.093	371769.757	3.900	0.359	1200					
						0	3.000	3.541	225	
HW1	553748.653	371781.294	3.750	0.287	1200		1	3.000	3.473	225
PS1	553791.783	371772.822	3.900	0.600	1200					
						0	1.000	3.300	300	
PS2	553789.197	371785.358	3.900	0.643	1200		1	1.000	3.257	300
						0	1.001	3.257	300	
PS3	553761.332	371782.632	3.900	0.736	1200		1	1.001	3.164	300
						0	1.002	3.164	300	
PS4	553756.260	371808.255	3.800	0.723	1200		1	1.002	3.077	300
						0	1.003	3.077	300	
PS5	553753.334	371823.073	3.800	0.773	1200		1	1.003	3.027	300
						0	1.004	3.027	300	
PS6	553744.119	371844.506	3.700	0.751	1200		1	1.004	2.949	300
						0	1.005	2.949	300	
PS7	553724.990	371880.831	3.600	0.788	1200		1	1.005	2.812	300
						0	1.006	2.812	300	
HW2	553712.286	371879.044	3.300	0.510	1200					
						0	4.000	2.790	300	

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)
HW3	553707.252	371879.521	3.500	0.750	1200	 1	4.000	2.755	300
HW4	553706.074	371884.455	3.500	0.767	1200	 1	1.006	2.733	300
HW5	553707.075	371901.175	3.500	0.860	1350	 0	2.000	2.640	450
S2	553712.673	371906.372	3.500	0.879	1350	 1	2.000	2.621	450
S3	553719.862	371945.318	3.500	0.977	1350	 1	2.001	2.523	450
S4	553688.664	371953.892	3.500	1.057	1350	 1	2.002	2.443	450
HW6	553690.965	371965.355	3.300	0.886	1350	 1	2.003	2.414	450

Simulation Settings

Rainfall Methodology	FSR	Analysis Speed	Normal
FSR Region	England and Wales	Skip Steady State	x
M5-60 (mm)	20.000	Drain Down Time (mins)	240
Ratio-R	0.400	Additional Storage (m ³ /ha)	0.0
Summer CV	0.750	Check Discharge Rate(s)	x
Winter CV	0.840	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
30	0	0	0
100	0	0	0
100	40	10	0

Node S4 Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	2.443	Product Number	CTL-SHE-0077-2500-0900-2500
Design Depth (m)	0.900	Min Outlet Diameter (m)	0.100
Design Flow (l/s)	2.5	Min Node Diameter (mm)	1200

Node HW5 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	22.000
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	2.640	Main Channel Slope (1:X)	200.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.035

Inlets

HW3

Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)
0.000	459.0	0.0	0.800	687.0	0.0

Node HW2 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	101.000
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	2.790	Main Channel Slope (1:X)	150.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.035

Inlets

HW1

Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)
0.000	65.0	0.0	0.300	390.0	0.0

Results for 1 year Critical Storm Duration. Lowest mass balance: 98.25%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	S1	10	3.619	0.078	9.6	0.0886	0.0000	OK
15 minute winter	HW1	11	3.581	0.117	50.1	0.1326	0.0000	OK
15 minute winter	PS1	10	3.370	0.070	7.1	0.0790	0.0000	OK
15 minute winter	PS2	11	3.325	0.068	7.0	0.0767	0.0000	OK
15 minute winter	PS3	11	3.229	0.065	6.9	0.0737	0.0000	OK
15 minute winter	PS4	11	3.164	0.087	10.9	0.0989	0.0000	OK
15 minute winter	PS5	11	3.127	0.100	14.7	0.1136	0.0000	OK
15 minute winter	PS6	12	3.045	0.096	14.4	0.1088	0.0000	OK
15 minute winter	PS7	12	2.921	0.109	18.4	0.1230	0.0000	OK
15 minute winter	HW2	15	2.927	0.137	56.6	0.1546	0.0000	OK
240 minute winter	HW3	208	2.783	0.033	9.9	0.0372	0.0000	OK
15 minute winter	HW4	12	2.836	0.103	18.3	0.0000	0.0000	OK
240 minute winter	HW5	208	2.783	0.143	12.6	0.2045	0.0000	OK
240 minute winter	S2	208	2.783	0.162	6.7	0.2316	0.0000	OK
240 minute winter	S3	208	2.783	0.260	6.5	0.3717	0.0000	OK
240 minute winter	S4	212	2.783	0.340	3.8	0.4862	0.0000	OK
15 minute summer	HW6	1	2.414	0.000	2.5	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	S1	3.000	HW1	9.5	0.646	0.239	0.1767	
15 minute winter	HW1	Flow through pond	HW2	56.6	0.400	0.015	14.8262	
15 minute winter	PS1	1.000	PS2	7.0	0.576	0.109	0.1552	
15 minute winter	PS2	1.001	PS3	6.9	0.603	0.109	0.3244	
15 minute winter	PS3	1.002	PS4	6.7	0.480	0.106	0.3698	
15 minute winter	PS4	1.003	PS5	10.7	0.571	0.168	0.2849	
15 minute winter	PS5	1.004	PS6	14.4	0.734	0.226	0.4641	
15 minute winter	PS6	1.005	PS7	14.4	0.678	0.226	0.8722	
15 minute winter	PS7	1.006	HW4	18.3	0.828	0.259	0.4272	9.6
15 minute winter	HW2	4.000	HW3	31.6	1.101	0.342	0.1452	
240 minute winter	HW3	Flow through pond	HW5	9.9	0.017	0.000	41.9129	
240 minute winter	HW5	2.000	S2	6.7	0.493	0.042	0.3609	
240 minute winter	S2	2.001	S3	6.5	0.415	0.041	2.8917	
240 minute winter	S3	2.002	S4	3.8	0.185	0.024	3.6105	
240 minute winter	S4	Hydro-Brake®	HW6	2.5				59.2

Results for 30 year Critical Storm Duration. Lowest mass balance: 98.25%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	S1	10	3.684	0.143	23.5	0.1614	0.0000	OK
15 minute winter	HW1	10	3.633	0.170	122.9	0.1919	0.0000	OK
15 minute winter	PS1	10	3.414	0.114	17.3	0.1285	0.0000	OK
15 minute winter	PS2	10	3.366	0.109	17.1	0.1227	0.0000	OK
15 minute winter	PS3	11	3.268	0.104	16.9	0.1178	0.0000	OK
15 minute winter	PS4	11	3.233	0.156	27.2	0.1764	0.0000	OK
15 minute winter	PS5	11	3.200	0.173	36.8	0.1956	0.0000	OK
15 minute winter	PS6	12	3.114	0.165	36.5	0.1867	0.0000	OK
15 minute winter	PS7	12	3.000	0.188	46.9	0.2127	0.0000	OK
15 minute winter	HW2	14	3.030	0.240	129.4	0.2714	0.0000	OK
360 minute winter	HW3	352	2.935	0.185	16.6	0.2093	0.0000	OK
15 minute winter	HW4	12	2.900	0.167	46.6	0.0000	0.0000	OK
360 minute winter	HW5	352	2.935	0.295	15.0	0.4222	0.0000	OK
360 minute winter	S2	352	2.935	0.314	5.2	0.4494	0.0000	OK
360 minute winter	S3	352	2.935	0.412	5.1	0.5896	0.0000	OK
360 minute winter	S4	352	2.935	0.492	3.4	0.7040	0.0000	SURCHARGED
15 minute summer	HW6	1	2.414	0.000	2.5	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	S1	3.000	HW1	23.3	0.822	0.585	0.3295	
15 minute winter	HW1	Flow through pond	HW2	129.4	0.505	0.034	33.0543	
15 minute winter	PS1	1.000	PS2	17.1	0.722	0.268	0.3033	
15 minute winter	PS2	1.001	PS3	16.9	0.767	0.265	0.6241	
15 minute winter	PS3	1.002	PS4	16.8	0.574	0.264	0.7670	
15 minute winter	PS4	1.003	PS5	27.0	0.683	0.423	0.5971	
15 minute winter	PS5	1.004	PS6	36.5	0.899	0.573	0.9494	
15 minute winter	PS6	1.005	PS7	36.1	0.837	0.566	1.7693	
15 minute winter	PS7	1.006	HW4	46.6	1.074	0.658	0.8362	23.6
15 minute winter	HW2	4.000	HW3	75.0	1.348	0.812	0.2803	
360 minute winter	HW3	Flow through pond	HW5	11.4	0.018	0.000	118.8648	
360 minute winter	HW5	2.000	S2	5.2	0.457	0.032	0.8718	
360 minute winter	S2	2.001	S3	5.1	0.380	0.032	5.3505	
360 minute winter	S3	2.002	S4	3.4	0.233	0.021	5.0234	
360 minute winter	S4	Hydro-Brake®	HW6	2.5				75.1

Results for 100 year Critical Storm Duration. Lowest mass balance: 98.25%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	S1	10	3.714	0.173	30.5	0.1953	0.0000	OK
15 minute winter	HW1	10	3.650	0.186	159.5	0.2108	0.0000	OK
15 minute winter	PS1	10	3.432	0.132	22.4	0.1493	0.0000	OK
15 minute winter	PS2	10	3.382	0.125	22.2	0.1419	0.0000	OK
15 minute winter	PS3	11	3.291	0.127	21.8	0.1433	0.0000	OK
15 minute winter	PS4	11	3.265	0.188	35.0	0.2125	0.0000	OK
15 minute winter	PS5	11	3.233	0.206	47.3	0.2326	0.0000	OK
15 minute winter	PS6	12	3.147	0.198	46.8	0.2239	0.0000	OK
15 minute winter	PS7	12	3.035	0.223	60.4	0.2526	0.0000	OK
15 minute winter	HW2	15	3.078	0.288	168.2	0.3258	0.0000	OK
480 minute winter	HW3	472	3.017	0.267	16.4	0.3024	0.0000	OK
15 minute winter	HW4	12	2.924	0.191	59.9	0.0000	0.0000	OK
480 minute winter	HW5	472	3.017	0.377	12.7	0.5400	0.0000	OK
480 minute winter	S2	472	3.017	0.396	4.3	0.5672	0.0000	OK
480 minute winter	S3	472	3.017	0.494	4.0	0.7074	0.0000	SURCHARGED
480 minute winter	S4	472	3.017	0.574	3.0	0.8219	0.0000	SURCHARGED
15 minute summer	HW6	1	2.414	0.000	2.5	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	S1	3.000	HW1	30.2	0.915	0.761	0.3843	
15 minute winter	HW1	Flow through pond	HW2	168.2	0.545	0.045	42.7585	
15 minute winter	PS1	1.000	PS2	22.2	0.767	0.347	0.3695	
15 minute winter	PS2	1.001	PS3	21.8	0.803	0.342	0.7840	
15 minute winter	PS3	1.002	PS4	21.5	0.582	0.337	0.9754	
15 minute winter	PS4	1.003	PS5	34.6	0.706	0.542	0.7393	
15 minute winter	PS5	1.004	PS6	46.8	0.942	0.734	1.1691	
15 minute winter	PS6	1.005	PS7	46.3	0.875	0.726	2.1673	
15 minute winter	PS7	1.006	HW4	59.9	1.156	0.846	0.9964	30.6
15 minute winter	HW2	4.000	HW3	89.4	1.376	0.968	0.3241	
480 minute winter	HW3	Flow through pond	HW5	8.6	0.018	0.000	163.2634	
480 minute winter	HW5	2.000	S2	4.3	0.425	0.027	1.1068	
480 minute winter	S2	2.001	S3	4.0	0.389	0.025	6.0655	
480 minute winter	S3	2.002	S4	3.0	0.186	0.019	5.1264	
480 minute winter	S4	Hydro-Brake®	HW6	2.5				85.5

Results for 100 year +40% CC +10% A Critical Storm Duration. Lowest mass balance: 98.25%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	S1	10	3.814	0.273	47.0	0.3085	0.0000	FLOOD RISK
15 minute winter	HW1	11	3.681	0.218	245.7	0.2465	0.0000	OK
15 minute winter	PS1	10	3.473	0.173	34.6	0.1953	0.0000	OK
15 minute winter	PS2	12	3.435	0.178	34.2	0.2019	0.0000	OK
15 minute winter	PS3	12	3.413	0.249	33.4	0.2818	0.0000	OK
15 minute winter	PS4	11	3.401	0.324	50.4	0.3662	0.0000	SURCHARGED
15 minute winter	PS5	12	3.363	0.336	67.2	0.3796	0.0000	SURCHARGED
15 minute winter	PS6	12	3.269	0.320	64.0	0.3615	0.0000	SURCHARGED
15 minute winter	PS7	11	3.123	0.311	84.2	0.3520	0.0000	SURCHARGED
720 minute winter	HW2	705	3.201	0.411	19.3	0.4653	0.0000	FLOOD RISK
720 minute winter	HW3	705	3.201	0.451	15.5	0.5105	0.0000	OK
15 minute winter	HW4	11	2.959	0.226	84.0	0.0000	0.0000	OK
720 minute winter	HW5	705	3.201	0.561	12.0	0.8033	0.0000	FLOOD RISK
720 minute winter	S2	720	3.202	0.581	4.0	0.8307	0.0000	FLOOD RISK
720 minute winter	S3	705	3.201	0.678	4.0	0.9706	0.0000	FLOOD RISK
720 minute winter	S4	705	3.201	0.758	3.0	1.0853	0.0000	FLOOD RISK
15 minute summer	HW6	1	2.414	0.000	2.5	0.0000	0.0000	OK

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	S1	3.000	HW1	46.6	1.173	1.173	0.4542	
15 minute winter	HW1	Flow through pond	HW2	237.9	0.581	0.063	67.0464	
15 minute winter	PS1	1.000	PS2	34.2	0.846	0.537	0.5183	
15 minute winter	PS2	1.001	PS3	33.4	0.841	0.524	1.4871	
15 minute winter	PS3	1.002	PS4	32.9	0.568	0.516	1.7365	
15 minute winter	PS4	1.003	PS5	49.2	0.709	0.771	1.0636	
15 minute winter	PS5	1.004	PS6	64.0	0.992	1.004	1.6429	
15 minute winter	PS6	1.005	PS7	63.9	0.938	1.002	2.8910	
15 minute winter	PS7	1.006	HW4	84.0	1.262	1.186	1.2271	47.2
720 minute winter	HW2	4.000	HW3	15.5	0.859	0.168	0.3561	
720 minute winter	HW3	Flow through pond	HW5	7.0	0.018	0.000	269.4156	
720 minute winter	HW5	2.000	S2	4.0	0.422	0.025	1.2102	
720 minute winter	S2	2.001	S3	4.0	0.374	0.025	6.2750	
720 minute winter	S3	2.002	S4	3.0	0.196	0.019	5.1264	
720 minute winter	S4	Hydro-Brake®	HW6	2.5				122.1