

**Flood Risk Assessment and
Drainage Report
for the

Proposed
Greenhouse Growing Facility
off
Clay Bank, Spalding
Lincolnshire
PE12 6BN**

**Prepared for
Bridge Farm Nurseries Ltd
& Clay Lake Farm Ltd**

December 2017

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1.0 DEVELOPMENT SITE AND LOCATION

- 1.1. The proposed development is located off Clay Lake bank, Spalding, Lincolnshire PE12 6BN. The OS Grid Reference of the application site is TF 259 206. The location of the site is shown on the drawings provided in Appendix 1.
- 1.2. The site covers approximately 39.7 hectares with dimensions of approximately 450m west to east and 890m north to south.
- 1.3. The site is bounded by a road named Clay Lake Bank and agricultural fields to the other three sides. The site currently consists of three fields and used for agricultural.
- 1.4. The site is bounded by drainage ditches along all four sides and there are two private ditches which cross the site in the line of the existing field boundaries. The drain on the eastern boundary becomes a South Holland IDB drain approximately 350m from the south east corner of the site.
- 1.5. The site falls is generally flat with levels varying between 2.0 and 2.5m AOD.
- 1.6. Drawing 605-010 provided in Appendix 1 illustrates the levels across the site and the key drainage features.
- 1.7. The site is located approximately 2km east of the River Welland and 20km inland from The Wash.
- 1.8. The site is located within Flood Zone 3 on the Flood Maps for Planning available on the gov.uk web site.

2.0 DEVELOPMENT PROPOSALS

- 2.1. The proposed development involves the construction of plant growing facility consisting of greenhouses, warehouses, offices and concrete hardstanding areas. The proposed development will create around 35.0 hectares of artificial surfaces.
- 2.2. Details of the proposed development are shown on Drawing 605-011 contained in Appendix 1.
- 2.3. The lifetime of the development is considered to be 100 years.
- 2.4. In accordance with Table 2 of the National Planning Policy Framework (NPPF) Technical Guidance Document the residential development would be classed as less vulnerable.
- 2.5. In accordance with Table 3 of the NPPF Technical Guidance Document less vulnerable developments in Flood Zone 3 are acceptable without the need to pass the Exception Test.
- 2.6. This Flood Risk & Drainage Assessment Report provides the information required to demonstrate a strategy for dealing with surface water run-off in a sustainable way such that the on and off site impacts are minimal.
- 2.7. This report also includes a section which considers how foul sewerage may be provided for the development.

3.0 SEQUENTIAL TEST

- 3.1. As stated previously the site is in Flood Zone 3 but the vast majority of land around Spalding is also in Flood Zone 3.
- 3.2. The proposed site has been selected for other operational reasons such as transport links, proximity to Spalding and a lower Environmental Impact.
- 3.3. Within Section 5.0 of this report it is demonstrated that although this site is in Flood Zone 3 it is considered to have a low Flood Hazard Rating
- 3.4. No other suitable sites in lower flood zones or sites with lower Flood Hazard Ratings have been identified within the local area
- 3.5. Taking into account the above points the site can be considered to have passed the Sequential Test.

4.0 CLIMATE CHANGE

- 4.1. The NPPF web based guidance provides guidance on potential effects of climate change on flooding which is based on information published by the Environment Agency.
- 4.2. The Environment Agency in February 2016 has published updated information on Climate Change. The new guidance advises that for more vulnerable developments in Anglian Region the Flood Risk should be assessed against climate change allowances of 35% and 65% for river flows and increases in peak rainfall intensity of up to 40%.
- 4.3. The Environment Agency Flood Maps have not been updated to take account of the revised climate change information. However, it is understood that the South Holland District Council Strategic Flood Risk Assessment does take into account the potential increase in flooding due to increases in sea levels to 2115.
- 4.4. Higher peak rainfall intensities may increase the risk of surface water flooding from the surface water drainage systems in the vicinity of the site. Although the frequency of the flooding may increase provided exceedance flow paths are provided then there will be minimal effect on surface water flooding.
- 4.5. The surface water drainage system serving the site will need to be designed such that potential additional flows due to climate change do not cause flooding on this development and do not contribute to an increased risk of flooding elsewhere in the catchment.
- 4.6. It should be noted that the projected increase peak rainfall intensities do not result in a similar increase in storage volume required i.e. peak intensity may increase by up to 40% but average rainfall will not increase by the same amount.
- 4.7. Previous guidance published by the Environment Agency states that for the period in which peak rainfall intensities may rise by up to 30%, the increase in the volume of run-off will only increase by 20%. Therefore it is reasonable to assume that for a 40% increase in rainfall intensity the increase in volume of run-off will not increase by more than 30%
- 4.8. It is proposed that the surface water collection and attenuation system for the development site is designed to take into account the potential effects of climate change.

5.0 SITE SPECIFIC FLOOD RISK

5.1. The site is at risk of flooding from the following sources

- a) Flooding from a breach of the raised defences of the River Welland
- b) Flooding from high water levels in the Drains Surrounding the Site
- c) Flooding from infrastructure failure
- d) Flooding from groundwater
- e) Flooding from failure of the site surface water drainage system.

5.2. Each of the above potential sources of flooding is assessed in more detail as follows

Flooding from a Breach of the Raised Defences on the River Welland

5.3. The Flood Risk Maps for Planning show that the site is in Flood Zone 3,

5.4. It is understood that the Environment Agency Flood Maps for Planning are based on flooding without the presence of defences and is generally a horizontal projection of the high tide or fluvial flood levels.

5.5. More detailed Flood Information for this site was requested from the Environment Agency and the information provided is contained in Appendix 1. The information is summarised as follows

5.6. Cowbit Washlands is functional flood plain and flooding will extend towards the site as far as the Barrier Bank some 1600m south west of the site.

5.7. The March 1947 flooding on the River Welland was contained within the Cowbit Washlands.

5.8. The modelled 1 in 100 year in channel flood level at the node closest to the site is 4.52m AOD. This increases to 4.66m AOD with a 20% allowance for Climate Change. The 1 in 100 year flood level is at least 2.0m higher than the ground level at the site.

5.9. The Environment Agency has stated that the raised earth flood defences that protect the site are in good condition and provide protection from a 1 in 100 year event.

5.10. The site is at a potential risk of flooding from either a breach of or overtopping of the defences. With earth defences any prolonged overtopping of the defences will normally lead to a breach.

5.11. It is understood that the River Welland is tidal as far as Fulney Lock and Marsh Road Sluice downstream of Spalding. Therefore the site is unlikely to be affected by tidal events.

5.12. It is understood that the Environment Agency has only undertaken Flood Hazard Mapping for the tidal section of the River Welland and has suggested that reference is made to the South Holland District Council Strategic Flood Risk Assessment (SFRA)

5.13. The SFRA contains several large maps showing modelled flood depths for various flooding scenarios. The maps show the Actual Risk and the Residual Risk. The Actual Risk Maps show the risk of flooding for overtopping and eventual breaching at the known locations where the available freeboard is less than the design minimum. The Residual Risk Maps show the risk of flooding due to a failure of the defences anywhere on the system.

- 5.14. For the present day the site is shown not to be at risk of flooding on either the Actual or Residual Risk Maps.
- 5.15. For the 2115 the site is shown to be at risk of flooding to depths between 0.0 and 0.5m on the Actual Flood Risk Maps increasing to 0.5 to 1.0m on the Residual Flood Risk Maps.
- 5.16. Copies of the parts of the SFRA 2115 Residual and Actual Flood Maps which cover the site are contained in Appendix 1.
- 5.17. A single 40m breach of the defences at the closest point to the site has been considered. Using a simplified breach analysis and assuming a flat unimpeded area for waters from the breach to flow it has been estimated that potential flood depths at the site would be less than 150mm. The velocity of the floodwaters would be less than 0.25m/s and would take over two hours to reach the site. This would result in a low Flood Hazard Rating.
- 5.18. Copies of the Breach Calculations are presented in Appendix 1.
- 5.19. It should also be noted that the breach calculations ignore the presence of the A16 Spalding by-pass which is elevated and will provide a partial restriction to floodwaters from a breach flowing towards the site.
- 5.20. The Long Term Flood Risk Information provided on the Gov.uk web-site indicates that the site is at risk of flooding from reservoir failure. It is understood that the reservoir in question is the Cowbit Washlands.
- 5.21. The SFRA has considered breaches of the fluvial flood embankments. However, as the Cowbit Washlands right hand bank has a crest in excess of 15.0m and has a road on top of it, the risk of breaching was considered negligible.
- 5.22. It is understood that the Environment Agency concur with this view and Flood Hazard Maps for a breach of the Barrier Bank have not been produced.
- 5.23. Therefore the risk of flooding from reservoir failure is considered minimal.

Flooding from High Water Levels in the Open Drains Surrounding the Site

- 5.24. The site is surrounded by open drainage ditches and two drains cross the site along the existing field boundaries. The drain on the eastern boundary becomes a South Holland IDB drain approximately 350m from the south east corner of the site.
- 5.25. The drains flow to the south eastern corner of the site.
- 5.26. The IDB Drain is around 2.0m deep and the private drains vary between 1.0m and 2.0m deep.
- 5.27. The Surface Water Flood Maps on the Open Government Web-site show that there is no potential for surface water flooding outside the main channel of the dyke.
- 5.28. If the water levels within the drains rose considerably, possible due to a blockage, then the water levels would just rise to bypass the blockage. Even if one of the drains was blocked completely the water level would just rise to ground level before flowing out of bank around the blockage. Any potential flooding would be localised and not to a significant depth.

Flooding from Infrastructure Failure

- 5.29. It is not known if there are any large diameter water or sewage mains in the area.
- 5.30. However, given the topology of the surrounding ground and the presence of the boundary drains provided ground levels are graded to the boundary drains with no artificial hollows created then the risk of internal flooding would be minimal.

Flooding from Groundwater

- 5.31. The presence of the numerous ditches in the area would indicate that groundwater levels are expected to be similar to the water levels in the drains.
- 5.32. However, given the topology of the surrounding ground and the presence of the boundary drains provided ground levels are graded to the boundary drains with no artificial hollows created then the risk of internal flooding would be minimal.

Flooding from failure of the Site Surface Water Drainage System.

- 5.33. There is a risk of localised flooding from a failure of the surface water drainage system serving the site. The surface water drainage system should be designed to cater for a 1 in 100 year event with an appropriate allowance for climate change.
- 5.34. However, given the topology of the surrounding ground and the presence of the boundary drains provided ground levels are graded to the boundary drains with no artificial hollows created then the risk of internal flooding would be minimal.

6.0 FLOOD RISK MITIGATION

- 6.1. There are no specific flood measures proposed for this development, however, the following will reduce flood risk over all.
 - a) The offices and furnished workspaces will be located at first floor or mezzanine level.
 - b) The main area for plant growing will be of flood resilient construction.
 - c) External critical infrastructure i.e. sub-stations and pumping controls will be set 500mm above existing ground levels.

7.0 SURFACE WATER MANAGEMENT STRATEGY

- 7.1. Sustainable Drainage Systems (SuDS) have been considered for this development.
- 7.2. Following the preferred hierarchy of drainage stated in Part H of the Building Regulations and The Suds Manual the following disposal routes have been considered
- a) Disposal via Infiltration
 - b) Disposal to a Watercourse
 - c) Disposal to Surface Water Sewer
- 7.3. A Desktop Geotechnical Study has been undertaken to assess if the site will be suitable for surface water disposal using infiltration systems.

Desktop Geotechnical Study

- 7.1. From the HR Wallingford Greenfield run-off Calculation Tool available on their web-site the tool identifies the site as having Soil Type 2 on the Winter Rainfall Acceptance Potential (WRAP) Map. Soil Type 2 has relatively good drainage and is generally suitable for infiltration drainage systems. A copy of the Greenfield Run-off Calculation Sheet is provided in Appendix 1.
- 7.2. The British Geological Society web-site was also checked for records of boreholes within the vicinity of the site. There are three boreholes within 700m south east of the site, 700m west of the site and 2km south west of the site.
- 7.3. The boreholes generally indicate a soft silty clayey material below the topsoil. Copies of the borehole records are presented in Appendix 1.
- 7.4. The presence of the drainage ditches along all the existing field boundaries and elsewhere in the area indicates that vertical drainage must be restricted.
- 7.5. In the absence of site specific geotechnical investigation reports this Desktop Geotechnical Study concludes that it is probable that the site would be unsuitable for surface water disposal via infiltration systems.

Disposal to a Watercourse

- 7.6. Following the hierarchy of Suds, a surface water drainage discharge to an open watercourse is the next preferred option. Therefore it is proposed that the attenuated surface water run-off is discharged to the open drainage ditches surrounding the site.
- 7.7. South Holland IDB has been approached for comment regarding the proposal to discharge attenuated surface water to their drainage system. At the time of writing no response has been received.

8.0 OUTLINE DESIGN OF THE PROPOSED SURFACE WATER DRAINAGE SYSTEM

- 8.1. The proposed development will create the following artificial surfaces potentially generating surface water run
- a) 300 hectares of roofs
 - b) 43 hectares of ground level, hardstanding, plant yards and access roads
- 8.2. The proportion of the site covered in artificial surfaces is 87%.
- 8.3. Access tracks around the buildings used only for maintenance will be constructed in stone with a permeable surface and be self draining

Roof Water Drainage

- 8.4. As part of the operational requirements of the proposed development rainwater falling on the roofs will be collected for re-use on site.
- 8.5. Based on figures provided by the client the monthly consumption of water will be 5430m³.
- 8.6. The growing area is around 288,000m², which equates to a rainfall consumption 19mm/m²/month.
- 8.7. Average annual rainfall at Spalding is 600mm. Average monthly rainfall varies between 38-65mm.
- 8.8. Based on the above figures there will be a surplus of supply measured against demand. Following the guidance in BS 8515 Code of Practice for Rainwater Harvesting Systems as the site will be in surplus, no deduction for spare capacity in the rainwater recycling system can be made in the calculation of surface water storage volumes.
- 8.9. At present it is proposed to drain all the roof water to a combined rainwater recycling storage facility in the south eastern corner of the site. It is proposed to attenuate the surface water run-off and discharge to the adjacent IDB drain at the IDB Greenfield run-off rate of 1.4 l/s/ha.
- 8.10. It has been calculated that to attenuate a range of storms up to the 1 in 100 year plus climate change event an attenuation volume of 29,300m³ will be required.
- 8.11. An area of 13,200m² has been allocated for surface water attenuation and rainwater recycling.
- 8.12. The depth of the IDB is approximately 0.32m AOD with ground levels around 2.3m in the south eastern corner of the site.
- 8.13. Assuming 0.5m of head loss will be required through the discharge control device and outlet pipes the lowest the base of the attenuation storage can be is 0.82m AOD.
- 8.14. With 300m freeboard the maximum depth of storage below ground level is 1.18m which with no reduction for sloping sides etc would result in a maximum attenuation volume of 15,600m³ a shortfall of 13,700m³.

- 8.15. However, as the surfaces the rainwater is collected from are more than 6.0m above ground, the Developer proposes to have a pressurised roof water pipework system so that surface water can be stored above ground level.
- 8.16. Raising the crest of the combined attenuation/recycling system to 4.6m AOD (2.3m) above existing ground level means that water can be stored up to 4.3m AOD.
- 8.17. It is understood that this is common practice in the Netherlands where the greenhouses will be manufactured.
- 8.18. All inlets pipework to the attenuation basin should have non return valves to prevent the attenuation facility draining if the pipework is damaged. All pipework to 4.6m AOD should be sealed and capable of withstanding at least 1 bar of pressure. Chambers should extend to above 4.6m AOD or have hatch boxes to provide access to the pipework.
- 8.19. Calculations provided in Appendix 1 should than within the plan area allocated in the layout and allowing for an earth embankment with 1 in 2 side slopes a 3.0m wide flat crest across the top and 1 in 2 internal slopes an attenuation volume of 29,300m³ can be provided.
- 8.20. It is proposed that the volume of water for recycling is located beneath the gravity outlet for the surface water attenuation outlet pipe. Setting the base of the pond at 0.32m AOD will provide 6000m³ of water for re-use. Recycled water would be pumped out to a day tank.
- 8.21. This is just over one month's average supply and ignores any water that is recycled whilst the water level is above the surface water outlet.
- 8.22. Should additional supply be required then, subject to suitable ground conditions the base of the combined facility could be deepened further.

Front Vehicular Loading Area

- 8.23. This area covers approximately 27,500 m². At this stage is not known what the construction of the surfaces will be but for the purposes of this Drainage Report it is assumed that they will all be concrete surfaces.
- 8.24. It would not be possible to drain this area to the attenuation pond in the south eastern corner. Therefore it is proposed to have a separate discharge to the private open drain located along the northern boundary of the site.
- 8.25. For an area of 2.75ha at 1.4 l/s/ha the discharge would be 3.4 l/s. It is generally agreed that the smallest practical size of discharge control device is 5.0 l/s. Therefore for this area it is proposed to limit the discharge to 5.0 l/s.
- 8.26. Initially, it was proposed to discharge the surface water to a 10m wide swale/attenuation basin running the full length of the hardstanding area. However after a allowing a 3.0m wide access strip to the existing drain, it was apparent that the proposed swale would impinge of the vehicular turning areas and routes out of the site.
- 8.27. It is now proposed to provide the attenuation volume in a layer of permeable sub-base. Due to the ground conditions it is probable that the permeable sub base will need to be tanked.

- 8.28. It is not proposed to have a permeable surface but selected small areas of permeable surface where the water will be allowed to pass to the permeable sub-base beneath. The location of the surface water collection points will be dependant on the operational areas and proposed falls in the slabs.
- 8.29. The permeable sub-base will provide sufficient treatment of the run-off as required by the SUDS Manual.
- 8.30. In general terms the 6 hour 1 in 100 year rainfall depth is around 63mm and with a 30 % allowance for climate change this increases to 82mm.
- 8.31. A discharge of 5.0 l/s for 2.75ha equates to a discharge rate of 0.56mm/hr which would reduce storage depth required to 79mm. With a permeable sub-base with a 30% void ratio a thickness of only 275mm would be required to provide adequate storage for the 1 in 100 year plus climate change event. For an HGV turning area it is anticipated that the minimum thickness of sub-base for structural requirements will be greater than 275mm

Side Access Road

- 8.32. There is a 10m wide access road running 350m along the western boundary.
- 8.33. At this stage is not known what the construction of the surface will be but for the purposes of this Drainage Report it is assumed that it will be concrete.
- 8.34. It would not be possible to drain this area to the attenuation pond in the south eastern corner. Therefore it is proposed to have a separate discharge to the private open drain located along the western boundary of the site.
- 8.35. For an area of 0.35ha, at 1.4 l/s/ha the discharge would be 0.5 l/s. It is generally agreed that the smallest practical size of discharge control device is 5.0 l/s. Therefore for this area it is proposed to limit the discharge to 5.0 l/s. Calculations are presented in Appendix 1.
- 8.36. It is proposed to construct the road with a cross fall towards the western boundary. To provide attenuation and treatment of the surface water run-off it is proposed to provide a 1.2m wide x 1.2m deep infiltration trench running along the full length.
- 8.37. To provide sufficient attenuation a 450mm perforated carrier pipe would be required. There would be a controlled outlet from the carrier pipe to ditch on the western boundary. The infiltration trench may need to be tanked to prevent softening of the material below the access road. This will be determined during the structural design of the access road.
- 8.38. The granular material within the infiltration trench should provide sufficient treatment of the run-off as required in the SUDS Manual.

West Side Vehicular Loading Area

- 8.39. This area covers approximately 12,000 m². At this stage is not known what the construction of the surfaces will be but for the purposes of this Drainage Report it is assumed that they will all be concrete surfaces.

- 8.40. It would not be possible to drain this area to the attenuation pond in the south eastern corner. Therefore it is proposed to have a separate discharge to the private open drain located along the western boundary of the site.
- 8.41. For an area of 1.2ha at 1.4 l/s/ha the discharge would be 1.7 l/s. It is generally agreed that the smallest practical size of discharge control device is 5.0 l/s. Therefore for this area it is proposed to limit the discharge to 5.0 l/s.
- 8.42. Initially, it was proposed to discharge the surface water to a 10m wide swale/attenuation basin running the full length of the hardstanding area. However after allowing a 3.0m wide access strip to the existing drain, it was apparent that the proposed swale would impinge on the vehicular turning areas and routes out of the site.
- 8.43. It is now proposed to either provide a swale/ attenuation basin within the working area or provide the attenuation volume in a layer of permeable sub-base.
- 8.44. A proposed swale/ attenuation basin is shown on the Outline Surface Water Drainage Drawing contained in Appendix 1. An area 41m x 31m with 1.2m overall depth and 300mm freeboard and 1 in 2 side slopes should provide sufficient attenuation volume. Calculations are presented in Appendix 1.
- 8.45. If this space is required for other operational requirements then the attenuation volume could be provided in permeable sub-base. Due to the ground conditions it is probable that the permeable sub base will need to be tanked.
- 8.46. It is not proposed to have a permeable surface but selected small areas of permeable surface where the water will be allowed to pass to the permeable sub-base beneath. The location of the surface water collection points will be dependant on the operational areas and proposed falls in the slabs. The permeable sub-base will provide sufficient treatment of the run-off as required by the SUDS Manual.
- 8.47. The thickness of permeable sub-base would be as calculated for the front loading area above.

General

- 8.48. An illustration of the outline design a surface water drainage system for the proposed layout is shown on drawing 575/002 provided in Appendix 1.
- 8.49. The detailed design of the surface water drainage system should follow the principles outlined in this report.

9.0 OCCUPIERS & USERS OF THE DEVELOPMENT

- 9.1. The proposed development will increase the number of users of the site by over 100. The users will visit the site for employment purposes with higher numbers during the day time shifts and few users on the night shifts.
- 9.2. There will be no residential occupiers of the site.

- 9.3. Spalding is low down in the catchment of the River Welland and occasions when the flood level is above surrounding ground levels is known in advance. It has been estimated that it would take over two hours for a floodwaters from a breach to reach the site, which if required is adequate time to evacuate the site.
- 9.4. It has also been estimated that the potential depth and velocity of flood waters from a breach is low, resulting in a low hazard rating. In addition, there is safe refuge available on the upper floors of the main building.
- 9.5. Therefore it can be concluded that the development would be safe for the users over the lifetime of the development.

10.0 RESIDUAL RISKS

- 10.1. There are residual risks that more extreme events are experienced than those evaluated in this report. However, the consequences of more extreme events will not be significantly greater than those assessed in this report.

11.0 FOUL SEWERAGE

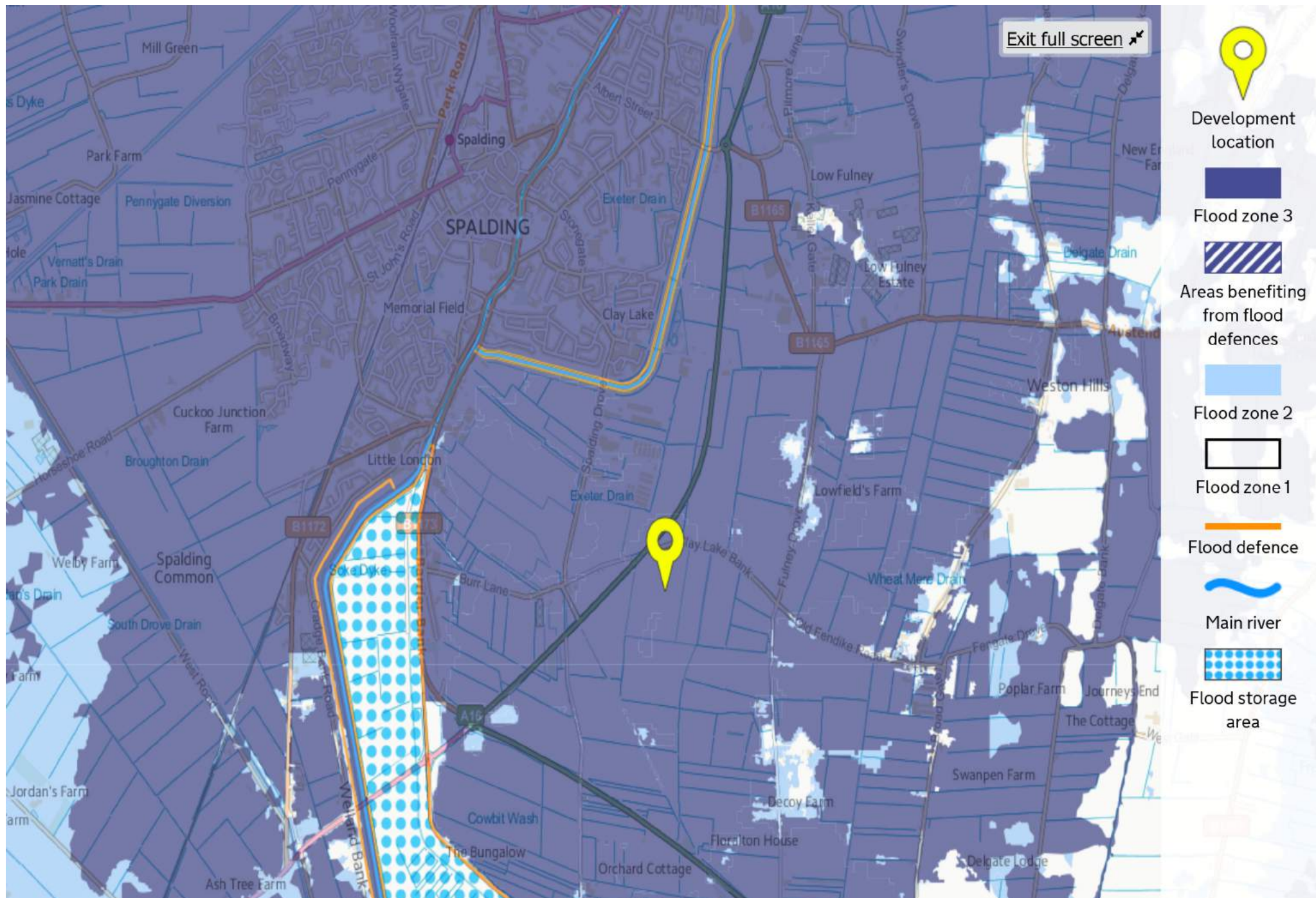
- 11.1. It is understood that there are Anglian Water foul sewers in Clay Bank.
- 11.2. It is proposed to install a packaged sewage treatment plant to treat foul sewage to the required standard before discharge to the open drain running along the eastern boundary of the site.

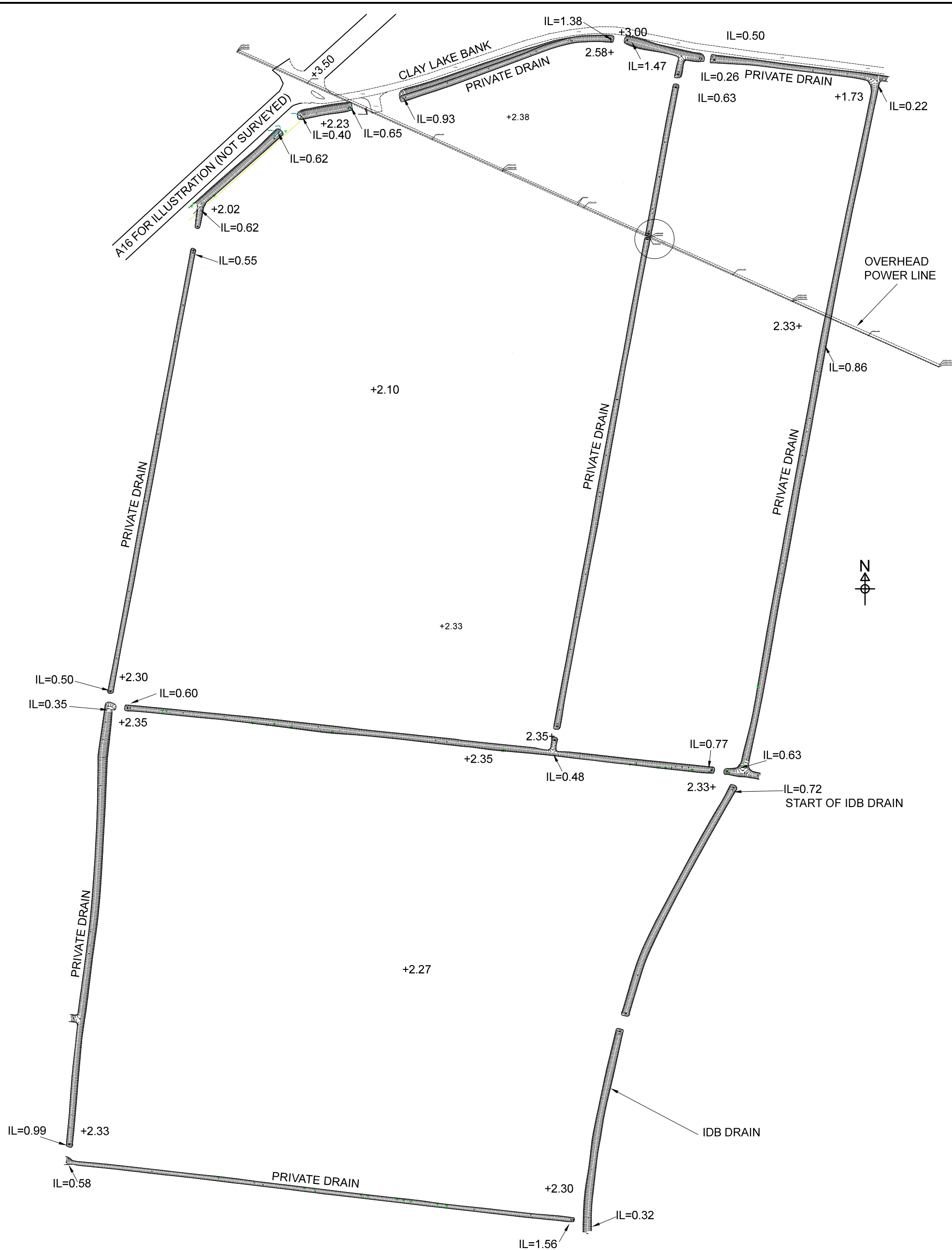
12.0 CONCLUSION

- 12.1. The site is in Flood Zone 3 but the modelling of breaches of the defences shown in the SFRA show that in the worst case the floodwaters from a breach may flood the site to up to 1.0m deep. However, the vast majority of the development is of flood resilient construction and more sensitive uses i.e. offices and laboratories will be located on the upper floors.
- 12.2. Simplified breach analysis has estimated that flood depths from a single breach closest to the site would take over two hours to reach the site, flood the site to no more than 150mm deep and have a velocity of less than 0.25m/s. The resulting flood hazard rating would be low,
- 12.3. Taking into account the above points the development can be assessed as safe for the lifetime of the development.
- 12.4. This report demonstrates that it is practical to install a sustainable surface water drainage system to serve the development such that the risk of flooding elsewhere in the catchment is not increased.
- 12.5. Taking into account the above points it is concluded that the proposed development can be considered appropriate in this location.

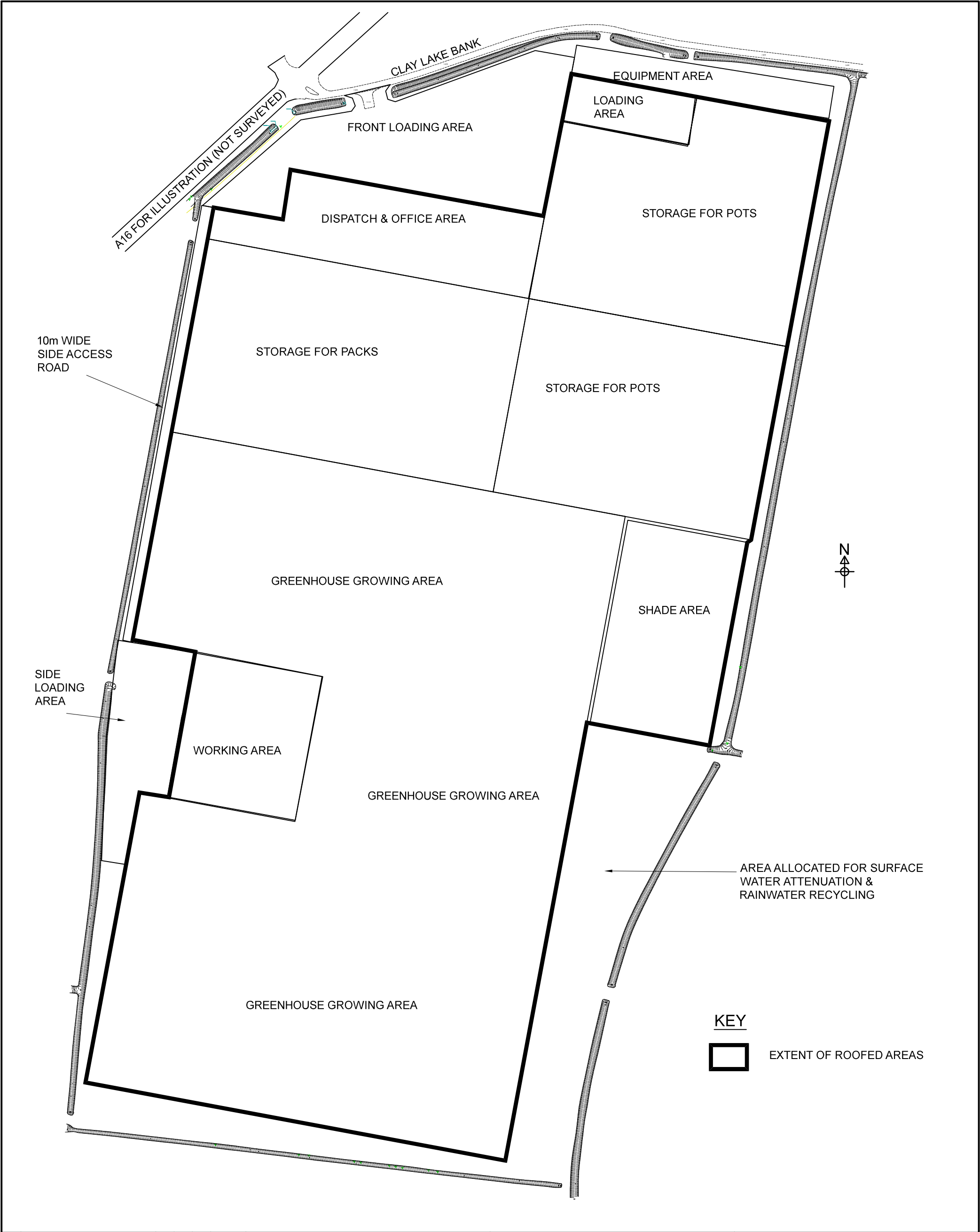
13.0 APPENDIX 1 SUPPORTING INFORMATION

- a) Environment Agency Flood Map for Planning with Site Location
- b) GSL Drawing 605-010 Existing Levels and Key Drainage Features
- c) GSL Drawing 605-011 Proposed Development
- d) Flood Information provided by the Environment Agency.
- e) SFRA 2115 Actual Risk Flood Depth Map – Part covering site only
- f) SFRA 2115 Residual Risk Flood Depth Map – Part covering site only
- g) Simplified Breach Analysis Calculations
- h) HR Wallingford Greenfield Run-Off Calculations
- i) BGS Borehole Records
- j) Surface Water & Water Recycling Calculations
- k) GSL Drawing 605-012 Outline Design of Proposed SW Drainage System
- l) GSL Drawing 605-013 Illustrative Section SW Attenuation/ Water Recycling Basin





								CLIENT BRIDGE FARM NURSERIES LTD & CLAY LAKE FARM LTD		DRAWING TITLE EXISTING LEVELS & KEY DRAINAGE FEATURES			George Shuttleworth Ltd Consulting Engineers 43 Hall Drive Lincoln LN6 7SW Tel: 01522 787710 Email: geo.shuttleworth@btconnect.com						
								PROJECT PROPOSED GREENHOUSE DEVELOPMENT OFF CLAY BANK SPALDING		SCALE AT A3 1:2500		DATE NOV17		APPROVED BY GS					
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					PROJECT PROPOSED GREENHOUSE DEVELOPMENT OFF CLAY BANK SPALDING		SCALE AT A3 1:2500	DATE NOV17	APPROVED BY GS			
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George Shuttleworth
geo.shuttleworth@btconnect.com

Our ref: CCN/2017/60138
Date: 25th September 2017

Dear George Shuttleworth,

Provision of Flood Risk Information for Clay Lake Bank, Spalding.

Thank you for your request to use our flood risk information in the development of the Flood Risk Assessment (FRA) for the above site. The information is set out below and attached. It is important you read any contextual notes on the maps provided.

We aim to review our information on a regular basis, so if you are using this data more than twelve months from the date of this letter, please contact us again to check it is still valid.

Flood Map

The attached map includes the current Flood Map for your area. The Flood Map indicates the area at risk of flooding, **assuming no flood defences exist**, for a flood with a 0.5% chance of occurring in any year for flooding from the sea, or a 1% chance of occurring for fluvial (river) flooding. It also shows the extent of the Extreme Flood Outline which represents the extent of a flood with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

In some locations, such as around the fens and the large coastal floodplains, showing the area at risk of flooding assuming no defences may give a slightly misleading picture in that if there were no flood defences, water would spread out across these large floodplains. This flooding could cover large areas of land but to relatively shallow depths and could leave pockets of locally slightly higher land as isolated dry islands. It is important to understand the actual risk of the flooding to these dry islands, particularly in the event of defence failure.

The Flood Map also shows the location of formal raised flood defences and flood storage reservoirs. It represents areas at risk of flooding for present day only and does not take account of climate change.

The Flood Map only indicates the extent and likelihood of flooding from rivers or the sea. It should also be remembered flooding may occur from other sources such as surface water sewers, road drainage, etc.

Historic Flood Extent Map

A copy of the Historic Flood Extent Map showing the extent of previous recorded flooding in your area is attached. This only covers information we hold and it is possible other flooding may have occurred which other organisations, such as the Local Authority or Internal Drainage Boards, may have records.

Fluvial Flood Risk Information

Fluvial Defence Information

The fluvial defences reducing the risk of flooding to this site consist of earth embankments, concrete floodwalls and upstream flood storage reservoirs. They are in good condition and reduce the risk of flooding to a 1% (1 in 100) chance of occurring in any year. We inspect these defences routinely to ensure potential defects are identified.

Modelled Levels and Flows

Available modelled fluvial flood levels and flows for the model nodes shown on the attached map are set out in the data table attached. This data is taken from the model named on the data table, which is the most up-to-date model currently available.

Please note these levels are “in-channel” levels and therefore may not represent the flood level on the floodplain, particularly where the channel is embanked or has raised defences.

Modelled Hazard Mapping

Please refer to South Holland District Council’s hazard mapping undertaken for their Strategic Flood Risk Assessment (SFRA). Hazard mapping can be found for the district using the following link:

<http://www.southeastlincslocalplan.org/2016-update-of-south-holland-strategic-flood-risk-assessment-spalding-maps/> for the updated 2016 maps.

Development Planning

If you have requested this information to help inform a development proposal, then you should note the information on GOV.UK on the use of our information for Flood Risk Assessments. We recommend that you undertake a formal pre-application enquiry using the form available from the website.

<https://www.gov.uk/planning-applications-assessing-flood-risk>

<https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion>

Climate change will increase flood risk due to overtopping of defences. Please note the climate change data included has an allowance for 20% increase in flow. Updated guidance on how climate change could affect flood risk to new development - 'Flood risk assessments: climate change allowances' was published on GOV.UK in February 2016. The appropriate updated climate change allowance should be applied in a Flood Risk Assessment.

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

Supporting Information

Please see the Standard Notice or licence for details of permitted use. The Standard Notice can be found at the link below.

<http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>

We respond to requests for recorded information we hold under the Freedom of Information Act 2000 (FOIA) and the associated Environmental Information Regulations 2004 (EIR).

Further information on flood risk can be found on the GOV.UK website at:

<https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather>

Other Flood Risk Management Authorities

The information provided with this letter relates to flood risk from main river or the sea. Additional information may be available from your Lead Local Flood Authority (ie county council or unitary authority) or, where they exist, the Internal Drainage Board.

Further Contact

I hope we have correctly interpreted your request. If you are not satisfied with our response to your request for information, you can contact us within two calendar months to ask for our decision to be reviewed.

If you have any queries or would like to discuss the content of this letter further please contact Emily Holroyd using the details below.

Yours faithfully,



FOR Alastair Windler
Partnerships and Strategic Overview Team Leader - Welland and Nene

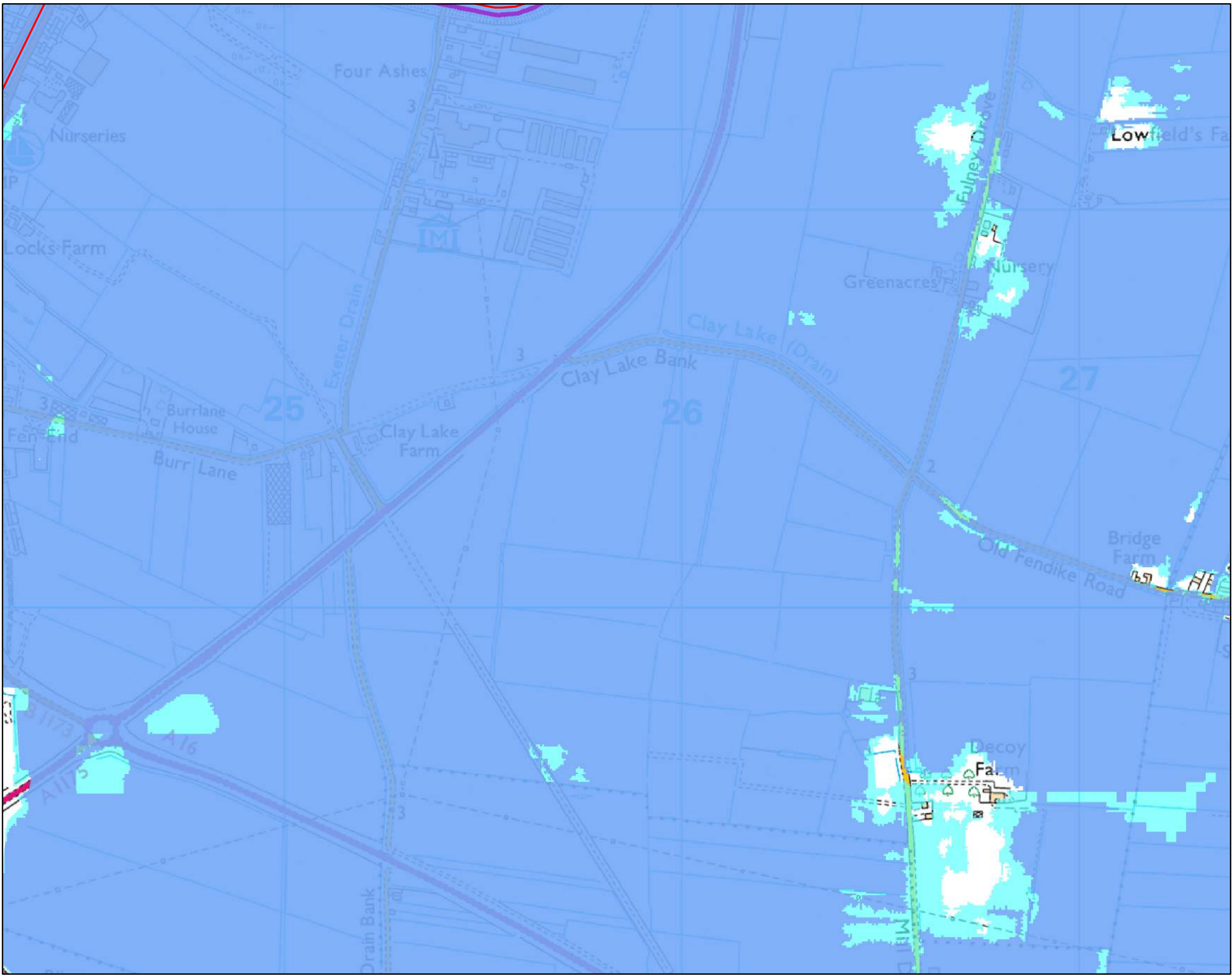
Direct dial 020 847 49385
Direct e-mail PSOWN@environment-agency.gov.uk

Enc.
Flood Map
Historic Flood Extent Map
Modelled Node Points Map
Modelled Fluvial and Flows Data Sheet



Awarded to Lincolnshire & Northamptonshire Area

Flood Map centred on TF 25838 20298 - created September 2017 [Ref: CCN-2017-60138]



Scale 1:10,000



- Main River
- Raised Defences
- Flood Storage Areas
- Area at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

- from the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year.
- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Sites outside the two extents, but behind raised defences, may be affected by flooding if the defences are overtopped or fail.

Created by the Partnerships and Strategic Overview Team, Kettering

Map centred on TF 25838 20298- created September 2017 [Ref: CCN-2017-60138]



Scale 1:20,000

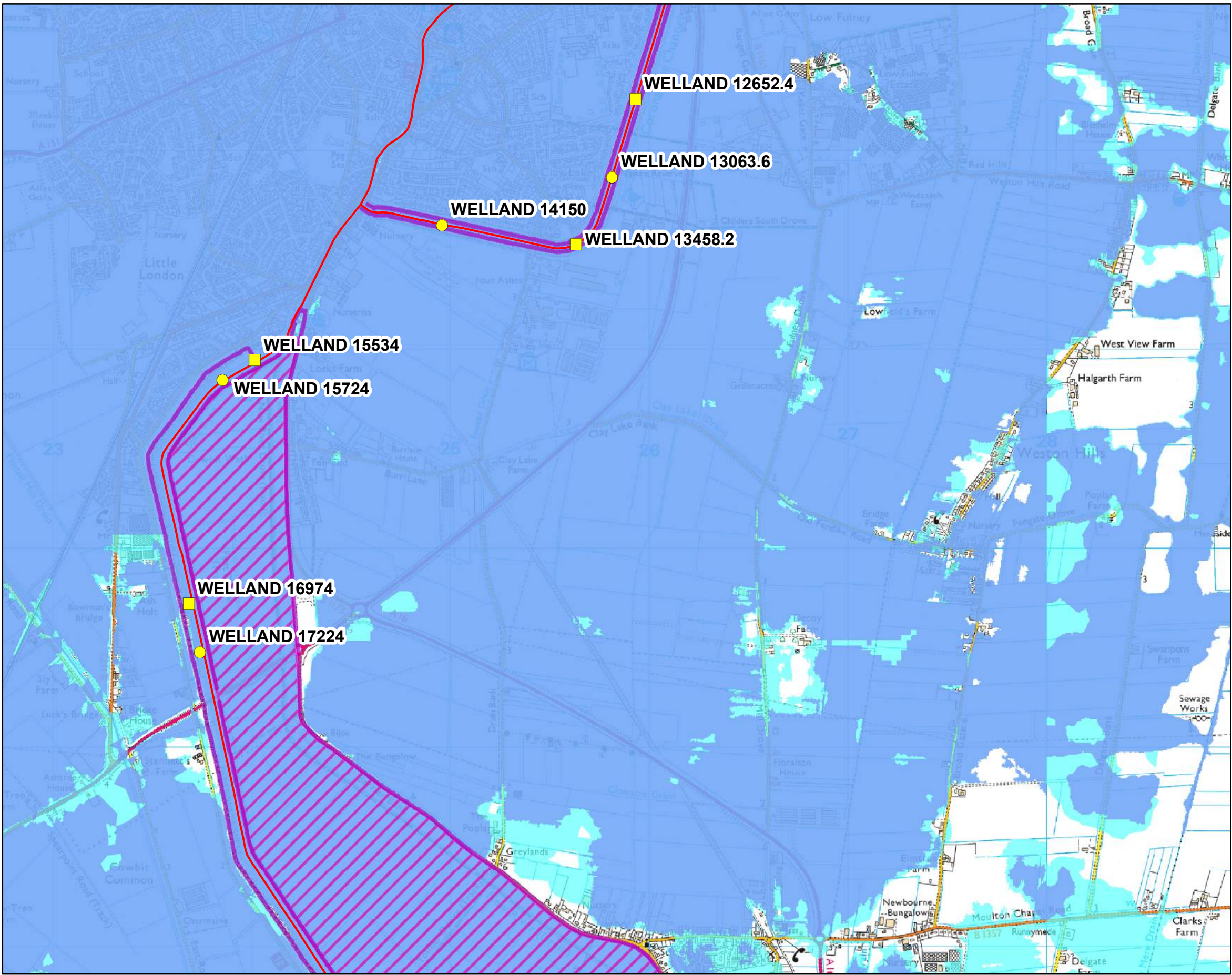


— Main River
March 1947 on the River Welland near Cowbit

Created by the Partnership & Strategic Overview Team,
Kettering

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Flood Map centred on TF 25838 20298 - created September 2017 [Ref: CCN-2017-60138]



Scale 1:20,000



- Modelled Nodes- Levels
- Modelled Nodes- Flows
- Main River
- Raised Defences
- ▨ Flood Storage Areas
- Area at Risk of Flooding from Rivers or The Sea
- Extreme Flood Outline

Dark blue shows the area that could be affected by flooding, either from rivers or the sea, if there were no flood defences. This area could be flooded:

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- or from a river by a flood that has a 1% (1 in 100) or greater chance of happening each year.

Light blue shows the extent of the Extreme Flood Outline, which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater.

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Created by the Partnerships and Strategic Overview Team, Kettering

Datasheet [Ref: CCN-2017-60138]

Data Model - Welland - Dated 2016

Fluvial Flood Levels (mODN)

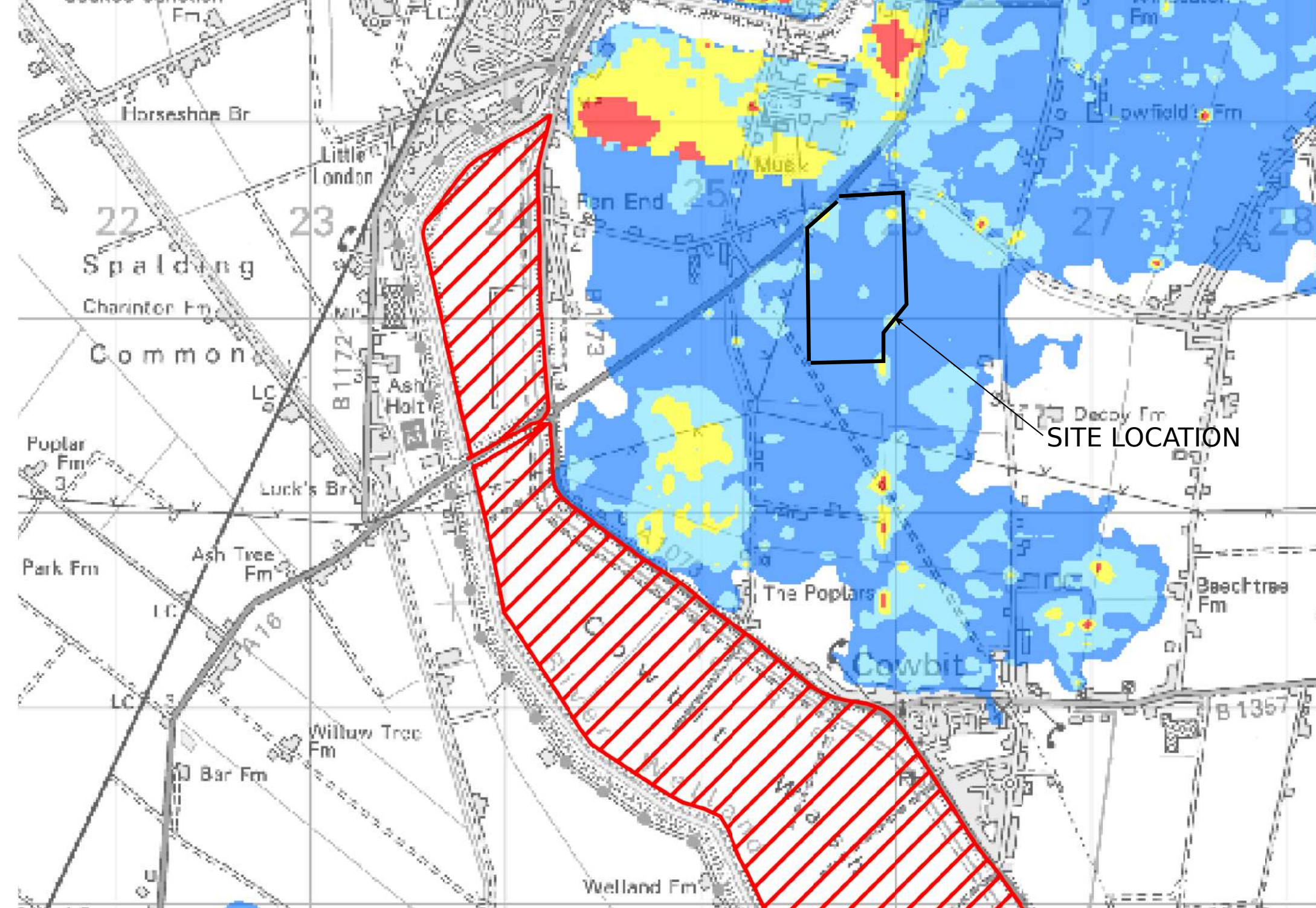
The fluvial flood levels for the model nodes shown on the attached map are set out in the table below. They are measured in metres above Ordnance Datum Newlyn (mODN).

Node Label	Easting	Northing	Annual Exceedance Probability - Maximum Water Levels (mODN)											
			50% (1 in 2)	20% (1 in 5)	10% (1 in 10)	5% (1 in 20)	4% (1 in 25)	2% (1 in 50)	1.33% (1 in 75)	1% (1 in 100)	1% (1 in 100) inc 20% Climate Change	0.5% (1 in 200)	0.1% (1 in 1000)	0.1% (1 in 1000) inc 20% Climate Change
WELLAND 13063.6	525815	321866	3.67	3.95	4.12	4.37	n/a	4.44	4.45	4.46	4.68	4.48	4.50	4.68
WELLAND 14150	524959	321626	3.67	3.96	4.14	4.39	n/a	4.46	4.47	4.48	4.67	4.50	4.51	4.67
WELLAND 15724	523856	320846	3.69	3.97	4.18	4.43	n/a	4.51	4.52	4.52	4.66	4.53	4.54	4.66
WELLAND 17224	523742	319477	3.70	4.00	4.20	4.44	n/a	4.53	4.54	4.54	4.66	4.54	4.56	4.66

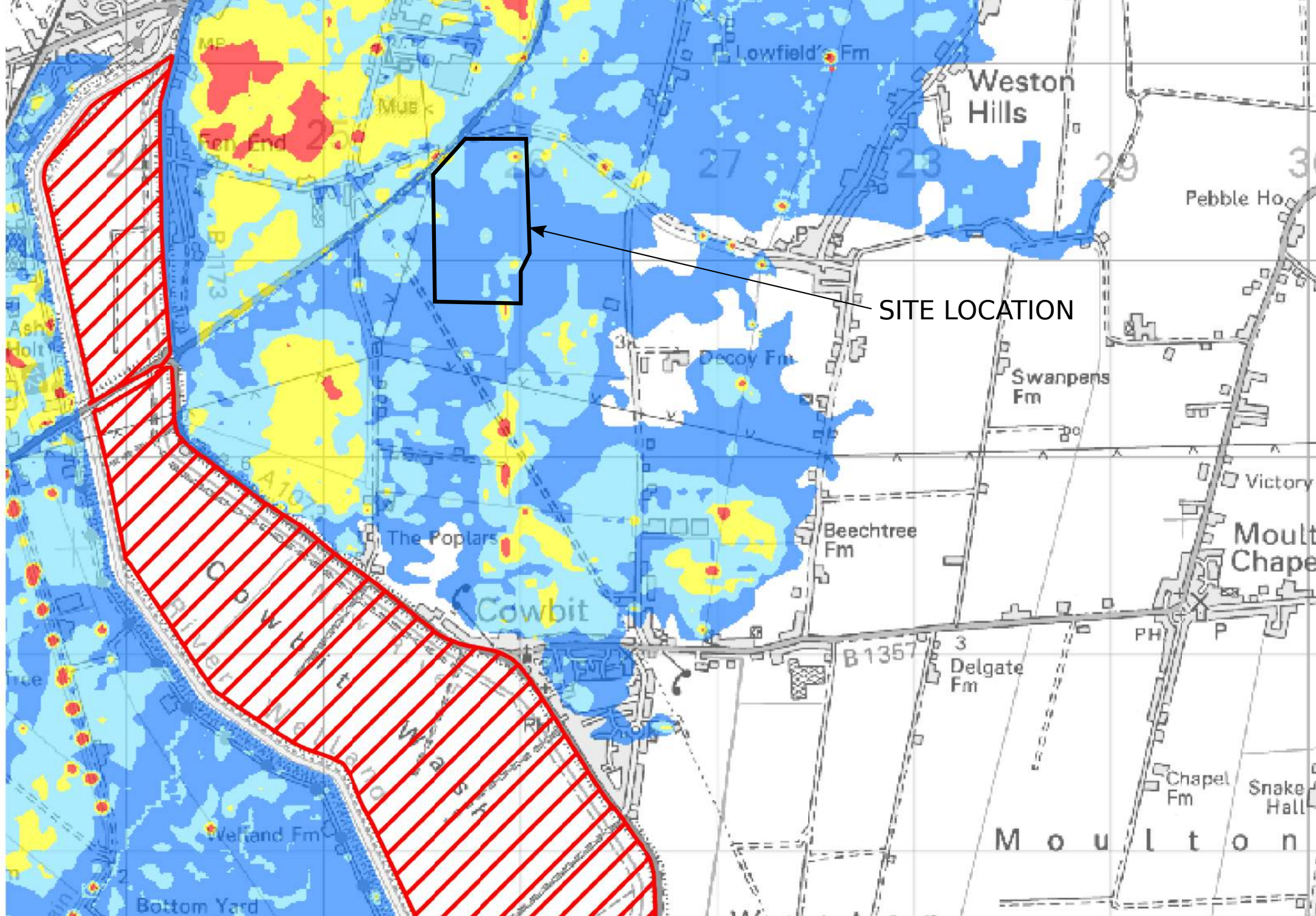
Fluvial Flood Flows (m³/s)

The fluvial flood flows for the model nodes shown on the attached map are set out in the table below. They are measured in metres cubed per second (m³/s).

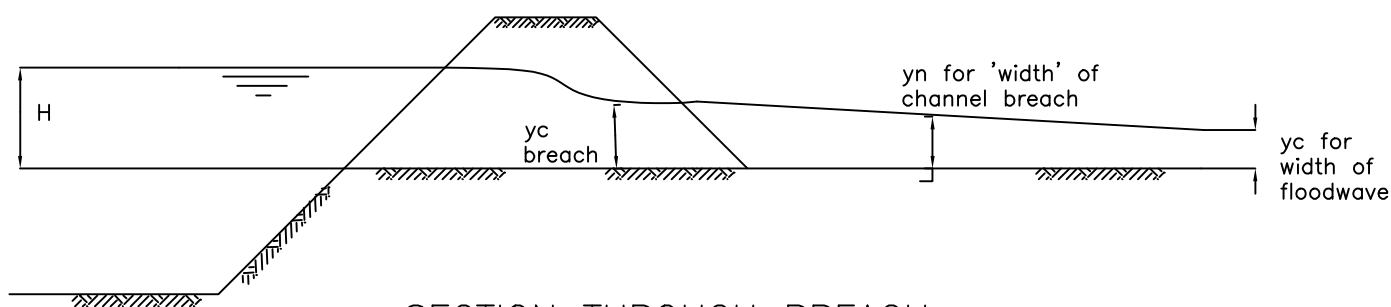
Node Label	Easting	Northing	Annual Exceedance Probability - Maximum Flows (m³/s)											
			50% (1 in 2)	20% (1 in 5)	10% (1 in 10)	5% (1 in 20)	4% (1 in 25)	2% (1 in 50)	1.33% (1 in 75)	1% (1 in 100)	1% (1 in 100) inc 20% Climate Change	0.5% (1 in 200)	0.1% (1 in 1000)	0.1% (1 in 1000) inc 20% Climate Change
WELLAND 12652.4	525934	322259	69.30	84.57	95.88	109.05	n/a	114.54	116.06	117.54	117.04	116.95	116.73	116.17
WELLAND 13458.2	525635	321529	67.16	82.60	93.79	106.90	n/a	113.87	115.26	116.63	115.90	116.11	115.91	115.46
WELLAND 15534	524017	320946	61.39	77.08	88.13	101.52	n/a	111.86	113.06	114.41	113.72	114.28	113.66	113.64
WELLAND 16974	523686	319721	59.28	75.10	85.95	99.45	n/a	111.74	112.95	114.31	113.94	114.87	113.65	113.62



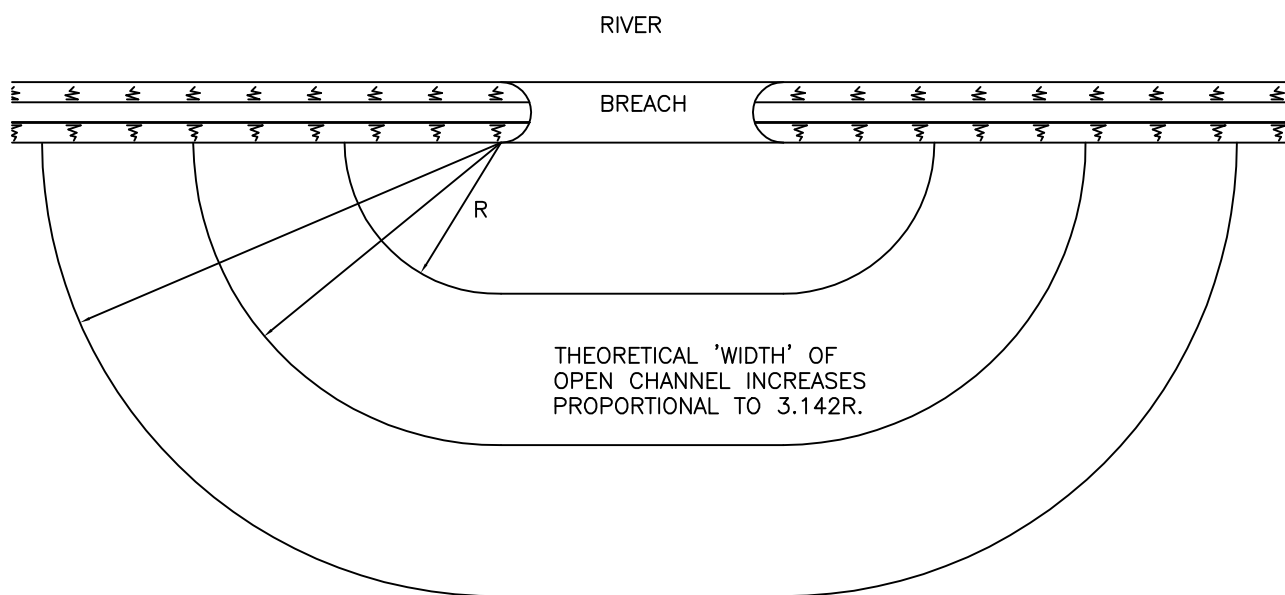
COPIED FROM SHDC SFRA 2115 ACTUAL FLOOD DEPTHS MAP



COPIED FROM SHDC SFRA 2115 RESIDUAL FLOOD DEPTHS MAP



SECTION THROUGH BREACH
SCALE 1:150



PLAN ON BREACH
SCALE 1:750

CLIENT BRIDGE FARM NURSERIES LTD & CLAY LAKE FARM LTD	PROJECT GREENHOUSE DEVELOPMENT OFF CLAY LAKE BANK, SPALDING	ENGINEER GS	DRAWN BY SS	APPROVED BY GS
		SCALE AT A3 AS SHOWN	DATE NOV 17	
		THIS DRAWING IS THE COPYRIGHT OF GEORGE SHUTTLEWORTH LTD AND SHALL NOT BE COPIED OR AMENDED WITHOUT THE WRITTEN PERMISSION OF GEORGE SHUTTLEWORTH LTD.		
		DRG SIZE A4	DRAWING NO. 605-002	REV. -
George Shuttleworth Ltd Consulting Engineers 43 Hall Drive, Lincoln LN6 7SW Tel: 01522 787710 Email: Geo.shuttleworth@btconnect.com		DRAWING TITLE SIMPLIFIED BREACH HYDRAULICS		

CALCULATIONS TO ESTIMATE DEPTHS OF FLOW FROM A BREACH OF THE EXISTING DEFENCES

Consider the potential flooding through a 40m breach of the existing defences

Defence Crest Levels = 5 m AOD
 Average Ground Level behind defences = 2.8 m AOD
 1 in 100+CC year flood level = 4.66 m AOD
 Assume Length of Breach = 40 m
 Max head over Breach 1.86
 Assume Breach acts as
 a Broad Crested Weir, $Q=1.7bh^{3/2}$ Peak Flow = 172.5 m³/s

Consider How Depth of Flood wave decreases with distance from the breach

As the flood wave will spread radially, the width of channel nominally increases at a rate of 3.142 x radius from the breach

Q Peak (m ³ /sec)	172.5					
Assuming Energy Grad =	0.001					
Assume % obstructions to flow	0					
Assuming Manning's n	0.030					
Distance From Breach	0	400	800	1200	1600	2000
Perimeter of Flood Wave(Assumed Channel Width)	40.0	1296.8	2553.6	3810.4	5067.2	6324.0
Effective perimeter	40.0	1296.8	2553.6	3810.4	5067.2	6324.0
Normal Depth $y=(Qn/(b \times S^{1/2}))^{0.6}$	2.329	0.289	0.192	0.151	0.127	0.112

Time to Reach Development

Distance From Breach above plus 1.0m	100	401	801	1201	1601	2001
Perimeter of Flood Wave(Assumed Channel Width)	354.2	1299.9	2556.7	3813.5	5070.3	6327.1
Normal Depth $y=(Qn/(b \times S^{1/2}))^{0.6}$	0.629	0.288	0.192	0.151	0.127	0.112
Volume in Additional 1.0m	291	375	491	577	646	706
Speed to Cover additional 1.0m (m/s)	0.592	0.460	0.351	0.299	0.267	0.244
Average time to reach radius (secs)	169	762	1974	3693	5655	7827
Average time to reach radius (mins)	2.82	12.70	32.90	61.56	94.26	130.45

Calculated by: George Shuttleworth

Site name: Clay Bank

Site location: Spalding

Site coordinates

Latitude: 52.76709° N

Longitude: 0.13727° W

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the SuDS Manual, C753 (Ciria, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Reference: 6185663

Date: 2017-11-20T11:52:52

Methodology	IH124
-------------	-------

Site characteristics

Total site area (ha)	35
----------------------	----

Methodology

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type

	Default	Edited
SOIL type	2	2
HOST class	---	---
SPR/SPRHOST	0.3	0.3

Hydrological characteristics

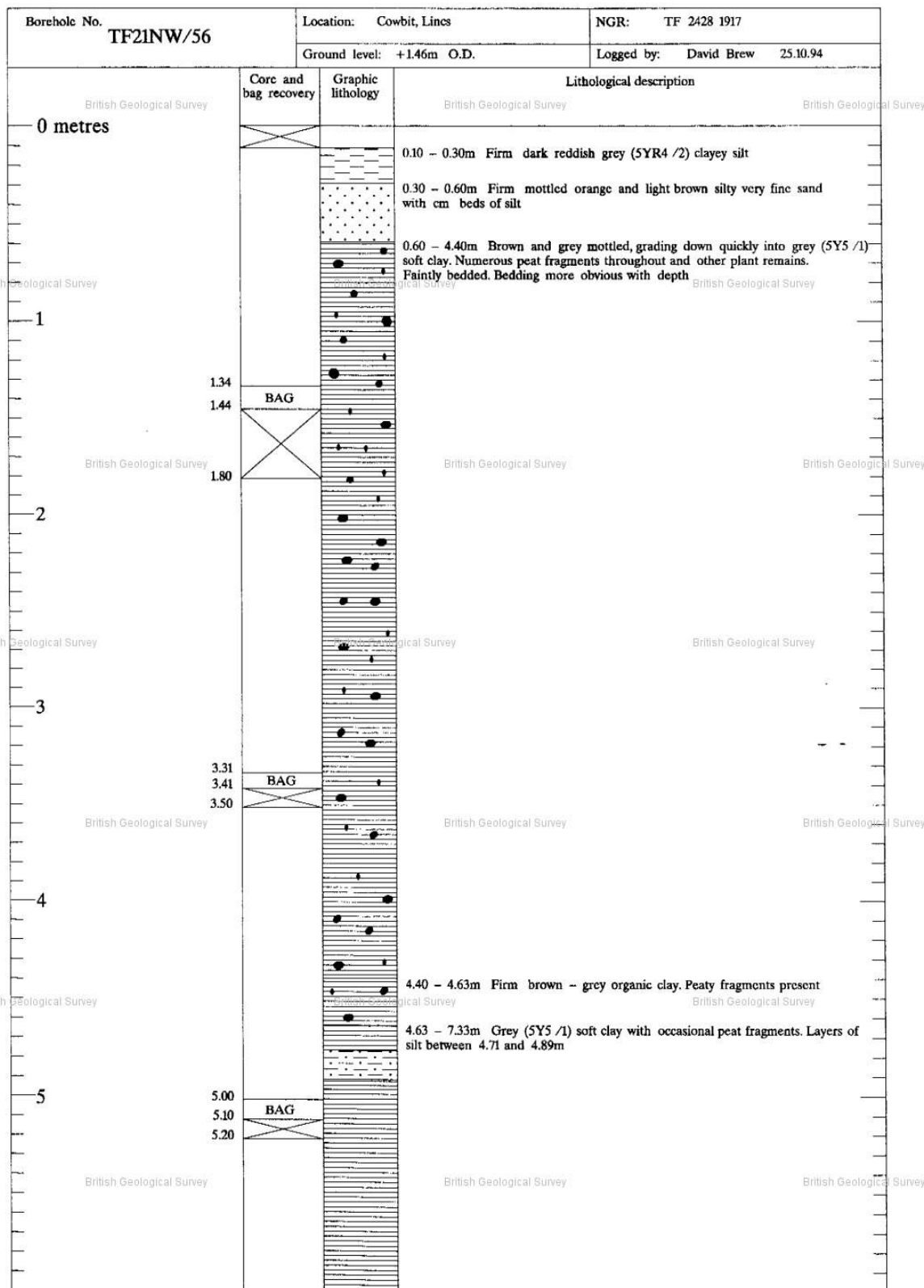
	Default	Edited
SAAR (mm)	559	559
Hydrological region	5	5
Growth curve factor: 1 year	0.87	0.87
Growth curve factor: 30 year	2.45	2.45
Growth curve factor: 100 year	3.56	3.56

Notes:

(1) Is $Q_{BAR} < 2.0$ l/s/ha?
Normally limiting discharge rates which are less than 2.0 l/s/ha are set at 2.0 l/s/ha.
(2) Are flow rates < 5.0 l/s?
(3) Is $SPR/SPRHOST \leq 0.3$?
Where groundwater levels are low enough the use of soakaways to avoid discharge offsite may be a requirement for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Qbar (l/s)	49.03	49.03
1 in 1 year (l/s)	42.65	42.65
1 in 30 years (l/s)	120.11	120.11
1 in 100 years (l/s)	174.53	174.53



TF 22 SE/5.

FIG. No:

MADE

DATE

CHECKED

DATE

RECORD OF BOREHOLE No. 6 (Sheet 1 of 2) 2516.2037

EstSL 3.0m

1" / 44.

GE.2218

DAILY PROGRESS	WATER LEVELS	DEPTH OF CASING	SAMPLES		No. OF BLOWS FOR SAMPLE OR TEST	LEG- END	DEPTH	Insitu m/c %	DESCRIPTION OF STRATA
			DEPTH FROM	TO					
16.5.70			0.00	0.45	1		0.45		TOP SOIL
			0.50		2		30.9		Soft light brown mottled SANDY SILTY
			1.00		5		1.45	30.3	CLAY with some roots.
	See page 5		1.50	1.85	4				Very soft brown grey PEATY
	0.45 V		2.40		5	V		53.3	SILTY CLAY
	Sealed								
8.6.70 PM	TRY	3.00	2.00	3.45	7				
14.5.70	TRY	2.30	2.90		9	V		53.3	
			4.50	5.75	10			4.95	
			5.40		11	V		68.7	Very soft grey and black
			6.00	6.45	15				SILTY CLAY with peat
			6.75		14			41.4	
			7.50	7.75	15				
			8.50		16			8.40	
			8.50		17			63.1	Firm black and grey CLAY
	STRUCK		9.00	9.45	18	L.P		169.9	PEAT 9.0 humic peaty clay with plant debris
	2.22		9.70	10.15	19			9.45	9.45 - 10.15 brown grey humic clay
					20	N=40			Dense brown and grey CLAY
								2.70	Slightly lumpy, dense to 10.15 m
11.5 PM	-	11.20	11.20	11.65	21	N=27			Medium dense brown and grey SAND
12.5.70	-	11.20							and GRAVEL with some pebbles
			12.70	13.15	22	N=17			gravel. Randomly distributed
			13.20	13.50	25			13.50	with chunks, rounded, 10-20
			13.50	14.20	26				13.00m diameter
			14.50		27			18.5	Stiff blue grey CLAY
			15.25	15.70	28				BOULDER CLAY
			16.00		29			17.0	
			16.75	17.20	30				
			17.50		31			18.4	
			18.15	18.60	32			15.3	Very soft to dense brown and
									grey SILTY CLAY
			19.65		33			20.0	

UNDISTURBED
SAMPLE
4" Dia.DISTURBED
SAMPLEWATER
SAMPLEBULK
SAMPLESTANDARD
PENETRATION
TEST

SYC

TYPE OF BORING

REMARKS

1. Standpipe installed to 10.0 m depth
2. Insitu info are of disturbed samples only

DIAMETER OF BORING

0.2m - 1.2m
0.15m - 2.1m

CASING TUBES

0.2m - 1.2m
0.15m - 2.1m

BOREHOLE

No: 6

A16 IMPROVEMENT

GROUND ENGINEERING LIMITED,
MANOR WAY, BOREHAMWOOD, HERTS.

British Geological Survey

British Geological Survey

National Grid Reference

W 1 Western Hills

British Geological Survey

2751 British (1981)

Enter 'C' if
Confidential

144

British Geological Survey

British Geological Survey

Made by Pre-Piling Surveys

Examined by

British Geological Survey

ARTIFICIAL AREAS

<u>Roofs</u>	<u>Area</u>
Dispatch and Office	14300
Pots 1	32896
Pots 2	31488
Packs 1	39186
Main Growing Area	161855
Working Area	6400
Shade Area	16640
Sub-total	302765

Ground Level Hardstandings

Plant yard	7175
Delivery/Dispatch Yard	20300
Side Road	3500
Working Area	12000
Sub-total	42975

Total Artificial Surfaces 345740

Total Site Area 397402

% Artificial 87.0

ATTENUATION & DISCHARGE TO DITCH

Calculation of Rain Profiles

M5-60	20								
r	0.4								
D (mins)	15	30	60	120	240	360	480	720	1440
Z1	0.64	0.81	1	1.21	1.4	1.62	1.76	1.8	2.2
M5-D	12.8	16.2	20.0	24.2	28.0	32.4	35.2	36.0	44.0
Z2(100)	1.94	1.99	2.03	2.02	2.01	1.95	1.93	1.92	1.86
Z2(30)	1.50	1.52	1.53	1.54	1.53	1.51	1.50	1.49	1.45
Z2(2)	0.80	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.85
Z2(1)	0.62	0.62	0.64	0.65	0.67	0.68	0.68	0.69	0.71
MT-D(100)	24.83	32.24	40.60	48.88	56.28	63.18	67.94	69.12	81.84
MT-D(30)	19.20	24.62	30.60	37.15	42.84	48.92	52.80	53.64	63.80
MT-D(2)	10.24	12.96	16.20	19.84	23.24	26.89	29.57	30.24	37.40
MT-D(1)	7.87	10.04	12.70	15.73	18.76	22.03	23.94	24.84	31.24
I(100)	99.33	64.48	40.60	24.44	14.07	10.53	8.49	5.76	3.41
I(30)	76.80	49.25	30.60	18.57	10.71	8.15	6.60	4.47	2.66
I(2)	40.96	25.92	16.20	9.92	5.81	4.48	3.70	2.52	1.56
I(1)	31.49	20.09	12.70	7.87	4.69	3.67	2.99	2.07	1.30

Note: Intensity I() limited to 100mm/hr

Calculation of Flows and Volumes

Contributing Impermeable Area =	302765 m ²								
Climate Change of	30%								
Flows (l/s) =	2.78 x I x A(ha) x Global warming								
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	10868.40	7054.92	4442.42	2674.43	1539.53	1152.18	929.19	630.26	373.12
1 in 30 yr	8403.40	5388.68	3348.23	2032.30	1171.88	892.20	722.17	489.10	290.87
2 in 30 yr	4481.81	2836.15	1772.59	1085.66	635.73	490.42	404.41	275.74	170.51
1 in 1 yr	3445.39	2198.01	1389.62	860.58	513.18	401.79	327.38	226.50	142.43

Volume (m3) =	Cv x A(ha) x I x D/60			Cv= 1.00					
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	9773.74	12688.70	15979.94	19240.47	22151.50	24867.30	26739.24	27205.25	32211.77
1 in 30 yr	7557.01	9691.87	12043.99	14620.85	16861.59	19256.22	20781.79	21112.41	25111.33
1 in 2 yr	4030.41	5100.98	6376.23	7810.49	9147.14	10584.54	11637.80	11902.30	14720.43
1 in 1 yr	3098.38	3953.26	4998.65	6191.24	7383.83	8671.67	9421.08	9776.89	12295.89

Initial Estimate of Balancing Volume Required

For Peak Discharge of	42.39 l/s			Av'ge Discharge Factor	0.8		Average Discharge = 33.91 l/s		
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	9743.22	12627.66	15857.86	18996.32	21663.20	24134.85	25762.64	25740.35	29281.98
1 in 30 yr	7526.50	9630.83	11921.92	14376.71	16373.29	18523.77	19805.19	19647.51	22181.53
1 in 2 yr	3999.89	5039.95	6254.16	7566.34	8658.84	9852.09	10661.20	10437.40	11790.64
1 in 1 yr	3067.86	3892.23	4876.58	5947.09	6895.53	7939.22	8444.48	8311.99	9366.10

	Depth (m)	Area (m ²)	Sq Dims (m)
Storage required for 1 in 30 yr storm	1	22182	149
Storage required for 1 in 100 yr storm	1	29282	171

ATTENUATION & DISCHARGE TO DITCH

Calculation of Rain Profiles

M5-60	20								
r	0.4								
D (mins)	15	30	60	120	240	360	480	720	1440
Z1	0.64	0.81	1	1.21	1.4	1.62	1.76	1.8	2.2
M5-D	12.8	16.2	20.0	24.2	28.0	32.4	35.2	36.0	44.0
Z2(100)	1.94	1.99	2.03	2.02	2.01	1.95	1.93	1.92	1.86
Z2(30)	1.50	1.52	1.53	1.54	1.53	1.51	1.50	1.49	1.45
Z2(2)	0.80	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.85
Z2(1)	0.62	0.62	0.64	0.65	0.67	0.68	0.68	0.69	0.71
MT-D(100)	24.83	32.24	40.60	48.88	56.28	63.18	67.94	69.12	81.84
MT-D(30)	19.20	24.62	30.60	37.15	42.84	48.92	52.80	53.64	63.80
MT-D(2)	10.24	12.96	16.20	19.84	23.24	26.89	29.57	30.24	37.40
MT-D(1)	7.87	10.04	12.70	15.73	18.76	22.03	23.94	24.84	31.24
I(100)	99.33	64.48	40.60	24.44	14.07	10.53	8.49	5.76	3.41
I(30)	76.80	49.25	30.60	18.57	10.71	8.15	6.60	4.47	2.66
I(2)	40.96	25.92	16.20	9.92	5.81	4.48	3.70	2.52	1.56
I(1)	31.49	20.09	12.70	7.87	4.69	3.67	2.99	2.07	1.30

Note: Intensity I() limited to 100mm/hr

Calculation of Flows and Volumes

Contributing Impermeable Area =	27475 m2								
Climate Change of	30%								
Flows (l/s) =	2.78 x I x A(ha) x Global warming								
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	986.27	640.21	403.14	242.70	139.71	104.56	84.32	57.19	33.86
1 in 30 yr	762.58	489.01	303.84	184.42	106.34	80.96	65.53	44.38	26.40
2 in 30 yr	406.71	257.37	160.86	98.52	57.69	44.50	36.70	25.02	15.47
1 in 1 yr	312.66	199.46	126.10	78.10	46.57	36.46	29.71	20.55	12.92

Volume (m3) =	Cv x A(ha) x I x D/60			Cv= 1.00					
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	886.94	1151.46	1450.13	1746.01	2010.18	2256.63	2426.50	2468.79	2923.12
1 in 30 yr	685.78	879.51	1092.96	1326.80	1530.14	1747.44	1885.88	1915.89	2278.78
1 in 2 yr	365.75	462.90	578.62	708.78	830.07	960.52	1056.10	1080.10	1335.83
1 in 1 yr	281.17	358.75	453.61	561.84	670.06	786.93	854.93	887.22	1115.81

Initial Estimate of Balancing Volume Required

For Peak Discharge of	5.00 l/s		Av'ge Discharge Factor		0.85	Average Discharge =		4.25 l/s	
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	883.11	1143.81	1434.83	1715.41	1948.98	2164.83	2304.10	2285.19	2555.92
1 in 30 yr	681.95	871.86	1077.66	1296.20	1468.94	1655.64	1763.48	1732.29	1911.58
1 in 2 yr	361.92	455.25	563.32	678.18	768.87	868.72	933.70	896.50	968.63
1 in 1 yr	277.34	351.10	438.31	531.24	608.86	695.13	732.53	703.62	748.61

	Depth (m)	Area (m2)	Sq Dims (m)
Storage required for 1 in 30 yr storm	1912 m3	1	44
Storage required for 1 in 100 yr storm	2556 m3	1	51

Consider Swale Along Edge

L=	430 m
Base Width	2 m
Depth	1.2 m
Side Slope 1 in	3
Top Width	9.2 m
Volume/m	6.72 m3
Volume	2890 m3

Consider Storage in Permeable Sub-base

MT-360(100) Rainfall	63.18 mm
Plus Climate Change Allowance	82.134 mm
Discharge	0.56 mm/hr
Net Rainfall	79 mm
Void Ratio	0.3
Type 3 Sub-base Req	263 mm

ATTENUATION & DISCHARGE TO DITCH

Calculation of Rain Profiles

M5-60	20								
r	0.4								
D (mins)	15	30	60	120	240	360	480	720	1440
Z1	0.64	0.81	1	1.21	1.4	1.62	1.76	1.8	2.2
M5-D	12.8	16.2	20.0	24.2	28.0	32.4	35.2	36.0	44.0
Z2(100)	1.94	1.99	2.03	2.02	2.01	1.95	1.93	1.92	1.86
Z2(30)	1.50	1.52	1.53	1.54	1.53	1.51	1.50	1.49	1.45
Z2(2)	0.80	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.85
Z2(1)	0.62	0.62	0.64	0.65	0.67	0.68	0.68	0.69	0.71
MT-D(100)	24.83	32.24	40.60	48.88	56.28	63.18	67.94	69.12	81.84
MT-D(30)	19.20	24.62	30.60	37.15	42.84	48.92	52.80	53.64	63.80
MT-D(2)	10.24	12.96	16.20	19.84	23.24	26.89	29.57	30.24	37.40
MT-D(1)	7.87	10.04	12.70	15.73	18.76	22.03	23.94	24.84	31.24
I(100)	99.33	64.48	40.60	24.44	14.07	10.53	8.49	5.76	3.41
I(30)	76.80	49.25	30.60	18.57	10.71	8.15	6.60	4.47	2.66
I(2)	40.96	25.92	16.20	9.92	5.81	4.48	3.70	2.52	1.56
I(1)	31.49	20.09	12.70	7.87	4.69	3.67	2.99	2.07	1.30

Note: Intensity I() limited to 100mm/hr

Calculation of Flows and Volumes

Contributing Impermeable Area =	3500 m2								
Climate Change of	30%								
Flows (l/s) =	2.78 x I x A(ha) x Global warming								
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	125.64	81.56	51.35	30.92	17.80	13.32	10.74	7.29	4.31
1 in 30 yr	97.14	62.29	38.71	23.49	13.55	10.31	8.35	5.65	3.36
2 in 30 yr	51.81	32.79	20.49	12.55	7.35	5.67	4.68	3.19	1.97
1 in 1 yr	39.83	25.41	16.06	9.95	5.93	4.64	3.78	2.62	1.65

Volume (m3) =	Cv x A(ha) x I x D/60			Cv=		1.00			
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	112.99	146.68	184.73	222.42	256.07	287.47	309.11	314.50	372.37
1 in 30 yr	87.36	112.04	139.23	169.02	194.92	222.60	240.24	244.06	290.29
1 in 2 yr	46.59	58.97	73.71	90.29	105.74	122.36	134.53	137.59	170.17
1 in 1 yr	35.82	45.70	57.79	71.57	85.36	100.25	108.91	113.02	142.14

Initial Estimate of Balancing Volume Required

For Peak Discharge of	5.00 l/s		Av'ge Discharge Factor		0.85	Average Discharge =		4.25 l/s	
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	109.16	139.03	169.43	191.82	194.87	195.67	186.71	130.90	5.17
1 in 30 yr	83.54	104.39	123.93	138.42	133.72	130.80	117.84	60.46	0.00
1 in 2 yr	42.77	51.32	58.41	59.69	44.54	30.56	12.13	0.00	0.00
1 in 1 yr	31.99	38.05	42.49	40.97	24.16	8.45	0.00	0.00	0.00

	Depth (m)	Area (m2)	Sq Dims (m)
Storage required for 1 in 30 yr storm	1	138	12
Storage required for 1 in 100 yr storm	1	196	14

Consider Infiltration Trench Along Road

L=	350 m
Width	1.2 m
Depth	1.2 m
Void Ratio	0.3
Volume	151.2 m3
Pipe	0.45 m
E/O Pipe	39.0 m3
Total	190 m3

ATTENUATION & DISCHARGE TO DITCH

Calculation of Rain Profiles

M5-60	20								
r	0.4								
D (mins)	15	30	60	120	240	360	480	720	1440
Z1	0.64	0.81	1	1.21	1.4	1.62	1.76	1.8	2.2
M5-D	12.8	16.2	20.0	24.2	28.0	32.4	35.2	36.0	44.0
Z2(100)	1.94	1.99	2.03	2.02	2.01	1.95	1.93	1.92	1.86
Z2(30)	1.50	1.52	1.53	1.54	1.53	1.51	1.50	1.49	1.45
Z2(2)	0.80	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.85
Z2(1)	0.62	0.62	0.64	0.65	0.67	0.68	0.68	0.69	0.71
MT-D(100)	24.83	32.24	40.60	48.88	56.28	63.18	67.94	69.12	81.84
MT-D(30)	19.20	24.62	30.60	37.15	42.84	48.92	52.80	53.64	63.80
MT-D(2)	10.24	12.96	16.20	19.84	23.24	26.89	29.57	30.24	37.40
MT-D(1)	7.87	10.04	12.70	15.73	18.76	22.03	23.94	24.84	31.24
I(100)	99.33	64.48	40.60	24.44	14.07	10.53	8.49	5.76	3.41
I(30)	76.80	49.25	30.60	18.57	10.71	8.15	6.60	4.47	2.66
I(2)	40.96	25.92	16.20	9.92	5.81	4.48	3.70	2.52	1.56
I(1)	31.49	20.09	12.70	7.87	4.69	3.67	2.99	2.07	1.30

Note: Intensity I() limited to 100mm/hr

Calculation of Flows and Volumes

Contributing Impermeable Area =	12000 m2								
Climate Change of	30%								
Flows (l/s) =	2.78 x I x A(ha) x Global warming								
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	430.77	279.62	176.07	106.00	61.02	45.67	36.83	24.98	14.79
1 in 30 yr	333.07	213.58	132.71	80.55	46.45	35.36	28.62	19.39	11.53
2 in 30 yr	177.64	112.41	70.26	43.03	25.20	19.44	16.03	10.93	6.76
1 in 1 yr	136.56	87.12	55.08	34.11	20.34	15.92	12.98	8.98	5.65

Volume (m3) =	Cv x A(ha) x I x D/60			Cv= 1.00					
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	387.38	502.91	633.36	762.59	877.97	985.61	1059.80	1078.27	1276.70
1 in 30 yr	299.52	384.13	477.36	579.49	668.30	763.21	823.68	836.78	995.28
1 in 2 yr	159.74	202.18	252.72	309.57	362.54	419.52	461.26	471.74	583.44
1 in 1 yr	122.80	156.69	198.12	245.39	292.66	343.70	373.40	387.50	487.34

Initial Estimate of Balancing Volume Required

For Peak Discharge of	5.00 l/s		Av'ge Discharge Factor		0.85	Average Discharge =		4.25 l/s	
Storm	15	30	60	120	240	360	480	720	1440
1 in 100 yr	383.55	495.26	618.06	731.99	816.77	893.81	937.40	894.67	909.50
1 in 30 yr	295.70	376.48	462.06	548.89	607.10	671.41	701.28	653.18	628.08
1 in 2 yr	155.92	194.53	237.42	278.97	301.34	327.72	338.86	288.14	216.24
1 in 1 yr	118.98	149.04	182.82	214.79	231.46	251.90	251.00	203.90	120.14

	Depth (m)	Area (m2)	Sq Dims (m)
Storage required for 1 in 30 yr storm	701 m3	1	701 26
Storage required for 1 in 100 yr storm	937 m3	1	937 31

Consider Swale Along Edge

L=	120 m
Base Width	3 m
Depth	1.2 m
Side Slope 1 in	3
Top Width	10.2 m
Volume/m	7.92 m3
Volume	950 m3

Consider Atten Basin in Middle

L=	41 m
Width	31 m
Depth	1.2 m
Side Slope 1 in	2
Top Area	1186.04 m2
Bottom Area	948.44 m3
Volume	961 m3

RAINWATER RECYCLING**Water Use (Provided by Client)**

	<u>Per Day</u>	<u>Per Week</u>	<u>Per Month</u>	<u>Per Year</u>	
Single Pot	25	175	757.75	9093	ml
Pots/m2	25				
per m2	0.6	4.4	18.9	227.3	litres
per m2	0.001	0.004	0.019	0.227	m3
Equiv rainfall Depth	0.625	4.375	18.94375	227.325	mm
Growing Area	282065				m2
Total Water Demand	176	1234	5343	64120	m3

Spalding Rainfall

	<u>Annual Profile</u>	<u>Adjusted</u>	<u>Demand</u>	<u>Surplus</u>
Jan	45	52.3	18.9	33
Feb	38	44.2	18.9	25
Mar	33	38.4	18.9	19
Apr	40	46.5	18.9	28
May	33	38.4	18.9	19
Jun	33	38.4	18.9	19
Jul	48	55.8	18.9	37
Aug	52	60.5	18.9	42
Sep	52	60.5	18.9	42
Oct	56	65.1	18.9	46
Nov	50	58.1	18.9	39
Dec	36	41.9	18.9	23
	516	600	227	373

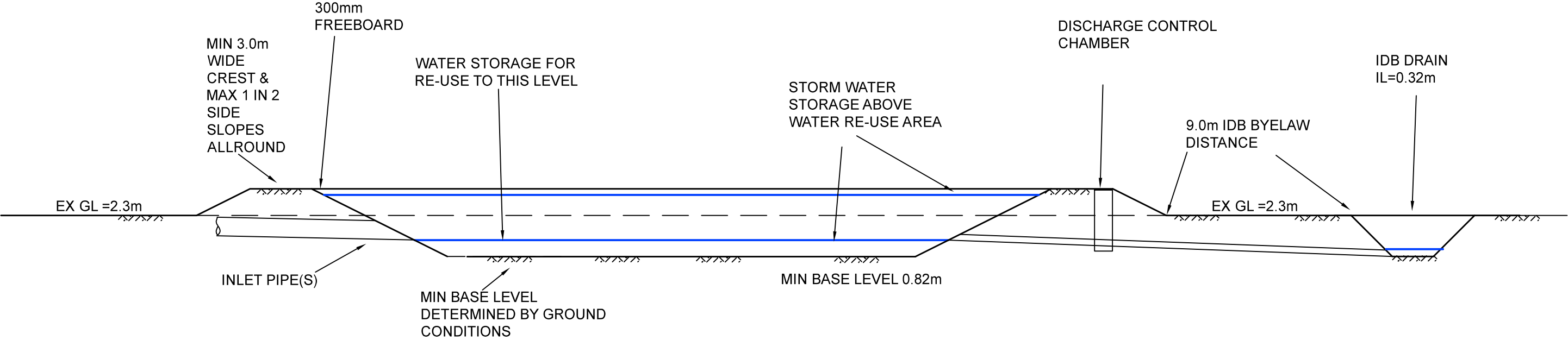
BS8515**Int Approach**

5% Rainfall	30 mm	8462 m3
5% Demand	11 mm	3206 m3

WATER STORAGE LEVELS AND VOLUMES

Pond Levels	
Ex GL	2.3
Crest Above GL	2.3
Crest Level	4.6
Freeboard	0.3
Design TWL	4.3
IDB Ditch Level	0.32
Gravity Outlet Allowance	0.6
Gravity Outlet	0.92
Depth for SW Attenuation	3.38
Depth for Water Re-use	0.32
Additional Depth For Water Re-use	0.5 Subject to Ground Conditions
Base of Pond	-0.18
Embankment Slope 1 in	2

		<u>Area (m2)</u>	<u>Volume (m3)</u>	
Area at	4.30 m	11178		
Area at	0.92 m	6172	29321.5	29300 req
Area at	0.32 m	5486	3497.4	
Potential Extral Volume For Water Re-		4808	2573.5	
Total Volume for Re-use			6070.9	



ILLUSTRATIVE SECTION THROUGH SW PROPOSED STORAGE

										PROJECT		George Shuttleworth Ltd Consulting Engineers 43 Hall Drive Lincoln LN6 7SW Tel: 01522 787710 Email: geo.shuttleworth@btconnect.com				
										NEW DEVELOPMENT AT CLAY BANK, SPALDING						
										DRAWING TITLE		This drawing is the copyright of George Shuttleworth Ltd and shall not be copied or amended or used without the written permission of George Shuttleworth Ltd.				
					OUTLINE OF SW STORAGE											
					SCALE AT A3		DATE		APPROVED BY		DRG SIZE		DRAWING NO.		REV.	
					1: 200		NOV 17		GS		A3		605-013		-	
REV							DR		CH		AP		DATE			