



FRITH:BLAKE
CONSULTING LTD

BULK GRAIN STORE, HOME FARM, LITTLE SUTTON
FLOOD RISK & DRAINAGE ASSESSMENT

For Thurlow Nunn Standen on behalf of T & A Piccaver

Version V1

Quality Assurance

Report Title: Flood Risk & Drainage Assessment
Project: Bulk Grain Store – Home Farm, Little Sutton,
Client: Thurlow Nunn Standen on behalf of T & A Piccaver
Project No: 2016-515
Revision: Version 1 – October 2016

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Appendix A – BRE 365 Percolation Tests

Appendix B – Proposed Drainage Layout Plan/Strategy

Appendix C – Surface Water Design Calculations

1. Introduction:

Frith Blake Consulting Ltd were instructed by Thurlow Nunn Standen on behalf of T&A Piccaver to prepare this Flood Risk and Drainage Assessment for the proposed construction of a bulk grain store. This report forms part of the supporting technical documentation for a Planning Application submitted by Thurlow Nunn Standen to South Holland District Council.

The purpose of this report is to provide information on the flood risk associated with the application site from all sources of flooding and present appropriate mitigation measures for the proposed development where flood risk has been identified. This report will also demonstrate that it is technically feasible to drain the increased volume of foul and surface water runoff created by the development of the site in a sustainable manner, without increasing flood risk to the site or any existing downstream development.

This report has been undertaken in accordance with the National Planning Policy Framework (NPPF), the Flood Risk and Coastal Change Planning Practice Guidance (PPG) and Lincolnshire County Council's Surface Water Guidance document.

2. Development Details:

2.1 Site Location

The site is located off Hundreds lane in Little Sutton, to the south west of the town of Long Sutton, Spalding, PE12 9AJ and is centre on Grid Reference: TF44887 20750 as shown in Figure 2.1 and 2.2 below.

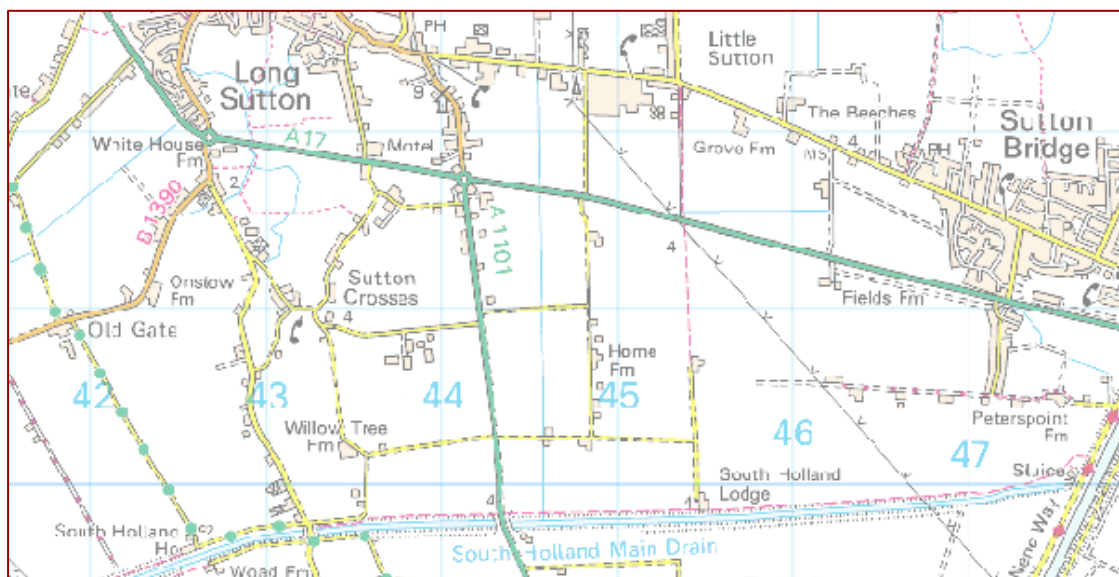


Figure 3.1; Site Location Plan



Figure 3.2; Aerial photograph of proposed site

2.2 Existing Site Description

The proposed development footprint, as indicated in Figure 2.2 above, encloses an area of 0.107 ha. The site is currently maintained grassland and is immediately adjacent to existing agricultural stores and apron slabs to the west and north west. Further north is an area of woodland separating the site from the farmhouse. To the east is agricultural land separated from the site by a small area of woodland. To the south is an area of maintained grassland separating the site from a small area of woodland surrounding a residential dwelling. The site is accessed via Hundreds Lane to the west.

The existing site layout has no areas of impermeable surfacing. Therefore, surface water runoff infiltrates into the open grassland and has a surface water discharge equal to the natural greenfield run-off rate.

3. Flood Hazard Review:

3.1 Source of Flooding

Fluvial Flooding is caused by rivers and occurs when the river channel capacity is exceeded by the flow. Most rivers have a natural floodplain which in built up areas is sometimes encroached upon by development.

The Environment Agency's (EA) indicative Fluvial and Tidal Flood Mapping as shown in Figure 3.1 below demonstrates that the proposed building site is located within Flood Zone 3 in accordance with Table 1 of the Flood Risk and Coastal Change PPG.

Therefore, the development is considered to be at a HIGH RISK of flooding from this source.



Figure 3.1; Fluvial & Tidal Indicative Flood Mapping

Tidal Flooding from the sea occurs when high tides and storm surges raise the level of tidal waters above the level of the shore or river bank. They can be sudden and severe, but are dependent upon a number of factors.

As shown within Figure 3.1 above the proposed grain store is located within Flood Zone 3 in accordance with Table 1 of the Flood Risk and Coastal Change PPG.

Therefore, the development is also considered to be at a HIGH RISK of flooding from this source.

Surface Water Flooding can occur within a highly dense urban area where there are large areas of impermeable surfacing e.g. roof areas, car parking and roads. It is possible during high intensity rainfall storms for surface water runoff to be unable to soak into the ground or enter the man-made drainage system at a quick enough rate. Where this occurs, the excess water can flow across land and potentially cause flooding.

The Environment Agency's (EA) indicative Surface Water Flood Mapping as shown in Figure 3.2 below demonstrates that the proposed building is located outside of the extent of surface water flooding with a risk rating of VERY LOW.

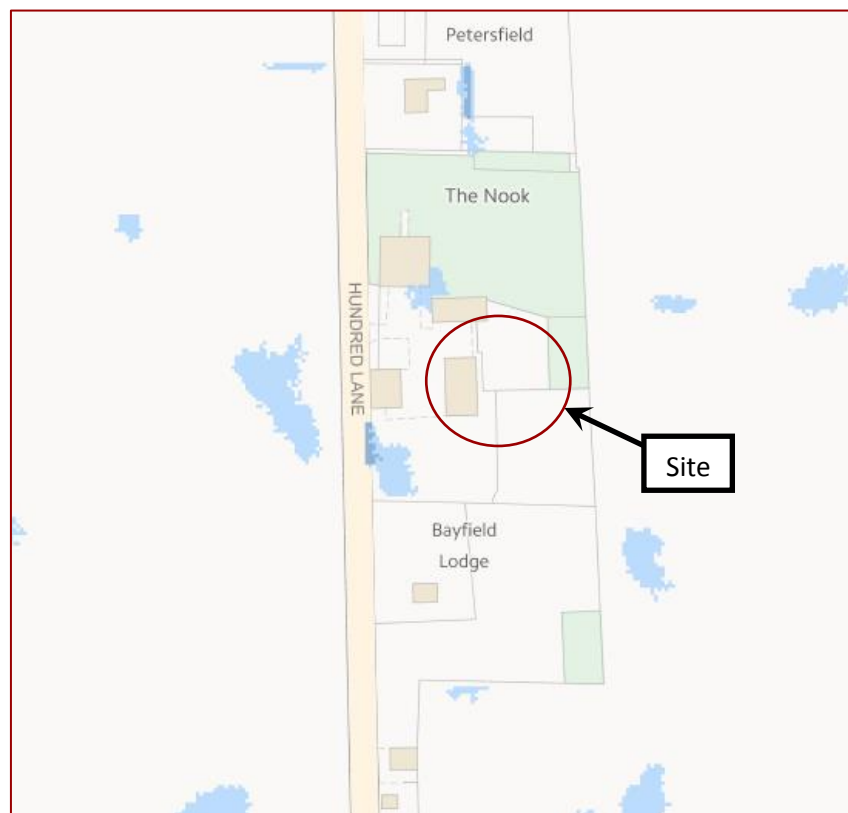


Figure 3.2; Surface Water Indicative Flood Mapping

However, to further reduce the risk of surface water flooding to the site and to make allowance for modelling error within Figure 3.2 above:

- An appropriate site level design as detail within Section 5 of this report will be required to channel flow away from the proposed in the event of a surcharging manhole of overland flow flood event across the site;
- An appropriate Surface Water Drainage Strategy should be incorporated into the development design as detailed within Section 5 of this report.

Groundwater Flooding occurs in areas where the level of groundwater is high; rainfall that soaks into the ground can raise it to a level where structures within the ground are at risk of flooding. Structures such as basements or detention ponds can be at risk, although this is dependent upon the ground conditions of the site.

The existing surrounding development has no visual effects of flood damage and the development proposal will incorporate FFL's to tie into the existing concrete apron slabs and store buildings as detailed within Section 5 of this report.

Trial holes have also been undertaken on site at the locations shown in Appendix A. The excavations were undertaken to a maximum depth of 2.8m below ground level (bgl). Very low seepage of perched ground water was identified in 3 of the trial pits at depths of between 2.4m and 2.8m.

Therefore, it is unlikely that the development will be affected by groundwater flooding and the risk of flooding from this source is considered to be VERY LOW at this stage.

Non-natural or artificial Flooding can include reservoirs, canals and lakes where water is retained above the natural ground level and flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure. The potential effects of flood risk management infrastructure should also be considered.

The Environment Agency's (EA) indicative Reservoir Flood Mapping as shown in Figure 3.3 below demonstrates that the proposed development site is located outside the extent of any reservoir breach flooding scenario.



Figure 4.3; Reservoir Indicative Flood Mapping

In addition to the above flood mapping a review of the OS mapping and a walk over survey of the site and surrounding area did not identify any artificial sources of flooding which could affect the proposed development.

Therefore, the risk of flooding from this source is considered to be LOW.

3.2 Strategic Flood Risk Assessment

A review of the South Holland District Council's Strategic Flood Risk Assessment (SFRA) undertaken by Scott Wilson in July 2011 has been carried out as part of this report.

The SFRA did not identify any site specific flood risks from any source of flooding and no historic flood events have been recorded/confirmed as part of the assessment.

The SFRA promotes the use of Sustainable Surface Water Drainage techniques as part of all new development in accordance with the NPPF and the Flood Risk and Coastal Change PPG.

3.3 Water Cycle Study

A review of the South Holland District Council's Water Cycle Study undertaken by Scott Wilson in September 2011 has been carried out as part of this report.

The Water Cycle Study did not identify any site specific flood risks from any source of flooding and no historic flood events have been recorded/confirmed as part of the assessment.

3.4 Description of Flooding

The site is considered to be at a VERY LOW RISK of flooding from all sources except:

- Surface water flooding which is considered to present a medium risk due to the increased area of impermeable surfacing created by the proposed development;
- Flooding from Rivers and Seas, however, Agricultural development is permitted within Flood Zone 3 and floor levels will be based on the levels of the existing concrete apron slab and building to ensure that the site is operational. It is not viable to elevate the building above the flood water levels.

Therefore, the focus of this report will be to mitigate the flood risks posed from this source by;

- Implementing the Finished Floor Level's (FFL's) and site level design parameters as detailed within Section 4 of this report during the detail design stage;
- Incorporating an appropriate surface water drainage strategy using sustainable drainage techniques as detailed within Section 5 of this report.

However, flood risk from other source will not be overlooked and the measures put forward to mitigate the risk of surface water flooding will also further reduce the already low risk from other potential sources of flooding.

3.5 Access and Egress

In accordance with the NPPF and the Flood Risk and Coastal Change PPG, access and egress to the site during a range of storm events should be considered with preference being over dry land, however, where this is not possible evacuation should fall within the white cells as classified within Table 13.1 of FD2320_TR2.

The proposed building is located within Flood Zone 3, however, it has been shown to be at a low risk of flooding from other sources with the appropriate mitigation implement into the site design. Therefore, the access and egress conditions for the site have been classified as safe and unlikely to require the assistance of the emergency services.

3.6 Vulnerability Classification

Table 2 of the Flood Risk and Coastal Change PPG provides a list of different types of development which fall into the vulnerability classifications also defined within the NPPF.

The proposed development is intended for agricultural use and therefore, the flood risk classification indicates that this falls within the **“Less Vulnerable”** classification.

3.7 Sequential and Exception Tests

The proposed grain store is classified as Less Vulnerable and is located with Flood Zone 3. Therefore, in accordance with Table 3 of the Flood Risk and Coastal Change PPG, the Exception Tests are not required to be undertaken by the Local Planning Authority as part of the planning process.

The store must be adjacent to the existing stores and apron slab and there are no other viable alternatives within Flood Zone 1 or 2. The site is therefore deemed to pass the sequential test.

4. Flood Risk Management Measure:

To enable the site to be considered in line with the NPPF and the Flood Risk and Coastal Change PPG, appropriate flood mitigation measures need to be set in place. The measures laid out below, are put forward as those that will be incorporated within the detailed design and operation of the proposed development.

4.1 Level Regime

The Finished Floor Level (FFL) of the agricultural building will be set to enable access from the existing apron slab. The external apron slabs will fall away from the proposed building towards a positive drainage system in the proposed concrete apron slab. This will ensure that during a flood event external areas flood prior to the building providing an early warning of rising flood water. It is not economically viable or operationally possible to raise the floor levels sufficiently high to avoid the risk of flooding entirely however the risks are associated with damage to crop and robust floor and wall elements which is considered to be an acceptable risk.

4.2 Flood Warning & Evacuation Plan

The site is located within an area where the Environment Agency operates a Flood Alert Service, as shown in Figure 4.1 below.

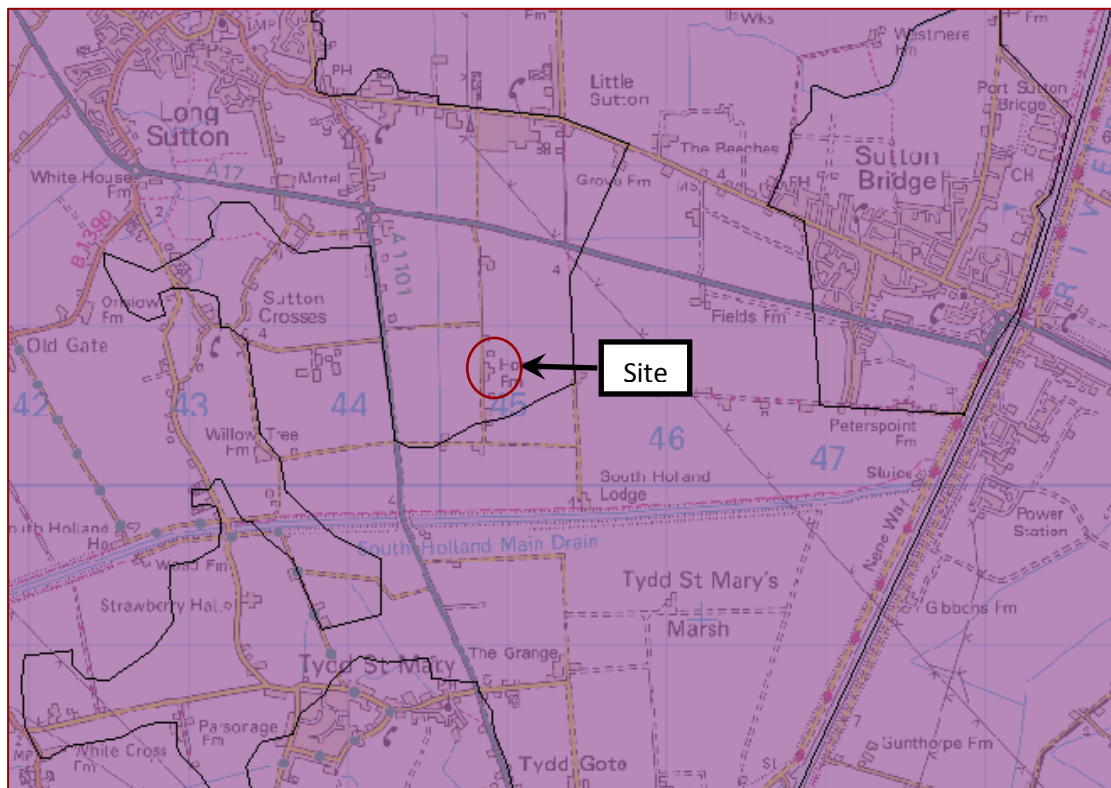


Figure 4.1; Environment Agency Flood Warning Areas

This scheme is free to join and provides early warning prior to the flood event, allowing for early and calm evacuation. Under the Scheme, there are three levels of flood warning, as shown in Table 4.1 below.

Flood Warning Code	Description
	Flood Alert: • Flooding is possible, be prepared. • Two hours to two days in advance of flooding.
	Flood Warning: • Flooding is expected, immediate action required. • Half an hour to one day in advance of flooding.
	Severe Flood Warning: • Severe flooding, danger to life. • When flooding poses a significant threat to life.

Table 4.1; Flood Warning Category

The following Flood Warning and Evacuation Plan has been prepared and will be put in place prior to the occupation of the proposed development. The following plan is considered as preliminary at this stage and the plan will be reviewed by the Client prior to its implementation and updated as necessary. The plan will then be maintained/reviewed and updated as necessary by the client on an annual basis:

- The site will be signed up to the Environment Agency's Flood Alert service as detailed above to provide early warning to the site and its operatives;
- The evacuation plan will be made available to all operatives and will be located within the on-site office. The plan will include information relating to the type of warning, Flood Alert, Flood Warning and Severe Flood Warning and will include key contact numbers of the emergency services, the Environment Agency and site managers;
- Flood response tasks will be allocated to individuals who have been trained in understanding the flood warnings, the type of flooding, the speed at which flood waters may rise and the evacuation procedures. Annual reviews will be undertaken to update the plan if necessary and ensure all relevant training has been given to all operatives;
- Any new or temporary staff will receive full health and safety training including the flood evacuation procedures;
- Should the site receive a Flood Alert, the supervising Flood Officer will alert all operatives and visitors on site to ensure that they safely depart over dry land prior to

flooding. All operatives and visitors to the site will be required to sign in on arrival and departure;

- Providing it is safe to do so any critical elements of plant will be shut down to limit damage and the risk of contamination and all vehicles will be placed on the highest parts of the site;
- On returning to site. Safety checks will be undertaken on all plant and machinery if it has been affected by flood water prior to use.

4.3 Surface Water Drainage Strategy

The surface water drainage strategy for the proposed development will be carried out in accordance with Section 5 of this report.

4.4 Detail Design

It is proposed that the mitigation measures set out above are controlled by conditions to the planning consent which will be approved by the LPA and their consultees.

5. Surface Water Drainage Strategy:

5.1 IDB Consultation

A formal pre-application consultation has not been undertaken at this stage as the proposed drainage strategy does not rely on an outfall into the IDB network.

5.2 Surface Water Runoff Rates

The area of the site intended for development currently comprises of permeable maintained grassland and therefore discharges its surface water runoff at the natural greenfield runoff rate.

The greenfield run-off rates shown in Table 5.1 below have been calculated using the IH 124 method while taking account of the existing site/ground conditions.

Return Period	Existing Discharge Rate	Existing Discharge Rate (+20%)
M1	0.1 l/s	N/A
M30	0.4 l/s	N/A
M100	0.6 l/s	N/A

Table 5.1 Existing Site Run-off Rates

The greenfield run-off volumes shown in Table 5.2 below have been calculated using the FSSR method during a 360-minute storm duration, and also taking account of the existing site/ground conditions.

Return Period	Existing Discharge Rate	Existing Discharge Rate (+20%)
M1	4.8 m ³	N/A
M30	11.6 m ³	N/A
M100	16.4 m ³	N/A

Table 5.2 Existing Site Run-off Volumes

The proposed development has an impermeable area of approximately 0.107 ha and prior to any mitigation measures being implemented as part of the surface water drainage strategy, the proposed development would produce unrestricted discharge rates and volumes as shown within Table 5.3 and 5.4 below (with and without the effects of climate change).

The runoff rates have been calculated using the Micro-Drainage design software (Colebrook-White Method) incorporating the FSR rainfall parameters for the site during a 15-minute winter event.

Return Period	Potential Discharge Rate	Potential Discharge Rate (+20%)
M1	16.0 l/s	19.2 l/s
M30	39.2 l/s	47.1 l/s
M100	50.9 l/s	61.1 l/s

Table 5.3 Potential Site Runoff Rates

The runoff volumes have also been calculated using the Micro-Drainage design software (Colebrook-White Method) incorporating the FSR rainfall parameters for the site during a 360-minute winter event.

Return Period	Potential Discharge Rate	Potential Discharge Rate (+20%)
M1	19.7 m ³	23.6 m ³
M30	43.3 m ³	52.0 m ³
M100	56.2 m ³	67.4 m ³

Table 5.4 Potential Site Run-off Volumes

The proposed development layout increases the impermeable area of the site by approximately 0.107 ha when compared to the existing site layout. To ensure the proposed development does not exceed the existing discharge rates and volumes as stated within Table 5.1 and 5.2 above, adequate mitigation measures will be required as part of the proposed surface water drainage strategy as detailed within Section 5.3 below.

5.3 Climate Change

In accordance with recently published document 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities' Table 4 provides advice in relation to changes to rainfall intensity as a result of future climate change.

For agricultural development the potential changes anticipated up to the year 2069 range between:

- Upper Estimate = 20%;
- Central Estimate = 10%;

The above document clearly states that there is uncertainty in relation to the accuracy of the above data and this is represented by the varying range of climate change allowance. As a precautionary approach, a 20% (Upper Estimate) increase in peak rainfall intensity has been

incorporated into the design of the developments surface water drainage strategy to allow for the effects of climate change over the lifetime of the development.

5.4 Sustainable Drainage Systems (SuDS)

The development will incorporate a Sustainable Drainage System (SuDS) that suits the site conditions and location. However, all sites have constraining factors and therefore the use of certain SuDS solutions may be restricted.

In accordance with the NPPF and the Flood Risk and Coastal Change PPG, infiltration drainage is the preferred method of surface water disposal and this has been considered during the early stages of the development's drainage strategy.

A review of the British Geological Survey (BGS) mapping website has identified the site geology as follows:

- Superficial deposits – Tidal Flat Deposits (Clay & Silt);
- Bedrock geology – Ampthill Clay Formation (Mudstone).

To obtain a more accurate understanding of the site geology and its potential for infiltration drainage techniques an intrusive investigation was undertaken across the area of the site (Home Farm) intended for development. The investigation included 2No. Percolation Tests in accordance with BRE 365 and these were both undertaken in the location of the proposed infiltration structure. A copy of the onsite field results and infiltration calculations have been included within Appendix A.

A summary of the results obtained for each test hole has been provided below:

- Test Hole 1B = 2.556E-05 m/s
- Test Hole 1C = 2.073E-05 m/s

Based on the percolation testing and trial holes undertaken to date, the use of infiltration drainage techniques are considered to be a suitable method of surface water disposal. This has been further reinforced by reviewing the existing drainage network that currently serves the surrounding buildings and hardstanding areas that currently drain to concrete ring soakaways.

It should be noted that due to time constraints that the BRE 365 percolation tests were not fully completed and some interpolation of the results was included within the calculations included with Appendix A. Therefore, further intrusive investigation will be undertaken at the detailed design stage and this will include additional percolation testing in accordance with BRE 365.

However, as a precautionary approach and to account for any potential discrepancies within the results obtained, the lowest infiltration rate of the two percolation tests undertaken has been utilised for the purpose of this outline drainage strategy. In addition to this, an increased safety factor of 10 was applied to the design calculations.

The preliminary surface water drainage layout/strategy and associated design calculations have been included within Appendix B and C respectively. At this outline design stage, the proposed drainage structure has been provided using an infiltration basin and the design of this structure has been undertaken in accordance with the following design criteria:

- The infiltration drainage system has been designed to contain the critical 100-year storm event with a 20% increase in rainfall intensity to allow for the effect of climate change;
- The infiltration drainage system has been designed to have a half drain time of less than 1440 minute (1 day) during the critical 100-year plus climate change storm event.
- The long term maintenance and ownership of the infiltration drainage system should be established early on during the design process.

By utilising infiltration drainage techniques, the above strategy will not increase the surface water discharge rate or volume from the site beyond the greenfield rates calculated with Table 5.1 and 5.2 above.

The positive surface water sewer network intended to serve the site development should be designed to ensure no surcharging of the network occurs during the critical 1-year storm event and no flooding of the network occurs during the critical 30-year storm event. The 100-year plus climate change storm event should be directed to the attenuation storage by either up sizing the positive surface water drainage network accordingly and/or by above ground flood routing, depending of the type of attenuation storage (above or below ground) used during the detailed design stage.

Due to the number of calculations sheets, the hydraulic calculations for the existing and proposed discharge rates and volumes as denoted within Table 5.1 – 5.4 have not been included as part of this report. A copy of these calculations are available for the site on requested.

5.5 Pollution Control Measures

Pollution control measures should be put in place during the detail design in accordance with the SuDS Manual CIRIA 753 to reduce the risk of contaminates entering any watercourse and/or groundwater table.

At part of the outline drainage strategy the following treatment stages have been implemented into the design for the various impermeable areas depending on the risk posed from this source:

The concrete hardstanding areas will present the highest pollution risk from this source and the pollution control measures put in place to mitigate this risk include:

- **Stage 1** – The runoff will be collected via catchpit gullies and the proposed positive drainage network will incorporate the use of catchpit manhole chambers along the entire length of the network;
- **Stage 2** – A T-shaped outlet pipe will be located on the final manhole prior to discharging into the Infiltration Basin;
- **Stage 3** – The vegetated Infiltration Basin will provide the final level of pollution treatment;

The roof area of the agricultural building will present a lower pollution risk however the following pollution control measures have been put in place to further minimise this risk:

- **Stage 1** – The runoff will be collected via RXP's and the proposed positive drainage network will incorporate the use of catchpit manhole chambers along the entire length of the network;
- **Stage 2** – A T-shaped outlet pipe will be located on the final manhole prior to discharging into the Infiltration Basin;
- **Stage 3** – The vegetated Infiltration Basin will provide the final level of pollution treatment;

6. Off-site Impact:

6.1 Impact of the Development on the Hydrological Morphology

The application site is located within Flood Zone 3 which forms part of a wider floodplain. The floodplain area is very large and therefore the impact of the development on flood levels associated with the loss of flood storage is not considered significant. Any overland flow is able to pass around all sides of the development and is therefore not impacted by the proposed development.

Therefore the development will have no significant impact on the hydrological morphology of the surrounding area.

6.2 Impact of the Surface Water Drainage Strategy

The proposed surface water drainage strategy as detailed within Section 5 of this report present a viable options for the control of surface water run off designed to accommodate the critical 100 year plus climate change storm event in accordance with the NPPF, the Flood Risk and Coastal Change PPG and Lincolnshire County Council's Surface Water Guidance documents.

Therefore there will be no significant increase in the risk of surface water flooding to the site, its occupants or existing surrounding development.

7. Residual Risk:

7.1 Remaining Flood Risk

There are two main residual flood risks to be considered within this report:

- The first residual flood risk is associated with the tidal and fluvial flood plain. The site is located within Flood Zone 3.
- The second residual flood risk is that from the possible blockage of the private sewers network which will surrounds and crosses the site. Should the maintenance of these structures not be undertaken then there is an increased risk that they could cause onsite flooding.

7.2 Risk Management Responsibility

The risk management measures below are recommended to reduce the residual risk to the site and its occupants:

- Whilst the maintenance and repair of the existing flood defences is the responsibility of the Environment Agency, the residual risk to the occupants in the event of a breach scenario can be significantly reduced by:
 - i) Signing up to the Environment Agency's early warning service.
 - ii) Acting on the early warning provided by the Environment Agency by implementing the pre-prepared flood response/evacuation plan.
- The maintenance of the private sewer network and attenuation located within the site can be dealt with through the implementation of a maintenance regime which will be undertaken by the onsite maintenance staff or external management company.

7.3 Maintenance Regime

The maintenance of the private sewer network and surface water attenuation located within the site and the principal farm reservoirs to the south can be dealt with through the implementation of a maintenance regime which will be undertaken by the Client.

The preliminary maintenance regime for the private storm and foul water drainage network is set out below;

- Inspection and clearance of all Catchpit Gullies, Inspection Chambers (IC) and Manholes to be undertaken on an annual basis.
- Inspection and clearance of all gutters and filter meshes to be undertaken on an annual basis.
- Inspection and clearance of the soakaway facility should be undertaken on an annual basis.

The maintenance regime recommended above is put in place to minimise the risk of blockages occurring and to prevent surface water surcharging from the inspection chambers and manholes. However, the final maintenance regime should be undertaken during the detail

design stage to ensure the proposal suits the final design of the surface water drainage network. If flooding from the drainage system occurs, then the cause should be identified and dealt with immediately and if considered appropriate, the maintenance regime should be adapted to ensure the cause of flooding does not occur again in the future.

8. Discussion and Conclusions:

This Flood Risk and Drainage Assessment has been undertaken in accordance with the National Planning Policy Framework (NPPF), the Flood Risk and Coastal Change PPG and Lincolnshire County Council's Surface Water Guidance document.

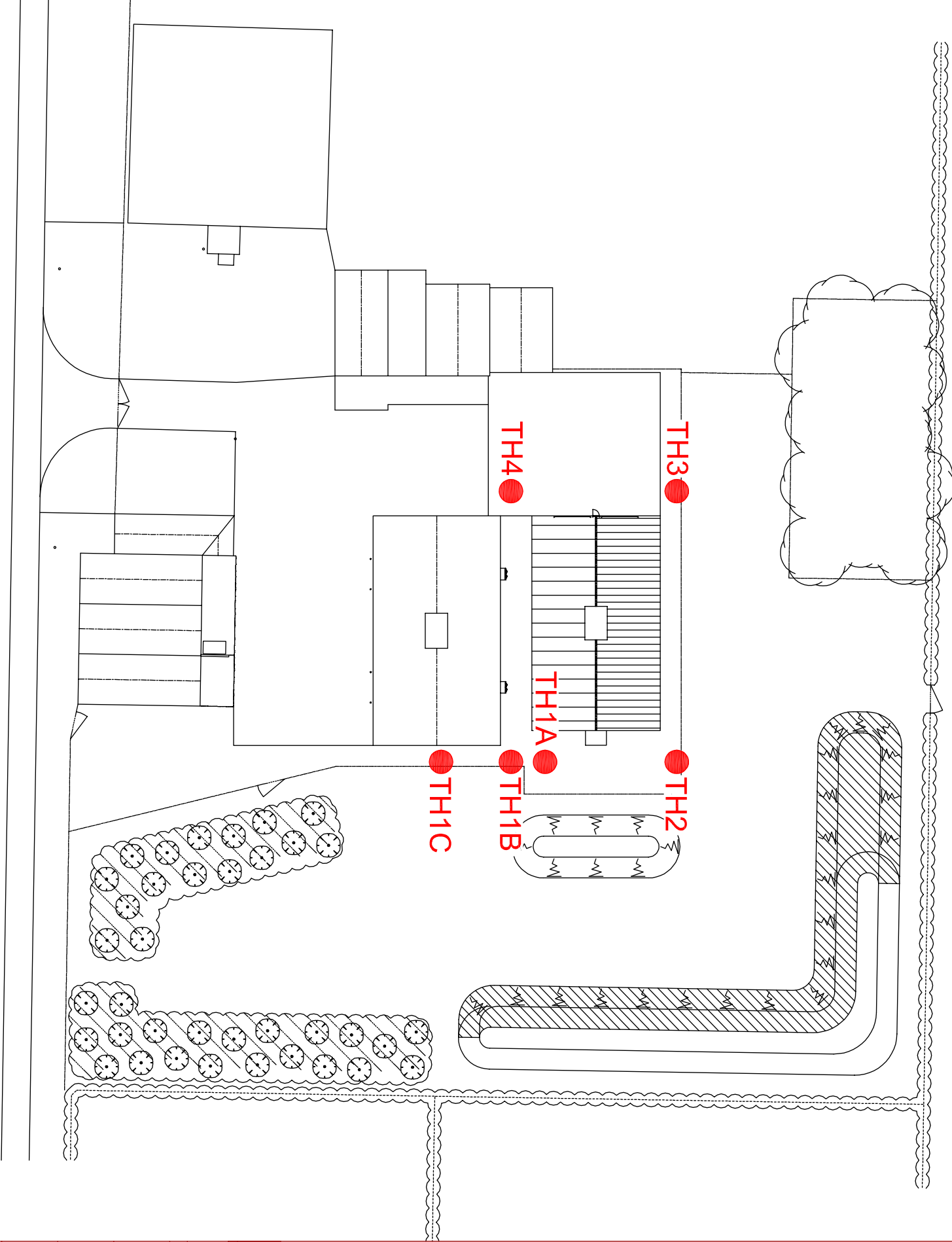
The report demonstrates that the development site;

- is located within Flood Zone 3 and an area considered to be at risk of flooding from artificial sources associated with the Whittlesey (Nene) Washes and associated IDB drainage network.
- is considered to pass the requirements of the Sequential test.
- is not subject to the Exception test during the planning process.
- will incorporate appropriate finished floor levels to ensure that the risks of flooding are minimised;
- will implement an appropriate Flood Evacuation Plan;
- will incorporate a sustainable surface water drainage strategy to drain the proposed developments impermeable areas and ensure flood risk is not increased to existing surrounding development and its users.

Therefore, the proposed development is considered appropriate from a flood risk and surface water drainage perspective subject to the implementation of the recommended mitigation measures put forward as part of this report.

APPENDIX A

BRE 365 PERCOLATION TEST RESULTS



REV	DESCRIPTION	DATE	BY	CHEK



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Project Name: Proposed Grain Store
Home Farm
Long Sutton, Lincolnshire

Drawn by: T A Plesner

Checked by: T A Plesner

Project Title: Infiltration Test & Trial Hole Location Plan

PROPOSED GRAIN STORE – HOME FARM, LONG SUTTON, LINCOLNSHIRE

TRIAL HOLE DESCRIPTION

Trial Pit 1A

- 0-300mm topsoil
- 300-2800mm yellow sandy SILT with slightly clayey inclusions. Becoming firmer with depth

Trial Pit 1B

- 0-300mm topsoil
- 300-1200mm yellow sandy SILT.

Trial Pit 1C

- 0-300mm topsoil
- 300-1000mm yellow sandy SILT.

Trial Pit 2

- 0-200mm topsoil
- 200-500mm loamy topsoil/silt mix;
- 500-1600mm – dark yellow-light brown clayey sandy SILT with very small organic inclusions;
- 1600-2000mm – dark grey clayey SILT;
- 2000mm-2800mm yellow sandy SILT with clayey inclusions becoming firmed with depth. Saturated;
- Low water seepage at 2.8m

Trial Pit 3

- 0-200mm topsoil
- 200-400mm topsoil/loamy mix;
- 400-2800mm yellow sandy silt with slightly clayey inclusions. Becoming firmer with depth
- Slow water ingress at 2400mm.

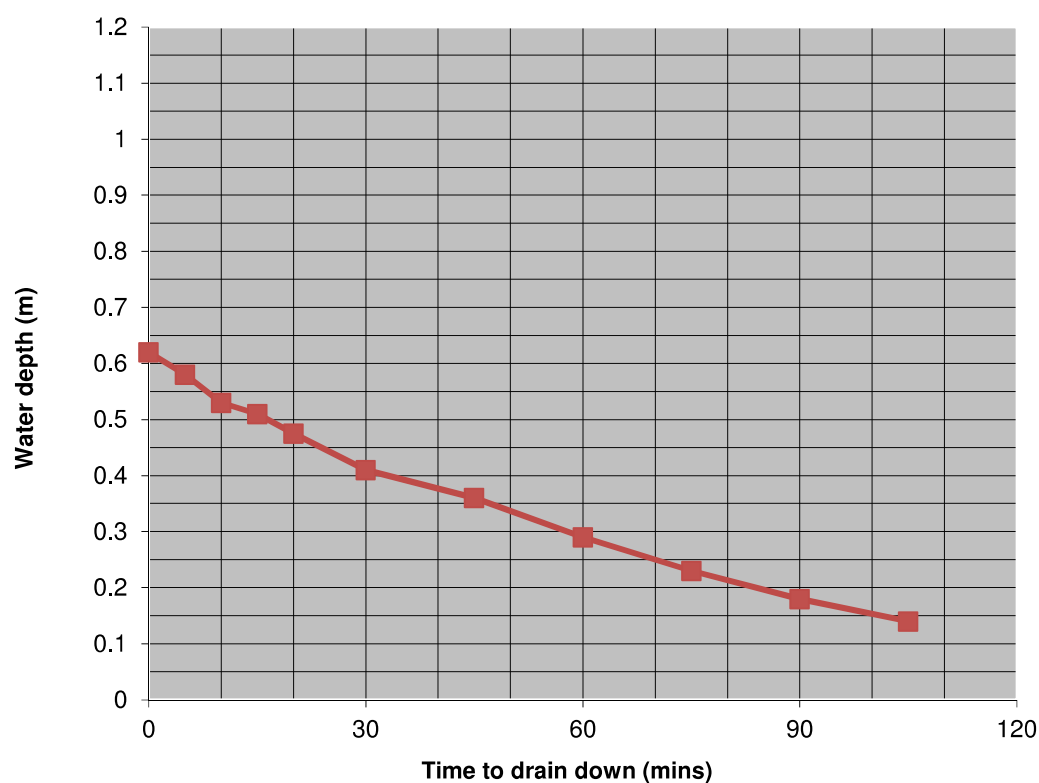
Trial Pit 4

- 0-300mm topsoil
- 300-2600mm yellow sandy silt with slightly clayey inclusions. Becoming firmer with depth
- 400-600; sandy/loamy mix
- 600-1100; orange sandy Boulder clay with large flints getting more sandy with depth
- 1100-2000; orange very clayey Sand
- 2000-2200; yellow sand with occasional gravel

Job No: 2016-	Date: Oct-16	Client: T A Piccaver
Prepared By: JF	Checked By: DB	Project: Grain Store
Sheet No: 4	Revision 0	Home Farm Long Sutton



Hole 1B: Test 1



V (75-25) 0.205 cu m

T (75-25) 1.297 hrs

Wetted Area (50%) 1.714 sq m

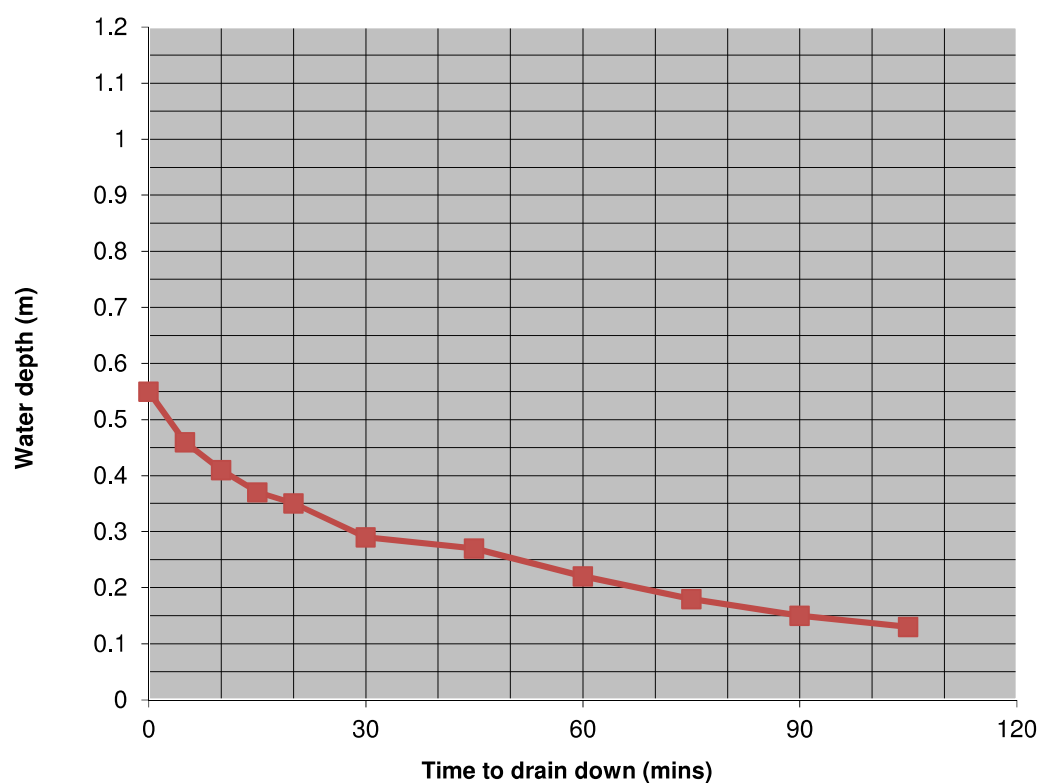
Infiltration rate m/hr 0.092015284 m/hr

Infiltration rate m 2.556E-05 m/s

Job No: 2016-	Date: Oct-16	Client: T A Piccaver
Prepared By: JF	Checked By: DB	Project: Grain Store
Sheet No: 6	Revision 0	Home Farm Long Sutton



Hole 1B: Test 1



V (75-25) 0.165 cu m

T (75-25) 1.494 hrs

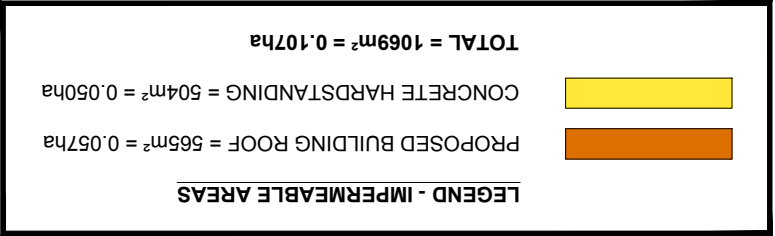
Wetted Area (50%) 1.480 sq m

Infiltration rate m/hr 0.074635305 m/hr

Infiltration rate m 2.073E-05 m/s

APPENDIX B

PREPOSED INDICATIVE DRAINAGE LAYOUT



NOTES: _____

APPENDIX C

SURFACE WATER DRAINAGE CALCULATIONS

BLI Consulting		Page 1
Norwich Norfolk .	Proposed Grain Store Home Farm, Long Sutton Lincolnshire	
Date October 2016 File M100+CC_INFILTRATION BASIN_V1...	Designed by JF Checked by DB	
Causeway	Source Control 2015.1	

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 1315 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m ³)	Status
15 min Summer	1.326	0.326	0.3	23.6	O K
30 min Summer	1.399	0.399	0.3	30.8	O K
60 min Summer	1.467	0.467	0.4	38.1	O K
120 min Summer	1.527	0.527	0.4	45.2	O K
180 min Summer	1.557	0.557	0.4	48.9	O K
240 min Summer	1.575	0.575	0.4	51.2	O K
360 min Summer	1.596	0.596	0.4	54.0	O K
480 min Summer	1.607	0.607	0.5	55.5	O K
600 min Summer	1.613	0.613	0.5	56.3	O K
720 min Summer	1.616	0.616	0.5	56.6	O K
960 min Summer	1.614	0.614	0.5	56.5	O K
1440 min Summer	1.609	0.609	0.5	55.7	O K
2160 min Summer	1.596	0.596	0.4	54.1	O K
2880 min Summer	1.581	0.581	0.4	52.1	O K
4320 min Summer	1.548	0.548	0.4	47.9	O K
5760 min Summer	1.517	0.517	0.4	44.0	O K
7200 min Summer	1.488	0.488	0.4	40.6	O K
8640 min Summer	1.462	0.462	0.4	37.6	O K
10080 min Summer	1.438	0.438	0.3	34.9	O K
15 min Winter	1.355	0.355	0.3	26.4	O K
30 min Winter	1.434	0.434	0.3	34.5	O K
60 min Winter	1.506	0.506	0.4	42.8	O K
120 min Winter	1.571	0.571	0.4	50.8	O K
180 min Winter	1.604	0.604	0.5	55.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Time-Peak (mins)
15 min Summer	118.417	0.0	19
30 min Summer	77.747	0.0	34
60 min Summer	48.611	0.0	64
120 min Summer	29.354	0.0	124
180 min Summer	21.556	0.0	182
240 min Summer	17.210	0.0	242
360 min Summer	12.501	0.0	362
480 min Summer	9.962	0.0	482
600 min Summer	8.347	0.0	600
720 min Summer	7.221	0.0	720
960 min Summer	5.740	0.0	894
1440 min Summer	4.148	0.0	1112
2160 min Summer	2.992	0.0	1512
2880 min Summer	2.371	0.0	1928
4320 min Summer	1.705	0.0	2764
5760 min Summer	1.348	0.0	3576
7200 min Summer	1.123	0.0	4392
8640 min Summer	0.967	0.0	5184
10080 min Summer	0.852	0.0	5944
15 min Winter	118.417	0.0	19
30 min Winter	77.747	0.0	33
60 min Winter	48.611	0.0	64
120 min Winter	29.354	0.0	122
180 min Winter	21.556	0.0	180

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Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
240 min Winter	1.623	0.623	0.5	57.7	O K
360 min Winter	1.647	0.647	0.5	60.9	O K
480 min Winter	1.660	0.660	0.5	62.8	O K
600 min Winter	1.668	0.668	0.5	63.9	O K
720 min Winter	1.672	0.672	0.5	64.5	O K
960 min Winter	1.673	0.673	0.5	64.7	O K
1440 min Winter	1.664	0.664	0.5	63.4	O K
2160 min Winter	1.649	0.649	0.5	61.2	O K
2880 min Winter	1.629	0.629	0.5	58.4	O K
4320 min Winter	1.585	0.585	0.4	52.5	O K
5760 min Winter	1.542	0.542	0.4	47.0	O K
7200 min Winter	1.503	0.503	0.4	42.3	O K
8640 min Winter	1.467	0.467	0.4	38.2	O K
10080 min Winter	1.435	0.435	0.3	34.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
240 min Winter	17.210	0.0	238
360 min Winter	12.501	0.0	356
480 min Winter	9.962	0.0	470
600 min Winter	8.347	0.0	584
720 min Winter	7.221	0.0	696
960 min Winter	5.740	0.0	914
1440 min Winter	4.148	0.0	1156
2160 min Winter	2.992	0.0	1620
2880 min Winter	2.371	0.0	2076
4320 min Winter	1.705	0.0	2944
5760 min Winter	1.348	0.0	3808
7200 min Winter	1.123	0.0	4680
8640 min Winter	0.967	0.0	5448
10080 min Winter	0.852	0.0	6256

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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+20

Time Area Diagram

Total Area (ha) 0.107

Time (mins)	Area
From:	To: (ha)

0	4 0.107
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Model Details

Storage is Online Cover Level (m) 1.700

Infiltration Basin Structure

Invert Level (m) 1.000 Safety Factor 10.0
Infiltration Coefficient Base (m/hr) 0.07463 Porosity 1.00
Infiltration Coefficient Side (m/hr) 0.07463

Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)	Depth (m)	Area (m ²)
0.000	52.1	0.600	133.2	1.200	234.7	1.800	334.8	2.400	334.8
0.100	64.2	0.700	148.7	1.300	253.6	1.900	334.8	2.500	334.8
0.200	76.9	0.800	164.8	1.400	273.1	2.000	334.8		
0.300	90.1	0.900	181.4	1.500	293.1	2.100	334.8		
0.400	103.9	1.000	198.6	1.600	313.7	2.200	334.8		
0.500	118.3	1.100	216.4	1.700	334.8	2.300	334.8		