Proof of Evidence relating to Flood Risk and Drainage Matters

Prepared by Alexander Bennett BSc(Hons), MCIHT MTPS

On behalf of:

Save Fulbourn Fields and Fulbourn Forum Rule 6 party

Section 78 of the town and country planning act 1990 (as amended)

Appeal by Castlefield International Limited

PINS Reference: APP/W0530/W/22/3291523
LPA Reference: S/3290/19/RM
M-EC Reference: 27275-01-TN-01 REV A

April 2022






Consulting Development Engineers

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[redacted]

…………………………………………………
Alexander Bennett BSc(Hons) MCIHT MTPS
Director

REGISTRATION OF AMENDMENTS

DATE	REV	CHANGE	PREPARED BY
April 2022	-	Initial Report	AB
April 2022	A	Client and Counsel comments	AB

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APPENDIX

1.0 INTRODUCTION

1.1 My name is Alexander Bennett and I am a Director and Shareholder of Mewies Engineering Consultants Ltd (M-EC). I hold a Bachelor of Science Degree (with Honours) in Geography.

1.2 In my role as a Director, I am responsible for overseeing all operational aspects of the business including managing and coordinating all technical disciplines, general day to day management and the development and growth of the business.

1.3 Prior to the inception of M-EC in 2009, I was an Associate Director of Millard Consulting.

1.4 I have over 19 years' experience. I have spent my career working with Consulting Engineers providing a wide range of professional engineering consultancy advice to private developers and landowners on a diverse range of issues.

1.5 I initially started out as a transportation engineer but my role has evolved to become a multi-disciplinary expert in several areas including highways, flood risk and drainage. I have significant experience in the preparation and production of Flood Risk Assessments and Drainage Strategies on development schemes across the UK and some examples of my current projects are outlined below:

- Mixed use residential development on Land West of Stevenage, Hertfordshire
- Commercial and retail scheme on Land off Angel Drove, Ely, Cambridgeshire
- Residential development on Land off Oakley Road, Chinnor, Oxfordshire
- Residential development on Land off Main Road, Oakham, Rutland
- Mixed use residential development off Long Lane, Costessey, Norfolk

1.6 In 2021 I gave evidence on drainage matters at a Public Inquiry in Chalfont St Giles, Buckinghamshire (re. APP/X0415/W/20/3265964) where I successfully defended the use of deep borehole soakaways.

1.7 My scope of evidence is submitted on behalf of Rule 6 Party Save Fulbourn's Fields and Fulbourn Forum and in particular local residents who live adjacent or very close to the site at 'Land East of Teversham Road' ("the Site").

2.0 SCOPE OF EVIDENCE

2.1 This Appeal relates to a refusal by South Cambridgeshire District Council (SCDC) to a Reserved Matters application for 110 dwellings, submitted by Castlefield International Limited in September 2019 under reference S/3290/19/RM. The application was refused by the SCDC Planning Committee on 13th October 2021 and five Reasons for Refusal were set out. Reason 2 relates to flood risk and drainage as set out below:

Insufficient information has been submitted to demonstrate that the reserved matters scheme can provide a satisfactory scheme of surface water drainage and prevent the increased risk of flooding. The proposal is therefore contrary to Policies CC/7, CC/8 and CC/9 of the South Cambridgeshire Local Plan 2018 and paragraph 167 of the National Planning Policy Framework 2021 which require development proposals to incorporate appropriate sustainable surface water drainage systems and to ensure that flood risk is not increased elsewhere.

2.2 It is noted the Lead Local Flood Authority (LLFA) did not formally object to the Reserved Matters application as set out on Pages 58-60 of the October 2021 committee report (**CDA9**) and in their September 2021 response to the application (see **Appendix 1**). The response from the LLFA indicates they considered that sufficient information had been provided to satisfy matters in respect of flood risk and surface water drainage although they noted a request for further information on groundwater depths and updated surface water modelling was required.

2.3 The Reserved Matters submission relates to appearance, landscaping, layout and scale, as opposed to the detailed design of the surface water network, which is subject to a condition (Condition 8) imposed as part of the original outline planning permission (ref. S/0202/17/OL) dated October 2017 (**CDC1**). Condition 8 is summarised below:

Prior to the commencement of the development a detailed surface water drainage scheme for the site, based on the agreed Flood Risk Assessment (FRA) CCE/B411/FRA-03 September 2014 by Cannon Consulting Engineers has been submitted to and approved in writing by the Local Planning Authority. Such a scheme shall include details of the long-term ownership/adoption of the surface water drainage system and maintenance of the same. The scheme shall be constructed, completed and properly retained /maintained thereafter in accordance with the approved plans and implementation programme agreed in writing with the Local Planning Authority. (Reason - To ensure a satisfactory method of surface water drainage and to prevent the increased risk of flooding in accordance with Policies DP/1 and NE/11 of the adopted Local Development Framework 2007.

2.4 The Flood Risk Assessment (ref. CCE/B411/FRA-03) dated September 2014 (**CDC12**) and prepared by Cannon Consulting Engineering to support the outline application, acknowledges the site is located in Flood Zone 1 but is subject to a surface water flood risk based on the available Environment Agency (EA) mapping. Surface water flood risk was subsequently modelled in order to more accurately identify flood extents and broad mitigation measures were outlined which includes maintaining space for floodwater and setting Finished Floor Levels 300mm above existing ground levels (see paragraph 4.2 of the Cannon Consulting Engineering Flood Risk Assessment).

2.5 The risk of flooding across the site and the required mitigation measures, coupled with the surface water attenuation requirements as identified within the Flood Risk Assessment, means the assessment of flood risk and drainage are inseparable from the development of a suitable and robust layout and landscape strategy. Therefore, as set out in the Rule 6 party's Statement of Case, flood risk and drainage matters must be considered hand in hand with the development of the layout and cannot simply be separated for the purposes of a Reserved Matters submission and this Appeal.

2.6 The need to consider flood risk and drainage as part of the Reserved Matters submission has clearly been considered by the Appellant. This is evidenced by the additional information submitted by Cannon Consulting Engineers in support of the proposals. However, it is clear from the numerous submissions and variations in reports and plans submitted with the application that establishing a suitable layout which deals with the various flood risk and drainage challenges of the site has been difficult. Indeed, additional information featuring a number of new details was submitted as late as April 2022[1]. The chronology of information submitted at various stages through the planning application process is set in the Proof of Evidence prepared by Dr Elizabeth Soilleux.

2.7 My evidence will consider the information submitted by the Appellant in respect of flood risk and drainage matters. Further, it will set out a) why insufficient information has been made available to satisfy the Planning Inspector, SCDC and local residents that flood risk can and will be managed on site without detriment to surrounding properties and b) that an informed decision on the submitted layout and landscaping strategy cannot be made at this stage due to the absence of robust flood risk and drainage proposals by the Appellant.

2.8 I can confirm that I have visited the site and I am familiar with the location and adjacent areas.

2.9 My evidence is supported by additional information prepared by representatives of Save Fulbourn's Fields and Fulbourn Forum including a Proof of Evidence by Dr Elizabeth Soilleux and a Flood Risk Assessment prepared by Professor Roger A. Falconer and Dr Dongfang Liang which is appended to Dr Elizabeth Soilleux's Proof of Evidence.

[1] I note that the legal submissions of Ms Hutton set out that issues of scale including finished floor levels and platform heights should have been applied for as part of the reserved matters and these have not been. This is a legal issue. I do not address this as part of this proof. Where appropriate, I comment upon the levels and heights assumed by the Appellant in its modelling work or proposed drainage schemes but give no indication as to whether it is lawful for these to be fixed now or at a later stage.'

3.0 PLANNING POLICIES

3.1 Reason for Refusal 2 references a number of national and local planning policy including Paragraph 167 from the National Planning Policy Framework 2021 (NPPF) and Policies CC/7, CC/8 and CC/9 of the South Cambridgeshire Local Plan 2018. The relevant policies are considered further in this section and in context to this Proof of Evidence.

National Planning Policy Framework (CDF1)

3.2 The NPPF seeks to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Reason for Refusal 2 makes specific references to Paragraph 167 of the NPPF which is set out below (emphasis added):

167. When determining any planning applications, local planning authorities should ensure that flood risk is <u>not increased elsewhere</u>. Where appropriate, applications should be supported by a site-specific flood-risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:

a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
b) the development is appropriately flood resistant and resilient such that, in the event of a flood, it could be quickly brought back into use without significant refurbishment;
c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;
d) any residual risk can be safely managed; and
e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

South Cambridgeshire Local Plan 2018 (CDE1)

<u>Policy CC/7: Water Quality</u>

3.3 This policy relates to the protection of water quality ensuring a suitable water supply, sewerage and land drainage systems are provided and that ground and surface water bodies are not harmed.

<u>Policy CC/8: Sustainable Drainage Systems</u>

3.4 Development proposals must incorporate sustainable drainage systems which are well planned and designed which provide a flood risk management function alongside benefits for amenity and biodiversity.

<u>Policy CC/9: Manging Flood Risk</u>

3.5 This policy outlines key measures to minimise flood risk including specific mitigation measures and the requirements around preparing a site specific Flood Risk Assessment. In respect of mitigation measures which are covered under Point 1 of the policy the following are noted:

- Floor levels should be set 300mm above the 1 in 100 year flood level plus an allowance for climate change
- Suitable flood protection/mitigation measures are incorporated in to the scheme
- There would be no increase to flood risk elsewhere, and opportunities to reduce flood risk elsewhere have been explored and taken where appropriate
- Discharge of surface water flows follows the SuDS hierarchy i.e. infiltration, water body, sewer

Cambridgeshire Flood and Water Supplementary Planning Document (CDE11)

3.6 Whilst not referenced in the reason for refusal, this SPD is a key document in the consideration of flood risk and drainage for any proposed development site. Key paragraphs include:

- The box below 4.3.13 which states what flood risk assessments should do including

  j. Consider the risk of flooding arising from the proposed development in addition to the risk of flooding to development on the site. This includes considering how the ability of water to soak into the ground may change after development. This would mean the preparation of surface water drainage proposals. This includes all flow routes including flood flow paths or ordinary watercourses flowing onto the development site and therefore needing to be taken account of;

  k. Take a 'whole system' approach to drainage to ensure site discharge does not cause problems further along in the drainage sub-catchment/can be safely catered for downstream and upstream of the site;

  l. Take the appropriate impacts of climate change into account for the lifetime of the development including the proposed vulnerability classification. Guidance is available on the .gov.uk website;

- Paragraph 4.3.14 states drainage strategy proposals should be sufficient to:

  "…demonstrate a scheme can be delivered that will adequately drain the proposed development whilst not increasing flood risk elsewhere."

- Paragraph 5.1.13 states:

  "The site layout of any proposed development should take into consideration areas of flood risk present on the site and this should influence the choice of where to locate elements of the proposed development including sustainable drainage systems (SuDS)…"

- Paragraph 5.1.23 acknowledges that where it is not possible to avoid flood risk or minimise through the site layout raising flood levels above predicted levels can be a possible option. However, this strategy can increase flood risk elsewhere.

- Paragraph 5.1.30 states:

  ‘Any proposals to modify ground levels will need to demonstrate in the FRA that there is no increase in flood risk to the development itself or to any existing property elsewhere’

4.0 EVIDENCE

4.1 In this section I have reviewed the core evidence presented by Cannon Consulting Engineers and HR Wallingford (as instructed by Cannon Consulting Engineers) on behalf of the Appellant. The key documents (in addition to the original Flood Risk Assessment) are summarised below and each have been appended to this Proof of Evidence for ease of reference where they are not listed as part of the Core Documents list.

- Discharge of Conditions, Surface Water Management, Cannon Consulting Engineers, Ref: B411, Dated: 12 September 2019 (**Appendix 2**)
- Discharge of Conditions, Surface water management, Cannon Consulting Engineers, Ref: B411, Dated: 3 December 2019 (**Appendix 3**)
- Discharge of Conditions, Surface Water Management, Cannon Consulting Engineers, Ref: B411, Dated: 27th February 2020 (**Appendix 4**)
- Review of surface water flood management, HR Wallingford, Ref RT001, Dated: 12th August 2020 (**CDG4**)
- Reserved Matters Application – Layout, Cannon Consulting Engineers, Dated: 12th August 2020 (**Appendix 5**)
- Reserved Matters Application – Layout Updated, Cannon Consulting Engineers, Dated: 13th April 2021 (**Appendix 6**)
- Flood Management Strategy, Cannon Consulting Engineers, Ref: B411-PL-SK-320 Rev P09, Dated: 14th April 2021 (**CDG7**)
- Cow Lane Flood Basin, Cannon Consulting Engineers, Ref: B411-PL-SK-321 Rev P02, Dated: 14 April 2021 (**CDG8**)
- Reserved Matters Appeal, Flood Modelling and Surface Water Management Update, Cannon Consulting Engineers, Ref: B411, Dated: 4th April 2022 (**CDG9**)
- Update to surface water flood management, HR Wallingford, Ref RT001, Dated: 4th April 2022 (**CDG10**)

4.2 The key issues for me to consider in this Proof of Evidence relate to surface water drainage and flood risk as reflected in Reason for Refusal 2. On that basis my evidence is split into these 2 aspects outlining the deficiencies in the information provided and how this impacts the acceptability of the Reserved Matters proposals.

4.3 It is my understanding that the information as submitted in April 2021, was the information before the committee in October 2021. Subsequent information has been submitted in April 2022 and it before this Appeal and so is considered accordingly.

Surface Water Drainage Strategy

4.4 Having reviewed the available documents including the original Flood Risk Assessment (**CDC12**), it would appear the drainage strategy has evolved from a primarily 'above ground' SuDS based strategy which included permeable paving and various basin features, to a strategy primarily comprising permeable paving and below ground storage features with above ground features only remaining to the north. The reason for this change appears to relate to the need to retain existing plant life. Condition 8 requires the detailed surface water strategy for the site to be based on the agreed Flood Risk Assessment and the observed changes would suggest a noticeable departure from the original strategy. These changes can be seen in Figure 1 and 2, which contain site plans from the relevant documents.

4.5 The latest drainage strategy would appear to be shown on Cannon Consulting Engineers drawing B411-PL-SK-350 Rev P01 which is appended to their April 2022 report and contained at **CDG9**. No Micro-drainage calculations or updated construction details are included within this report and so I have assumed the details as contained in their February 2020 report remain valid which is contained in **Appendix 4**. This is despite the fact the drainage strategy appears to have changed between 2020 and 2022 however no other calculations have been identified in the supporting information. Changes include the loss of attenuation areas along the southern boundary and a tank in the north eastern corner.

4.6 Whilst the geology across the site (Chalk) would typically favour the use of soakage, reported high groundwater levels would preclude the use of soakage. Indeed, the Cambridgeshire Flood and Water SPD (CD E12) at Paragraph 6.2.4 acknowledges the geology in the north and central areas of Cambridgeshire is relatively impermeable, consisting mainly of soils with properties similar to clay.

4.7 The lack of infiltration is accepted by both the Appellant and the LLFA and as such the proposed drainage features outfall into the central watercourse which runs south to north before being culverted beneath the railway line. A total of 3 outfall locations are proposed with discharge rates set to the 1 in 1 year Greenfield runoff rate.

4.8 The 2014 Flood Risk Assessment (**CDC12**) utilises EA borehole data and states a 'design groundwater flood level' of 0.67 mbgl. Groundwater monitoring information contained in **Appendix 2** from 2016 indicates a maximum observed ground water level of 0.65 mbgl. It is noted out of 12 visits, only 1 visit covers a 'winter' month which was January 2016.

4.9 A measurement of groundwater undertaken by myself in April 2022 on the eastern part of the site (see **Appendix 7**) shows a groundwater level of 0.65 mbgl in a period when groundwater levels would typically be reducing. Other observations on ground water are presented in evidence by Dr Elizabeth Soilleux, Professor Roger A. Falconer and Dr Dongfang Liang. These observations indicate that the Appellant has over-estimated the groundwater levels at the site.

4.10 It is my view that groundwater levels are under represented by the Appellant and within the drainage design and further assessment in the form of continuous 12 month monitoring is required. Groundwater will have a significant influence on the drainage design for this site and this is acknowledged by Cannon Consulting Engineers in their various technical reports. It is noted that there has been sufficient time since the granting of outline planning permission in 2017 for this work to be completed.

4.11 Having reviewed the drainage design and supporting calculations and construction details across the various document, I have a number of concerns over what is presented and whether the design is a workable solution which in turn would affect the deliverability of the submitted layout. My concerns are:

- There are a number of issues with Micro-drainage calculations which underpin the drainage strategy and these are concerns are as follows

  - No updated calculations have been prepared since 2020 (see **Appendix 4**) with no new calculations prepared as part of the 2022 submission (**CDG9**) despite changes to the drainage strategy.

  - The discharge rate for the site has changed since the original strategy presented in the Flood Risk Assessment (**CDC12**) up to the latest submission (**CDG9**). The original calculations indicate a proposed discharge rate for the whole site of 0.3 l/s based on the 1 in 1 year greenfield discharge rate. This rate is low and unrealistic. As the calculations have evolved the rate has increased with the 2020 calculations proposing a discharge rate of 3.1 l/s and the most recent 2022 drainage design suggesting 4.4 l/s (albeit not supported by any calculations). The reason for the change in rate has not been explained or justified and the LLFA response contained in **Appendix 1** indicates a discharge rate of 0.3 l/s/ha, equivalent to the 1 in 1 year greenfield runoff rate is expected.

  - If the 1 in 1 greenfield rate of 0.3l/s/ha is applied to the proposed site area of 6.85ha, the 1 in 1 greenfield rate for the whole site is 2.1l/s. Given that in 2022 submissions at **CDG9** the site is proposed to discharge at a rate of 4.4l/s and the 1 in 1 greenfield rate for the whole site is 2.1l/s, the 2022 strategy is discharging twice as fast as the recommended 1 in 1 greenfield rate. This raises concerns over the potential for increased flood risk and the potential need for additional storage on site if the LLFA apply the 1 in 1 year greenfield run off rate as stated in their response.

  - The impermeable areas outlined on drawing B411-PL-SK-350 REV P01 at **CDG9** do not appear to include for the roads as proposed impermeable areas are very low.

  - The calculations show no clear evidence for the inclusion of urban creep. Urban creep is the conversion of permeable surfaces to impermeable ones over time, e.g. extensions to existing buildings. It has been shown that, over the lifetime of a residential development, urban creep can increase impermeable areas by as much as 10% and its allowance is a standard requirement on residential developments. The application of urban creep will increase storage volumes.

- Proposed orifice sizes (flow control devices) appear unrealistic in size based on the 2020 calculations in **Appendix 4**. Whilst they have been "theoretically" modelled in the software the devices would be extremely small, and would be subject to significant risk of blockage unless maintained extremely regularly. I note reference is made to additional filtration features however I have seen no detailed maintenance plan and the expectations on the management company (or otherwise) to keep a difficult drainage regime clear of issues.

- The Micro-drainage calculations included in **Appendix 4** state "Outfall is too low. Design is unsatisfactory" and I can see no evidence that this is explained. Based on experience this is often an indication that either the discharge rate is too low or the attenuation needs to be increased. The calculations also include references to half drain down times, however as soakage cannot be relied upon on this site, I am unsure what relevance this has to the scheme or why it has been applied.

- The calculations do not appear to include any assessment for a submerged outfall which we would expect to be a requirement when considering the likelihood of high-water levels in the watercourse channel in the higher storm events.

- Tank systems are proposed under the majority of roads including roads that we would assume would be put forward for adoption by the Local Highway Authority unless the entire site is to remain private? In my experience these features would not be acceptable to the Local Highway Authority. On page 5 of the note contained in **Appendix 4**, it is suggested there will be adopted roads but if the presence of the tanks prevents this then the presented drainage strategy may need change with tanks located in alternative locations.

- The tanks proposed under the play area are likely to be in conflict with proposed play equipment and associated foundations.

- Limited road levels are provided on drawing B411 - PL - SK – 320 Rev P09 at **CDG5** and this shows road levels will be raised which is consistent with comments in **Appendix 4** where is states development parcels and roads linking them will be set above the modelled floodwater. Based on the available information, road levels would need to be raised approximately 1m around the central area of the eastern parcel which is likely to result in highway retaining walls being required. These are not shown on any drawings and would need to be factored into road adoption considerations and the landscape strategy for the site.

- Permeable paving is shown across the site. The construction details as presented in **Appendix 4** (see Cannon Consulting drawing B411-PL-SK-304 Rev P02) do not include any dimensions or depths. In our experience a typical detail for permeable paving as proposed would have a depth of 0.79m as shown on the example in **Appendix 8**. Based on the recorded groundwater levels permeable paving would fail and would be subject to flooding unless all roads are raised which we assume will be the case, albeit limited road levels are provided and no updated levels are presented in the 2022 reports.

- The typical construction details as presented in **Appendix 4** show permeable paving discharging into a cellular storage tank which is wrapped in a geotextile to prevent groundwater ingress. The permeable paving is shown to discharge directly into the storage tank, however this cannot be achieved due to the presence of the geotextile which would prevent permeability. The same is also shown for the basin over crates. These details are flawed and would ultimately render the storage ineffective.

- On the latest drainage strategy drawing at **CDG9**, the north basin is shown to be 0.8m deep which means it would be located below the Appellants identified groundwater level of 0.65m. Utilising the previous construction details, as no new details are provided, there is no evidence to show this feature would be lined and permeability down into a drainage layer and below ground tank is required.

- Part of the highway is proposed to drain to the pump house garden pond. Information contained in **Appendix 2** would suggest assumptions have been made about how this pond drains and the maximum water level. The maximum water level has been assumed to coincide with the groundwater levels but as already indicated, I consider that groundwater levels have been underestimated and so placing additional flows into this pond could also result in flooding to nearby properties. In addition, I question whether this feature would be an acceptable outfall to the highway authority at the point of adoption as they will not have ownership of this pond and it does not appear to have a positive outfall.

- The Finished Floor Levels as presented at **CDG9** appear to show the levels falls from north to south and this is assumed to be the same for road levels, albeit these are not provided. However, the drainage strategy appears to falls from south to north, based on the location of the limited pipe network and outfall position, so against the proposed platform levels. No details on drainage levels are provided and so questions are raised about the ability to drain the parcel as illustrated.

- The HR Wallingford report presented at **CDG10** discusses a number of proposed culverts as illustrated in Figure 3.1. These culverts do not appear to any part of the drainage design to ensure they can be accommodated without conflict.

4.12 A number of my comments have been annotated onto the latest drainage design and a copy of this for reference can be found in **Appendix 9**.

4.13 My review of the drainage strategy raises a number of concerns over how robust and deliverable the strategy is. Whilst I can accept some key principles presented i.e. discharge rates set to the 1 in 1 year storm event for all return periods and the provision of attenuation/SuDS features, there are significant flaws in the approach which may render the scheme useless and may increase flood risk to third parties. This includes the application of extremely low discharge rates to each proposed outfall which could result in significant blockage concerns, the use of permeable paving which could be impacted by groundwater and appear unworkable based on the design presented, a basin design set below groundwater levels and proposed platform levels which go against the drainage design.

4.14 Surface water drainage is a fundamental component to the development of the layout and landscape strategy and so if flawed or requiring further change, then this will impact the delivery of the reserved matters as presented and the subject of this Appeal. The surface water drainage strategy should be established first with the key principles agreed and set down and the layout developed around it. This is set out in the Cambridgeshire Flood and Water SPD (**CDE12**), where the following is stated at paragraph 6.3.2 (emphasis added):

Considering SuDS during the <u>preliminary stages</u> of site design provides the opportunity to incorporate features that are appropriate to the local context and character of an area. Integrated design to achieve multi-functional benefits is inherent to the site master planning and layout process; therefore it is most efficient and cost effective to design SuDS schemes into a site as early as possible. <u>When drainage is accounted for from the beginning of the design process, it provides opportunity for the built up areas to be designed in-line with the topography, rather than to fit the drainage around the site at a later stage which is much less effective</u>.

4.15 It is my view the strategy is neither sufficiently settled nor detailed enough to confirm the acceptability of the reserved matters.

Flood Risk

4.16 The site is subject to extensive surface water flooding and as such modelling has been undertaken by HR Wallingford. An original report was prepared in 2016 (attached to the Flood Risk Assessment at **CDC12**) with updated reports prepared in August 2020 (**CDG4**) and April 2022 (**CDG10**). All reports were commissioned by Cannon Consulting Engineers on behalf of the Appellant.

4.17 It is unclear from the available information whether any formal scoping took place with the EA or LLFA for the modelling work undertaken previously or most recently. Paragraph 5.1.3 of the Cambridgeshire Flood and Water SPD (**CDE12**) states:

"If developers need to undertake more detailed modelling for their sites to be able to accurately demonstrate the timings, velocity and depth of water inundation to their site, then it is recommended that the scope of works is discussed with the Environment Agency (EA)…"

4.18 The general strategy for the site appears to involve raising the development platforms (dwellings and roads) above 1 in 100 year plus climate change flood level with lower lying areas, including some proposed back gardens in the latest iterations, able to flood thereby providing the required floodplain storage. The primary concern for Save Fulbourn Fields and Fulbourn Forum is the potential risk of flooding to properties along the southern boundary of the site and the robustness of the work undertaken.

4.19 It is noted the LLFA have responded to the April 2022 HR Wallingford modelling report and this is contained in **Appendix 10**. On this occasion, the LLFA contracted an expert to provide commentary. The LLFA response is largely critical and it is noted the model files requested by the Planning Inspector have not been made available. In the penultimate paragraph, the LLFA comments:

"Currently there is low confidence in the flood risk mapping outputs provided and would expect further work is required to support the conclusions that are made in the flood risk report".

4.20 It is clear based on the above comment from the LLFA alone, that more work is needed. Whilst the LLFA acknowledge this work is required for a condition rather than for Reserved Matters, I stand by my comments made earlier in that if the modelling is not robust then the reserved matters, which is for consideration at this stage, cannot be considered to be settled and may have to be subject to further change.

4.21 Having reviewed the modelling work available a number of concerns are apparent and these are set out below.

<u>Modelling Specification</u>

4.22 To date we have only seen the information made available via the various submission by the Appellant and have not been party to the instructions between HR Wallingford and Cannon Consulting Engineers. This includes having no sight of a detailed specification setting out the information required by HR Wallingford to complete this work and the agreed outcomes. Similarly, we are not aware of how many schemes/layouts have been modelled, what input parameters have been explored, nor why the results for the scheme/layout put before SCDC are not present.

4.23 As a company, M-EC operate in a similar way to Cannon Consulting Engineers in that we use third party consultants to undertake specialist flood modelling on our behalf. Enclosed in **Appendix 11** is an example of the type of specification we would expect and this raises a number of queries including:

- Was a topographical survey spec requested and agreed?
- What hydrological analysis was agreed?
- Why has no blockage scenario been considered for the culvert under the railway line or elsewhere

4.24 A key concern in my observations is a lack of detail around the watercourses running through the site with no channel cross-sections included as part of the topographical survey. Based on my review of the report, a 1D model has been prepared for the watercourse and so cross-sections as shown on the specification included in **Appendix 11** would usually be required to improve accuracy. In addition, we would expect the channel survey to extend upstream and downstream of the site to ensure flood extents are mapped accurately and all structures should have been surveyed in accordance with the EA specification version 5.1. I can see no evidence this has been done and note the LLFA in their most recent response raise similar queries:

"From the report it is inferred that the 1D channel across the site leaves the site via a 0.8m arched culvert under the railway embankment. It is not clear if this continues as a 1D element beyond the downstream face of the railway embankment or if representation returns to 2D only beyond the railway embankment. There is no discussion of downstream condition / boundary".

4.25 As part of the sensitivity test for the model, we would generally expect to see a blockage scenario for any hydraulic structure such as the culvert under the railway line. This should not only be a required for the EA and LLFA but also for Network Rail. Structures can often be a key source of flood risk especially if not maintained and so sensitivity testing to consider a 50% blockage for example are common place. This does not appear to have been included for in the model either for the railway line culvert or for any other key drainage channels or flow control systems which may affect the site.

<u>Topographical Survey</u>

4.26 The model utilises LIDAR for the wider catchment however the use of a site-specific topographical survey would ensure increased accuracy for the site. As well as the lack of detail to inform the hydrological model (cross-section etc), the topographical survey as included at **CDG9**, would appear to be lacking in several other areas including:

1. A general absence of levels along the boundaries of the site especially to the north and south with the southern boundary being particularly relevant to the concerns raised by local residents.

2. The survey includes no levels 'beyond' the site boundary and in particular within garden areas along the southern boundary. Whilst we would not expect levels in third party land to be obtained as a matter of course (due to accuracy of reflective shots and access) I am surprised that over the course of this application no attempt has been made to discuss access with local residents to extend the survey into these sensitive boundaries ensuring robust data is available to inform the model.

<u>Geology</u>

4.27 This matter is picked up by Professor Roger A. Falconer and Dr Dongfang Liang in their Flood Risk Assessment contained in Dr Elizabeth Soilleux's Proof of Evidence and relates to the wrong assumptions made in respect of the local geology. The modelling report describes the geology as free-draining chalk however the geology actually comprises West Melbury Marly Chalk, which has a high clay content and is relatively impermeable. Relevant information provided by Dr Christine Donnelly of the Cambridgeshire Geological Society can be found in **Appendix 12**.

<u>Winter Assessment</u>

4.28 The HR Wallingford reports only utilises a summer rainfall profile as this produced higher peak flows than the winter profile as the summer storm is more "peaky" than the winder profile owing to the prevalence of intense storm events. This matter is covered in detail by Professor Roger A. Falconer and Dr Dongfang Liang.

4.29 Whilst the reasoning for the use of a summer rainfall profile is accepted, I am surprised a winter profile was not run to take account of longer storm durations and higher base watercourse flows, ground saturation etc. No explanation for this is given. Indeed, no sensitivity testing is considered at all within the report as raised previously. This issue is raised by the LLFA's expert commentary which forms part of their April 2022 response as stated below:

It is expected that sensitivity testing to runoff coefficient and storm duration and storm profile (within direct rainfall model – not just ReFH2 lumped flow) should be undertaken as a minimum. Sensitivity to Manning's 'n' and downstream boundary condition should be undertaken would also improve confidence in results provided.

<u>Post Development Ground Levels and Platform Extents Plan</u>

4.30 This drawing is contained on Page 9 of the April 2022 report (**CDG9**). This plan is not labelled and is difficult to read in context, but it is my understanding, based on available commentary within the report, that this plan depicts post development ground levels. However, beyond the general poor nature and presentation of this plan the following observations are made:

- We assume the levels shown within the 'development platform' to the west are meant to represent the proposed development platform levels, however these do not correspond to the proposed Finished Floor Levels shown on Cannon Consulting Engineers drawing B411-PL-SK-351 on Page 10 of their April 2022 report (**CDG9**) with the levels generally being 1m out so not representing 'Post development levels'.

- No levels are shown for the eastern development platform (existing or proposed) so it is unclear to what extent this plan is informing post development levels in this area. Only limited interval levels are provided along the platform boundary

- Along the southern boundary, within the eastern part of the site, a group of levels remain which we assume represents the Cow Lane Flood Basin and so we assume this is consistent to the plan included at **CDG8** and is included as mitigation in the model. The basin appears to extend up to a height of 9.9m on the southern boundary (based on an excavation depth of 9.4m and the basin being 500mm deep). No updated design for this basin is presented in any recent submissions.

- A number of levels overlap each other and are difficult to read.

4.31 **Appendix 6** defines the Cow Lane Flood Basin as a floodwater storage basin providing space for floodwater to offset the potential increase in flood volumes. The basin is sized to accommodate 150m^3. As this is a flood compensation device, it does not appear to form part of the proposed surface water drainage network and as such is not considered to be a SuDS feature i.e. a device which limits/controls the rate of runoff from new hardstanding areas. No surface water drainage from the proposed development appears to discharge into this feature.

Flood Levels

4.32 Predicted flood levels appear to have varied significantly between the April 2021 (**CDG7**) and April 2022 submission (**CDG9**). We assume these flood levels are taken from the HR Wallingford reports as these levels are not published in the available document.

4.33 We have also assumed the flood levels presented in April 2021, and presented to the planning committee, take flood levels from the August 2020 HR Wallingford Road and that the 2021 proposals were not modelled specifically. The more recent modelling appears to assess a new set of proposals and so the plans submitted to the committee and subsequently refused have not been specially modelled. As the scheme has changed, we assume the proposals as submitted to the planning committee did not work.

4.34 The flood levels shown in **CDG7** indicate flood levels (1 in 100 year plus 40% climate change) of between 10.17m and 10.57m. These levels have reduced in the more recent modelling (**CDG9**) and vary between 9.89m and 10.28m. The definitive reason for this change is not overly clear however it is noted some of the proposed gardens within the south eastern development area are now shown to flood and a new connecting culvert is included. However, details are limited as there is no indication how this culvert would work or how the gardens would be allowed to flood, for example will culverts be provided within fence or wall lines and what restrictions will be posed to stop development of gardens which in turn would reduce flood storage. Whilst flooding proposed gardens is a strategy sometimes used in flood mitigation schemes, this may have wider implication on the proposals as outlined in paragraph 5.1.24 of the Cambridgeshire Flood and Water SPD (**CDE11**):

"If floor levels are raised to mitigate flooding to the development, this may not prevent the roads and gardens from flooding which can affect house (flood) insurance and cause concern to the owners of the properties seeing flood water surrounding their property".

4.35 It is noted climate change is provided in accordance with the Upper End to account for a typical lifetime of 100 years for a residential development. The percentage is table from Table 2 (Peak Rainfall intensity allowance in small and urban catchments) from the Flood Risk Assessments: Climate Change Allowances Guidance (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances).

4.36 Due to the lack of levels around the site boundary and within adjacent gardens, topographical survey work of these areas has been commissioned by Save Fulbourn Fields and Fulbourn Forum and is presented in **Appendix 13**. This includes additional data along the southern boundary and within private garden areas.

4.37 The April 2021 and April 2022 flood levels, focused around No. 60 Cow Lane, where flood depths are shown to increase by over 300mm in Figure 4.11 of **CDG10**, have been extrapolated onto the topographical survey. **Appendix 14** shows the flooding of third-party land would occur in both cases with significant flooding noted from the April 2021 levels, justifying the Reason for Refusal imposed by the planning committee.

4.38 This flooding occurs despite continued comments from the Appellant and the results present at **CDG10** where the predicted flood level increases are shown to stop on the site boundary. It is noted whilst the Cow Lane Flood Basin appears to remain based on the Post Development Ground Levels and Platform Extents Plan, the maximum height of the basin (based on the poor information available) is 9.9m, however the maximum flood height is 9.97m in that location so the basin will overtop.

4.39 The significant change in flood levels between two plans drawn up 1 year apart demonstrates the uncertainty in the modelling and how predicted flood extents are impacted by the model parameters, include the scheme design. The modelling likely underestimates true flood risk, as detailed above, however we can be confident that the proposals as presented will result in additional flooding to third parties and this is evident in **Appendix 14**.

<u>Mitigation</u>

4.40 As raised previously, the HR Wallingford Road report at Figure 3.1 identifies a number of proposed culverts across the scheme which provide flood mitigation through the conveyance of flood water flows across the scheme. No detail beyond this figure is presented. The culverts have not been integrated into the site wider drainage design, no details are provided in terms of levels and construction in the context of the wider proposals. Whilst, from a modelling perspective, they provide the ability to convey flows, their use appears only ‘theoretic’ with no civils designs presented in any of the submissions.

4.41 For example, the eastern 1m x 0.25m box culvert would appear to be located along a proposed section of road. At what depth will this be provided and how will it interact with proposed services for this road and the tanked drainage strategy in this area, which as described earlier will need to be laid at a suitable depth to achieve drainage against the gradient of the platform. This matter is not addressed.

4.42 The Cow Lane Flood Basin is neither shown on any recent designs nor integrated into the updated site wide drainage proposals so we cannot assess all measures in the context of each other.

5.0 SUMMARY AND CONCLUSIONS

5.1 This Appeal relates to a proposed residential development for 110 dwellings on Land East of Teversham Road, Fulbourn. The application was refused by South Cambridgeshire District Council with five Reasons for Refusal. Reason 2 relates to flood risk and drainage, and it is this which my evidence considers. My report is submitted on behalf of Save Fulbourn Fields and Fulbourn Forum Rule 6 party.

5.2 It is acknowledged the Reserved Matters submission made by the Appellant relates to appearance, landscaping, layout and scale, as opposed to the detailed design of the surface water network, which is subject to a condition (Condition 8) imposed as part of the original outline planning permission (ref. S/0202/17/OL) dated October 2017.

5.3 However, the clearly identified risk of flooding across the site and the required mitigation measures to deal with this, coupled with the surface water attenuation requirements means the assessment of flood risk and drainage are inseparable from the development of a suitable and robust layout and landscape strategy. Whilst in planning terms the flood risk and drainage matters can be considered at a later stage, in practice the technical detail is required upfront to ensure flood risk and drainage matters do not compromise the layout and landscaping and the layout and landscaping is compatible with and support the required surface water management, flood risk and drainage mitigation. The need to consider surface water drainage at first principles is set out in the Cambridgeshire Flood and Water Supplementary Planning Document.

5.4 It is noted the Lead Local Flood Authority (LLFA) did not object formally to the proposals put before the Planning Committee in 2021; however, their most recent response to updated material in April 2022 shows they have a low confidence in the flood modelling material which has been made available by the Appellant.

5.5 The submissions made by the Appellant are extensive with 11 sets of material referred to in this Proof of Evidence. However, there is a distinct lack of detailed and coordinated material which provides a comprehensive and robust set of proposals confirming the deliverability of the mitigation proposals and ensuring affected third parties clearly understand the implications on their properties. This has led to increased uncertainty, confusion and ambiguity about what is proposed.

5.6 I am of the view the following is missing from the technical submissions:

- Updated, extensive and consistent groundwater monitoring across the site ensuring all winter months are observed.

- Detailed engineering design proposals which clearly set out the required mitigation measures for the site. Designs should include:
    - Road levels
    - Plot Finished Floor Levels
    - Drainage designs including all adoptable surface and foul water sewers including pipe sizes / attenuation volumes / SuDS features (depths/details) / Flow control devices and proposed discharge rartes
    - Conceptual cut and fill plans
    - Dimensioned construction details
    - Flood mitigation/compensation measures e.g. ground level changes, Cow Lane flood basin etc

- Flood zoning plans taking account of predicted flood levels extrapolated from the available modelling report onto topographical survey and LIDAR data.

- Updated drainage calculations specific to the submitted scheme with identified errors removed.

- Preparation of (at least a draft) Management and Maintenance plan for all proposed devices (drainage and flood mitigation) and all associated infrastructure to show a clear regime can be put in place.

- Flood modelling prepared to an agreed specification and subsequently agreed with the Lead Local Flood Authority and Environment Agency as required.

5.7 The scheme as presented also appears to conflict with Condition 8 as it is not based upon the original Flood Risk Assessment. The original Flood Risk Assessment included a strategy which comprised several shallow bio-retention areas/attenuation basins along with a new watercourse and clear flood storage areas. All proposed surface water drainage discharged to the central watercourse within the site. The scheme has evolved to remove the majority of the open attenuation areas in favour of underground solutions with only the northern basin remaining. No central watercourse is shown. A connection for part of the site is now proposed to the pump garden house pond. Discharge rates have also changed with the proposed discharge rate on the latest 2022 submissions significantly higher than originally proposed.

5.8 The changes between the design are shown in Figure 1 and 2 below and can be considered to be materially different.

Figure 1: Drainage Strategy – 2014 Flood Risk Assessment (CDC12)

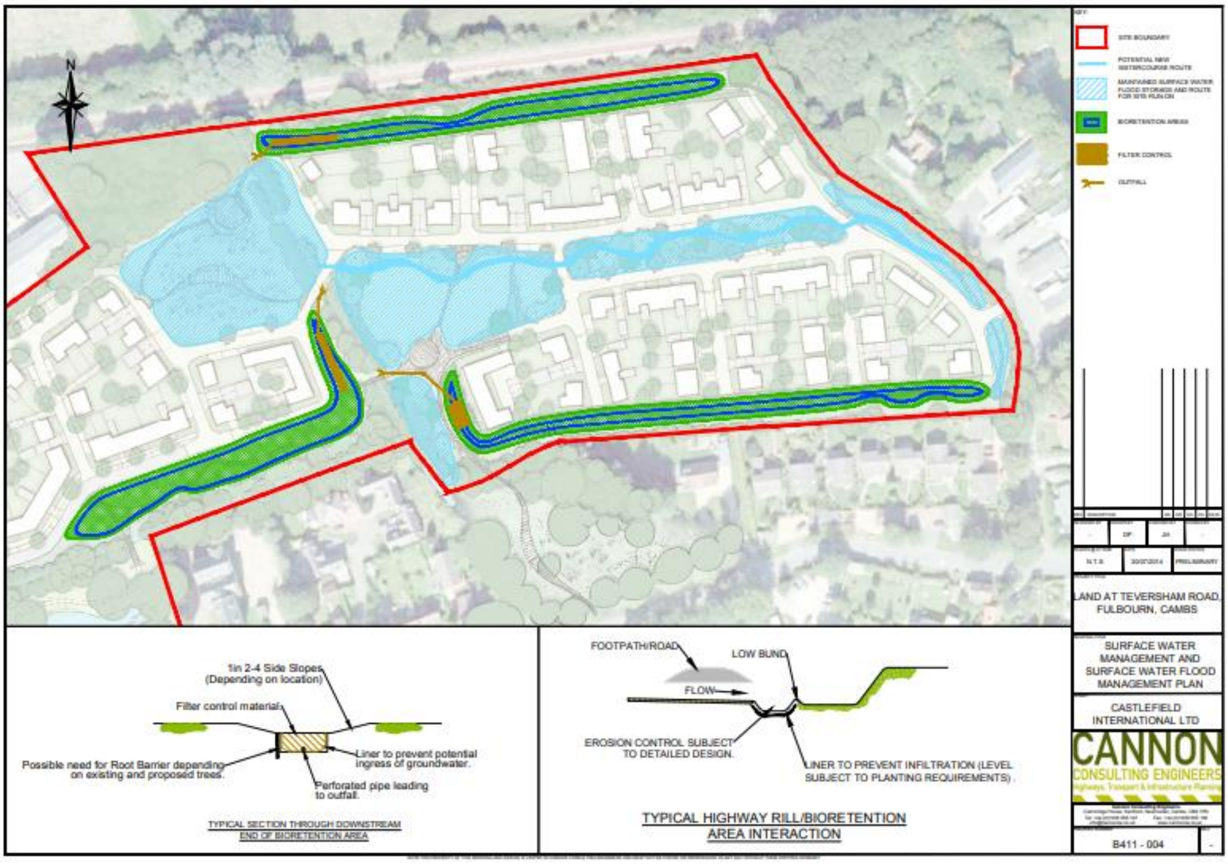
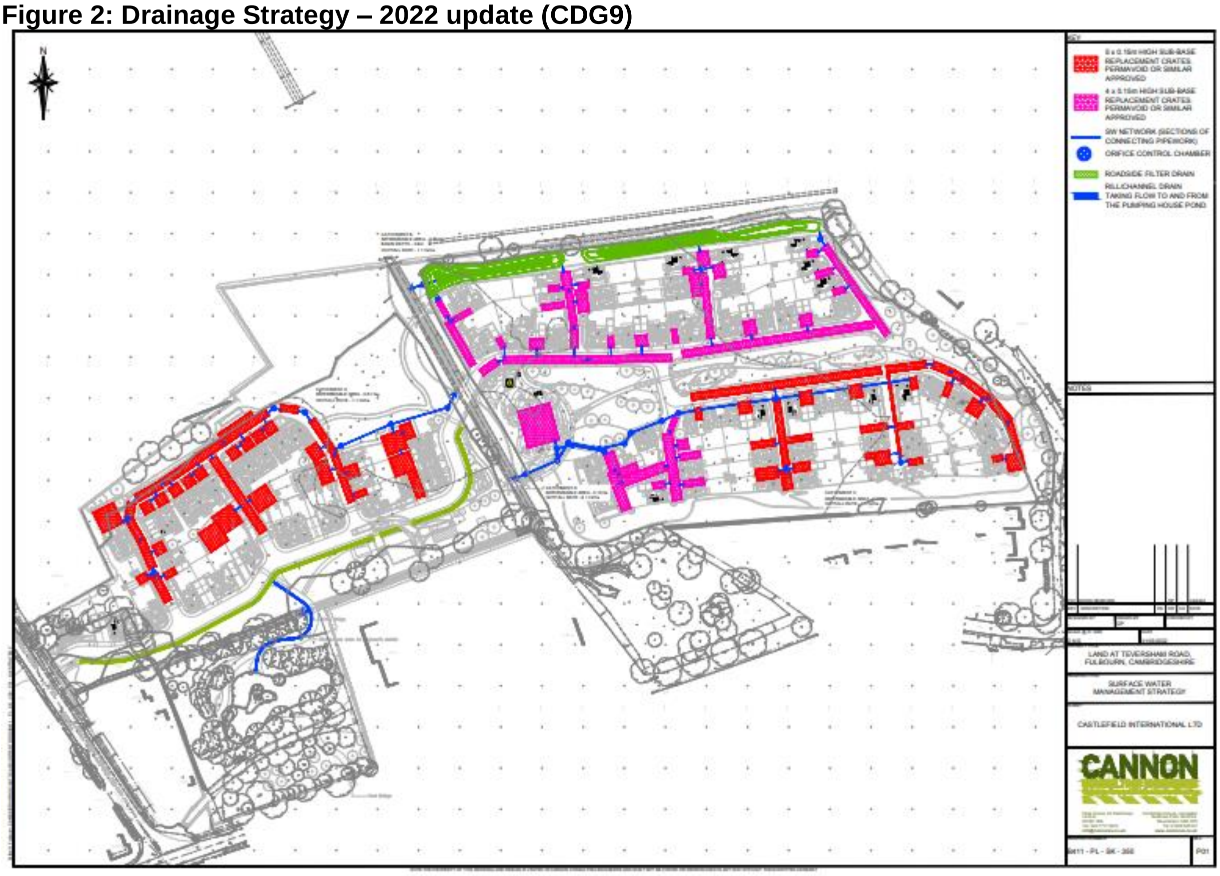


Figure 2: Drainage Strategy – 2022 update (CDG9)



5.9 Throughout my Proof of Evidence, I have provided comments on the suitability of the information presented by the Appellant. The following key points are made:

Drainage

- Changes in the proposed discharge rate across the various submissions suggest discharge rates are no longer set to the 1 in 1 year greenfield runoff rate as required by the LLFA. No reason for this has been given. The calculations do not include allowance for urban creep. The latest submissions appear to exclude the roads from the proposed impermeable areas. The amount of storage volume may therefore have been under estimated and the increased discharge rates may increase the risk of flooding.

- No new drainage calculations have been provided to support the submission made in April 2022.

- Drainage calculations include an error warning and inaccuracies and have not been updated to reflect the latest submissions.

- Tanks are proposed under what are likely to be adopted roads. This approach is unlikely to be acceptable to the highway authority so the strategy may need to change at the detailed design stage if roads are to remain proposed for adoption.

- Limited road levels are identified on available plans, but what is available, indicates significant level increases will be required which is likely to result in highway retaining features. As this includes potential adoptable roads this approach may not be acceptable to the local highway authority.

- The construction details provided are limited and appear unworkable. No dimensions are provided for the permeable paving which depending on eventual road levels may encroach into groundwater depths. Other features are proposed to discharge into geo-cellular storage tanks which are wrapped with an impermeable membrane and so will not function as described.

- The proposed northern attenuation basin has an invert level set below the groundwater level.

- Part of the site is proposed to drain to pump house garden pond. Limited information is made available on this outfall solution and several assumptions are made including the peak groundwater level affecting the pond. Limited capacity in this pond could result in flooding to third parties as a result of additional flows.

- Based on the latest 2022 submissions, the southern parcel to the east of the site appears to propose site levels which fall the opposite way to the envisaged drainage strategy, albeit no drainage levels are provided. No indication of this has been considered or factored into the design rationale for this area.

- Proposed flood mitigation culverts are not factored into the drainage strategy design so no indication of location and potential conflicts with other features.

Flood Risk

- The Lead Local Flood Authority has low confidence in the modelling prepared to date.

- No details of the agreed modelling specification are provided to understand the exact requirements of HR Wallingford and predicted outcomes to ensure a comprehensive assessment is provided. No details are provided of any scoping discussions with the Lead Local Flood Authority and/or Environment Agency.

- There is a lack of topographical survey work including no watercourse cross-sections, no detailed survey of key structures, limited upstream and downstream survey extents, lack of levels along key boundaries and no off site levels within adjacent garden areas.

- No model sensitivity testing including blockage scenario for railway culvert, key internal culverts or for winter storm events has been presented.

- Wrong geology description is in the HR Wallingford reports.

- Post Development Ground Levels and Platform Extents Plan is poor and difficult to read. This appears to show incorrect levels to the west and limited levels to the east.

- Predicted flood levels are shown to extend into third party land. There has been improved in recent 2022 modelling, indicating plans put in front of the planning committee were deficient, however this issue has not been fully resolved. The change in flood levels between 2021 and 2022 plans show how changes to layout can impact predicted flood levels. Both 2020 and 2022 modelling demonstrated flood extents outside the development and as such this would suggest a robust flood model is not yet available with an acceptable layout and mitigation strategy.

- Proposed flood mitigation measures have not been designed holistically with the wider site layout and drainage proposals. Updated plans do not show the Cow Lane Flood Basin and several proposed culverts do not feature in any designs.

5.10 In summary the information presented by the Appellant is deficient in several areas leading to significant uncertainty over the deliverability of suitable flood risk and surface water mitigation measures against the proposed layout. Indeed, given the many failed attempts by the appellant at arriving at a suitable drainage scheme, it appears that it is not possible for this reserved matters proposal to be adequately mitigated through a scheme provided under Condition 8. The scheme as presented also appears to conflict with Condition 8 as it is not based upon the original Flood Risk Assessment and is materially different.

5.11 It has been demonstrated (even on the basis of what appears to be modelling which is likely to have underestimated the impact) that the proposals will increase flood risk to third parties which is contrary to Paragraph 167 of the National Planning Policy Framework and Local Plan Policy CC/9. Therefore, the proposal is contrary to local and national policy and should be refused.

6.0 STATEMENT OF TRUTH

6.1 The evidence which we have prepared and provide for this appeal reference APP/W0530/W/22/3291523 in this proof of evidence is true and we confirm that the opinions expressed are our true and professional opinions.

Alexander Bennett BSc(Hons) MCIHT MTPS [redacted]

Date 26th April 2022

APPENDIX 1

My ref: FR/19-000431
Your ref: S/3290/19/RM
Date: 09/09/2021
Doc no: 201106687
Officer: **Harry Pickford**
E Mail: **harry.pickford@cambridgeshire.gov.uk**

Cambridgeshire County Council

Place and Economy
Environment and Commercial

Michael Sexton
South Cambridgeshire District Council
South Cambridge Hall
Cambourne Business Park
CB23 6EA

Alconbury Weald Civic Hub
Emery Crescent
Enterprise Campus
Alconbury Weald
PE28 4YE

Proposal: Approval of matters reserved for appearance, landscaping, layout and scale following outline planning permission S/0202/17/OL for the development of 110 dwellings with areas of landscaping and public open space and associated infrastructure works The outline was screened and confirmed not too be EIA development

Land east of Teversham Road, Fulbourn, Cambs

<u>Comments from Lead Local Flood Authority (LLFA)</u>

Dear Sir,

Thank you for your re-consultation which we received on 28th July 2021.

We have reviewed the following documents:

- Discharge of Conditions – Surface Water Management, Cannon Consulting Engineers, Dated: 12 September 2019
- Discharge of Conditions – Surface Water Management, Cannon Consulting Engineers, Dated: 3 December 2019
- Discharge of Conditions – Surface Water Management, Cannon Consulting Engineers, Dated: 27 February 2020
- Review of Surface Water Management, HR Wallingford, Ref: FWM8709-RT001-R01-00, Dated: August 2020
- Reserved Matters Application – Layout, Cannon Consulting Engineers, Dated: 12 August 2020
- Reserved Matters Application – Layout Updated, Cannon Consulting Engineers, Dated: 13 April 2021
- Flood Management Strategy, Cannon Consulting Engineers, Ref: B411-PL-SK-320 Rev P09, Dated: 14 April 2021
- Cow Lane Flood Basin, Cannon Consulting Engineers, Ref: B411-PL-SK-321 Rev P02, Dated: 14 April 2021

Based on these, as Lead Local Flood Authority (LLFA) we **have no objection** to the reserved matters application.

The above documents demonstrate that surface water from the proposed development can be managed through the use of tanked permeable paving throughout the private and shared access areas and parking. Highway access from Teversham Road will be managed through a filter drain. Surface water will be shared across basins around the development, and crated attenuation below permeable paving before discharge from the site at a rate of 0.3 l/s/ha, equivalent to the 1 in 1 year greenfield runoff rate.

A flood mitigation basin is proposed along the southern boundary of the site, to capture and retain flood flows which may come down the southern boundary, with a filter drain allowing the water to seep out from the basin and empty into the watercourse. The basin is sized to accommodate the displaced surface water from the development platforms without impacting the land or properties to the south. An illustrative LiDAR survey has been submitted to demonstrate the fall of land from the south to the north adjacent to the basin, indicating that any surface water which may be present on the surface will flow to the north and west.

The proposals have left a lower greenspace in the centre of the proposed development platforms to provide passage of surface water flows in times of flooding. There are a number of culverts to allow this water to pass through the proposed infrastructure and into the watercourse passing through the centre of the site.

Informatives

Groundwater Monitoring
The groundwater report included as part of the outline planning permission was carried out in 2014. This recorded groundwater levels at approximately 0.8m below ground level. Anecdotal data has been provided which indicates that groundwater may be shallower than this, at approximately 0.4m below ground level, which would impinge on the base of attenuation features across the site. It must be investigated and demonstrated as part of the discharge of condition application whether there is a clearance to groundwater from the base of the attenuation features, to avoid groundwater ingress. If groundwater is discovered to be shallower than previously recorded, measures will be required to ensure that this does not impact the proposed surface water drainage strategy, or significantly displace groundwater.

Surface Water Modelling
It is noted that mitigation measures are being implemented as part of the proposed scheme to reduce the risk of flooding from overland surface water flows. While this is acceptable in principle, the LLFA would be looking for updated modelling as part of the discharge of condition application to demonstrate that these features will work in the landscape, without increasing flood risk to any adjacent land or property.

OW Consent
Constructions or alterations within an ordinary watercourse (temporary or permanent) require consent from the Lead Local Flood Authority under the Land Drainage Act 1991. Ordinary watercourses include every river, drain, stream, ditch, dyke, sewer (other than public sewer) and

passage through which water flows that do not form part of Main Rivers (Main Rivers are regulated by the Environment Agency). The applicant should refer to Cambridgeshire County Council's Culvert Policy for further guidance:

https://www.cambridgeshire.gov.uk/business/planning-and-development/water-minerals-and-waste/watercourse-management/

Please note the council does not regulate ordinary watercourses in Internal Drainage Board areas.

Signage
Appropriate signage should be used in multi-function open space areas that would normally be used for recreation but infrequently can flood during extreme events. The signage should clearly explain the use of such areas for flood control and recreation. It should be fully visible so that infrequent flood inundation does not cause alarm. Signage should not be used as a replacement for appropriate design.

Pollution Control
Surface water and groundwater bodies are highly vulnerable to pollution and the impact of construction activities. It is essential that the risk of pollution (particularly during the construction phase) is considered and mitigated appropriately. It is important to remember that flow within the watercourse is likely to vary by season and it could be dry at certain times throughout the year. Dry watercourses should not be overlooked as these watercourses may flow or even flood following heavy rainfall.

Yours faithfully,

H Ellis

Hilary Ellis

Acting Flood Risk & Biodiversity Business Manager
Environment and Commercial

If you have any queries regarding this application please contact the Officer named at the top of this letter (contact details are above).

Please note: We are reliant on the accuracy and completeness of the reports in undertaking our review, and can take no responsibility for incorrect data or interpretation made by the authors.

APPENDIX 2

B411 – Teversham Road, Fulbourn, Cambridgeshire
Discharge of Conditions – surface water management
For Castlefield International Ltd
12th September 2019

Introduction

This note addresses Condition 8 South Cambridgeshire District Council outline planning permission reference S/0202/17/OL for residential development of land to the east of Teversham Road in Fulbourn.

Background

The surface water management proposals for the permitted scheme comprised sub-catchment attenuation facilities for each of the three proposed development parcels (as identified on the approved parameters plan which accompanied the outline application in 2017).

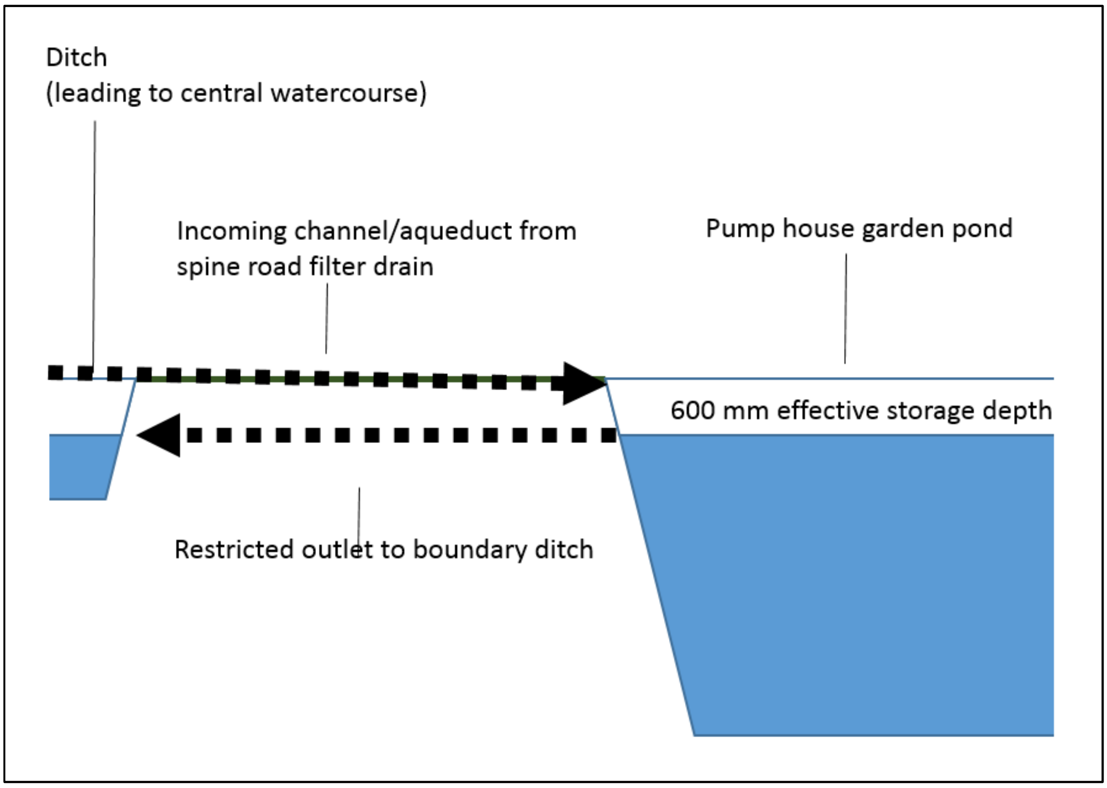
Because of the potential for shallow groundwater at the site, disposal of runoff to infiltration was ruled out. The scheme relied (and relies) on a restricted discharge to the on-site watercourse. The proposed discharge rate was (and remains) the 1 in 1 greenfield rate of 0.3 l/s/ha. As discussed in the flood risk and surface water note which supported the 2017 outline planning application (to which the Flood Risk Assessment referenced in Condition 8 was appended), the attenuation facilities are sized to manage a long duration storm and the commonly quoted drain-down requirement of 24 to 48 hours is not therefore applicable (low runoff rates and short drain-down time being mutually exclusive).

Surface water management

The proposed detailed strategy (shown on appended drawings 300 and 301) comprises five sub-catchments (shown on appended drawing 303) managing runoff from the three development parcels. The three attenuation facilities in the eastern part of the site (attenuation facilities B to D) comprise both sub-base replacement crates (beneath permeable paving) and bio-retention basins. The attenuation facilities for the western part of the site differ from the earlier outline strategy in that the bio-retention basin to the south of the development parcel has been removed to retain more of the existing plant life in situ. The residential element of the parcel (housing and shared surface/private roads) now drains to attenuation facility A (crates below permeable paving). Runoff from the spine road will now drain via a grassed filter drain and channel/aqueduct ,to the existing pond in the pump house garden.

The invert level of each of the attenuation facilities is based on the highest groundwater levels recorded in one of three groundwater monitoring boreholes (see appended groundwater monitoring report). Further monitoring in additional boreholes may allow invert levels to be reduced at the detailed design stages.

The available storage within the pump house garden pond has been calculated based on the conservative assumption that it is unlined and groundwater fed. The effective storage depth has therefore been modelled as 600 mm (based on the highest recorded groundwater bgl value in the closest monitoring well). It is worth noting that as well as allowing for more of the existing plant life to be left in situ, increasing the flow of clean water to the pump house garden pond should compliment the proposals to improve the amenity value and interest of the pond and garden.



Sketch showing the proposed pump house garden attenuation arrangement

Each facility includes sufficient surface water attenuation will be provided to manage the 1 in 100 annual probability storm inclusive of 40 % climate change. The appended calculations include a 10 % increase in paved area as an allowance for urban creep. The modelled discharge rate has been set at 'pre-creep' rates to test the facilities.

Treatment

Suitable treatment for runoff will be provided by the permeable paving which will accept direct rainfall and some flow from adjacent impermeable surfaces. Spine road runoff in the east of the site will be conveyed to either the bio-retention basins (via slot and/or channel drains running along the private roads). Runoff from the spine road in the west of the site will be treated by the services/filter strip and filter drain arrangement.

Aside from the in-chamber protection (perforated riser tube) the small flow control diameters which are necessary to achieve 0.3 l/s/ha will require upstream filtration to remove debris. Additional debris removal/filtration features (small gabion filter boxes for example) will therefore be provided at outlets/inlets between, above, and below ground storage components.

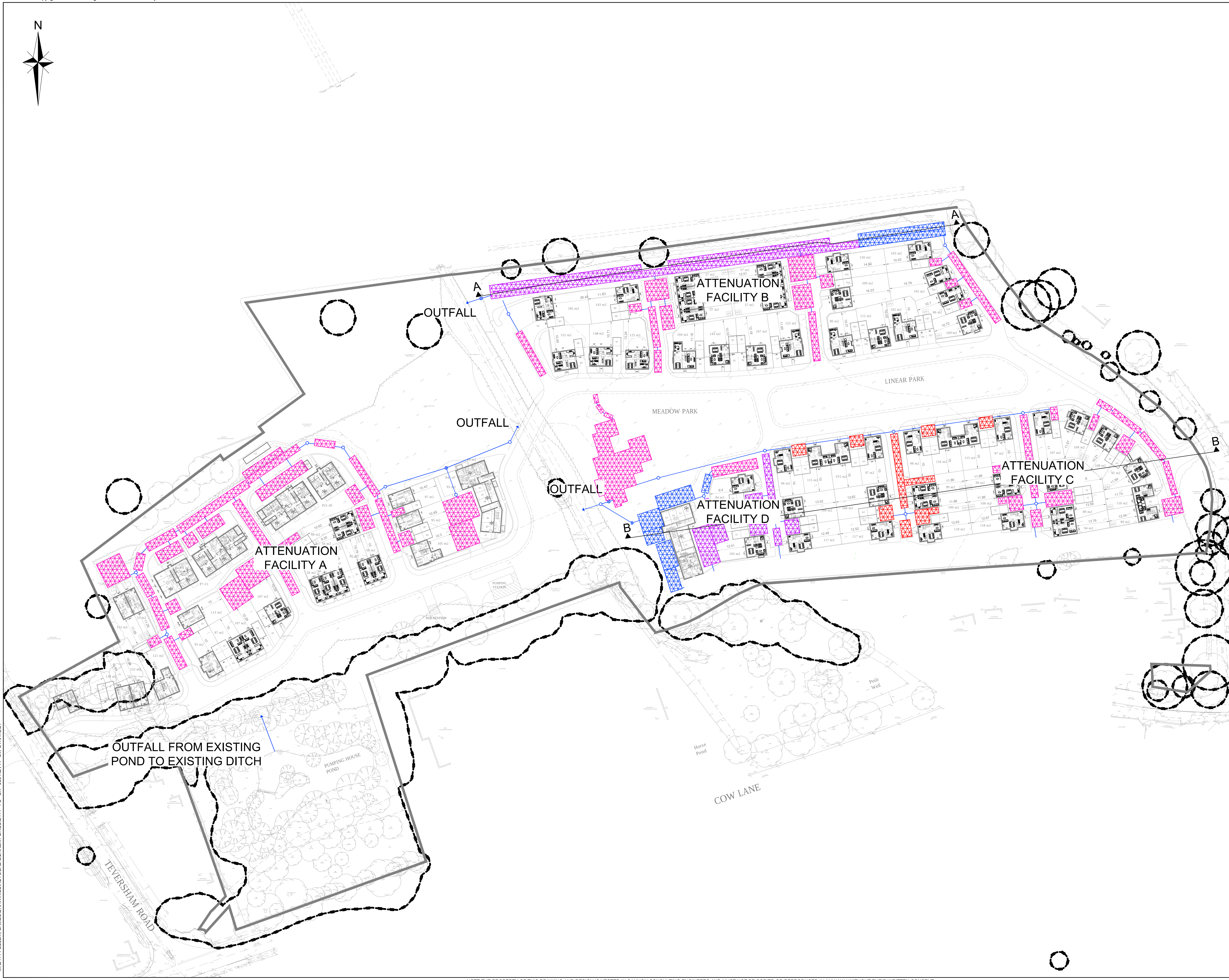
Maintenance

Currently maintenance of the surface water management will be undertaken by a private management company (details of which will be determined at the appropriate later stages).

Appended information

B411-PL-SK-300 - Surface water management strategy (below ground)
B411-PL-SK-301 - Surface water management strategy (above ground)
B411-PL-SK-302 - Catchment plan
B411-PL-SK-303 - Sections
MicroDrainage simulation results
Groundwater monitoring report

All proposals are subject to detailed design and the approval of relevant parties.



KEY

- 1 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 2 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 3 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 4 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- SW NETWORK
- ORIFICE CONTROL CHAMBER
- HEADWALL
- ROADSIDE FILTER DRAIN
- RILL/CHANNEL DRAIN
- DEBRIS FILTER

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P01	REVISED TO REFLECT CHANGING LAYOUT LEAP CRATES REVISED		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
DETAILED SURFACE WATER MANAGEMENT STRATEGY

CLIENT
CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning

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DRAWING NUMBER	REV.
B411 - PL - SK - 300	P01

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 300 REV A - SW STRATEGY

KEY

- ATTENUATION BASIN
- PERMEABLE PAVING
- ROADSIDE FILTER DRAIN
- RILL/CHANNEL DRAIN
- SW NETWORK
- DEBRIS FILTER
- HEADWALL
- FLOW ROUTES

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P01	REVISED TO REFLECT CHANGING LAYOUT		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
DETAILED SURFACE WATER MANAGEMENT STRATEGY (ABOVE GROUND)

CLIENT
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DRAWING NUMBER	REV.
B411 - PL - SK - 301	P01

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 301 REV A - SW STRATEGY ABOVE GROUND

KEY

IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY A

IMPERMEABLE CATCHMENT AREA DRAINING TO EXISTING POND

IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY B

IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY C

IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY D

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P01	REVISED TO REFLECT CHANGING LAYOUT		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE

LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE

CATCHMENT PLAN

CLIENT

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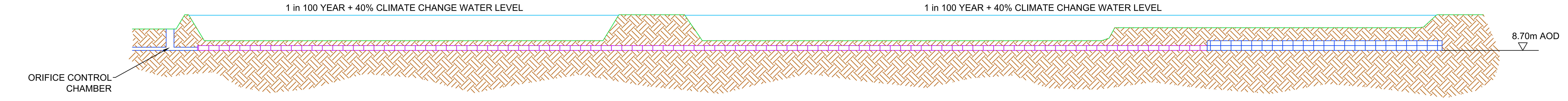
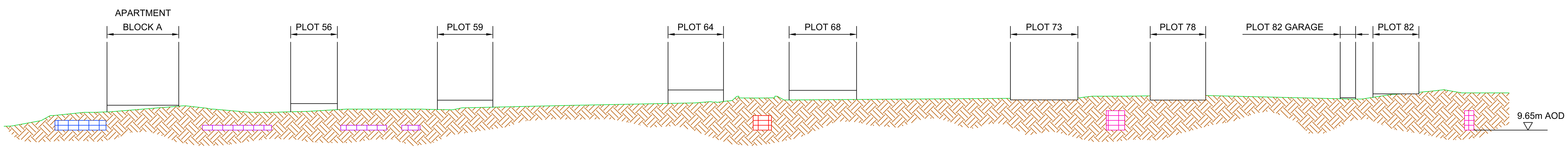
DRAWING NUMBER	REV.
B411 - PL - SK - 302	P01

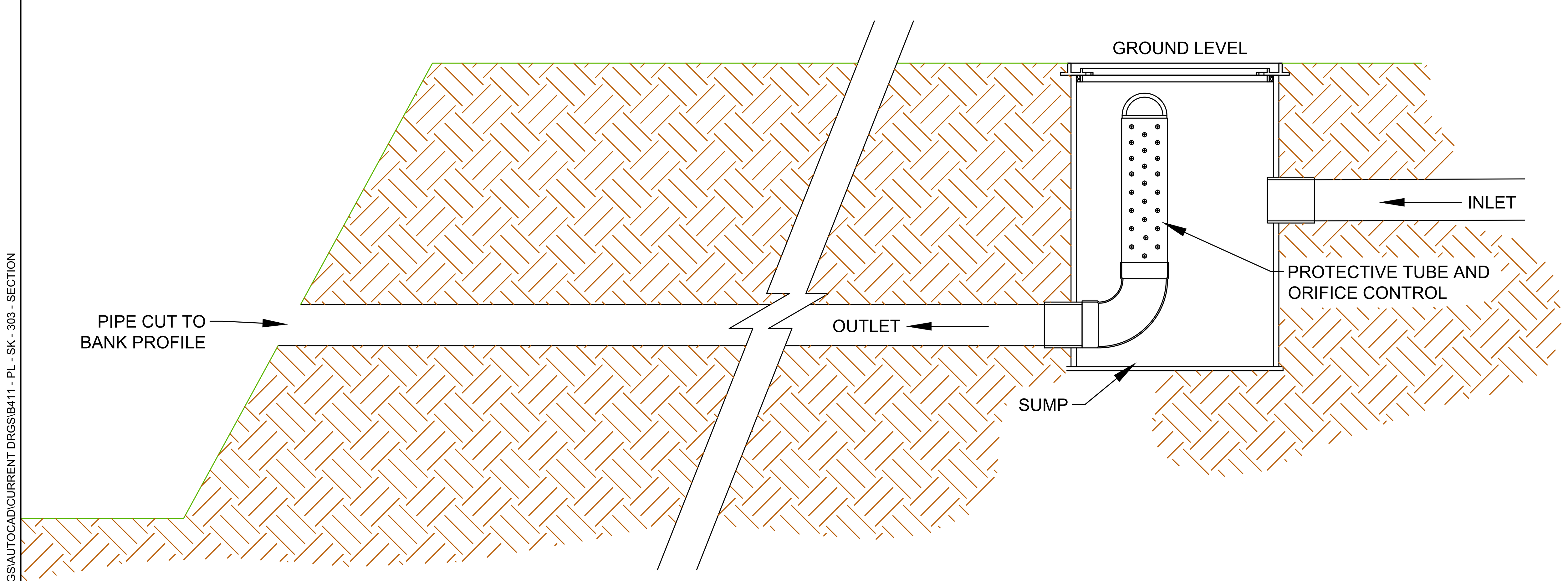
M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 302 REV A - CATCHMENT PLAN



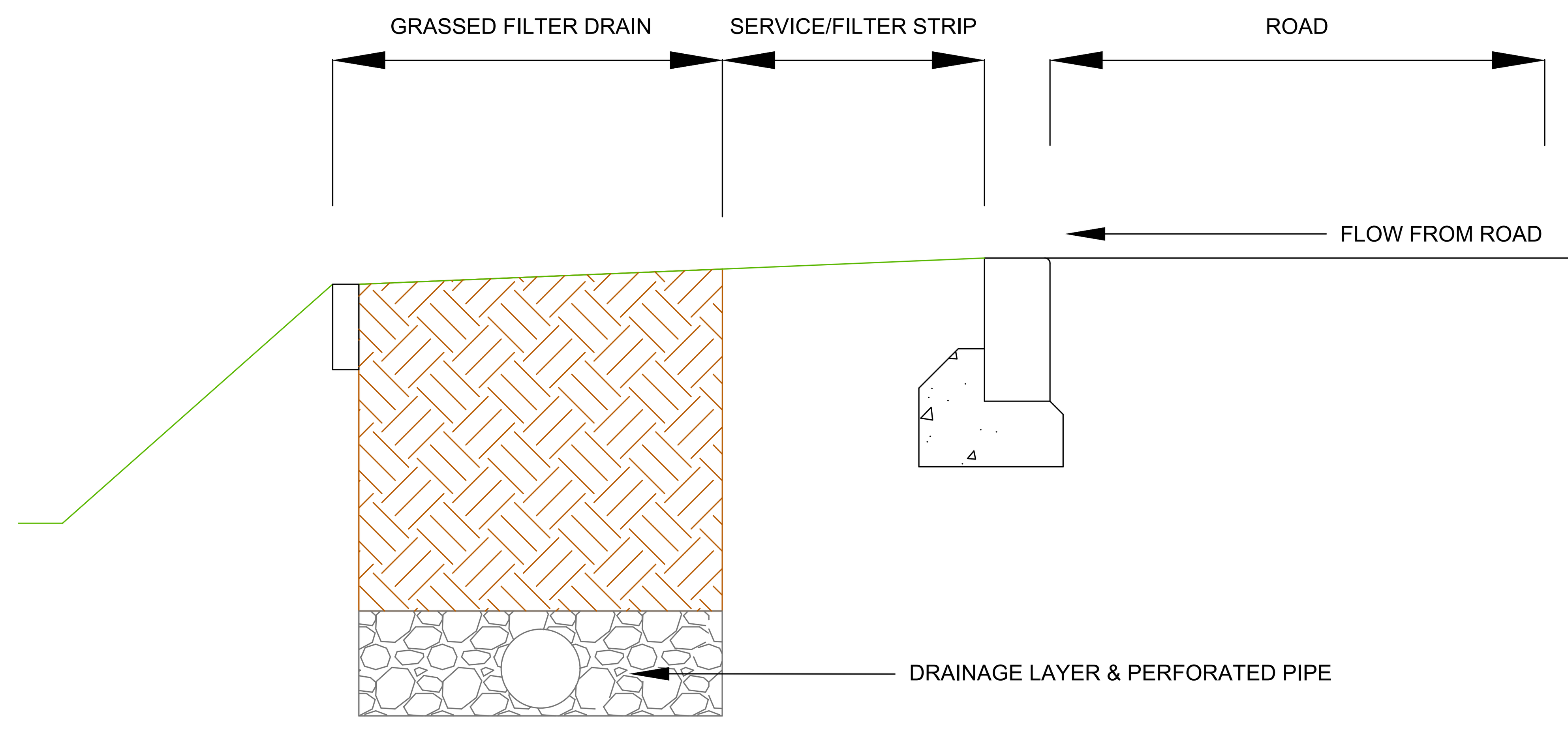
SECTION A-A



SECTION B-B



TYPICAL SECTION OF OUTFALL AND ORIFICE CONTROL CHAMBER



TYPICAL SECTION OF GRASSED FILTER DRAIN

KEY

1 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED

2 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED

3 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED

4 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
SECTIONS PLAN

CLIENT
CASTLEFIELD INTERNATIONAL LTD

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DRAWING NUMBER	REV.
B411 - PL - SK - 303	

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 303 - SECTION

Summary of Results for 100 year Return Period (+40%)

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.586	0.096	0.0	95.6	O K
30 min Summer	9.613	0.123	0.0	123.2	O K
60 min Summer	9.641	0.151	0.0	150.7	O K
120 min Summer	9.681	0.191	0.0	190.8	O K
180 min Summer	9.705	0.215	0.0	215.3	O K
240 min Summer	9.722	0.232	0.0	232.1	O K
360 min Summer	9.744	0.254	0.1	253.6	O K
480 min Summer	9.757	0.267	0.1	266.9	O K
600 min Summer	9.766	0.276	0.1	276.1	O K
720 min Summer	9.773	0.283	0.1	282.8	O K
960 min Summer	9.782	0.292	0.1	292.3	O K
1440 min Summer	9.793	0.303	0.1	303.1	Flood Risk
2160 min Summer	9.804	0.314	0.1	313.5	Flood Risk
2880 min Summer	9.812	0.322	0.1	322.0	Flood Risk
4320 min Summer	9.828	0.338	0.1	338.4	Flood Risk
5760 min Summer	9.844	0.354	0.1	354.3	Flood Risk
7200 min Summer	9.862	0.372	0.1	371.5	Flood Risk
8640 min Summer	9.879	0.389	0.1	389.5	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	2.6	23
30 min Summer	101.360	0.0	3.0	38
60 min Summer	62.020	0.0	6.6	68
120 min Summer	39.270	0.0	7.4	128
180 min Summer	29.549	0.0	7.9	188
240 min Summer	23.905	0.0	8.1	248
360 min Summer	17.430	0.0	8.3	368
480 min Summer	13.768	0.0	8.4	488
600 min Summer	11.401	0.0	8.4	608
720 min Summer	9.742	0.0	8.4	728
960 min Summer	7.561	0.0	8.2	968
1440 min Summer	5.244	0.0	7.8	1448
2160 min Summer	3.633	0.0	16.7	2168
2880 min Summer	2.812	0.0	16.1	2888
4320 min Summer	1.987	0.0	14.6	4328
5760 min Summer	1.574	0.0	33.7	5768
7200 min Summer	1.330	0.0	32.6	7208
8640 min Summer	1.171	0.0	31.5	8648

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	9.898	0.408	0.1	408.3	Flood Risk
15 min Winter	9.586	0.096	0.0	95.6	O K
30 min Winter	9.613	0.123	0.0	123.2	O K
60 min Winter	9.641	0.151	0.0	150.7	O K
120 min Winter	9.681	0.191	0.0	190.8	O K
180 min Winter	9.705	0.215	0.0	215.3	O K
240 min Winter	9.722	0.232	0.0	232.1	O K
360 min Winter	9.744	0.254	0.1	253.6	O K
480 min Winter	9.757	0.267	0.1	266.9	O K
600 min Winter	9.766	0.276	0.1	276.1	O K
720 min Winter	9.773	0.283	0.1	282.8	O K
960 min Winter	9.782	0.292	0.1	292.3	O K
1440 min Winter	9.793	0.303	0.1	303.1	Flood Risk
2160 min Winter	9.804	0.314	0.1	313.5	Flood Risk
2880 min Winter	9.812	0.322	0.1	322.0	Flood Risk
4320 min Winter	9.828	0.338	0.1	338.4	Flood Risk
5760 min Winter	9.844	0.354	0.1	354.4	Flood Risk
7200 min Winter	9.862	0.372	0.1	371.7	Flood Risk
8640 min Winter	9.880	0.390	0.1	389.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.060	0.0	30.3	10088
15 min Winter	157.360	0.0	2.6	23
30 min Winter	101.360	0.0	3.0	38
60 min Winter	62.020	0.0	6.6	68
120 min Winter	39.270	0.0	7.4	128
180 min Winter	29.549	0.0	7.9	188
240 min Winter	23.905	0.0	8.1	248
360 min Winter	17.430	0.0	8.3	366
480 min Winter	13.768	0.0	8.4	486
600 min Winter	11.401	0.0	8.4	606
720 min Winter	9.742	0.0	8.4	726
960 min Winter	7.561	0.0	8.2	964
1440 min Winter	5.244	0.0	7.8	1444
2160 min Winter	3.633	0.0	16.7	2160
2880 min Winter	2.812	0.0	16.1	2880
4320 min Winter	1.987	0.0	14.6	4284
5760 min Winter	1.574	0.0	33.7	5712
7200 min Winter	1.330	0.0	32.6	7136
8640 min Winter	1.171	0.0	31.5	8560

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Winter	9.899	0.409	0.1	408.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Winter	1.060	0.0	30.3	9984

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.256

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.156	4	8	0.100

Model Details

Storage is Online Cover Level (m) 10.090

Tank or Pond Structure

Invert Level (m) 9.490

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1000.0	0.600	1000.0

Orifice Outflow Control

Diameter (m) 0.007 Discharge Coefficient 0.600 Invert Level (m) 9.490

Summary of Results for 100 year Return Period (+40%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	99.238	0.138	0.0	0.1	0.1	238.7	O K
30 min Summer	99.278	0.178	0.0	0.1	0.1	307.5	O K
60 min Summer	99.318	0.218	0.0	0.1	0.1	376.2	O K
120 min Summer	99.375	0.275	0.0	0.1	0.1	476.3	O K
180 min Summer	99.411	0.311	0.0	0.1	0.1	537.3	O K
240 min Summer	99.435	0.335	0.0	0.1	0.1	579.4	O K
360 min Summer	99.466	0.366	0.0	0.1	0.1	633.1	O K
480 min Summer	99.485	0.385	0.0	0.1	0.1	666.3	O K
600 min Summer	99.499	0.399	0.0	0.1	0.1	689.1	O K
720 min Summer	99.508	0.408	0.0	0.1	0.1	706.1	O K
960 min Summer	99.522	0.422	0.0	0.1	0.1	729.6	O K
1440 min Summer	99.538	0.438	0.0	0.1	0.1	756.7	O K
2160 min Summer	99.553	0.453	0.0	0.1	0.1	782.8	O K
2880 min Summer	99.565	0.465	0.0	0.1	0.1	804.1	O K
4320 min Summer	99.589	0.489	0.0	0.1	0.1	845.1	O K
5760 min Summer	99.612	0.512	0.0	0.1	0.1	885.0	O K
7200 min Summer	99.637	0.537	0.0	0.2	0.2	928.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	6.5	27
30 min Summer	101.360	0.0	7.4	42
60 min Summer	62.020	0.0	16.3	72
120 min Summer	39.270	0.0	18.2	132
180 min Summer	29.549	0.0	19.3	192
240 min Summer	23.905	0.0	19.9	252
360 min Summer	17.430	0.0	20.5	372
480 min Summer	13.768	0.0	20.7	492
600 min Summer	11.401	0.0	20.7	612
720 min Summer	9.742	0.0	20.6	732
960 min Summer	7.561	0.0	20.2	972
1440 min Summer	5.244	0.0	19.1	1452
2160 min Summer	3.633	0.0	41.0	2172
2880 min Summer	2.812	0.0	39.4	2892
4320 min Summer	1.987	0.0	35.8	4332
5760 min Summer	1.574	0.0	82.6	5768
7200 min Summer	1.330	0.0	80.0	7208

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	99.663	0.563	0.0	0.2	0.2	973.0	O K
10080 min Summer	99.690	0.590	0.0	0.2	0.2	1020.2	O K
15 min Winter	99.238	0.138	0.0	0.1	0.1	238.7	O K
30 min Winter	99.278	0.178	0.0	0.1	0.1	307.5	O K
60 min Winter	99.318	0.218	0.0	0.1	0.1	376.2	O K
120 min Winter	99.375	0.275	0.0	0.1	0.1	476.3	O K
180 min Winter	99.411	0.311	0.0	0.1	0.1	537.3	O K
240 min Winter	99.435	0.335	0.0	0.1	0.1	579.4	O K
360 min Winter	99.466	0.366	0.0	0.1	0.1	633.1	O K
480 min Winter	99.485	0.385	0.0	0.1	0.1	666.3	O K
600 min Winter	99.499	0.399	0.0	0.1	0.1	689.1	O K
720 min Winter	99.508	0.408	0.0	0.1	0.1	706.1	O K
960 min Winter	99.522	0.422	0.0	0.1	0.1	729.6	O K
1440 min Winter	99.538	0.438	0.0	0.1	0.1	756.7	O K
2160 min Winter	99.553	0.453	0.0	0.1	0.1	782.8	O K
2880 min Winter	99.565	0.465	0.0	0.1	0.1	804.1	O K
4320 min Winter	99.589	0.489	0.0	0.1	0.1	845.2	O K
5760 min Winter	99.612	0.512	0.0	0.1	0.1	885.2	O K
7200 min Winter	99.637	0.537	0.0	0.2	0.2	928.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.171	0.0	77.3	8648
10080 min Summer	1.060	0.0	74.2	10088
15 min Winter	157.360	0.0	6.5	27
30 min Winter	101.360	0.0	7.4	42
60 min Winter	62.020	0.0	16.3	72
120 min Winter	39.270	0.0	18.3	132
180 min Winter	29.549	0.0	19.3	192
240 min Winter	23.905	0.0	19.9	250
360 min Winter	17.430	0.0	20.5	370
480 min Winter	13.768	0.0	20.7	490
600 min Winter	11.401	0.0	20.7	610
720 min Winter	9.742	0.0	20.6	730
960 min Winter	7.561	0.0	20.2	968
1440 min Winter	5.244	0.0	19.1	1446
2160 min Winter	3.633	0.0	41.1	2164
2880 min Winter	2.812	0.0	39.4	2880
4320 min Winter	1.987	0.0	35.9	4288
5760 min Winter	1.574	0.0	82.6	5712
7200 min Winter	1.330	0.0	80.1	7136

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
8640 min Winter	99.663	0.563	0.0	0.2	0.2	973.5	O K
10080 min Winter	99.690	0.590	0.0	0.2	0.2	1020.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
8640 min Winter	1.171	0.0	77.3	8560
10080 min Winter	1.060	0.0	74.2	9984

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.639

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.213	4	8	0.213	8	12	0.213

Model Details

Storage is Online Cover Level (m) 100.000

Cellular Storage Structure

Invert Level (m) 99.100 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	1820.0	1820.0	0.601	0.0	1922.5
0.600	1820.0	1922.4			

Orifice Outflow Control

Diameter (m) 0.010 Discharge Coefficient 0.600 Invert Level (m) 99.100

Summary of Results for 100 year Return Period (+40%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.067	0.367	0.0	0.1	0.1	226.4	O K
30 min Summer	9.146	0.446	0.0	0.1	0.1	291.6	O K
60 min Summer	9.220	0.520	0.0	0.1	0.1	356.7	O K
120 min Summer	9.320	0.620	0.0	0.1	0.1	451.5	O K
180 min Summer	9.378	0.678	0.0	0.1	0.1	509.4	O K
240 min Summer	9.414	0.714	0.0	0.1	0.1	549.2	O K
360 min Summer	9.457	0.757	0.0	0.1	0.1	600.0	O K
480 min Summer	9.482	0.782	0.0	0.1	0.1	631.3	O K
600 min Summer	9.500	0.800	0.0	0.2	0.2	652.8	O K
720 min Summer	9.512	0.812	0.0	0.2	0.2	668.8	Flood Risk
960 min Summer	9.529	0.829	0.0	0.2	0.2	690.8	Flood Risk
1440 min Summer	9.549	0.849	0.0	0.2	0.2	715.9	Flood Risk
2160 min Summer	9.567	0.867	0.0	0.2	0.2	739.9	Flood Risk
2880 min Summer	9.581	0.881	0.0	0.2	0.2	759.3	Flood Risk
4320 min Summer	9.614	0.914	0.0	0.2	0.2	796.6	Flood Risk
5760 min Summer	9.657	0.957	0.0	0.2	0.2	832.9	Flood Risk
7200 min Summer	9.701	1.001	0.0	0.2	0.2	872.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	8.7	27
30 min Summer	101.360	0.0	9.5	42
60 min Summer	62.020	0.0	20.5	72
120 min Summer	39.270	0.0	22.3	132
180 min Summer	29.549	0.0	23.2	192
240 min Summer	23.905	0.0	23.6	252
360 min Summer	17.430	0.0	24.0	372
480 min Summer	13.768	0.0	24.0	492
600 min Summer	11.401	0.0	23.9	612
720 min Summer	9.742	0.0	23.7	732
960 min Summer	7.561	0.0	23.2	972
1440 min Summer	5.244	0.0	21.9	1452
2160 min Summer	3.633	0.0	46.7	2172
2880 min Summer	2.812	0.0	44.8	2892
4320 min Summer	1.987	0.0	40.8	4332
5760 min Summer	1.574	0.0	92.7	5768
7200 min Summer	1.330	0.0	90.1	7208

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	9.744	1.044	0.0	0.2	0.2	913.1	Flood Risk
10080 min Summer	9.786	1.086	0.0	0.2	0.2	956.1	Flood Risk
15 min Winter	9.067	0.367	0.0	0.1	0.1	226.4	O K
30 min Winter	9.146	0.446	0.0	0.1	0.1	291.6	O K
60 min Winter	9.220	0.520	0.0	0.1	0.1	356.7	O K
120 min Winter	9.320	0.620	0.0	0.1	0.1	451.5	O K
180 min Winter	9.378	0.678	0.0	0.1	0.1	509.3	O K
240 min Winter	9.414	0.714	0.0	0.1	0.1	549.1	O K
360 min Winter	9.457	0.757	0.0	0.1	0.1	600.0	O K
480 min Winter	9.482	0.782	0.0	0.1	0.1	631.3	O K
600 min Winter	9.500	0.800	0.0	0.2	0.2	652.8	O K
720 min Winter	9.512	0.812	0.0	0.2	0.2	668.8	Flood Risk
960 min Winter	9.529	0.829	0.0	0.2	0.2	690.8	Flood Risk
1440 min Winter	9.549	0.849	0.0	0.2	0.2	715.9	Flood Risk
2160 min Winter	9.567	0.867	0.0	0.2	0.2	739.9	Flood Risk
2880 min Winter	9.581	0.881	0.0	0.2	0.2	759.3	Flood Risk
4320 min Winter	9.614	0.914	0.0	0.2	0.2	796.7	Flood Risk
5760 min Winter	9.657	0.957	0.0	0.2	0.2	833.0	Flood Risk
7200 min Winter	9.701	1.001	0.0	0.2	0.2	872.3	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.171	0.0	87.1	8648
10080 min Summer	1.060	0.0	83.9	10088
15 min Winter	157.360	0.0	8.7	27
30 min Winter	101.360	0.0	9.5	42
60 min Winter	62.020	0.0	20.5	72
120 min Winter	39.270	0.0	22.3	132
180 min Winter	29.549	0.0	23.2	192
240 min Winter	23.905	0.0	23.7	250
360 min Winter	17.430	0.0	24.0	370
480 min Winter	13.768	0.0	24.0	490
600 min Winter	11.401	0.0	23.9	608
720 min Winter	9.742	0.0	23.8	728
960 min Winter	7.561	0.0	23.2	968
1440 min Winter	5.244	0.0	22.0	1446
2160 min Winter	3.633	0.0	46.8	2164
2880 min Winter	2.812	0.0	44.9	2864
4320 min Winter	1.987	0.0	41.0	4288
5760 min Winter	1.574	0.0	92.9	5712
7200 min Winter	1.330	0.0	90.4	7136

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
8640 min Winter	9.744	1.044	0.0	0.2	0.2	913.4	Flood Risk
10080 min Winter	9.786	1.086	0.0	0.2	0.2	956.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
8640 min Winter	1.171	0.0	87.4	8560
10080 min Winter	1.060	0.0	84.2	9984

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.606

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.206	4	8	0.200	8	12	0.200

Model Details

Storage is Online Cover Level (m) 9.800

Complex Structure

Cellular Storage

Invert Level (m) 8.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	204.5	204.5	0.301	0.0	221.7
0.300	204.5	221.7			

Cellular Storage

Invert Level (m) 8.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	812.0	812.0	0.151	0.0	829.2
0.150	812.0	829.1			

Tank or Pond

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	123.0	0.800	456.0

Tank or Pond

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	67.0	0.400	227.0	0.401	321.0	0.800	605.0

Cellular Storage

Invert Level (m) 9.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	598.4	598.4	0.601	0.0	657.2
0.600	598.5	657.1			

Orifice Outflow Control

Diameter (m) 0.009 Discharge Coefficient 0.600 Invert Level (m) 8.700

Summary of Results for 100 year Return Period (+40%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.792	0.142	0.0	0.1	0.1	203.6	O K
30 min Summer	9.833	0.183	0.0	0.1	0.1	262.2	O K
60 min Summer	9.872	0.222	0.0	0.1	0.1	320.8	O K
120 min Summer	9.929	0.279	0.0	0.1	0.1	406.0	O K
180 min Summer	9.963	0.313	0.0	0.1	0.1	458.0	Flood Risk
240 min Summer	9.986	0.336	0.0	0.1	0.1	493.7	Flood Risk
360 min Summer	10.016	0.366	0.0	0.2	0.2	539.4	Flood Risk
480 min Summer	10.034	0.384	0.0	0.2	0.2	567.4	Flood Risk
600 min Summer	10.046	0.396	0.0	0.2	0.2	586.7	Flood Risk
720 min Summer	10.055	0.405	0.0	0.2	0.2	600.9	Flood Risk
960 min Summer	10.068	0.418	0.0	0.2	0.2	620.5	Flood Risk
1440 min Summer	10.082	0.432	0.0	0.2	0.2	642.7	Flood Risk
2160 min Summer	10.095	0.445	0.0	0.2	0.2	663.6	Flood Risk
2880 min Summer	10.107	0.457	0.0	0.2	0.2	680.4	Flood Risk
4320 min Summer	10.132	0.482	0.0	0.2	0.2	712.5	Flood Risk
5760 min Summer	10.156	0.506	0.0	0.2	0.2	743.5	Flood Risk
7200 min Summer	10.181	0.531	0.0	0.2	0.2	777.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	7.9	27
30 min Summer	101.360	0.0	9.0	42
60 min Summer	62.020	0.0	19.8	72
120 min Summer	39.270	0.0	22.1	132
180 min Summer	29.549	0.0	23.3	192
240 min Summer	23.905	0.0	24.0	252
360 min Summer	17.430	0.0	24.7	372
480 min Summer	13.768	0.0	24.9	492
600 min Summer	11.401	0.0	24.9	612
720 min Summer	9.742	0.0	24.8	732
960 min Summer	7.561	0.0	24.3	970
1440 min Summer	5.244	0.0	23.0	1450
2160 min Summer	3.633	0.0	49.2	2168
2880 min Summer	2.812	0.0	47.3	2888
4320 min Summer	1.987	0.0	43.2	4328
5760 min Summer	1.574	0.0	98.8	5768
7200 min Summer	1.330	0.0	96.1	7208

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	10.207	0.557	0.0	0.2	0.2	812.1	Flood Risk
10080 min Summer	10.235	0.585	0.0	0.2	0.2	848.7	Flood Risk
15 min Winter	9.792	0.142	0.0	0.1	0.1	203.6	O K
30 min Winter	9.833	0.183	0.0	0.1	0.1	262.2	O K
60 min Winter	9.872	0.222	0.0	0.1	0.1	320.8	O K
120 min Winter	9.929	0.279	0.0	0.1	0.1	406.0	O K
180 min Winter	9.963	0.313	0.0	0.1	0.1	458.0	Flood Risk
240 min Winter	9.986	0.336	0.0	0.1	0.1	493.7	Flood Risk
360 min Winter	10.016	0.366	0.0	0.2	0.2	539.4	Flood Risk
480 min Winter	10.034	0.384	0.0	0.2	0.2	567.4	Flood Risk
600 min Winter	10.046	0.396	0.0	0.2	0.2	586.7	Flood Risk
720 min Winter	10.055	0.405	0.0	0.2	0.2	600.9	Flood Risk
960 min Winter	10.068	0.418	0.0	0.2	0.2	620.5	Flood Risk
1440 min Winter	10.082	0.432	0.0	0.2	0.2	642.7	Flood Risk
2160 min Winter	10.095	0.445	0.0	0.2	0.2	663.7	Flood Risk
2880 min Winter	10.107	0.457	0.0	0.2	0.2	680.5	Flood Risk
4320 min Winter	10.132	0.482	0.0	0.2	0.2	712.7	Flood Risk
5760 min Winter	10.156	0.506	0.0	0.2	0.2	743.8	Flood Risk
7200 min Winter	10.181	0.531	0.0	0.2	0.2	777.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.171	0.0	93.0	8648
10080 min Summer	1.060	0.0	89.5	10088
15 min Winter	157.360	0.0	7.9	27
30 min Winter	101.360	0.0	9.0	42
60 min Winter	62.020	0.0	19.8	72
120 min Winter	39.270	0.0	22.1	132
180 min Winter	29.549	0.0	23.3	190
240 min Winter	23.905	0.0	24.0	250
360 min Winter	17.430	0.0	24.7	368
480 min Winter	13.768	0.0	24.9	488
600 min Winter	11.401	0.0	24.9	606
720 min Winter	9.742	0.0	24.8	726
960 min Winter	7.561	0.0	24.3	964
1440 min Winter	5.244	0.0	23.0	1442
2160 min Winter	3.633	0.0	49.2	2160
2880 min Winter	2.812	0.0	47.3	2860
4320 min Winter	1.987	0.0	43.2	4284
5760 min Winter	1.574	0.0	98.8	5712
7200 min Winter	1.330	0.0	96.1	7128

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Winter	10.208	0.558	0.0	0.2	0.2	812.7	Flood Risk
10080 min Winter	10.235	0.585	0.0	0.2	0.2	849.6	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Winter	1.171	0.0	93.0	8552
10080 min Winter	1.060	0.0	89.5	9976

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.545

Time (mins) From:	**To:**	**Area (ha)**	**Time (mins) From:**	**To:**	**Area (ha)**	**Time (mins) From:**	**To:**	**Area (ha)**
0	4	0.330	4	8	0.115	8	12	0.100

Model Details

Storage is Online Cover Level (m) 10.250

Complex Structure

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	1041.7	1041.7	0.600	1041.7	1119.2

Tank or Pond

Invert Level (m) 9.650

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	62.0	0.600	228.0

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	332.8	332.8	0.451	0.0	365.7
0.450	332.8	365.6			

Tank or Pond

Invert Level (m) 9.650

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	38.0	0.600	146.0

Orifice Outflow Control

Diameter (m) 0.011 Discharge Coefficient 0.600 Invert Level (m) 9.650

Summary of Results for 100 year Return Period (+40%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.727	0.077	0.0	0.0	0.0	69.1	O K
30 min Summer	9.748	0.098	0.0	0.0	0.0	89.0	O K
60 min Summer	9.770	0.120	0.0	0.0	0.0	108.9	O K
120 min Summer	9.801	0.151	0.0	0.0	0.0	137.9	O K
180 min Summer	9.833	0.183	0.0	0.0	0.0	155.5	O K
240 min Summer	9.854	0.204	0.0	0.0	0.0	167.7	O K
360 min Summer	9.880	0.230	0.0	0.0	0.0	183.2	Flood Risk
480 min Summer	9.896	0.246	0.0	0.1	0.1	192.7	Flood Risk
600 min Summer	9.907	0.257	0.0	0.1	0.1	199.3	Flood Risk
720 min Summer	9.915	0.265	0.0	0.1	0.1	204.1	Flood Risk
960 min Summer	9.926	0.276	0.0	0.1	0.1	210.8	Flood Risk
1440 min Summer	9.939	0.289	0.0	0.1	0.1	218.4	Flood Risk
2160 min Summer	9.950	0.300	0.0	0.1	0.1	225.6	Flood Risk
2880 min Summer	9.970	0.320	0.0	0.1	0.1	231.4	Flood Risk
4320 min Summer	10.007	0.357	0.0	0.1	0.1	242.4	Flood Risk
5760 min Summer	10.041	0.391	0.0	0.1	0.1	252.9	Flood Risk
7200 min Summer	10.075	0.425	0.0	0.1	0.1	264.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	2.4	19
30 min Summer	101.360	0.0	2.7	34
60 min Summer	62.020	0.0	5.9	64
120 min Summer	39.270	0.0	6.6	124
180 min Summer	29.549	0.0	7.2	184
240 min Summer	23.905	0.0	7.5	244
360 min Summer	17.430	0.0	7.9	364
480 min Summer	13.768	0.0	8.0	484
600 min Summer	11.401	0.0	8.1	604
720 min Summer	9.742	0.0	8.0	724
960 min Summer	7.561	0.0	7.9	964
1440 min Summer	5.244	0.0	7.5	1444
2160 min Summer	3.633	0.0	16.1	2164
2880 min Summer	2.812	0.0	15.5	2884
4320 min Summer	1.987	0.0	14.3	4324
5760 min Summer	1.574	0.0	33.6	5768
7200 min Summer	1.330	0.0	33.1	7208

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
8640 min Summer	10.108	0.458	0.0	0.1	0.1	275.8	Flood Risk
10080 min Summer	10.142	0.492	0.0	0.1	0.1	287.9	Flood Risk
15 min Winter	9.727	0.077	0.0	0.0	0.0	69.1	O K
30 min Winter	9.748	0.098	0.0	0.0	0.0	89.0	O K
60 min Winter	9.770	0.120	0.0	0.0	0.0	108.9	O K
120 min Winter	9.801	0.151	0.0	0.0	0.0	137.9	O K
180 min Winter	9.833	0.183	0.0	0.0	0.0	155.5	O K
240 min Winter	9.854	0.204	0.0	0.0	0.0	167.7	O K
360 min Winter	9.880	0.230	0.0	0.0	0.0	183.2	Flood Risk
480 min Winter	9.896	0.246	0.0	0.1	0.1	192.7	Flood Risk
600 min Winter	9.907	0.257	0.0	0.1	0.1	199.3	Flood Risk
720 min Winter	9.915	0.265	0.0	0.1	0.1	204.1	Flood Risk
960 min Winter	9.926	0.276	0.0	0.1	0.1	210.8	Flood Risk
1440 min Winter	9.939	0.289	0.0	0.1	0.1	218.4	Flood Risk
2160 min Winter	9.950	0.300	0.0	0.1	0.1	225.6	Flood Risk
2880 min Winter	9.971	0.321	0.0	0.1	0.1	231.4	Flood Risk
4320 min Winter	10.008	0.358	0.0	0.1	0.1	242.4	Flood Risk
5760 min Winter	10.041	0.391	0.0	0.1	0.1	253.0	Flood Risk
7200 min Winter	10.076	0.426	0.0	0.1	0.1	264.4	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
8640 min Summer	1.171	0.0	32.2	8648
10080 min Summer	1.060	0.0	31.1	10088
15 min Winter	157.360	0.0	2.4	19
30 min Winter	101.360	0.0	2.7	34
60 min Winter	62.020	0.0	5.9	64
120 min Winter	39.270	0.0	6.6	124
180 min Winter	29.549	0.0	7.2	184
240 min Winter	23.905	0.0	7.5	244
360 min Winter	17.430	0.0	7.9	364
480 min Winter	13.768	0.0	8.0	484
600 min Winter	11.401	0.0	8.1	602
720 min Winter	9.742	0.0	8.0	722
960 min Winter	7.561	0.0	7.9	962
1440 min Winter	5.244	0.0	7.5	1442
2160 min Winter	3.633	0.0	16.1	2160
2880 min Winter	2.812	0.0	15.5	2856
4320 min Winter	1.987	0.0	14.3	4280
5760 min Winter	1.574	0.0	33.6	5704
7200 min Winter	1.330	0.0	33.1	7128

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
8640 min Winter	10.109	0.459	0.0	0.1	0.1	276.1	Flood Risk
10080 min Winter	10.143	0.493	0.0	0.1	0.1	288.4	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
8640 min Winter	1.171	0.0	32.2	8552
10080 min Winter	1.060	0.0	31.0	9888

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.185

Time (mins) From:	To:	Area (ha)
0	4	0.185

Model Details

Storage is Online Cover Level (m) 10.160

Complex Structure

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	356.6	393.0	0.301	0.0	416.8
0.300	356.6	416.8			

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	399.5	399.5	0.151	0.0	411.5
0.150	399.5	411.5			

Tank or Pond

Invert Level (m) 9.650

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	94.0	0.600	355.0

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	81.2	81.2	0.600	81.2	102.8

Orifice Outflow Control

Diameter (m) 0.007 Discharge Coefficient 0.600 Invert Level (m) 9.650

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Our Ref 1630,MO/Ltr01/JG,JD,PD/21-06-16/V1
Your Ref

Date 21 June 2016

Castlefield International Ltd c/o Cannon Consulting Engineers
Cambridge House
Lanwades Business Park
Kennett
Newmarket
Suffolk
CB8 7PN

For the attention of James Howard

By Email
- james.howard@cannonce.co.uk

Dear Mr Howard

GROUNDWATER MONITORING AT TEVERSHAM ROAD, FULBOURNE, CAMBRIDGESHIRE, CB21 5HE

1. Introduction

This factual letter report has been prepared for the Client, Castlefield International Ltd c/o Cannon Consulting Engineers.

Geosphere Environmental was commissioned to undertake additional groundwater monitoring visits at the subject site, outlined by and located by Drawing reference 1630,MO/001, attached.

This was to be achieved by:

- Undertaking monthly monitoring of the groundwater levels over a period of six months to assess the changes in groundwater.

This is a continuation of monitoring groundwater levels with the previous data included below.

2. Groundwater Level Monitoring

The groundwater level monitoring involved multiple visits to the site over six months, and using a dipmeter to determine the depth to groundwater below the surrounding ground level. The monitoring points were WS1a and WS3a, as illustrated by the attached Exploratory Hole Location Plan, Drawing ref. 1630,MO 001/Rev 0.
Another monitoring point, WS6a, was available during previous phases of groundwater monitoring, but could not be located during any of the recent monitoring visits, despite numerous additional visits by Geosphere Environmental personnel to search for the monitoring pipe.

2.1 Groundwater Monitoring Data Summary

Groundwater was measured within the locatable monitoring wells on six occasions, within this phase of works and this is summarised below. In addition to which, the data from the previous phases, (report or project reference 1058,CO), are displayed below to assist assessment:

Summary of groundwater depth results			
Date of visit	**WS1a (mbgl)**	**WS3a (mbgl)**	**WS6a (mbgl)**
05/02/2015	0.65	0.92	0.63
16/02/2015	0.75	1.00	0.66
13/03/2015	0.74	1.03	0.67
28/04/2015	0.79	n/m	0.60
28/05/2015	0.81	1.14	0.59
05/06/2015	0.88	1.08	0.66
16/11/2016	0.80	1.10	n/m
18/01/2016	1.03	0.68	n/m
24/02/2016	0.71	1.00	n/m
23/03/2016	0.98	0.78	n/m
19/04/2016	0.68	0.99	n/m
20/05/2016	1.00	1.25	n/m

The stream running through the site was observed however the best access point was obstructed by a fallen tree. Where the stream was observable it was flowing northwards, with clear water and at a moderate rate.

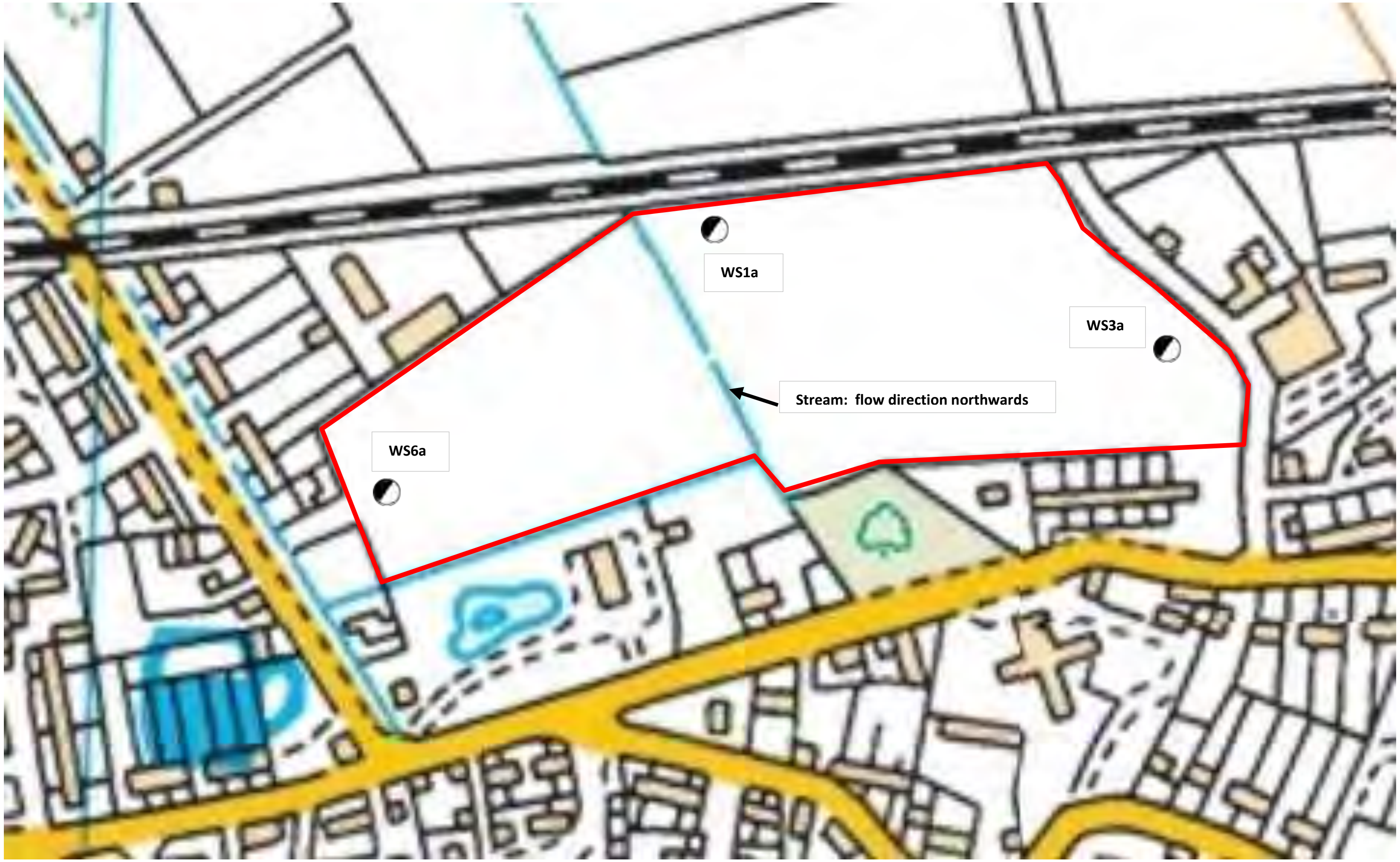
The results are provided as an attachment. Our standard report conditions and limitations apply to this letter report and these are available upon request.

We trust the above is clear and acceptable, however if you have any comments or queries please do not hesitate to contact us.

Yours sincerely

Jim Dawson
Principal Geoenvironmental Consultant
Geosphere Environmental Ltd

Enclosures/Attachments:
Exploratory Hole Location Plan - Drawing 1630,MO/001 (June 2016)
Groundwater monitoring data, project 1630,MO
Groundwater monitoring data, project 1058,CO



LEGEND:

Site boundary

Monitoring well locations

Approximate site boundary

N

geosphere environmental ltd

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SITE	TITLE	REPORT NO.	DRAWING NO.	DATE
Teversham Road, Fulbourne, Cambridgeshire, CB21 5HE	Exploratory Hole Location Plan	1630, MO	001.	June2016
	CLIENT	**DRAWN BY**	**CHECKED**	**SCALE**
	Castlefield International Ltd c/o Cannon Consulting Engineers.	JG	LF, JD	Not to scale

geosphere environmental ltd

Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

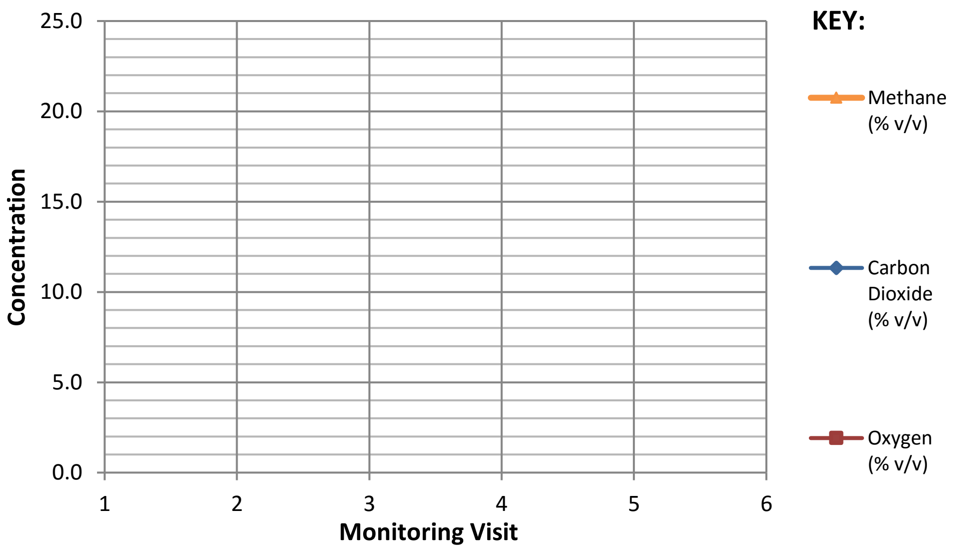
Exploratory Hole Location WS1a

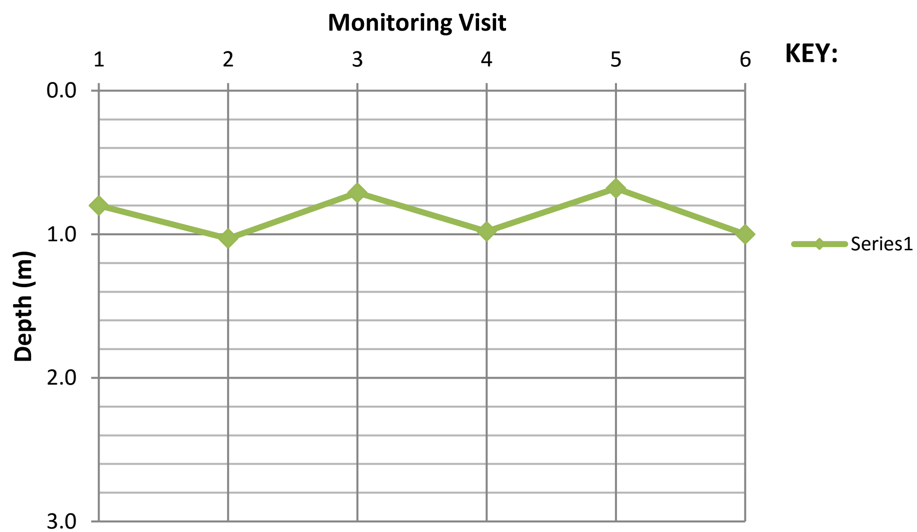
Return Visit #	Monitoring Date	Atmospheric Pressure (mb)	Methane Content (% v/v)	Methane Content (% LEL)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Flow Rate (l/hr)	Water Level (mbgl)	Comments
1st visit	16/11/2015							0.80	Cool, cloudy, dry, calm
2nd visit	18/01/2016							1.03	Cold, overcast, damp, breezy
3rd visit	24/02/2016							0.71	Cool, sunny, damp, calm
4th visit	23/03/2016							0.98	Cool, cloudy, damp, calm
5th visit	19/04/2016							0.68	Sunny, cool, dry, still
6th visit	20/05/2016							1.00	Cool, overcast, damp, calm

Instrument Used: Dipmeter

REMARKS: WS1 located approximately 10m from rail line at NW corner of Cox Drove field

NOTE: **n/a** Not applicable; **nm** Not measured





SITE
Land off Teversham Road, Fulbourn, Cambridgeshire

REPORT 1630,MO

DATE 20 June 2016

geosphere environmental ltd

Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

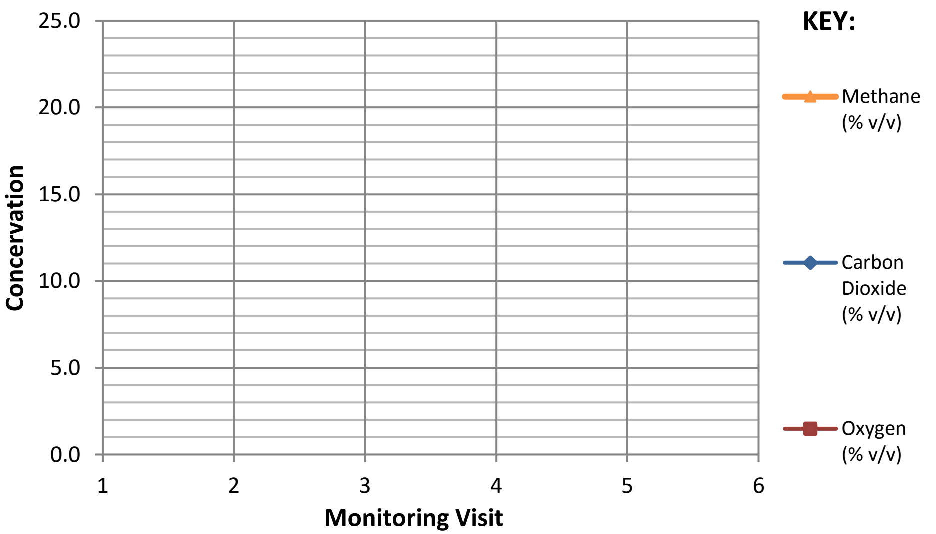
Exploratory Hole Location WS3a

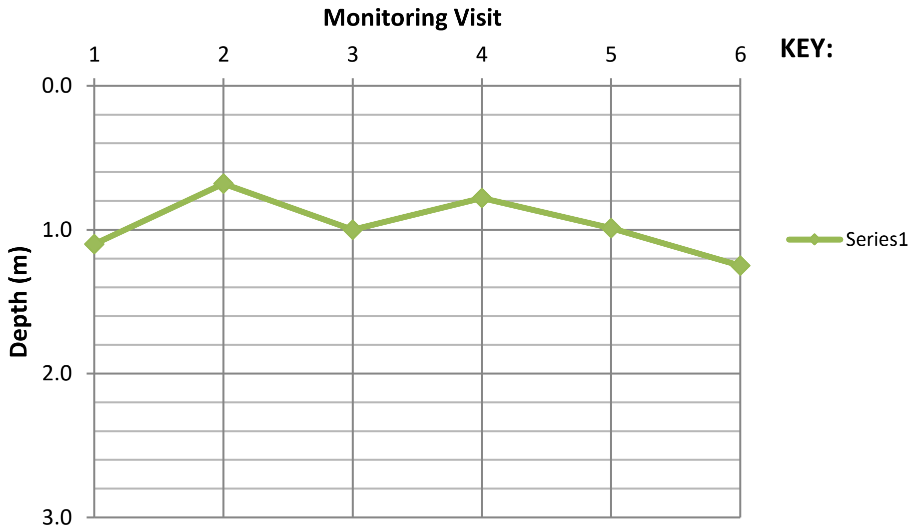
Return Visit #	Monitoring Date	Atmospheric Pressure (mb)	Methane Content (% v/v)	Methane Content (% LEL)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Flow Rate (l/hr)	Water Level (mbgl)	Comments
1st visit	16/11/2015							1.10	Cool, cloudy, dry, calm
2nd visit	18/01/2016							0.68	Cold, overcast, damp, breezy
3rd visit	24/02/2016							1.00	Cool, sunny, damp, calm
4th visit	23/03/2016							0.78	Cool, cloudy, damp, calm
5th visit	19/04/2016							0.99	Sunny, cool, dry, still
6th visit	20/05/2016							1.25	Cool, overcast, damp, calm

Instrument Used: Dipmeter

REMARKS: WS3 located approx approx 25m from Cox Drove access point

NOTE: **n/a** Not applicable; **nm** Not measured





SITE
Land off Teversham Road, Fulbourn, Cambridgeshire

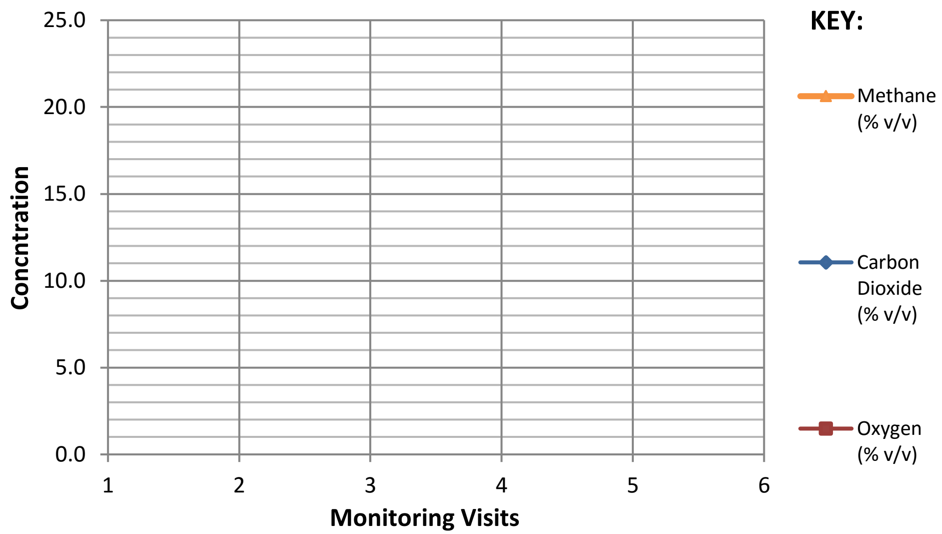
REPORT 1630,MO

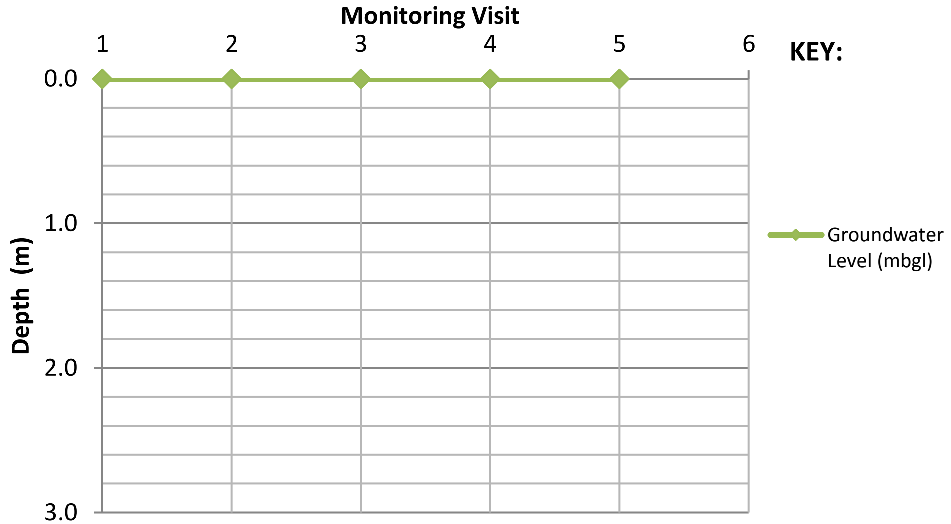
DATE 20 June 2016

geosphere environmental ltd
Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

Exploratory Hole Location WS6A

Return Visit #	Monitoring Date	Atmospheric Pressure (mb)	Methane Content (% v/v)	Methane Content (% LEL)	Carbon Dioxide (% v/v)	Oxygen (% v/v)	Flow Rate (l/hr)	Water Level (mbgl)	Comments
1st visit								n/m	Not located during this phase of monitoring; searched-for by at least three consultants, with previous experience of the site on separate occasions.
2nd visit								n/m	
3rd visit								n/m	
4th visit								n/m	
5th visit								n/m	
6th visit								n/m	





SITE
Land off Teversham Road, Fulbourn, Cambridgeshire

GROUNDWATER MONITORING DATA

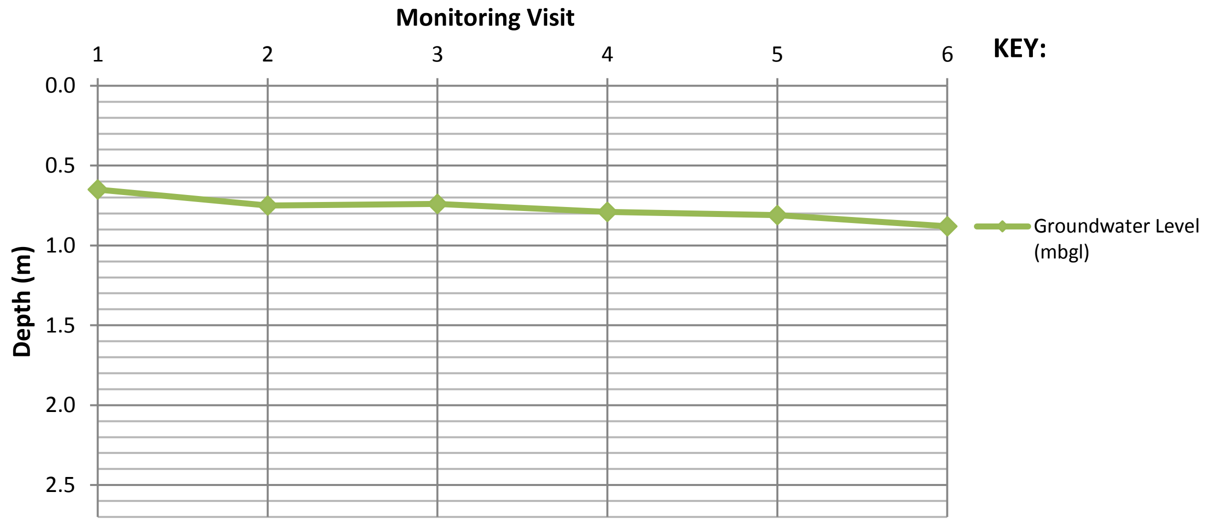
geosphere environmental ltd
Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

Exploratory Hole Location		WS1a	Date of Installation	04/02/2015

Return Visit #	Monitoring Date	Depth of Monitoring Well (mbgl)	Water Level (mbgl)	Comments
1st visit	05/02/2015	2.70	0.65	Cool, overcast, damp and breezy
2nd visit	16/02/2015	2.70	0.75	Cool, cloudy, damp and calm
3rd visit	13/03/2015	2.70	0.74	Cool, overcast, dry and calm
4th visit	28/04/2015	2.70	0.79	Cool, cloudy, dry and breezy
5th visit	28/05/2015	2.70	0.81	Warm, cloudy, dry and breezy
6th visit	05/06/2015	2.70	0.88	Hot, overcast, damp and calm

Instrument Used: GA2000 gas analyser — **n/a** Not applicable

REMARKS: — **nm** Not measured



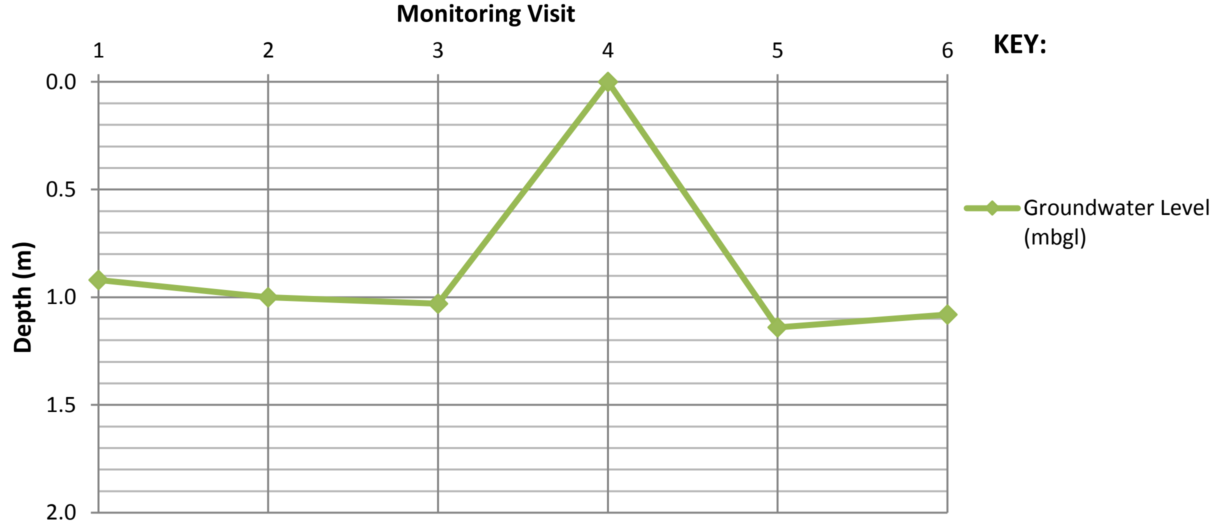
SITE	REPORT	DATE
Teversham Road, Fulbourn	1058,CO	10 November 2015

geosphere environmental ltd
Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

Exploratory Hole Location WS3a **Date of Installation** 04/02/2015

Return Visit #	Monitoring Date	Depth of Monitoring Well (mbgl)	Water Level (mbgl)	Comments
1st visit	05/02/2015	2.00	0.92	Cool, overcast, damp and breezy
2nd visit	16/02/2015	2.00	1.00	Cool, cloudy, damp and calm
3rd visit	13/03/2015	2.00	1.03	Cool, overcast, dry and calm
4th visit	28/04/2015	2.00	n/m	Cool, cloudy, dry and breezy
5th visit	28/05/2015	2.00	1.14	Warm, cloudy, dry and breezy
6th visit	05/06/2015	2.00	1.08	Hot, overcast, damp and calm

Instrument Used: GA2000 gas analyser **n/a** Not applicable
REMARKS: **nm** Not measured



SITE
Teversham Road, Fulbourn

REPORT
1058,CO

DATE
10 November 2015

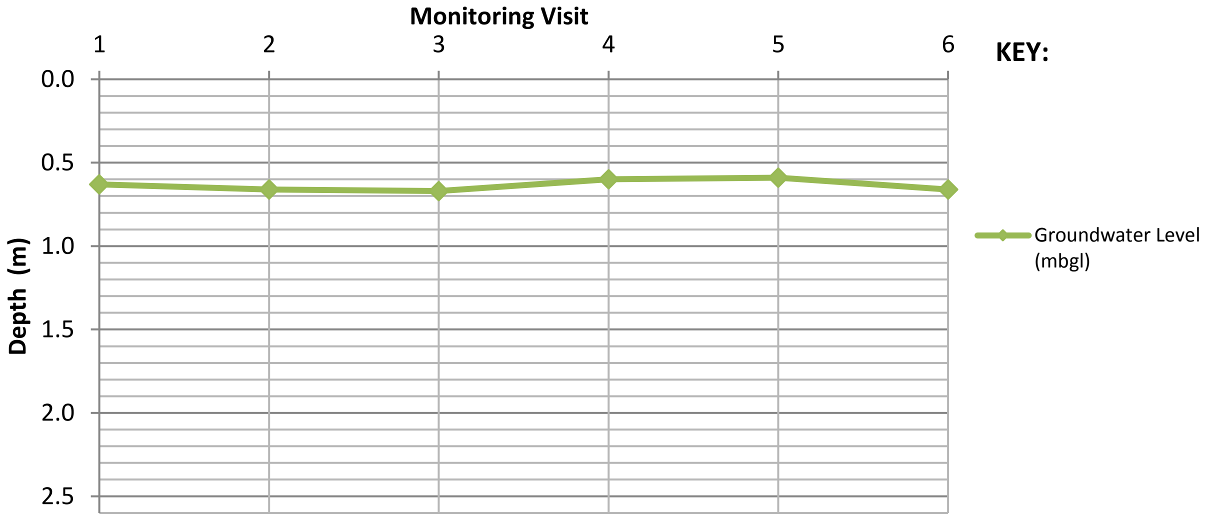
Geosphere Environmental Ltd, Brightwell Barns, Ipswich Road, Brightwell, Suffolk, IP10 0BJ

Exploratory Hole Location	WS6a	Date of Installation	04/02/2015

Return Visit #	Monitoring Date	Depth of Monitoring Well (mbgl)	Water Level (mbgl)	Comments
1st visit	05/02/2015	2.60	0.63	Cool, overcast, damp and breezy
2nd visit	16/02/2015	2.60	0.66	Cool, cloudy, damp and calm
3rd visit	13/03/2015	2.60	0.67	Cool, overcast, dry and calm
4th visit	28/04/2015	2.60	0.60	Cool, cloudy, dry and breezy
5th visit	28/05/2015	2.60	0.59	Warm, cloudy, dry and breezy
6th visit	05/06/2015	2.60	0.66	Hot, overcast, damp and calm

Instrument Used: GA2000 gas analyser — **n/a** Not applicable

REMARKS: — **nm** Not measured



SITE	REPORT	DATE
Teversham Road, Fulbourn	1058,CO	10 November 2015

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APPENDIX 3

B411 – Teversham Road, Fulbourn, Cambridgeshire
Discharge of Conditions - surface water management
For Castlefield International Ltd
3rd December 2019

Please see below with regards to the comments raised by the Lead Local Flood Authority with regards to the reserved matters application for the approved development at Teversham Road, Fulbourn (S/0202/17/OL and S/3290/19/RM). The response also addresses comments raised by Simon Bunn.

Surface water flooding

For context the outline application and appeal was supported by a Flood Risk Assessment (FRA) and site specific flood model which assessed the flood levels and extents at the site with the development in place. The document is available on the South Cambridgeshire planning site (ref S/0202/17/OL) and includes the supporting work which was used to steer the development proposals. The flood modelling assesses how the proposed (now approved) development parcels will influence surface water flooding for various events (figures 4.5 to 4.8 in the flood model, inserted below and into the following pages for convenience).

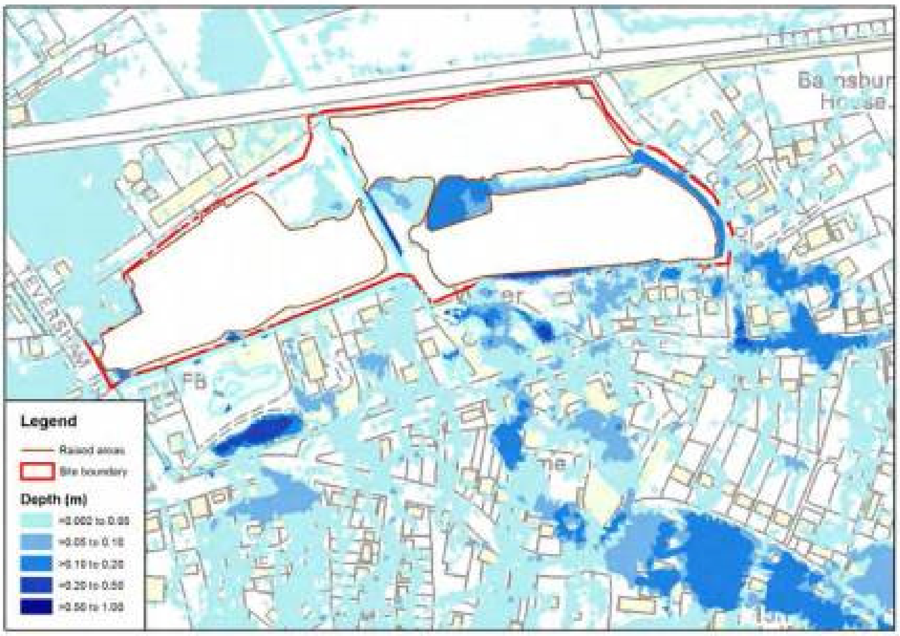


Figure 4.5: Surface water flood depths for the 1 in 30 year rainfall with the development in place

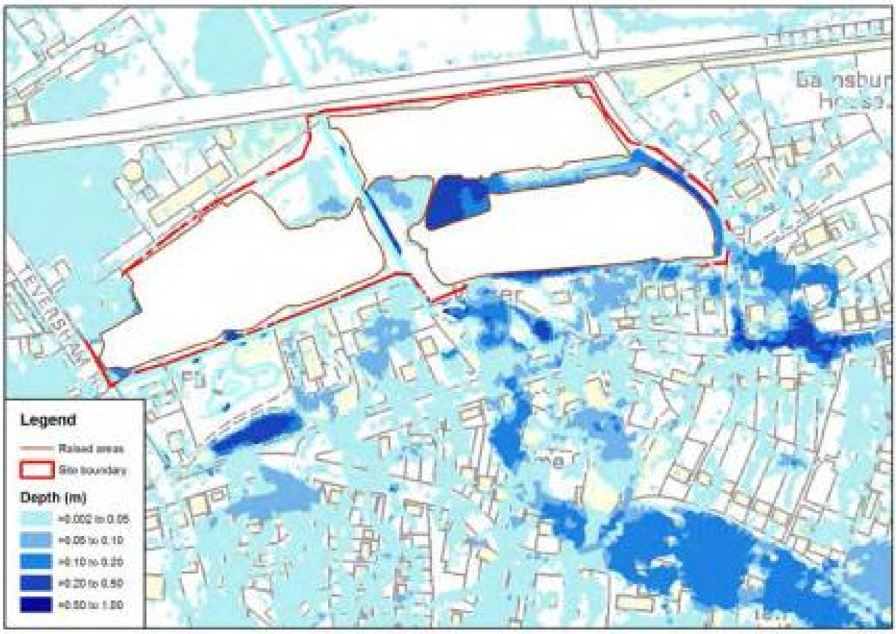


Figure 4.6: Surface water flood depths for the 1 in 100 year rainfall with development in place

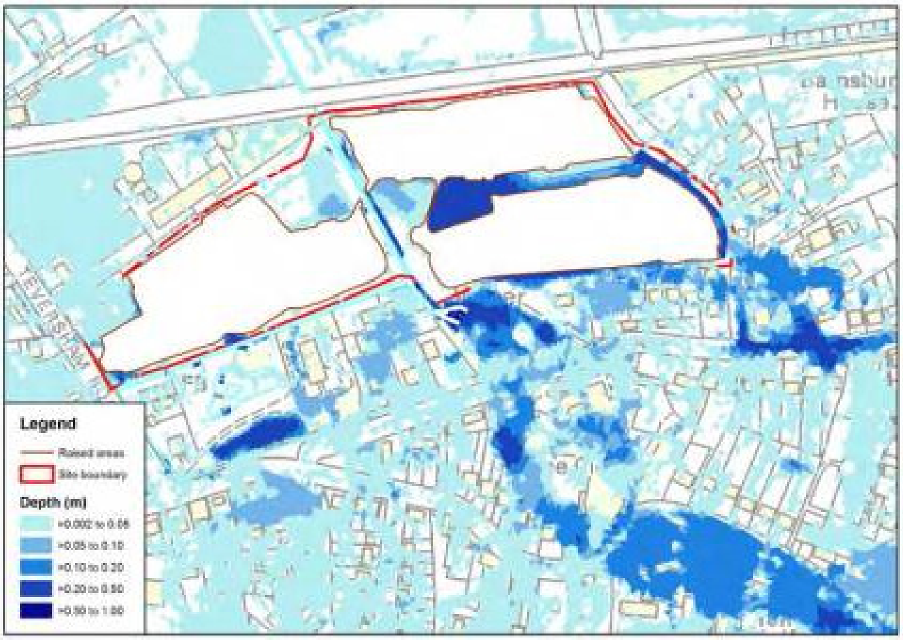


Figure 4.7: Surface water flood depths for the 1 in 100 year climate change rainfall with development in place

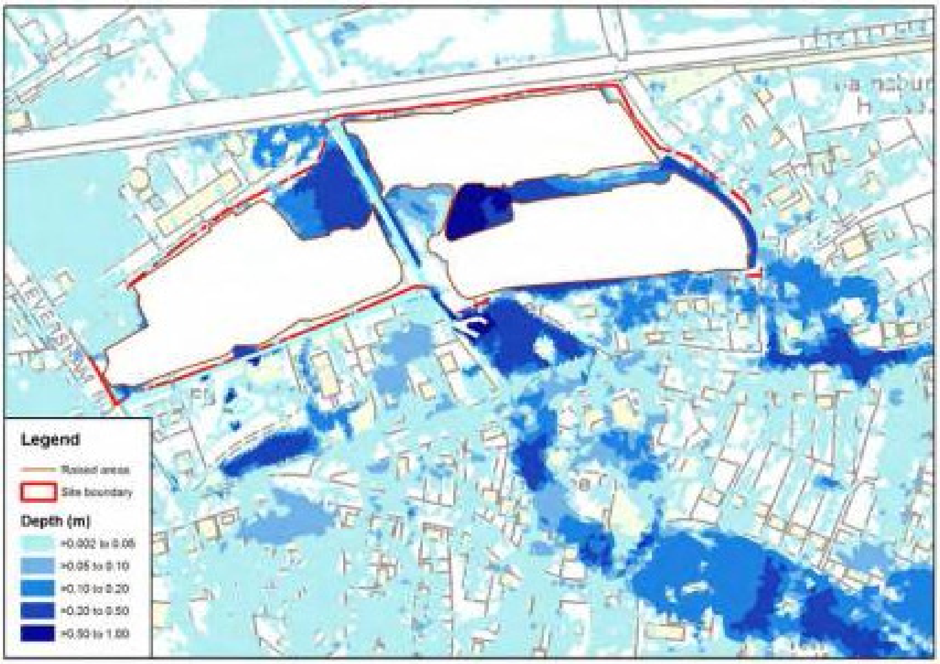
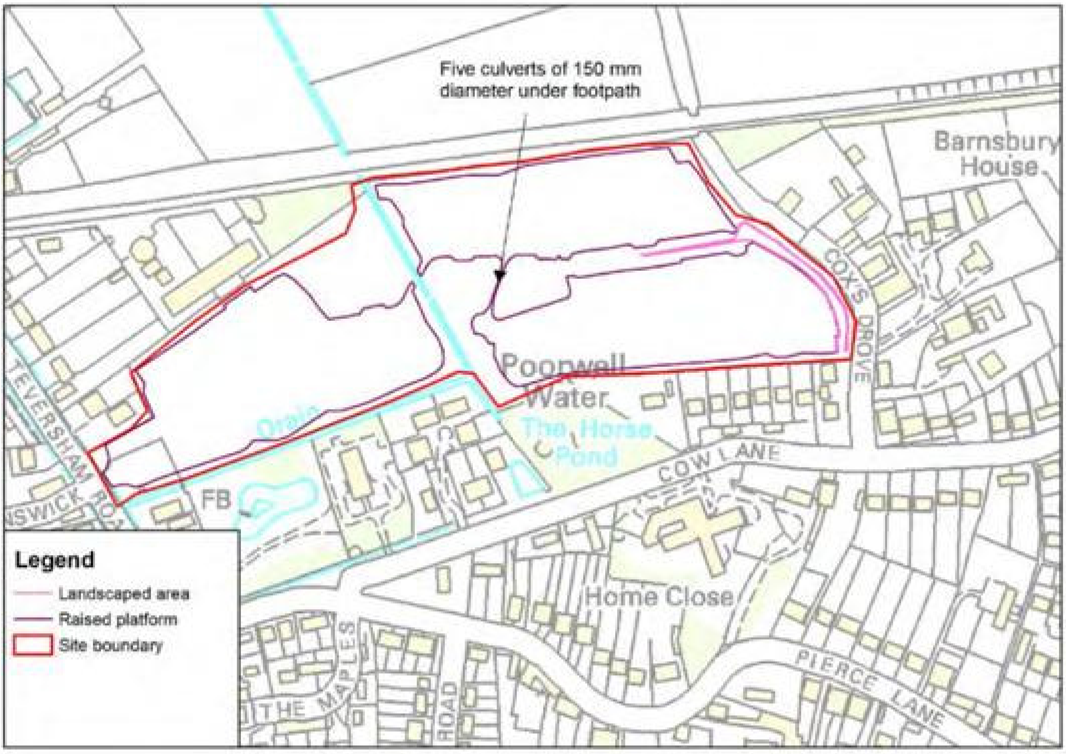


Figure 4.8: Surface water flood depths for the 1 in 1,000 year climate change rainfall with development in place

The Reserved Matters (RM) layout continues to allow space for the predicted surface water floodwater within the site boundary. The RM layout follows the same principle which was established at the outline stage in that westwards flow from ('out of') the central storage area between the two parcels in the east of the site will be restricted. The previous restriction was formed by a raised (embanked) footpath and pipe arrangement which sat a little to the east of the current LEAP. The arrangement is shown on Figure 3.1 (overleaf) from the HR Wallingford flood model which supported the outline application.

The orientation of the detailed LEAP (which it is worth noting will be a split level facility with the northern section being at a lower level than the southern) allows for the raised footpath to be moved further west than was originally modelled (the pathway now runs along the eastern boundary of the split level LEAP). This allows for a larger flood storage area upstream of the pipe arrangement. This will in turn allow for the floodwater originally shown to affect the piece of land now occupied by the LEAP to be stored 'upstream' of the LEAP. The design of the topographically lower part of the LEAP will allow for the restricted flows to pass through and around the LEAP. It is also worth noting that the proposed improvement works to the central stream (discussed in the biodiversity documentation) should provide additional capacity for floodwater.


Five culverts of 150 mm diameter under footpath
Barnsbury House
Poorwell Water
The Horse Pond
Drain
FB
COX'S DROVE
COW LANE
TEVERSHAM ROAD
Home Close
PIERCE LANE
THE MAPLES
ROAD
Legend
Landscaped area
Raised platform
Site boundary

APPENDIX 4

B411 – Teversham Road, Fulbourn, Cambridgeshire
Discharge of Conditions - surface water management
For Castlefield International Ltd
27th February 2020

This note includes revised surface water management drawings and calculations to reflect the updated development layout. It also addresses queries raised by the Lead Local Flood Authority (LLFA) in their role as statutory consultee on surface water management as well as comments from Cambridge City Council/South Cambridgeshire District Council representatives. This note has been prepared following informal discussions and liaison with the LLFA.

LLFA responses FR/19-000423 and FR/19-000431

Access

The parcels of development and the roads linking them will be set above the modelled floodwater so access to the parcels from Teversham Road will be maintained during the modelled 1 in 100 event plus 40 %. The Cox's Drove access is an emergency access, not the primary access.

1 and 2 Drain down times and control sizes

The drain down time is necessarily long because the greenfield rate is so low. We have increased the outflow slightly to reduce the half drain down to less than 7 days.

As suggested we have increased the flow control sizes to at least 20 mm, each control will be protected by two filters (in the control chamber and at the inlets/outlet to the bio-retention/swale features).

3 Freeboard

The 300 mm figure discussed in C753 as being applicable to large, end of pipe/network, basins (the typical 1.5 m deep basin design to store 1.2 m of water).

Freeboard is discussed in C753 with reference to both additional storage in the system and also the distance between water levels and floor levels. With regard to the latter, finished floor levels are still to be detailed (at the detailed design stage). However, currently we are working on water levels (during the 1 in 100 plus 40 % storm) being between 150 to 300 mm below finished floor levels for the respective surface water Facility/complex.

With regards to the latter the argument is that the storage provided in the system is precautious enough for additional freeboard volume to not be necessary. The scheme is sized based on 10 % creep, relatively swift entry of runoff into the attenuation, 0.95 effective runoff, and no incidential loss or interception/depression storage. The scheme also manages the 7 day storm (a lengthy and precautious duration by most standards).

Notwithstanding the above, we have assessed and adjusted the attenuation volumes of Facilities A to D so that they are able to accommodate a six hour duration 1 in 10 storm (7 mm/hr or 42 mm total) within 24 hours of the end of the 7 day 1 in 100 storm plus 40 % climate change. The figures for each are summarised below. It is worth noting that Facility D provides some of the additional storage for Catchment C. This would be achieved by a high level outlet from Facility C to Facility D.

Catchment	Spare volume 24 hours after a 7 day rainfall event	1 in 10 volume (assuming 95 % runoff and no losses)
A	277	269
B	251	241
C	98	201
D	200	87

4 Maintenance

At this stage maintenance of the various facilities would follow the attached schedules (based on C753).

The specific party who will maintain the surface water scheme will depend on later stage work and negotiations and agreements (ideally Anglian Water will adopt the whole scheme). At this stage the details of the maintainer will be necessarily non-specific, but will realistically be either a communally funded private management company or Anglian Water.

5 Network

The scheme does not include a traditional piped network. Instead it relies on source control with no dominant piped conveyance of flows from impermeable catchments to the attenuation facilities. It is proposed to drain the potentially adoptable spine roads in the east overland to the permeable paved private roads (with the western spine road draining to the grassed filter drain). Runoff from the spine roads in the east will enter the crates through the permeable paving (having been conveyed overland along the road channels).

The location of the outfalls will depend on the later stage vegetation clearance so we haven't shown them or the connective pipework as precise locations.

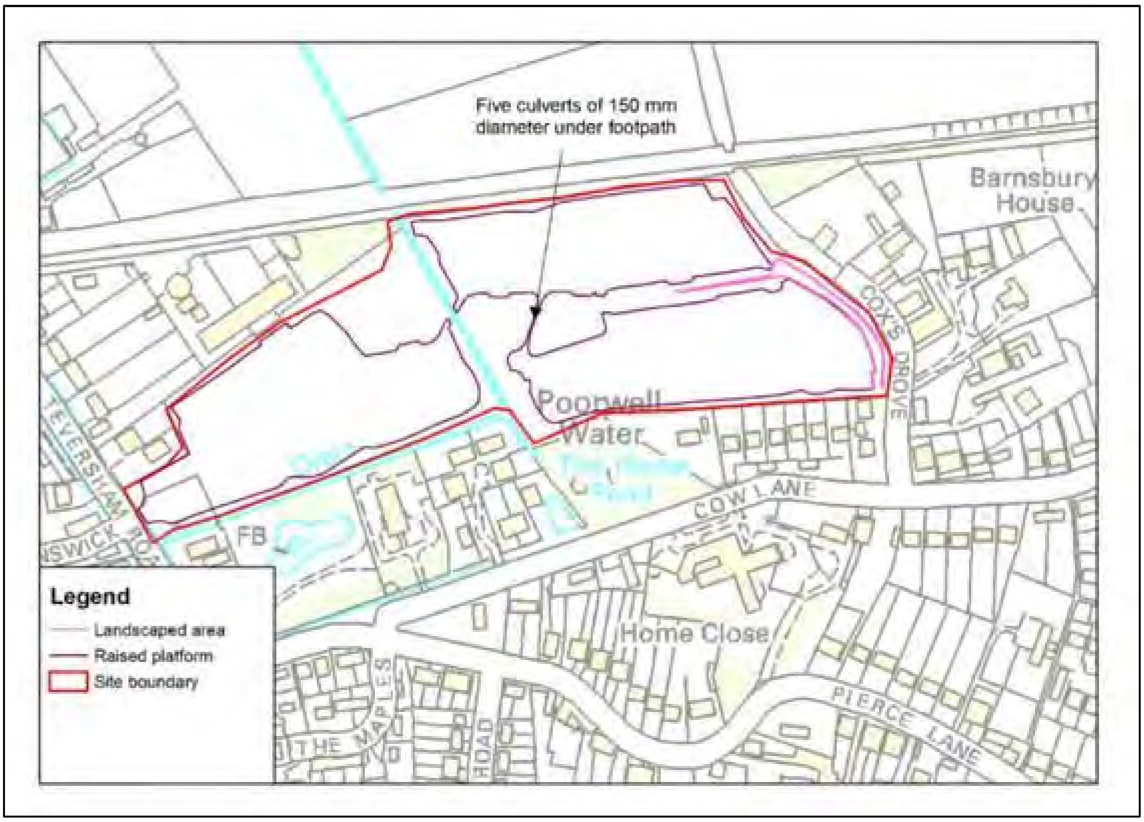
Cambridge City/South Cambridgeshire response to S/3209/19/DC dated 28/09/19

As a point of clarification, the surface water management network is entirely separate from the floodwater management with one not influencing the other. This separation of floodwater is by virtue of the development parcels being raised above the floodwater.

The proposal to move the originally proposed/approved flood management bund west provides more space for flood water in the flood storage area (as does the removal of a section of road in the revised masterplan). This in turn allows for the shallow post development floodwater on the site of the LEAP to be stored upstream of the LEAP.

Should flood levels in the floodwater storage area increase when the final detailed design is modelled at the post application stages then external ground levels and/or finished floor levels (determined during the detailed design stage) would be increased slightly to suit.

It is worth clarifying that the five 150 mm diameter pipes (their purpose being to restrict flows from the floodwater storage area) are in the original model and are not new (see image below from the FRA which supported the 2017 outline application).



Taking the above into account the current model (used to support the outline permission) is therefore suitable to support the Reserved Matters (RM) application.

The outlet from the existing pond will be to the ditch which separates the development from the pumping house garden. The current route of the channel follows the cycleway/footway which runs from the site to the pumping house garden. The channel will be flat (effectively an extension of the pond with flow being driven by head). Levels will be subject to the usual detailed design and further investigations. The currently proposed invert level of the channel is approximately 9.25 m AOD.

Cambridge City/South Cambridgeshire response to S3290/19/RM dated 14/12/19.

Comments 1, 2, and 3

Typical sections of the proposed facilities are appended. Detailed design drawings will be prepared at the post planning stages. Silt control would be via the usual geotextile.

Comment 4

Please see attached for typical sections of potential 'headwalls'. Details of precise locations will be established following the post planning ecological site work (to assess the current vegetation and propose areas for thinning/removal as part of the improvement of the watercourse). As advised by the team ecologist, the process of assessment and thinning/removal is best carried out in one operation (combining assessment, guidance and supervision in one).

Comment 5

Detailed drawings would be prepared at the detailed design stages. The scheme is effectively four large/flat multi part source control systems with the majority of pipework limited to connecting pipes between crates. Discharge will be head driven. As discussed above the precise locations of outlets (and upstream pipework) will be rely on later stage ecological survey work.

Comment 6

Drawing 302 shows the impermeable catchments labelled by their respective attenuation facilities (A to D).

Comment 7

Crate areas, heights, volumes, and performance are included on drawing 300 and in the submitted MicroDrainage calculations. Detailed design will be undertaken at the appropriate later stages.

Comments 8 and 9

No temporary storage is expected to be necessary. Raising the parcels will involve the early creation/installation of the attenuation (the crates form part of the 'imported material' to form the raised parcels).

Comment 10

The detailed design of the external levels will follow the usual guidance to allow overland flow.

Comment 11

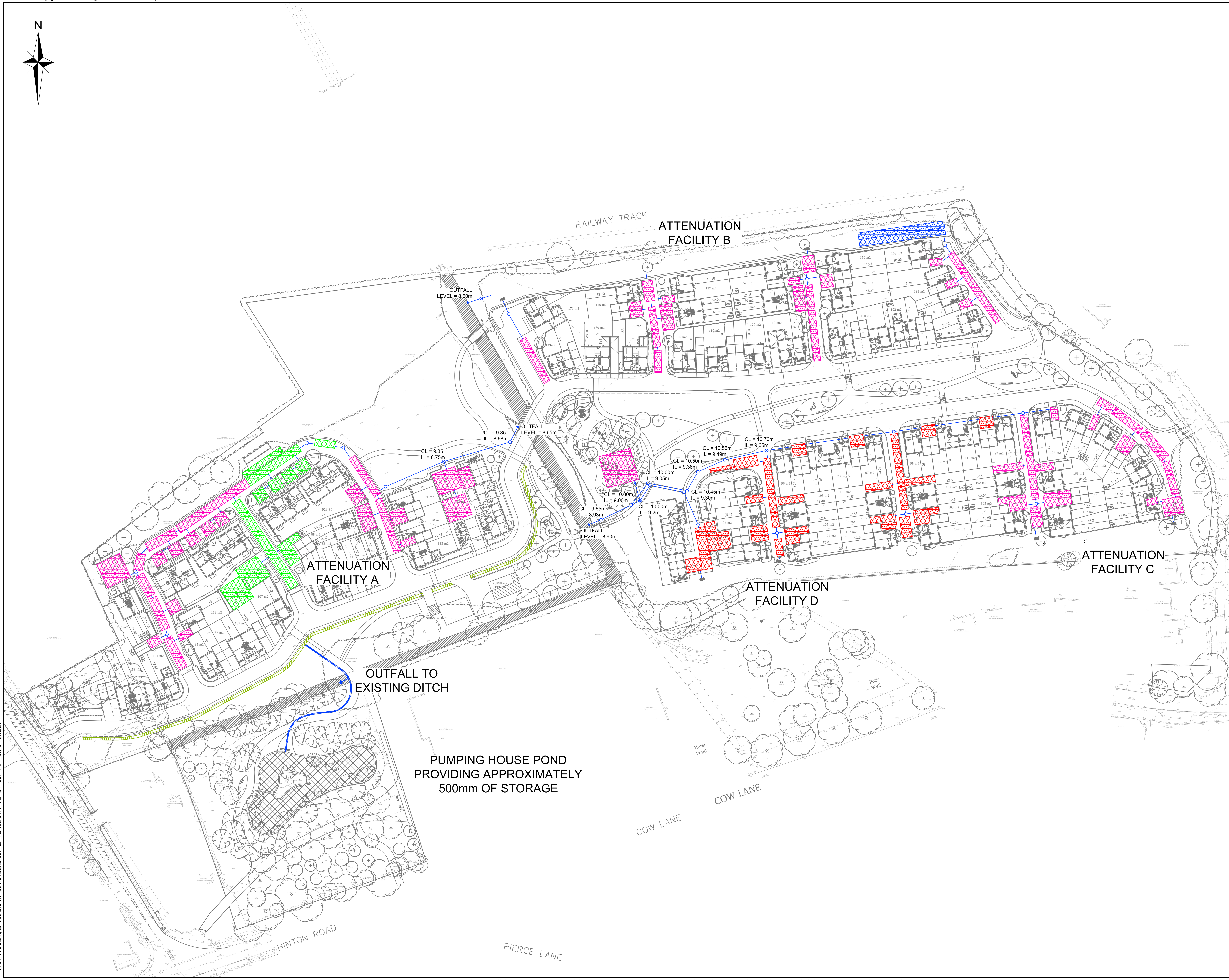
Details of the party responsible for adopting and/or maintaining the surface water management scheme will depend on later stage work and agreements (commercial arrangements, management companies, detailed approval from Anglian Water, etc). The two realistic options for maintenance are a communally funded private management company or Anglian Water (as part of their recent push to take on SuDS). Maintenance activities would be as per the attached 'C753 schedules' with the usual evolution in response to the observed field performance of the features.

Comment 12

Treatment will be provided by the permeable paving, filter drains and bio-retention features. Construction phase pollution prevention and control would be addressed as part of the application to discharge Condition 16 (CEMP).

Appended information

Drawing B411-PL-SK-300 - SW strategy
Drawing B411-PL-SK-301 - SW strategy above ground
Drawing B411-PL-SK-302 - Catchment plan
Drawing B411-PL-SK-303 - Sections
Drawing B411-PL-SK-304 - Typical sections
Drawing B411-PL-SK-305 - Typical outfalls
Drawing B411-PL-SK-306 - Below ground maintenance plan
Drawing B411-PL-SK-307 - Above ground maintenance plan
Drawing B411-PL-SK-308 - Exceedance route plan
MicroDrainage calculations, catchments A to D and western spine road.



M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 300 - P04 - SW STRATEGY

KEY

- 2 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 3 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 4 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 3 x 0.15m AND 1 x 0.085m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- SW NETWORK (SECTIONS OF CONNECTING PIPEWORK)
- ORIFICE CONTROL CHAMBER
- HEADWALL
- ROADSIDE FILTER DRAIN
- RILL/CHANNEL DRAIN TAKING FLOW TO AND FROM THE PUMPING HOUSE POND
- DEBRIS FILTER
- OVERFLOW BETWEEN FACILITY C AND D TO MANAGE THE 1 in 10 STORM

NOTES

LEVELS ARE SUBJECT TO LONG TERM GROUND WATER MONITORING AND DETAILED DESIGN.

REV	DESCRIPTION	DE	DR	CH	DATE
P04	REVISED TO REFLECT CHANGING LAYOUT		DP	-	FEB 2020
P03	SURFACE WATER MANAGEMENT STRATEGY REVISED		DP	-	FEB 2020
P02	REVISED TO REFLECT CHANGING LAYOUT		DP	-	JAN 2020
P01	REVISED TO REFLECT CHANGING LAYOUT LEAP CRATES REVISED		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE: D.N.S.
DATE: 21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
DETAILED SURFACE WATER MANAGEMENT STRATEGY

CLIENT
CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning
Peek House, 20 Eastcheap London, EC3M 1EB Tel: 020 7717 5870 info@cannonce.co.uk
Cambridge House, Lanwades Business Park, Kentford, Newmarket, CB8 7PN Tel: 01638 555107 www.cannonce.co.uk

DRAWING NUMBER: B411 - PL - SK - 300
REV.: P04

KEY

- ATTENUATION BASIN
- PERMEABLE PAVING
- ROADSIDE FILTER DRAIN
- RILL/CHANNEL DRAIN TAKING FLOW TO AND FROM THE PUMPING HOUSE POND
- DEBRIS FILTER
- HEADWALL
- FLOW ROUTES

NOTES

REFER TO DRAWING B411-PL-SK-303 FOR SECTIONS

REV	DESCRIPTION	DE	DR	CH	DATE
P04	REVISED TO REFLECT CHANGING LAYOUT		DP	-	FEB 2020
P03	SURFACE WATER MANAGEMENT STRATEGY REVISED		DP	-	FEB 2020
P02	REVISED TO REFLECT CHANGING LAYOUT		DP	-	JAN 2020
P01	REVISED TO REFLECT CHANGING LAYOUT		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
DETAILED SURFACE WATER MANAGEMENT STRATEGY (ABOVE GROUND)

CLIENT
CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning

Peek House, 20 Eastcheap London, EC3M 1EB Tel: 020 7717 5870 info@cannonce.co.uk

Cambridge House, Lanwades Business Park, Kentford, Newmarket, CB8 7PN Tel: 01638 555107 www.cannonce.co.uk

DRAWING NUMBER	REV.
B411 - PL - SK - 301	P04

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 301 - P04 - SW STRATEGY ABOVE GROUND

KEY

- IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY A
- IMPERMEABLE CATCHMENT AREA DRAINING TO EXISTING POND
- IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY B
- IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY C
- IMPERMEABLE CATCHMENT AREA DRAINING TO ATTENUATION FACILITY D

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P04	REVISED TO REFLECT CHANGING LAYOUT		DP	-	FEB 2020
P03	CATCHMENT AREAS REVISED		DP	-	FEB 2020
P02	REVISED TO REFLECT CHANGING LAYOUT		DP	-	JAN 2020
P01	REVISED TO REFLECT CHANGING LAYOUT		JAM	JOH	SEPT 2019

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	21/08/2019

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
CATCHMENT PLAN

CLIENT
CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning

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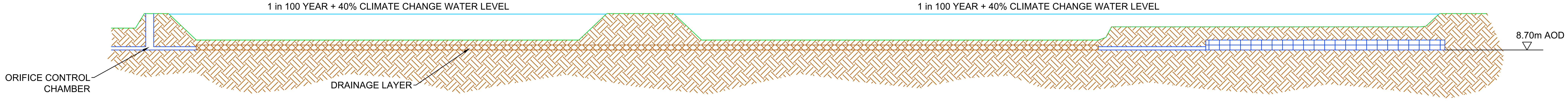
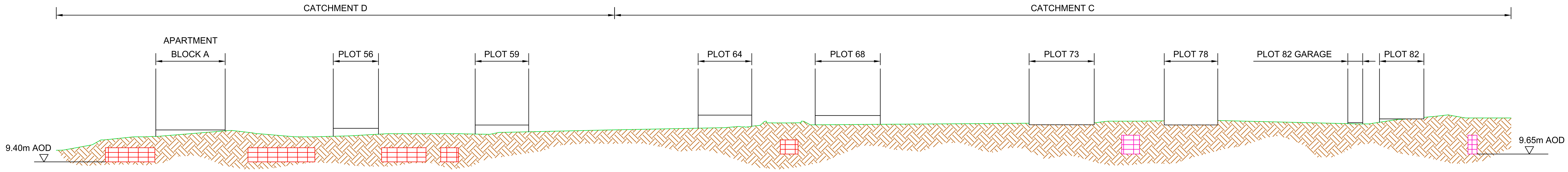
DRAWING NUMBER: B411 - PL - SK - 302
REV.: P04

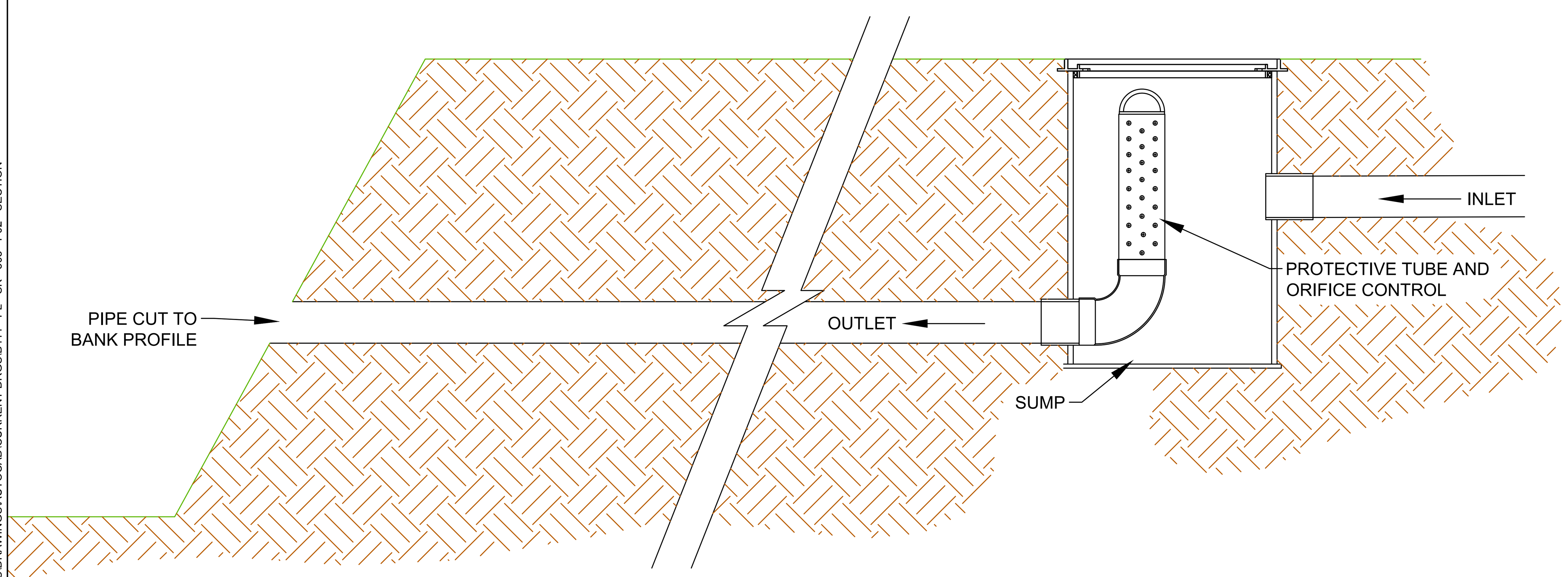
M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 302 P04 - CATCHMENT PLAN



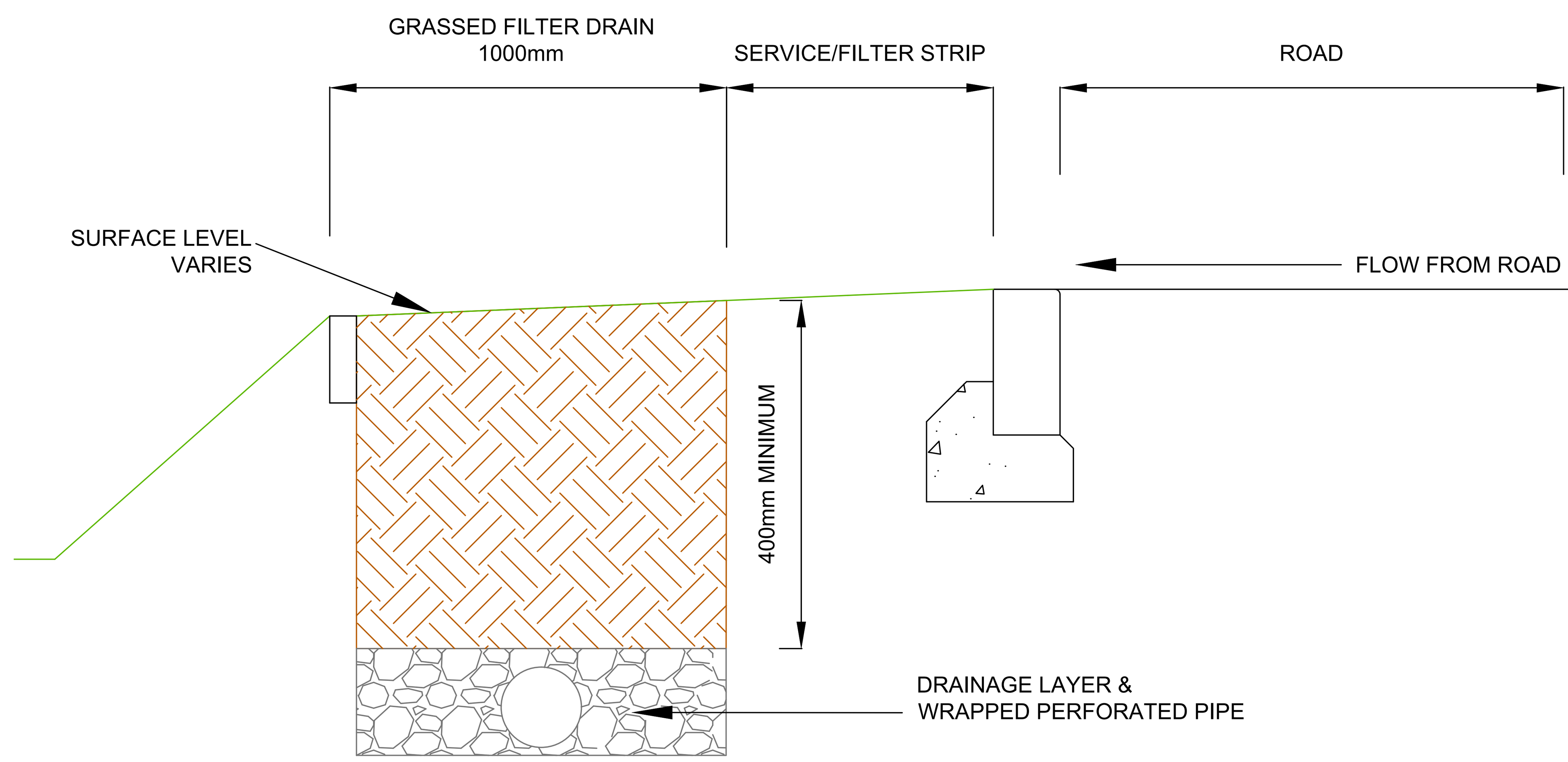
SECTION A-A



SECTION B-B



TYPICAL SECTION OF OUTFALL AND ORIFICE CONTROL CHAMBER



TYPICAL SECTION OF GRASSED FILTER DRAIN

KEY

- 1 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 2 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 3 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 4 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED

NOTES

REFER TO DRAWING B411-PL-SK-301 FOR SECTION LOCATIONS

REV	DESCRIPTION	DE	DR	CH	DATE
P02	SECTIONS REVISED		DP		02/2020
P01	SECTIONS REVISED		DP		02/2020

DESIGNED BY -	DRAWN BY DP	CHECKED BY -
SCALE @ A1 SIZE D.N.S.	DATE 21/08/2019	

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
SECTIONS PLAN

CLIENT
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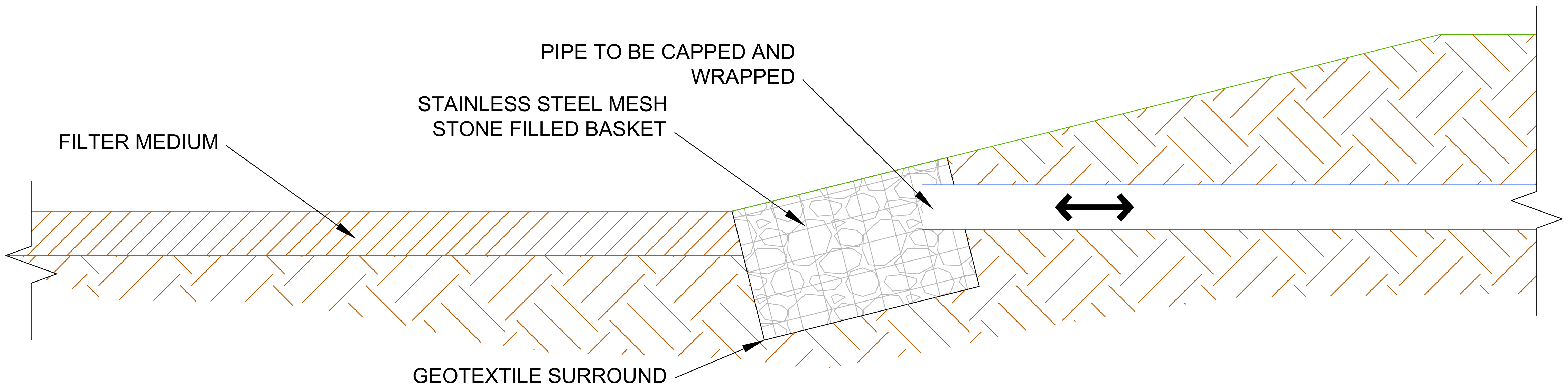
DRAWING NUMBER: B411 - PL - SK - 303
REV.: P02

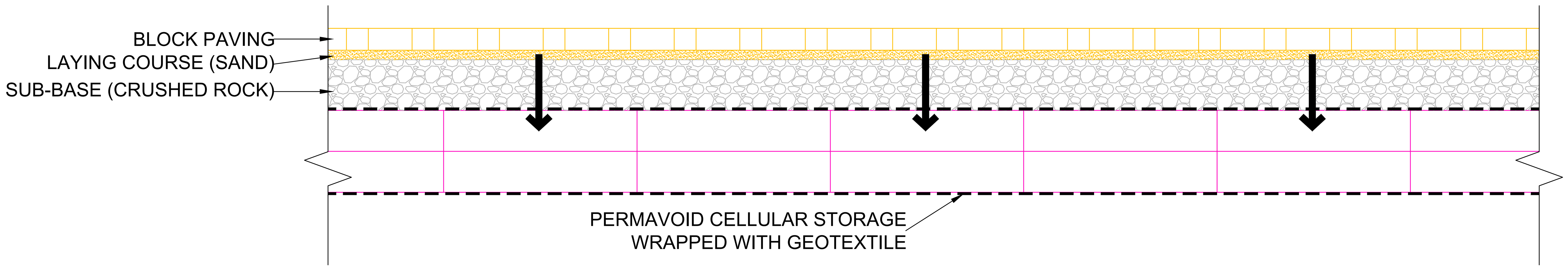
M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 303 - P02 - SECTION

KEY

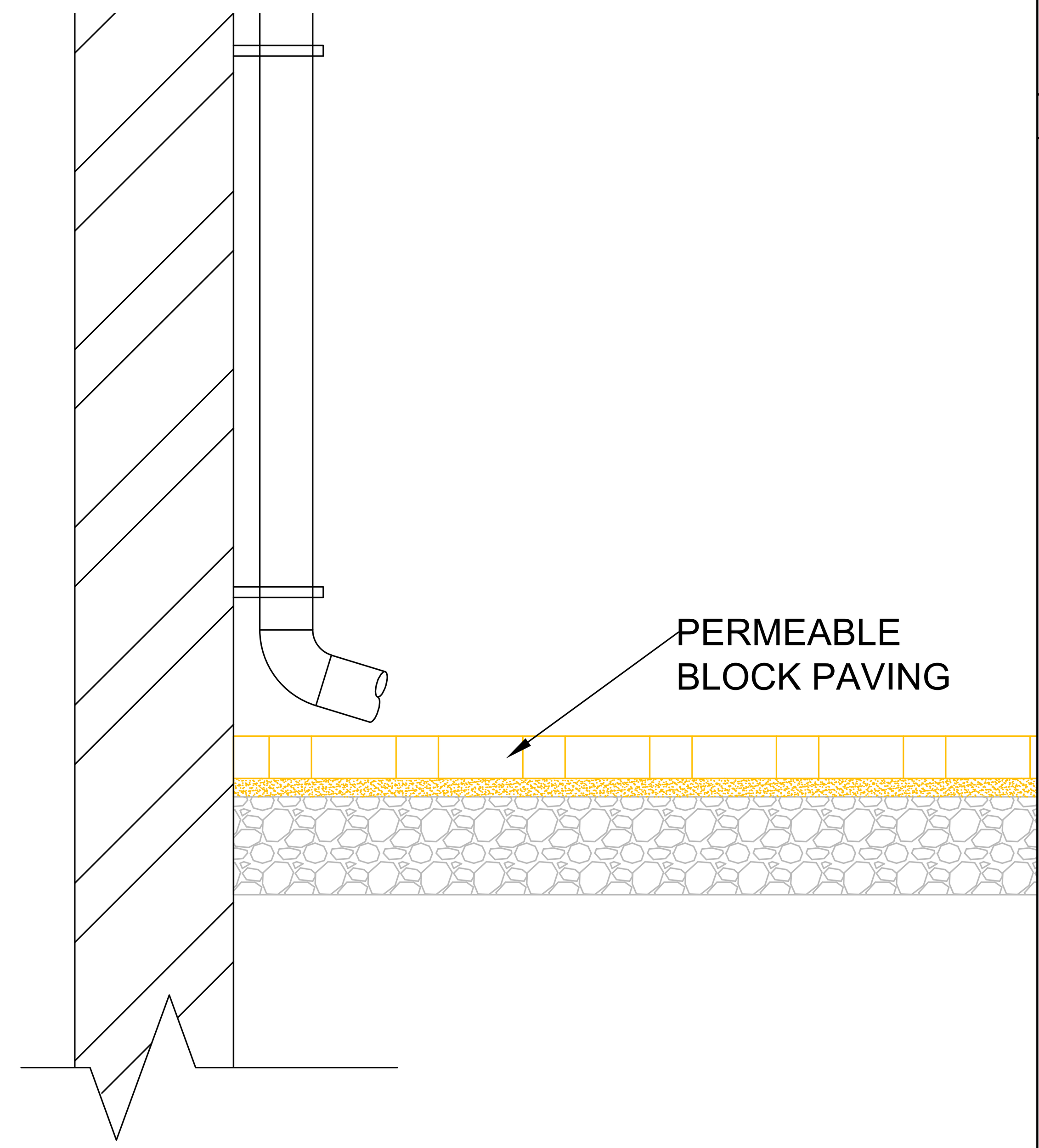
DIRECTION OF FLOW



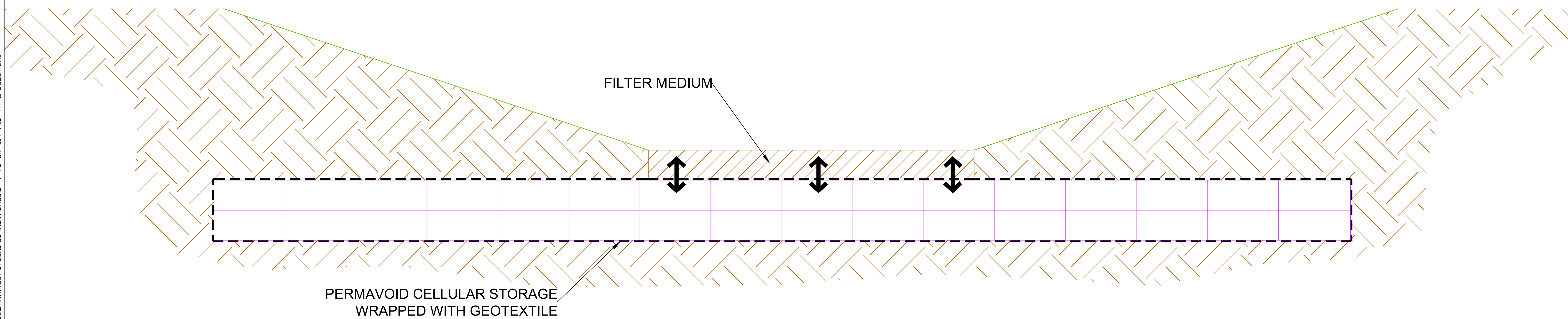
TYPICAL SECTION OF DEBRIS FILTER



TYPICAL SECTION OF PERMEABLE
PAVING OVER CRATES



TYPICAL SECTION OF DOWNPIPE
SPILLING ONTO PERMEABLE PAVING



TYPICAL SECTION OF BASIN
OVER CRATES

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P02	SECTION ADDED	-	DP	-	02/2020
P01	SECTIONS REVISED	-	DP	-	02/2020

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	20/01/2020

PROJECT TITLE
LAND AT TEVERSHAM ROAD,
FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
TYPICAL SECTIONS

CLIENT
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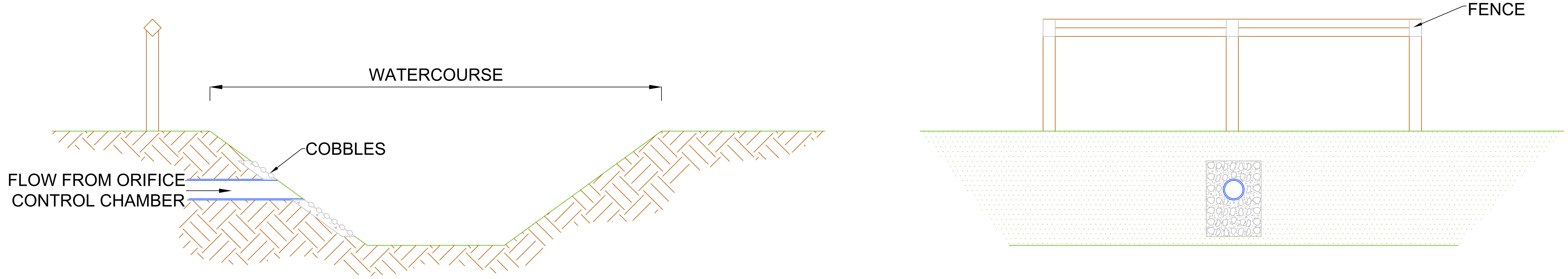
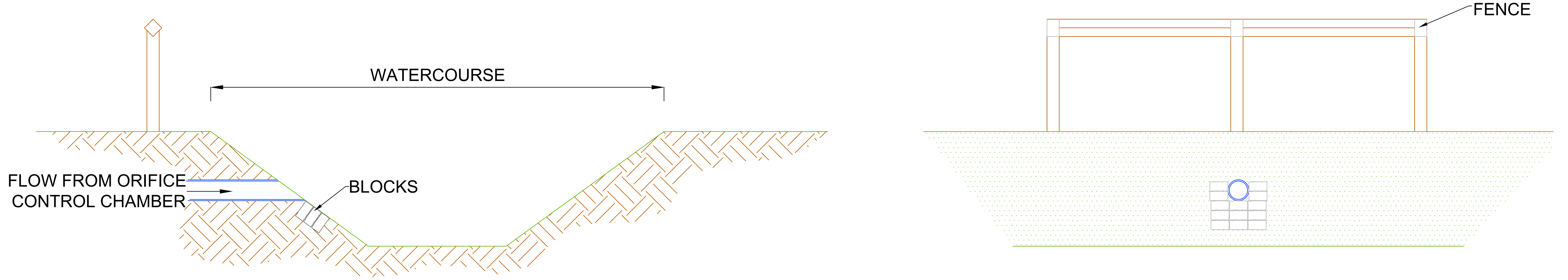
DRAWING NUMBER	REV.
B411 - PL - SK - 304	P02

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 304 - P02 - TYPICAL SECTIONS





KEY

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE

DESIGNED BY: -
DRAWN BY: DP
CHECKED BY: -

SCALE @ A1 SIZE: D.N.S.
DATE: 20/01/2020

PROJECT TITLE: LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE: TYPICAL OUTFALLS

CLIENT: CASTLEFIELD INTERNATIONAL LTD

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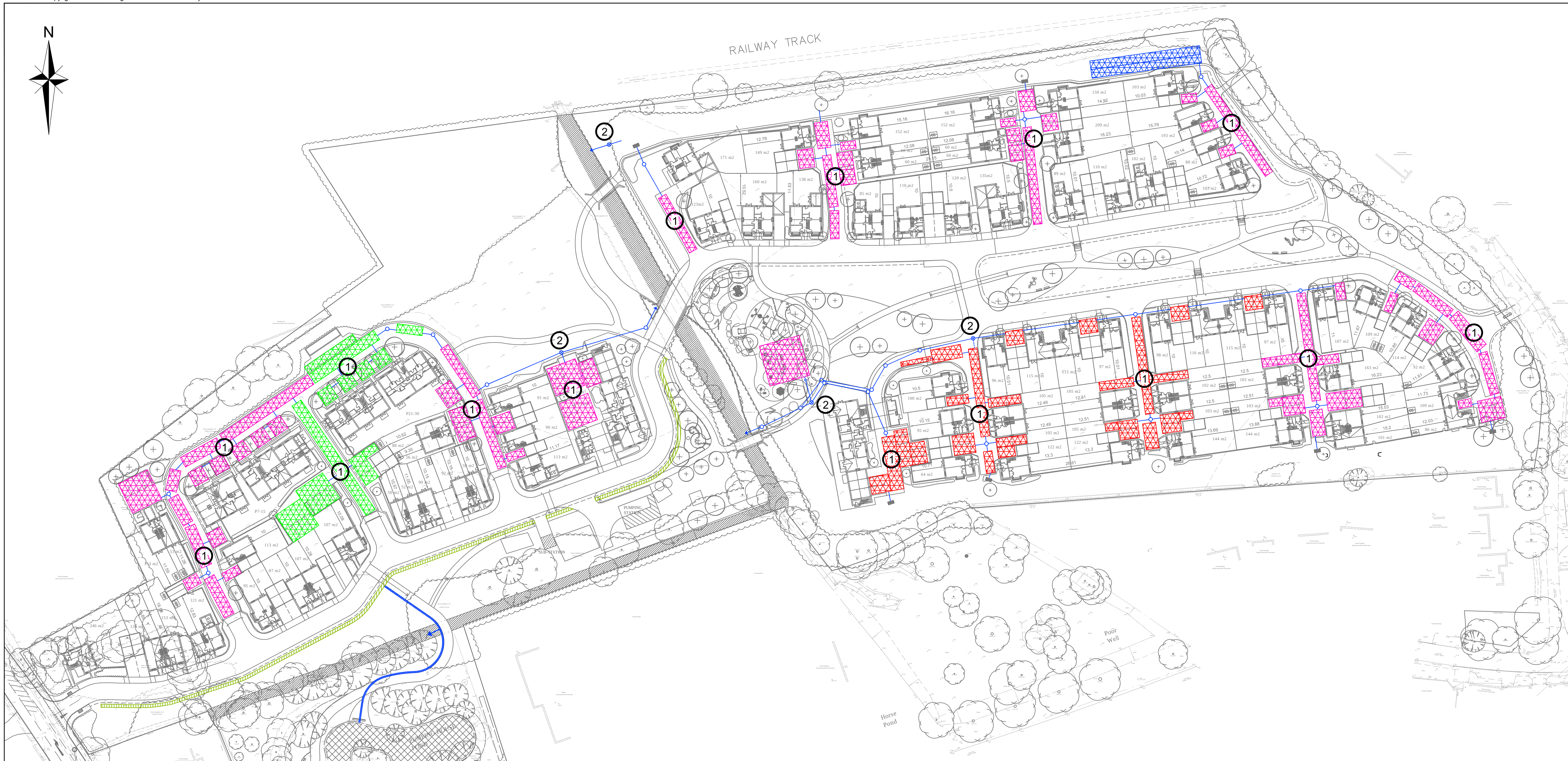
DRAWING NUMBER: B411 - PL - SK - 305
REV.: -

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 305 - TYPICAL OUTFALLS



KEY

1 CELLULAR STORAGE CRATES

2 ORIFICE CONTROL CHAMBER

NOTES

1 - MAINTENANCE PLAN SUBJECT TO REGULAR REVISION AND UPDATE.

1

Maintenance schedule	Required action	Frequency
Regular maintenance	Inspect to identify any area of underperformance and correct (repair, improve etc)	Monthly for 3 months then annually
	Remove debris from drained area to prevent entry to the system	Monthly
	Check any infiltration surfaces which allow water to percolate into the tanks for blockages, correct as necessary	Annually
	Remove sediment from traps	Annually/as required
Remedial actions	Repair/replace inlets, outlets, overflows, and vents	As required.
Monitoring	Check that outlets, inlets, vents, and overflows are in good condition and working as intended	Annually
	Inspect tank internally, remove any sediment if present and if required	Every 5 years (or more frequently if necessary)

2

Maintenance schedule	Required action	Frequency
Remedial actions	Repair/replace inlets, outlets, overflows.	As required
Monitoring	Check that controls, protection, outlets, inlets and overflows are in good condition and working as intended	Half Yearly

REV	DESCRIPTION	DE	DR	CH	DATE

DESIGNED BY -
DRAWN BY DP
CHECKED BY -

SCALE @ A1 SIZE D.N.S.
DATE 27/02/2020

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
BELOW GROUND MAINTENANCE PLAN

CLIENT
CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
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DRAWING NUMBER B411 - PL - SK - 306
REV. -

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 306 - BELOW GROUND MAINTENANCE SCHEDULE

KEY

1. ATTENUATION BASIN
2. PERMEABLE PAVING
3. CHANNEL DRAIN
4. FILTER DRAIN

NOTES

1 - MAINTENANCE PLAN SUBJECT TO REGULAR REVISION AND UPDATE.

2 - DEAD VEGETATION, TRIMMINGS, SILT ETC TO BE APPLIED/STORED IN GREEN SPACE OR REMOVED FROM SITE AS APPROPRIATE.

1

Maintenance schedule	Required action	Frequency
Regular maintenance	Removal of litter and debris	Monthly
	Cut grass	Half yearly
	Manage other vegetation	Monthly then as required
	Inspect and clear inlets, outlets, overflows etc	Monthly
	Inspect and repair banks, pipes, headwalls etc	Monthly
	Inspect inlets and basin for silt accumulation	Monthly until able to establish the required silt removal frequency, then in accordance with established frequency
	Manage vegetation in wetter areas (micro-pools etc)	Annually or as established by ecologist/landscape architect
	Tidy dead growth	Annually (as per growing season)
	Remove sediment from traps, forebays etc	Annually
Occasional maintenance	Reseed	As required.
	Prune adjacent trees	Every 2 years, or as otherwise advised
	Silt removal	Every 5 years (depending on the requirement for regular maintenance)
Remedial actions	Repair erosion or other damage	As required
	Repair inlets, outlets and overflows	As required

2

Maintenance schedule	Required action	Frequency
Regular inspections	Check function of perforated pipes and drainage layer (inspection after rainfall)	Annually
	Check planting for health, weeds etc and replace as required	Quarterly
	Check inlets outlet and overflows	Quarterly
Regular maintenance	Removal of litter, debris and weeds	As required (at least quarterly)
	Re-plant / replace plants	As required
	Removed litter, silt etc	Quarterly to biannually as required
Occasional maintenance	Redress surface (mulch etc) general making good of surface, re-levelling etc	As required.
Remedial actions	Replace filter medium and vegetation	As required*

3

Maintenance schedule	Required action	Frequency
Regular Maintenance	Litter removal. Also removal of debris from site.	Monthly
Occasional Maintenance	Removal of leaves during the autumn to prevent blockage.	As required

4

Maintenance schedule	Required action	Frequency
Regular inspections	Check function of perforated pipes and drainage layer (inspection after rainfall)	Annually
	Check planting for health, weeds etc and replace as required	Quarterly
	Check inlets outlet and overflows	Quarterly
Regular maintenance	Removal of litter, debris and weeds	As required (at least quarterly)
	Re-plant / replace plants	As required
	Removed litter, silt etc	Quarterly to biannually as required
Occasional maintenance	Redress surface (mulch etc) general making good of surface, re-levelling etc	As required.
Remedial actions	Replace filter medium and vegetation	As required*

REV	DESCRIPTION	DE	DR	CH	DATE

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	27/02/2020

PROJECT TITLE

LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE

ABOVE GROUND MAINTENANCE PLAN

CLIENT

CASTLEFIELD INTERNATIONAL LTD

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DRAWING NUMBER	REV.
B411 - PL - SK - 307	-

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 307 - ABOVE GROUND MAINTENANCE SCHEDULE

KEY

EXCEEDANCE ROUTE

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	27/02/2020

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
EXCEEDANCE ROUTE PLAN

CLIENT
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DRAWING NUMBER	REV.
B411 - PL - SK - 308	-

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - 308 - EXCEEDANCE ROUTE PLAN

Summary of Results for 100 year Return Period (+40%)

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.588	0.098	0.2	97.7	O K
30 min Summer	9.616	0.126	0.3	125.8	O K
60 min Summer	9.644	0.154	0.3	153.6	O K
120 min Summer	9.684	0.194	0.4	193.9	O K
180 min Summer	9.708	0.218	0.4	218.1	O K
240 min Summer	9.725	0.235	0.4	234.5	O K
360 min Summer	9.745	0.255	0.4	254.9	O K
480 min Summer	9.757	0.267	0.4	266.8	O K
600 min Summer	9.764	0.274	0.4	274.5	O K
720 min Summer	9.770	0.280	0.4	279.7	O K
960 min Summer	9.776	0.286	0.4	285.9	O K
1440 min Summer	9.780	0.290	0.4	290.2	O K
2160 min Summer	9.781	0.291	0.4	290.6	O K
2880 min Summer	9.779	0.289	0.4	289.1	O K
4320 min Summer	9.775	0.285	0.4	285.3	O K
5760 min Summer	9.773	0.283	0.4	283.3	O K
7200 min Summer	9.775	0.285	0.4	285.2	O K
8640 min Summer	9.779	0.289	0.4	289.1	O K
10080 min Summer	9.784	0.294	0.4	294.4	O K
15 min Winter	9.588	0.098	0.2	97.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	20.0	23
30 min Summer	101.360	0.0	23.0	38
60 min Summer	62.020	0.0	49.2	68
120 min Summer	39.270	0.0	56.0	128
180 min Summer	29.549	0.0	59.5	188
240 min Summer	23.905	0.0	61.6	248
360 min Summer	17.430	0.0	63.7	366
480 min Summer	13.768	0.0	64.5	486
600 min Summer	11.401	0.0	64.6	606
720 min Summer	9.742	0.0	64.4	726
960 min Summer	7.561	0.0	63.3	966
1440 min Summer	5.244	0.0	59.9	1444
2160 min Summer	3.633	0.0	122.3	2164
2880 min Summer	2.812	0.0	117.7	2880
4320 min Summer	1.987	0.0	107.3	4320
5760 min Summer	1.574	0.0	224.5	4904
7200 min Summer	1.330	0.0	220.2	5688
8640 min Summer	1.171	0.0	214.3	6400
10080 min Summer	1.060	0.0	206.9	7256
15 min Winter	157.360	0.0	20.0	23

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
30 min Winter	9.616	0.126	0.3	125.8	O K
60 min Winter	9.644	0.154	0.3	153.6	O K
120 min Winter	9.684	0.194	0.4	193.9	O K
180 min Winter	9.708	0.218	0.4	218.2	O K
240 min Winter	9.725	0.235	0.4	234.6	O K
360 min Winter	9.745	0.255	0.4	255.0	O K
480 min Winter	9.757	0.267	0.4	266.9	O K
600 min Winter	9.765	0.275	0.4	274.5	O K
720 min Winter	9.770	0.280	0.4	279.8	O K
960 min Winter	9.776	0.286	0.4	286.0	O K
1440 min Winter	9.780	0.290	0.4	290.4	O K
2160 min Winter	9.781	0.291	0.4	291.1	O K
2880 min Winter	9.780	0.290	0.4	290.0	O K
4320 min Winter	9.777	0.287	0.4	287.3	O K
5760 min Winter	9.775	0.285	0.4	284.6	O K
7200 min Winter	9.775	0.285	0.4	284.8	O K
8640 min Winter	9.778	0.288	0.4	288.0	O K
10080 min Winter	9.782	0.292	0.4	292.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	101.360	0.0	23.0	38
60 min Winter	62.020	0.0	49.2	68
120 min Winter	39.270	0.0	56.0	126
180 min Winter	29.549	0.0	59.5	186
240 min Winter	23.905	0.0	61.6	244
360 min Winter	17.430	0.0	63.7	362
480 min Winter	13.768	0.0	64.5	482
600 min Winter	11.401	0.0	64.7	600
720 min Winter	9.742	0.0	64.4	718
960 min Winter	7.561	0.0	63.4	954
1440 min Winter	5.244	0.0	59.9	1426
2160 min Winter	3.633	0.0	122.4	2120
2880 min Winter	2.812	0.0	117.9	2800
4320 min Winter	1.987	0.0	107.6	4144
5760 min Winter	1.574	0.0	224.7	5360
7200 min Winter	1.330	0.0	220.5	5768
8640 min Winter	1.171	0.0	214.8	6664
10080 min Winter	1.060	0.0	207.5	7568

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.262

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.162	4	8	0.100

Model Details

Storage is Online Cover Level (m) 10.090

Tank or Pond Structure

Invert Level (m) 9.490

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1000.0	0.600	1000.0

Orifice Outflow Control

Diameter (m) 0.020 Discharge Coefficient 0.600 Invert Level (m) 9.490

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 9648 minutes.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.338	0.138	0.0	0.4	0.4	237.7	O K
30 min Summer	9.378	0.178	0.0	0.5	0.5	306.0	O K
60 min Summer	9.417	0.217	0.0	0.5	0.5	374.0	O K
120 min Summer	9.474	0.274	0.0	0.6	0.6	472.5	O K
180 min Summer	9.509	0.309	0.0	0.7	0.7	532.0	O K
240 min Summer	9.533	0.333	0.0	0.7	0.7	572.6	O K
360 min Summer	9.562	0.362	0.0	0.7	0.7	623.4	O K
480 min Summer	9.580	0.380	0.0	0.7	0.7	653.7	O K
600 min Summer	9.591	0.391	0.0	0.7	0.7	673.7	O K
720 min Summer	9.599	0.399	0.0	0.7	0.7	687.8	O K
960 min Summer	9.610	0.410	0.0	0.8	0.8	705.6	O K
1440 min Summer	9.619	0.419	0.0	0.8	0.8	721.3	O K
2160 min Summer	9.624	0.424	0.0	0.8	0.8	730.4	O K
2880 min Summer	9.627	0.427	0.0	0.8	0.8	734.5	O K
4320 min Summer	9.630	0.430	0.0	0.8	0.8	740.7	O K
5760 min Summer	9.633	0.433	0.0	0.8	0.8	745.2	O K
7200 min Summer	9.637	0.437	0.0	0.8	0.8	752.6	O K
8640 min Summer	9.645	0.445	0.0	0.8	0.8	765.8	O K
10080 min Summer	9.655	0.455	0.0	0.8	0.8	783.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	35.1	27
30 min Summer	101.360	0.0	40.3	42
60 min Summer	62.020	0.0	87.2	72
120 min Summer	39.270	0.0	98.7	132
180 min Summer	29.549	0.0	104.7	192
240 min Summer	23.905	0.0	108.2	252
360 min Summer	17.430	0.0	111.8	372
480 min Summer	13.768	0.0	113.0	490
600 min Summer	11.401	0.0	113.2	610
720 min Summer	9.742	0.0	112.7	730
960 min Summer	7.561	0.0	110.7	970
1440 min Summer	5.244	0.0	104.6	1448
2160 min Summer	3.633	0.0	217.8	2168
2880 min Summer	2.812	0.0	209.4	2884
4320 min Summer	1.987	0.0	190.4	4324
5760 min Summer	1.574	0.0	413.3	5760
7200 min Summer	1.330	0.0	403.3	6712
8640 min Summer	1.171	0.0	390.9	7352
10080 min Summer	1.060	0.0	376.3	8160

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	9.338	0.138	0.0	0.4	0.4	237.7	O K
30 min Winter	9.378	0.178	0.0	0.5	0.5	306.0	O K
60 min Winter	9.417	0.217	0.0	0.5	0.5	374.0	O K
120 min Winter	9.474	0.274	0.0	0.6	0.6	472.5	O K
180 min Winter	9.509	0.309	0.0	0.7	0.7	532.1	O K
240 min Winter	9.533	0.333	0.0	0.7	0.7	572.6	O K
360 min Winter	9.562	0.362	0.0	0.7	0.7	623.5	O K
480 min Winter	9.580	0.380	0.0	0.7	0.7	653.8	O K
600 min Winter	9.591	0.391	0.0	0.7	0.7	673.8	O K
720 min Winter	9.600	0.400	0.0	0.7	0.7	687.9	O K
960 min Winter	9.610	0.410	0.0	0.8	0.8	705.8	O K
1440 min Winter	9.619	0.419	0.0	0.8	0.8	721.7	O K
2160 min Winter	9.625	0.425	0.0	0.8	0.8	731.1	O K
2880 min Winter	9.627	0.427	0.0	0.8	0.8	735.7	O K
4320 min Winter	9.632	0.432	0.0	0.8	0.8	743.2	O K
5760 min Winter	9.635	0.435	0.0	0.8	0.8	749.6	O K
7200 min Winter	9.641	0.441	0.0	0.8	0.8	758.7	O K
8640 min Winter	9.647	0.447	0.0	0.8	0.8	769.5	O K
10080 min Winter	9.655	0.455	0.0	0.8	0.8	783.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Winter	157.360	0.0	35.1	27
30 min Winter	101.360	0.0	40.3	42
60 min Winter	62.020	0.0	87.2	72
120 min Winter	39.270	0.0	98.7	130
180 min Winter	29.549	0.0	104.7	190
240 min Winter	23.905	0.0	108.2	248
360 min Winter	17.430	0.0	111.8	368
480 min Winter	13.768	0.0	113.1	486
600 min Winter	11.401	0.0	113.2	604
720 min Winter	9.742	0.0	112.8	722
960 min Winter	7.561	0.0	110.8	960
1440 min Winter	5.244	0.0	104.8	1430
2160 min Winter	3.633	0.0	218.0	2136
2880 min Winter	2.812	0.0	209.6	2828
4320 min Winter	1.987	0.0	190.8	4196
5760 min Winter	1.574	0.0	413.8	5536
7200 min Winter	1.330	0.0	403.9	6840
8640 min Winter	1.171	0.0	391.7	8040
10080 min Winter	1.060	0.0	377.3	8376

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.637

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.213	4	8	0.212	8	12	0.212

Model Details

Storage is Online Cover Level (m) 10.100

Complex Structure

Cellular Storage

Invert Level (m) 9.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	1120.7	1120.7	0.601	0.0	1201.1
0.600	1120.7	1201.0			

Cellular Storage

Invert Level (m) 9.200 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	691.5	691.5	0.536	0.0	747.8
0.535	691.5	747.8			

Orifice Outflow Control

Diameter (m) 0.024 Discharge Coefficient 0.600 Invert Level (m) 9.200

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 7562 minutes.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.197	0.497	0.0	0.6	0.6	216.9	O K
30 min Summer	9.267	0.567	0.0	0.6	0.6	279.1	O K
60 min Summer	9.331	0.631	0.0	0.7	0.7	340.9	O K
120 min Summer	9.417	0.717	0.0	0.7	0.7	430.3	O K
180 min Summer	9.463	0.763	0.0	0.7	0.7	484.1	O K
240 min Summer	9.493	0.793	0.0	0.7	0.7	520.6	O K
360 min Summer	9.530	0.830	0.0	0.8	0.8	565.9	Flood Risk
480 min Summer	9.550	0.850	0.0	0.8	0.8	592.4	Flood Risk
600 min Summer	9.563	0.863	0.0	0.8	0.8	609.6	Flood Risk
720 min Summer	9.572	0.872	0.0	0.8	0.8	621.3	Flood Risk
960 min Summer	9.583	0.883	0.0	0.8	0.8	635.4	Flood Risk
1440 min Summer	9.590	0.890	0.0	0.8	0.8	645.5	Flood Risk
2160 min Summer	9.592	0.892	0.0	0.8	0.8	647.5	Flood Risk
2880 min Summer	9.590	0.890	0.0	0.8	0.8	645.3	Flood Risk
4320 min Summer	9.586	0.886	0.0	0.8	0.8	639.7	Flood Risk
5760 min Summer	9.581	0.881	0.0	0.8	0.8	633.5	Flood Risk
7200 min Summer	9.581	0.881	0.0	0.8	0.8	633.5	Flood Risk
8640 min Summer	9.586	0.886	0.0	0.8	0.8	639.5	Flood Risk
10080 min Summer	9.593	0.893	0.0	0.8	0.8	649.7	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	48.6	27
30 min Summer	101.360	0.0	52.0	42
60 min Summer	62.020	0.0	107.7	72
120 min Summer	39.270	0.0	115.3	132
180 min Summer	29.549	0.0	119.0	192
240 min Summer	23.905	0.0	121.1	252
360 min Summer	17.430	0.0	122.9	370
480 min Summer	13.768	0.0	123.4	490
600 min Summer	11.401	0.0	123.3	610
720 min Summer	9.742	0.0	122.8	730
960 min Summer	7.561	0.0	121.2	970
1440 min Summer	5.244	0.0	116.7	1448
2160 min Summer	3.633	0.0	238.4	2168
2880 min Summer	2.812	0.0	232.0	2884
4320 min Summer	1.987	0.0	217.6	4324
5760 min Summer	1.574	0.0	454.3	5712
7200 min Summer	1.330	0.0	445.0	6280
8640 min Summer	1.171	0.0	434.0	7096
10080 min Summer	1.060	0.0	421.5	7872

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	9.197	0.497	0.0	0.6	0.6	216.9	O K
30 min Winter	9.267	0.567	0.0	0.6	0.6	279.1	O K
60 min Winter	9.331	0.631	0.0	0.7	0.7	340.9	O K
120 min Winter	9.418	0.718	0.0	0.7	0.7	430.3	O K
180 min Winter	9.464	0.764	0.0	0.7	0.7	484.2	O K
240 min Winter	9.494	0.794	0.0	0.7	0.7	520.7	O K
360 min Winter	9.530	0.830	0.0	0.8	0.8	566.1	Flood Risk
480 min Winter	9.550	0.850	0.0	0.8	0.8	592.7	Flood Risk
600 min Winter	9.564	0.864	0.0	0.8	0.8	609.9	Flood Risk
720 min Winter	9.573	0.873	0.0	0.8	0.8	621.7	Flood Risk
960 min Winter	9.583	0.883	0.0	0.8	0.8	635.9	Flood Risk
1440 min Winter	9.591	0.891	0.0	0.8	0.8	646.3	Flood Risk
2160 min Winter	9.593	0.893	0.0	0.8	0.8	648.9	Flood Risk
2880 min Winter	9.592	0.892	0.0	0.8	0.8	647.4	Flood Risk
4320 min Winter	9.589	0.889	0.0	0.8	0.8	643.5	Flood Risk
5760 min Winter	9.586	0.886	0.0	0.8	0.8	639.5	Flood Risk
7200 min Winter	9.586	0.886	0.0	0.8	0.8	639.2	Flood Risk
8640 min Winter	9.587	0.887	0.0	0.8	0.8	641.6	Flood Risk
10080 min Winter	9.594	0.894	0.0	0.8	0.8	650.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Winter	157.360	0.0	48.6	27
30 min Winter	101.360	0.0	52.0	42
60 min Winter	62.020	0.0	107.7	72
120 min Winter	39.270	0.0	115.3	130
180 min Winter	29.549	0.0	119.0	190
240 min Winter	23.905	0.0	121.0	248
360 min Winter	17.430	0.0	122.9	366
480 min Winter	13.768	0.0	123.4	486
600 min Winter	11.401	0.0	123.2	604
720 min Winter	9.742	0.0	122.7	722
960 min Winter	7.561	0.0	121.0	958
1440 min Winter	5.244	0.0	116.4	1430
2160 min Winter	3.633	0.0	238.1	2128
2880 min Winter	2.812	0.0	231.5	2828
4320 min Winter	1.987	0.0	217.0	4192
5760 min Winter	1.574	0.0	453.8	5488
7200 min Winter	1.330	0.0	444.5	6776
8640 min Winter	1.171	0.0	433.6	7864
10080 min Winter	1.060	0.0	421.3	8072

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.582

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	0.194	4	8	0.194	8	12	0.194

Model Details

Storage is Online Cover Level (m) 9.800

Complex Structure

Cellular Storage

Invert Level (m) 8.700 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	204.5	204.5	0.301	0.0	221.7
0.300	204.5	221.7			

Tank or Pond

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	107.0	0.800	456.0

Tank or Pond

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	54.0	0.400	212.0	0.401	294.0	0.800	605.0

Cellular Storage

Invert Level (m) 9.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	612.6	612.6	0.601	0.0	672.1
0.600	612.6	672.0			

Orifice Outflow Control

Diameter (m) 0.020 Discharge Coefficient 0.600 Invert Level (m) 8.700

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 9644 minutes.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.820	0.170	0.0	0.3	0.3	182.9	O K
30 min Summer	9.867	0.217	0.0	0.4	0.4	235.5	O K
60 min Summer	9.913	0.263	0.0	0.4	0.4	287.8	O K
120 min Summer	9.978	0.328	0.0	0.5	0.5	363.5	O K
180 min Summer	10.016	0.366	0.0	0.5	0.5	409.3	O K
240 min Summer	10.042	0.392	0.0	0.5	0.5	440.5	O K
360 min Summer	10.075	0.425	0.0	0.5	0.5	479.6	O K
480 min Summer	10.093	0.443	0.0	0.5	0.5	502.9	O K
600 min Summer	10.108	0.458	0.0	0.6	0.6	518.3	O K
720 min Summer	10.121	0.471	0.0	0.6	0.6	529.1	O K
960 min Summer	10.136	0.486	0.0	0.6	0.6	542.7	O K
1440 min Summer	10.150	0.500	0.0	0.6	0.6	554.7	O K
2160 min Summer	10.157	0.507	0.0	0.6	0.6	561.6	O K
2880 min Summer	10.161	0.511	0.0	0.6	0.6	564.7	O K
4320 min Summer	10.166	0.516	0.0	0.6	0.6	569.3	O K
5760 min Summer	10.169	0.519	0.0	0.6	0.6	572.5	O K
7200 min Summer	10.175	0.525	0.0	0.6	0.6	577.9	O K
8640 min Summer	10.186	0.536	0.0	0.6	0.6	587.6	O K
10080 min Summer	10.200	0.550	0.0	0.6	0.6	600.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	27.5	19
30 min Summer	101.360	0.0	31.4	34
60 min Summer	62.020	0.0	67.5	64
120 min Summer	39.270	0.0	75.9	124
180 min Summer	29.549	0.0	80.1	184
240 min Summer	23.905	0.0	82.6	244
360 min Summer	17.430	0.0	85.1	364
480 min Summer	13.768	0.0	85.9	484
600 min Summer	11.401	0.0	86.0	604
720 min Summer	9.742	0.0	85.7	724
960 min Summer	7.561	0.0	84.3	964
1440 min Summer	5.244	0.0	80.1	1442
2160 min Summer	3.633	0.0	166.1	2164
2880 min Summer	2.812	0.0	160.0	2880
4320 min Summer	1.987	0.0	146.5	4320
5760 min Summer	1.574	0.0	316.2	5760
7200 min Summer	1.330	0.0	309.1	6840
8640 min Summer	1.171	0.0	300.6	7352
10080 min Summer	1.060	0.0	290.7	8168

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
15 min Winter	9.820	0.170	0.0	0.3	0.3	182.9	O K
30 min Winter	9.867	0.217	0.0	0.4	0.4	235.5	O K
60 min Winter	9.913	0.263	0.0	0.4	0.4	287.7	O K
120 min Winter	9.978	0.328	0.0	0.5	0.5	363.5	O K
180 min Winter	10.016	0.366	0.0	0.5	0.5	409.3	O K
240 min Winter	10.042	0.392	0.0	0.5	0.5	440.5	O K
360 min Winter	10.075	0.425	0.0	0.5	0.5	479.6	O K
480 min Winter	10.093	0.443	0.0	0.5	0.5	502.9	O K
600 min Winter	10.108	0.458	0.0	0.6	0.6	518.3	O K
720 min Winter	10.121	0.471	0.0	0.6	0.6	529.1	O K
960 min Winter	10.136	0.486	0.0	0.6	0.6	542.8	O K
1440 min Winter	10.150	0.500	0.0	0.6	0.6	555.0	O K
2160 min Winter	10.158	0.508	0.0	0.6	0.6	562.1	O K
2880 min Winter	10.162	0.512	0.0	0.6	0.6	565.6	O K
4320 min Winter	10.168	0.518	0.0	0.6	0.6	571.3	O K
5760 min Winter	10.173	0.523	0.0	0.6	0.6	576.0	O K
7200 min Winter	10.181	0.531	0.0	0.6	0.6	582.8	O K
8640 min Winter	10.190	0.540	0.0	0.6	0.6	590.9	O K
10080 min Winter	10.201	0.551	0.0	0.6	0.6	601.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m^3)	Discharge Volume (m^3)	Time-Peak (mins)
15 min Winter	157.360	0.0	27.5	19
30 min Winter	101.360	0.0	31.4	34
60 min Winter	62.020	0.0	67.5	64
120 min Winter	39.270	0.0	75.9	124
180 min Winter	29.549	0.0	80.2	182
240 min Winter	23.905	0.0	82.7	242
360 min Winter	17.430	0.0	85.1	362
480 min Winter	13.768	0.0	86.0	480
600 min Winter	11.401	0.0	86.0	598
720 min Winter	9.742	0.0	85.7	716
960 min Winter	7.561	0.0	84.3	954
1440 min Winter	5.244	0.0	80.1	1428
2160 min Winter	3.633	0.0	166.2	2136
2880 min Winter	2.812	0.0	160.2	2824
4320 min Winter	1.987	0.0	146.7	4192
5760 min Winter	1.574	0.0	316.4	5536
7200 min Winter	1.330	0.0	309.3	6840
8640 min Winter	1.171	0.0	300.9	8040
10080 min Winter	1.060	0.0	291.0	8376

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.490

Time (mins) From:	To:	Area (ha)
0	4	0.490

Model Details

Storage is Online Cover Level (m) 10.550

Complex Structure

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	392.0	392.0	0.451	0.0	427.7
0.450	392.0	427.6			

Cellular Storage

Invert Level (m) 9.650 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	607.1	607.1	0.601	0.0	666.3
0.600	607.1	666.2			

Tank or Pond

Invert Level (m) 9.650

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	38.0	0.600	146.0

Tank or Pond

Invert Level (m) 9.650

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	62.0	0.600	228.0

Orifice Outflow Control

Diameter (m) 0.020 Discharge Coefficient 0.600 Invert Level (m) 9.650

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 4739 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.527	0.127	0.0	0.3	0.3	82.0	O K
30 min Summer	9.563	0.163	0.0	0.3	0.3	105.5	O K
60 min Summer	9.599	0.199	0.0	0.4	0.4	128.8	O K
120 min Summer	9.651	0.251	0.0	0.4	0.4	162.4	O K
180 min Summer	9.680	0.280	0.0	0.4	0.4	182.4	O K
240 min Summer	9.699	0.299	0.0	0.4	0.4	195.9	O K
360 min Summer	9.722	0.322	0.0	0.5	0.5	212.4	O K
480 min Summer	9.735	0.335	0.0	0.5	0.5	221.8	O K
600 min Summer	9.743	0.343	0.0	0.5	0.5	227.7	O K
720 min Summer	9.748	0.348	0.0	0.5	0.5	231.5	O K
960 min Summer	9.754	0.354	0.0	0.5	0.5	235.5	O K
1440 min Summer	9.755	0.355	0.0	0.5	0.5	236.8	O K
2160 min Summer	9.751	0.351	0.0	0.5	0.5	233.9	O K
2880 min Summer	9.745	0.345	0.0	0.5	0.5	229.4	O K
4320 min Summer	9.736	0.336	0.0	0.5	0.5	222.5	O K
5760 min Summer	9.732	0.332	0.0	0.5	0.5	219.7	O K
7200 min Summer	9.732	0.332	0.0	0.5	0.5	219.8	O K
8640 min Summer	9.734	0.334	0.0	0.5	0.5	221.2	O K
10080 min Summer	9.737	0.337	0.0	0.5	0.5	223.6	O K
15 min Winter	9.527	0.127	0.0	0.3	0.3	82.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	157.360	0.0	22.6	19
30 min Summer	101.360	0.0	26.0	34
60 min Summer	62.020	0.0	54.5	64
120 min Summer	39.270	0.0	62.2	124
180 min Summer	29.549	0.0	66.2	184
240 min Summer	23.905	0.0	68.6	244
360 min Summer	17.430	0.0	70.9	364
480 min Summer	13.768	0.0	71.7	484
600 min Summer	11.401	0.0	71.9	604
720 min Summer	9.742	0.0	71.6	722
960 min Summer	7.561	0.0	70.4	962
1440 min Summer	5.244	0.0	66.8	1442
2160 min Summer	3.633	0.0	133.4	2160
2880 min Summer	2.812	0.0	128.9	2880
4320 min Summer	1.987	0.0	118.1	3632
5760 min Summer	1.574	0.0	234.9	4376
7200 min Summer	1.330	0.0	232.3	5120
8640 min Summer	1.171	0.0	227.6	5968
10080 min Summer	1.060	0.0	220.7	6848
15 min Winter	157.360	0.0	22.6	19

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	9.563	0.163	0.0	0.3	0.3	105.5	O K
60 min Winter	9.599	0.199	0.0	0.4	0.4	128.8	O K
120 min Winter	9.651	0.251	0.0	0.4	0.4	162.4	O K
180 min Winter	9.680	0.280	0.0	0.4	0.4	182.4	O K
240 min Winter	9.699	0.299	0.0	0.4	0.4	195.9	O K
360 min Winter	9.722	0.322	0.0	0.5	0.5	212.5	O K
480 min Winter	9.735	0.335	0.0	0.5	0.5	221.9	O K
600 min Winter	9.743	0.343	0.0	0.5	0.5	227.8	O K
720 min Winter	9.748	0.348	0.0	0.5	0.5	231.6	O K
960 min Winter	9.754	0.354	0.0	0.5	0.5	235.7	O K
1440 min Winter	9.756	0.356	0.0	0.5	0.5	237.2	O K
2160 min Winter	9.752	0.352	0.0	0.5	0.5	234.6	O K
2880 min Winter	9.747	0.347	0.0	0.5	0.5	230.8	O K
4320 min Winter	9.737	0.337	0.0	0.5	0.5	223.3	O K
5760 min Winter	9.731	0.331	0.0	0.5	0.5	219.1	O K
7200 min Winter	9.729	0.329	0.0	0.5	0.5	218.0	O K
8640 min Winter	9.729	0.329	0.0	0.5	0.5	218.0	O K
10080 min Winter	9.731	0.331	0.0	0.5	0.5	218.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	101.360	0.0	26.0	34
60 min Winter	62.020	0.0	54.5	64
120 min Winter	39.270	0.0	62.3	122
180 min Winter	29.549	0.0	66.2	182
240 min Winter	23.905	0.0	68.6	242
360 min Winter	17.430	0.0	70.9	360
480 min Winter	13.768	0.0	71.8	478
600 min Winter	11.401	0.0	71.9	596
720 min Winter	9.742	0.0	71.7	714
960 min Winter	7.561	0.0	70.5	950
1440 min Winter	5.244	0.0	66.9	1414
2160 min Winter	3.633	0.0	133.5	2100
2880 min Winter	2.812	0.0	129.1	2768
4320 min Winter	1.987	0.0	118.3	4016
5760 min Winter	1.574	0.0	235.1	4496
7200 min Winter	1.330	0.0	232.6	5408
8640 min Winter	1.171	0.0	228.1	6392
10080 min Winter	1.060	0.0	221.3	7264

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 550950 257200 TL 50950 57200
Data Type	Catchment
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.950
Cv (Winter)	0.950
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.220

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.220

Model Details

Storage is Online Cover Level (m) 10.250

Complex Structure

Cellular Storage

Invert Level (m) 9.400 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	499.3	499.3	0.451	0.0	539.6
0.450	499.3	539.5			

Cellular Storage

Invert Level (m) 9.400 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	181.0	181.0	0.601	0.0	213.3
0.600	181.0	213.3			

Tank or Pond

Invert Level (m) 9.650

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	57.0	0.600	218.0

Orifice Outflow Control

Diameter (m) 0.020 Discharge Coefficient 0.600 Invert Level (m) 9.400

APPENDIX 5

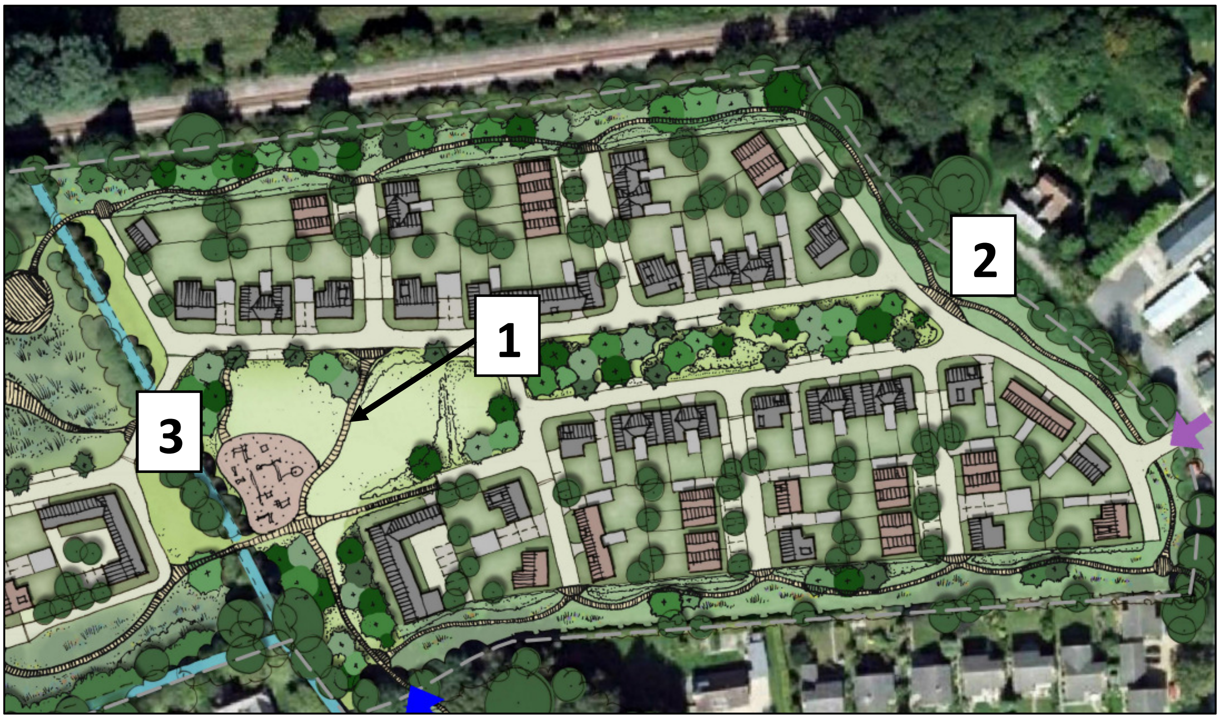
B411 – Teversham Road, Fulbourn, Cambridgeshire
Reserved Matters Application - Layout
For Castlefield International Ltd
12th August 2020

This note summarises the results of a refreshed surface water/overland flow flood model for the permitted development between Teversham Road and Cox's Drove in Fulbourn Cambridgeshire.

The purpose of refreshing the model was to address concerns raised by the interim Sustainable Drainage Engineer about the potential impacts of amendments to the footprint (the development parcels) on flood levels at the site. The refreshed flood modelling report, reference FWM8709-RT001-R01-00 (from HR Wallingford) is provided separately. For convenience this note presents the 'worse-case' flood levels resulting from the 1 in 1,000 storm event. As before the 1 in 1,000 storm levels will be the reference flood levels.

The key changes from the approved outline layout with regards to a potential impact on flooding are listed below and identified on the image below (illustrative outline layout) and overleaf (June 2020 layout).

1) The shift of the flood retention bank (which houses the five 150 mm diameter flow control pipes) in the central linear park and meadow park westwards.
2) The removal the short section of road from the east of the linear park.
3) The increase in the size of the play area and raising 2/3 of the area to create a solid platform.

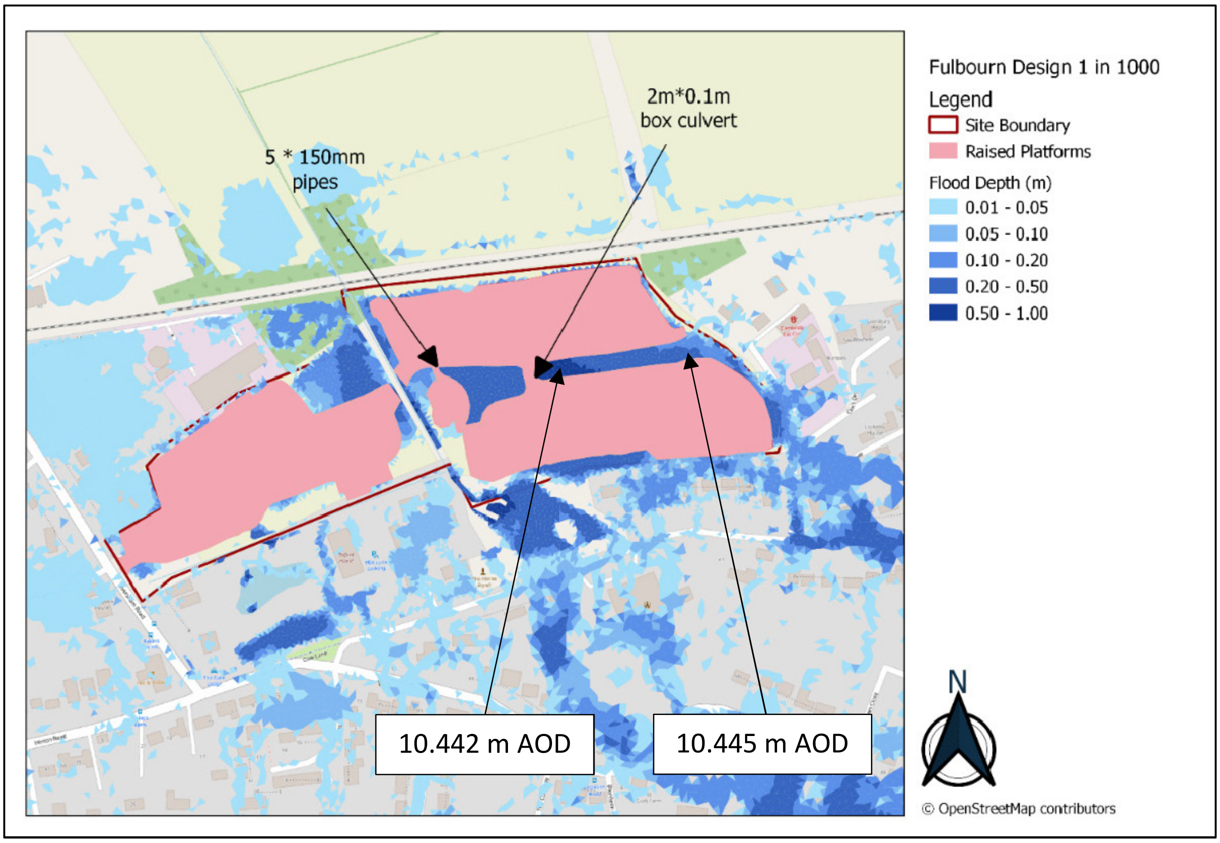


Illustrative layout from the 2017 application.

Reserved Matters application layout.

The primary purpose of the model refresh was to test that the Reserved Matters layout did not result in unmanageable flood levels and continued to provide sufficient space for floodwater. The process of refreshing the model also allowed a detailed investigation of how more use could be made of the linear park storage area. As discussed in the HR Wallingford report (reference FWM8709-RT001-R01-00) this was achieved by simulating a single box culvert (2 m wide by 0.1 m high) beneath the short section of road which divides the linear park from the meadow park. This has the effect of limiting flows from the linear park into the meadow park. This arrangement resulted in flood levels during the 1 in 1,000 event (the worse-case event) in the linear park ranging from 10.442 to 10.445 m AOD and levels in the meadow park of 9.980 m AOD.

For the rest of the development platforms the images in the modelling report confirm that, as before, platform levels of 500 mm above existing ground level will effectively manage flooding (and keep the units dry). The extracted image from the modelling report overleaf shows that aside from a deeper area of flooding in the west of the linear park (for which a specific level has been confirmed) the floodwater around the platforms is 500 mm or less than existing ground levels.



Extract from the modelling report showing the 1 in 1,000 flood event with specific linear park levels added.

As levels are not one of the five Reserved Matters, the levels will not be set at this stage (although a condition may be added to the Reserved Matters permission if deemed necessary).

In conclusion:

- The proposed layout does not materially alter flooding in comparison to the approved illustrative layout and maintains sufficient space for floodwater to be held within, and move through, the site.
- Worse case flood levels (during the 1 in 1,000 storm) are approximately 10.45 m AOD. This will be achieved by setting road levels around the linear park at or above 10.45 m AOD.
- The revised model confirms that for the rest of the site raising the platform levels 500 mm above existing ground levels will continue to protect the proposed units as the worse-case flood depths are in the 200 to 500 mm depth band.

APPENDIX 6

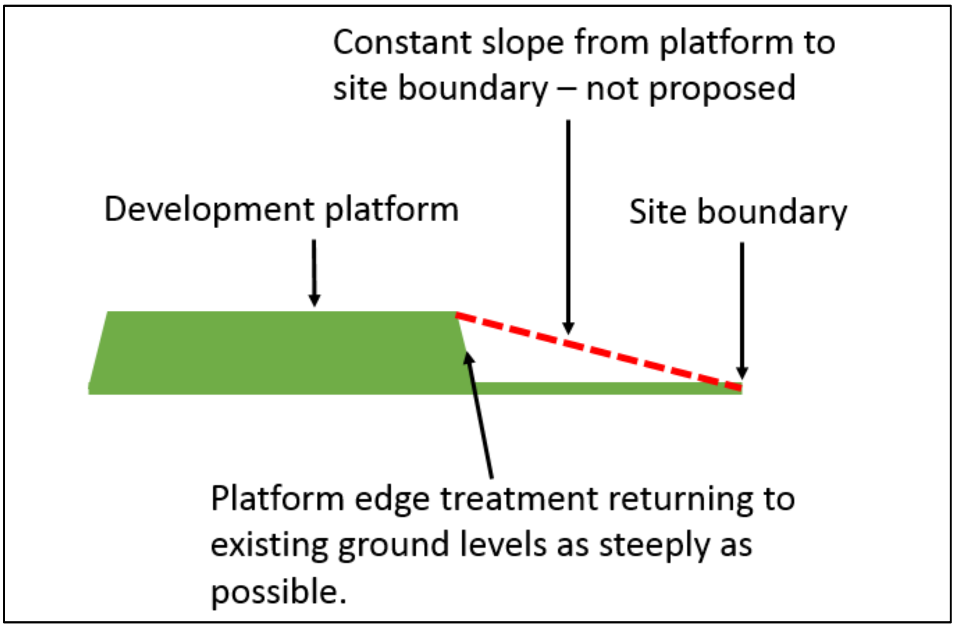
B411 – Teversham Road, Fulbourn, Cambridgeshire
Reserved Matters Application – Layout Update
For Castlefield International Ltd
13th April 2021

This note accompanies an amendment to the Reserved Matters Application (reference S/3290/RM/19) currently under consideration for the permitted development between Teversham Road and Cox's Drove in Fulbourn, Cambridgeshire.

The note addresses flood risk queries raised in January 2021 by local residents. Residents expressed concerns about the potential for site runoff to be directed towards properties on the south-eastern boundary of the site, and the increase in surface water flooding to the south-east of the site which was indicated by the flood modelling (the flood modelling which supported the outline application and the revised flood model prepared and submitted in 2020).

For clarity, the 2017 outline application was supported by a surface water flood model. This flood model was updated in 2020 (to reflect the revised layout submitted for Reserved Matters approval). The new layout which this note accompanies occupies a smaller parcel than the earlier layout submitted for Reserved Matters approval. The revised layout will not therefore have a negative impact on the flood risk (levels, depths etc) established by the 2020 flood model.

The concern that runoff from the site will be shed overland towards the properties on Cow Lane can be addressed by confirming that it is not proposed create a continuous slope between the edge of the raised development platforms and the site boundary. Proposed ground levels will instead return to existing ground levels (or lower) as 'quickly' as possible (see illustrative sketch below).



Simple development platform edge treatment illustration

To address the concerns about increased flood depths predicted by the 2017 and 2020 flood modelling, a floodwater storage basin will be provided along the southern boundary. The shallow basin (500 mm deep) is sized to accommodate a volume of 150 m^3. This volume has been calculated by comparing the post development floodwater surface to the baseline floodwater surface for the 1 in 1,000 annual probability flood. The two floodwater surfaces are not simple flat surfaces as floodwater is typically a flowing, complex surface. The increase in volume has therefore been modelled using terrain modelling software to determine the difference between the two complex surfaces. The basin therefore provides space for floodwater to offset the potential increase in flood volumes predicted by the flood modelling. Currently it is proposed to allow the floodwater from the basin to dissipate through infiltration, evaporation etc (to provide some small benefit); however should a more formal outflow be required then a simple grass topped stone trench would be constructed to allow natural seepage into the central watercourse.

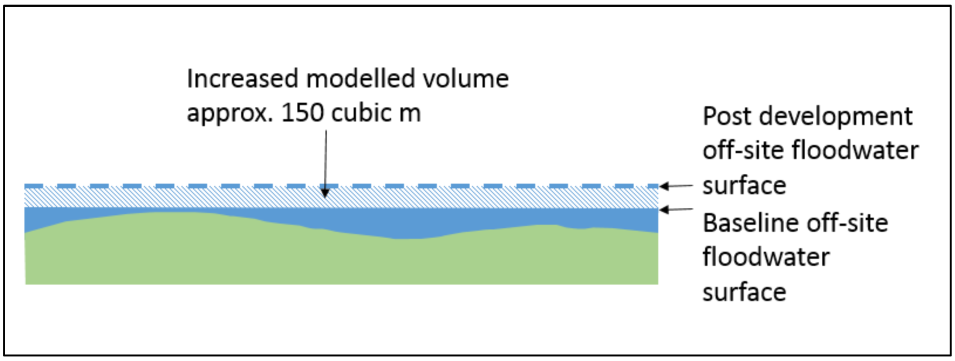
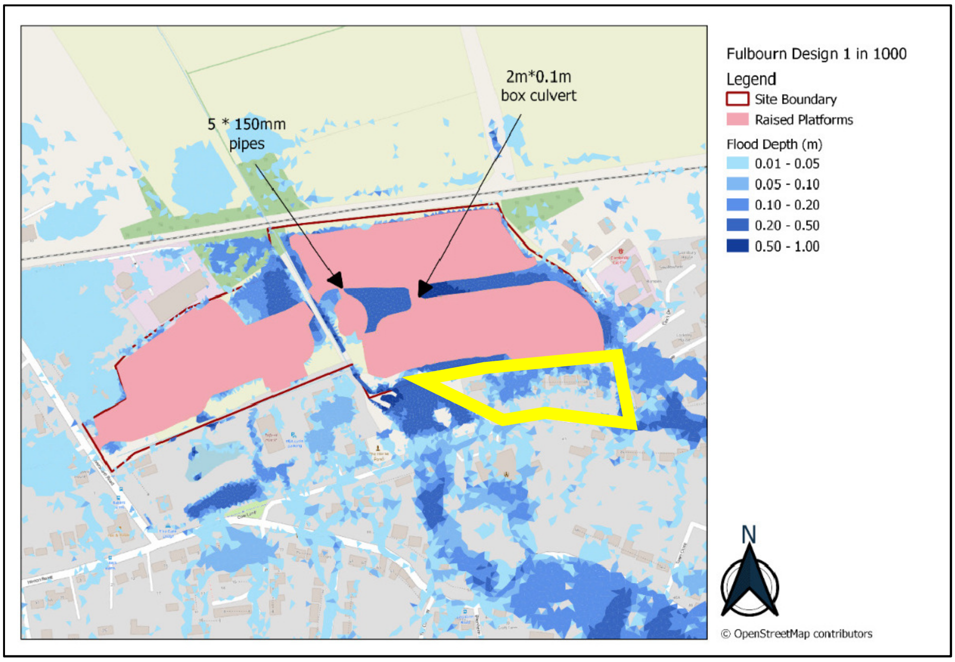


Illustration of the compensatory flood storage volume provided by the scheme.



Area of compensatory storage assessment – note that the flood depths in the legend are ranges and do not show actual depths.

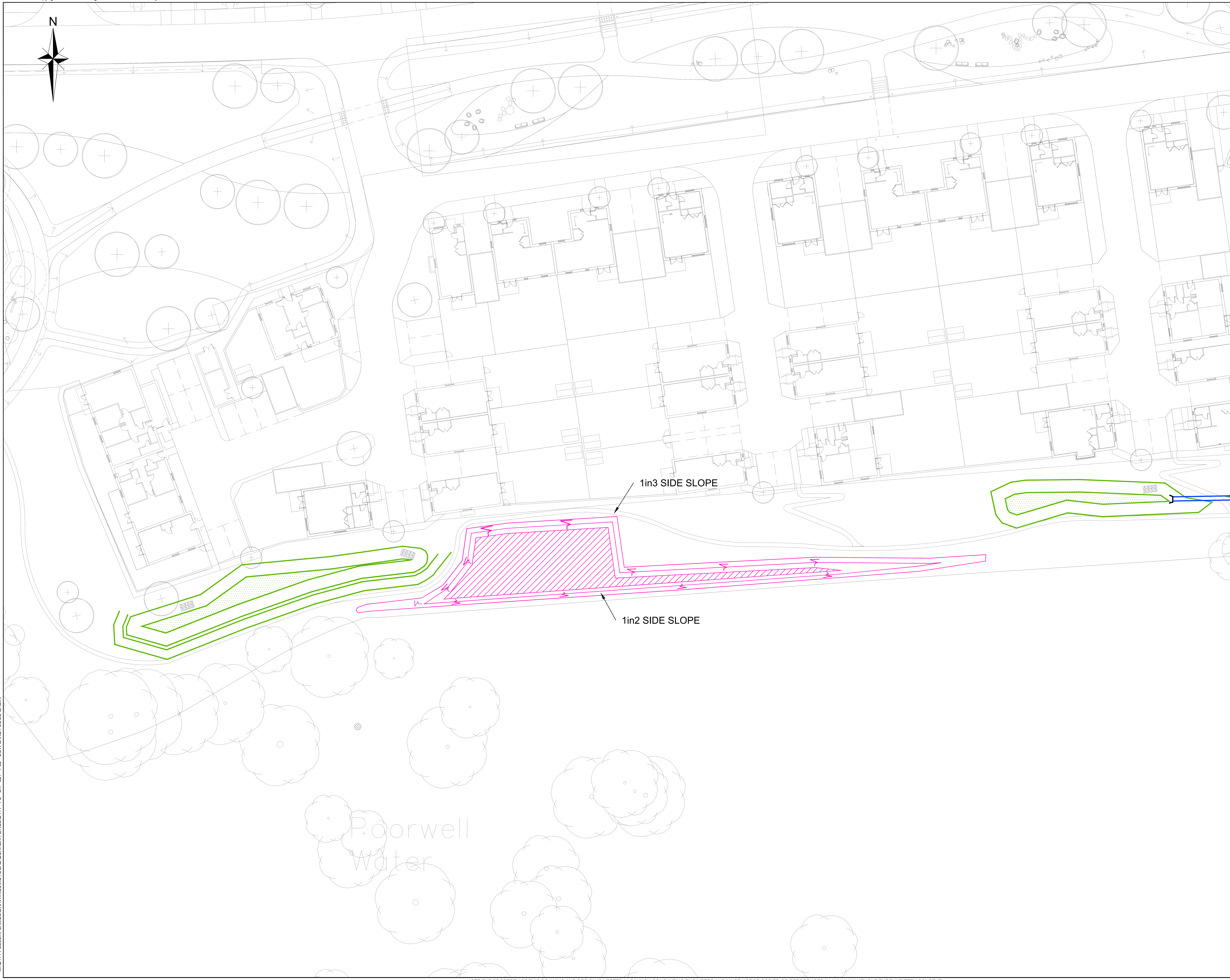
The provision of such a compensatory flood storage basin was discussed in a video meeting with the Lead Local Flood Authority (LLFA) and the Cambridge City/South Cambridgeshire sustainable drainage team.

To reiterate, there are no plans to increase ground levels along the south-eastern boundary of the site to prevent floodwater from spilling onto the site from the properties on Cow Lane. As part of the 'water centric' design progression of the site, the strip of land along the south-eastern boundary of the site has always been set aside as an area for floodwater (as well as ecology and landscaping).

For clarity, the surface water management scheme for the site falls under a separate application (reference S3209/19/DC). Revisions to, and queries about, the surface water management (drainage) scheme will therefore continue to be addressed under this Discharge of Condition application.

Appended information

Drawing B411 – PL – SK – 321 – Cow Lane Flood Basin



KEY

SURFACE WATER ATTENUATION BASIN (FOR REFERENCE)

COW LANE FLOOD BASIN 500mm DEEP PROVIDING 150m³ STORAGE

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P02	REVISED TO SUIT NEW LAYOUT	DP			14/04/2021
P01	REVISED TO SUIT NEW LAYOUT	DP			13/04/2021

DESIGNED BY	DRAWN BY	CHECKED BY
-	DP	-

SCALE @ A1 SIZE	DATE
D.N.S.	12/04/2021

PROJECT TITLE

FULBOURN, CAMBRIDGE

DRAWING TITLE

COW LANE FLOOD BASIN

CLIENT

CASTLEFIELD INTERNATIONAL LTD

CANNON CONSULTING ENGINEERS
Highways, Transport & Infrastructure Planning

Peek House, 20 Eastcheap
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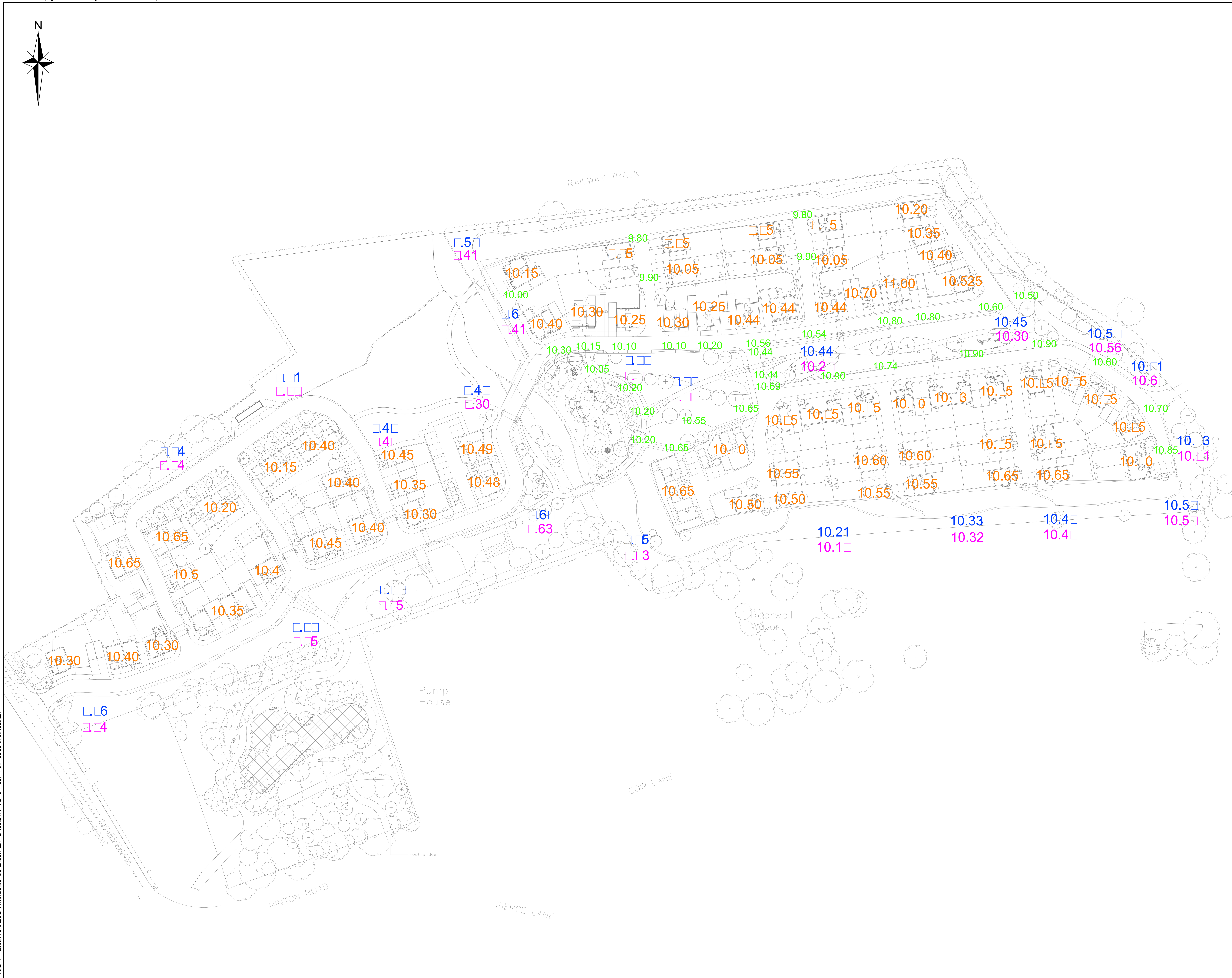
EC3M 1EB
Tel: 020 □□1□5□□0
info@cannonce.co.uk

Cambridge House, Lanwades
Business Park, Kentford,
Newmarket, CB□ □PN
Tel: 0163□55510□
www.cannonce.co.uk

DRAWING NUMBER	REV.
B411 - PL - SK - 321	P02

M:□B411 Fulbourn, CAMBS□DRAWINGS□AUTOCAD□CURRENT DRGS□B411 - PL - SK - 321 - P02 - COW LANE FLOOD BASIN

APPENDIX 7



KEY

X.XX	1 in 1,000 FLOOD LEVEL.
X.XX	1 in 100 FLOOD LEVEL PLUS 40 □ CLIMATE CHANGE.
X.XX	PROPOSED FINISHED FLOOR LEVELS
X.XX	PROPOSED ROAD EDGE/FOOTPATH LEVELS

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P0□	REVISED TO SUIT NEW LAYOUT	DP			14/04/2021
P0□	REVISED TO SUIT NEW LAYOUT	DP			13/04/2021
P0□	REVISED TO SUIT NEW LAYOUT	DP			12/04/2021
P06	LEVELS REVISED	JH			1□/11/2020
P05	LEVELS ADDED AND REVISED	JH			1□/11/2020
P04	LEVELS ADDED	JH			01/11/2020
P03	LEVELS ADDED	JH			2□/10/2020
P02	LEVELS ADDED AND REVISED	JH			14/10/2020

DESIGNED BY: -
DRAWN BY: JH
CHECKED BY: -

SCALE @ A1 SIZE: D.N.S.
DATE: 1□/0□/2020

PROJECT TITLE
LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE
FLOOD MANAGEMENT STRATEGY

CLIENT
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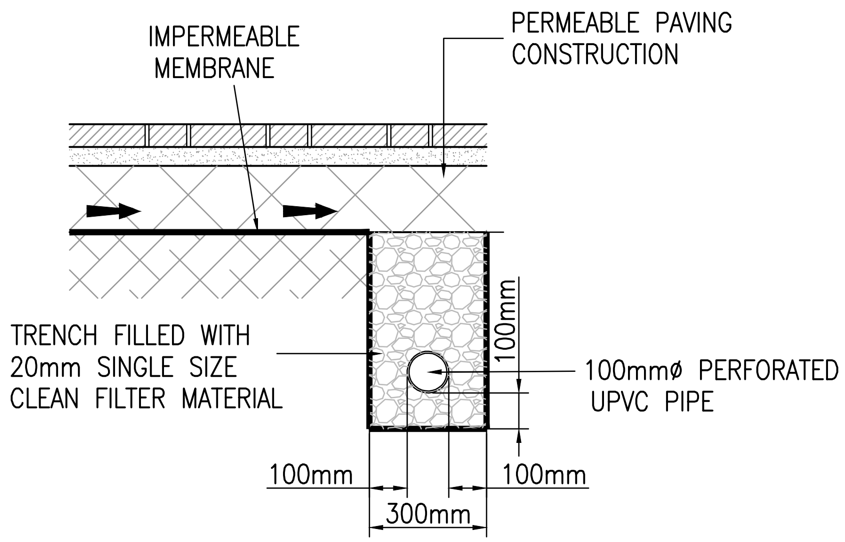
DRAWING NUMBER: B411 - PL - SK - 320
REV.: P0□

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 320 - P0□ FLOOD MANAGEMENT

APPENDIX 8

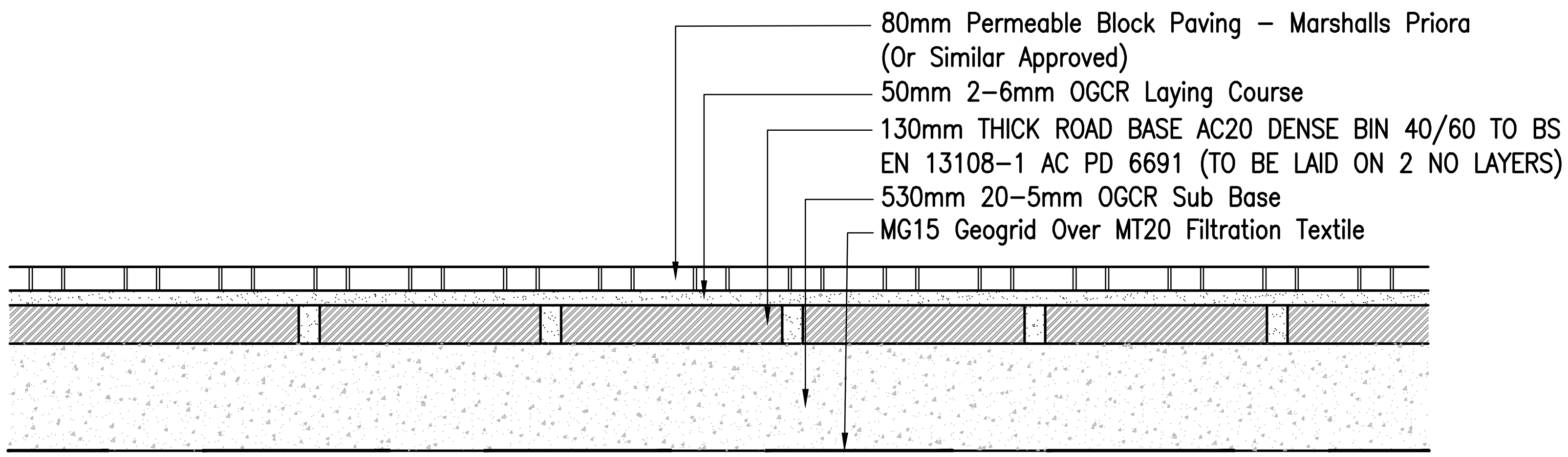

GROUND WATER
LEVEL 12/04/22
65 cms
Explore

APPENDIX 9



CROSS SECTION OF DRAIN

PERFORATED PIPE DRAINAGE DETAILS
SCALE 1:20



TYPICAL PERMEABLE CONSTRUCTION SECTION – (TO BE INSTALLED TO MANUFACTURERS SPECIFICATION)
SCALE 1:25

NOTES:

1. DO NOT SCALE THIS DRAWING.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ENGINEERS, ARCHITECTS AND SPECIALIST DESIGN DRAWINGS AND DETAILS.
3. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE. ALL LEVELS ARE IN METRES UNLESS NOTED OTHERWISE.
4. ANY DISCREPANCIES NOTED ON SITE ARE TO BE REPORTED TO THE ENGINEER IMMEDIATELY.

REV:	AMENDMENTS:	DRN:	CHK:	APP:	DATE:
-	FIRST ISSUE	RC	PT	AB	26.04.22

PROJECT:
LAND EAST OF TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE:
PERMEABLE PAVING CONSTRUCTION DETAILS

CLIENT:
SAVE FULBOURN FIELDS AND FULBOURN FORUM RULE 6 PARTY

DRAWING NUMBER:
27275_01_230_02

REVISION:	SHEET SIZE:	SCALE:
-	A3	AS SHOWN

STATUS:
FOR INFORMATION / APPROVAL

M-EC
Consulting Development Engineers

Telephone: 01530 264 753
Email: group@m-ec.co.uk
Website: www.m-ec.co.uk

File Location: T:\M-EC Job Book\27275\drawing\Standard Permeable Paving Construction Details.dwg
Printed:26.04.2022

APPENDIX 10

How will crates be delivered with play equipment?

Basin depth below groundwater level!

No attenuation volume details ... anywhere!

No tanks?

Tanks in adoptable roads?

Potential retaining requirements.

No details on specific discharge rates for each outfall

Cow Lane Flood Basin not shown!

Impermeable areas don't appear to include roads.

Pond outfall and suitability to take flows?

M-EG

SK_27275.

Drawn By: AB

Date: 26/4/22

KEY

- 5 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- 4 x 0.15m HIGH SUB-BASE REPLACEMENT CRATES. PERMAVOID OR SIMILAR APPROVED
- SW NETWORK (SECTIONS OF CONNECTING PIPEWORK)
- ORIFICE CONTROL CHAMBER
- ROADSIDE FILTER DRAIN
- RILL/CHANNEL DRAIN TAKING FLOW TO AND FROM THE PUMPING HOUSE POND

NOTES

REV	DESCRIPTION	DE	DR	CH	DATE
P01	NOTES REMOVED		DP	-	04/2022

DESIGNED BY: -
DRAWN BY: DP
CHECKED BY: -

SCALE @ A1 SIZE: D.N.S.
DATE: 31/03/2022

PROJECT TITLE: LAND AT TEVERSHAM ROAD, FULBOURN, CAMBRIDGESHIRE

DRAWING TITLE: SURFACE WATER MANAGEMENT STRATEGY

CLIENT: CASTLEFIELD INTERNATIONAL LTD

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DRAWING NUMBER: B411 - PL - SK - 350
REV.: P01

M:\B411 Fulbourn, CAMBS\DRAWINGS\AUTOCAD\CURRENT DRGS\B411 - PL - SK - 350 - P01 - SW STRATEGY

APPENDIX 11

My ref: FR/19-000431
Your ref: S/3290/19/RM
Date: 14/04/2022
Doc no: 201107457
Officer: **Harry Pickford**
E Mail: **harry.pickford@cambridgeshire.gov.uk**

Cambridgeshire County Council

Steve Cox: Executive Director
Place and Economy
Planning, Growth & Environment

New Shire Hall
Emery Crescent
Enterprise Campus
Alconbury Weald
PE28 4YE

Michael Sexton
South Cambridgeshire District Council
South Cambridge Hall
Cambourne Business Park
CB23 6EA

Proposal: Approval of matters reserved for appearance, landscaping, layout and scale following outline planning permission S/0202/17/OL for the development of 110 dwellings with areas of landscaping and public open space and associated infrastructure works The outline was screened and confirmed not too be EIA development

Land east of Teversham Road, Fulbourn, Cambridgeshire

<u>Comments from Lead Local Flood Authority (LLFA)</u>

Dear Sir,

Thank you for your re-consultation which we received on 5th April 2022.

The LLFA has been consulted as further information has been provided to support this application. The documents provided are:

- Flood Modelling and Surface Water Management Update, Canon Consulting Engineers, Dated: April 2022
- Update to Surface Water Flood Management, HR Wallingford, Ref: FWM9010-RT-0001-R3-00, Dated: 1 April 2022

Due to the high levels of local concern regarding surface water flood risk in this area, the LLFA commissioned a consultancy to undertake the review of the modelling document, to peer review the results. The findings of the modelling report provided by the consultant are set out below:

General
No model files have been provided to verify the information in the report therefore it is possible that other findings may be identified on receipt of an ICMT of the model run files and results.

Catchment
The catchment area has been updated based on LIDAR data by the applicant – consideration should be paid to the action of local drainage ditches or channels (such as those running along-

side roads) that have potential to extend the catchment draining to the watercourse running through the site.

Catchment Descriptors
Final catchment descriptors used to generate flows and rainfall should be quoted in the report for auditability. Only limited descriptors are quoted.

Urban Area / Impermeable Area
The measure of impermeable area may be appropriate for ReFH2 lumped flow estimate however where this is used to define runoff surfaces in the ICM model it appears that only roof and carriageways have been identified as impermeable surfaces. From review of local ground level photos there appear to be extensive paved curtilages associated with the residential properties that are expected to be majority impermeable suggesting that the impermeable area is underestimated. The assumption of 70% runoff from urban areas is generally to account for the more generous delineation of urban surfaces. Therefore, it is expected that the model may be underestimating runoff from urban areas.

Rural Runoff
A rural runoff value of 6.1% has been used for all rural areas and non-impermeable urban areas, to create in effect a continuing loss where 93.9% of rainfall falling on rural areas is assumed to infiltrate for all return periods and storm durations. The runoff percentage is consistent with catchment descriptor SPRHOST. However, it is noted that the area of interest has a very shallow ground water level and for shorter duration events rainfall intensity is expected to surpass infiltration potential. Therefore, the use of such a high continuous loss should be reviewed and justified. Currently the hydrology section of the report is not reproducible due to a general absence of specific information.

Sensitivity testing
It is expected that sensitivity testing to runoff coefficient and storm duration and storm profile (within direct rainfall model – not just ReFH2 lumped flow) should be undertaken as a minimum. Sensitivity to Manning's 'n' and downstream boundary condition should be undertaken would also improve confidence in results provided.

Representation of channels
Notwithstanding comments above regarding the review of the catchment in respect to the action of local drainage ditches or channels such as those that run along-side roads it is noted that most channels in the model domain are represented in the 2D domain only. Only the main channel that crosses the site is included as a 1D element. It is not clear the source of the 1D model geometry (survey or from LIDAR). It is not clear how well the channels in the 2D model are represented. Where the upstream channels form a continuous network with the channel that crosses the site it is expected that they may have significant influence on in channel flows and levels that are not fully accounted for in their current 2D representation. A figure to show the extent of the 1D modelled element would be welcome. The source of dimensions and inverts of culverts and other features mentioned in the report should be stated.

Downstream boundary
From the report it is inferred that the 1D channel across the site leaves the site via a 0.8m arched culvert under the railway embankment. It is not clear if this continues as a 1D element beyond the downstream face of the railway embankment or if representation returns to 2D only beyond the railway embankment. There is no discussion of downstream condition / boundary.

Proposed development
It is not clear if runoff has been updated for the proposed development runs to account for the additional impermeable surfaces. It appears that elements of the surface water management design including the Cow Lane flood basin have been included in the site level changes so it would be reasonable to include any additional runoff from developed areas that route to this etc.

Closure
As noted above this review does not benefit from access to the actual model files and has had to rely on what information is included in the report provided. A full review of the model files is recommended in addition to actioning the comments observed above.

Currently there is low confidence in the flood risk mapping outputs provided and would expect further work is required to support the conclusions that are made in the flood risk report.

The above information sets out the concerns regarding the submitted modelling report. However, it has been discussed with the LPA that this is a reserved matters application and the details of the design are reserved under condition 8 of planning permission S/0202/17/OL. The reserved matters application is to confirm appearance, landscaping, layout and scale, as opposed to the detailed design of the surface water network.

Yours faithfully,

H Ellis

Hilary Ellis

Flood Risk Business Manager
Environment and Commercial

If you have any queries regarding this application, please contact the Officer named at the top of this letter (contact details are above).

Please note: We are reliant on the accuracy and completeness of the reports in undertaking our review and can take no responsibility for incorrect data or interpretation made by the authors.

APPENDIX 12

JBA consulting

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Old Lane North
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BD23 3FD
United Kingdom

Jeremy Benn Associates Limited
Registerd in England 3246693

JBA Group Ltd is certified to:
ISO 9001:2015
ISO 14001:2015
ISO27001:2013
ISO 45001:2018

M-EC Consulting Development Engineers
The Old Chapel
Station Road
HUGGLESCOTE
Leicestershire
LE67 2GB

For the attention of Tim Rose, M-EC

Our Ref: GH\Q22-0662-0-S-L001-1.doc

14 April 2021

Dear Sirs,

Mushroom Farm, Pakington – Hydraulic Model Proposal

Thank you for your email dated 5 April 2022 inviting us to provide a proposal to undertake a hydraulic model for the watercourse known as Gilwiskaw Brook adjacent to Lower Fields Mushroom Farm, Normanton Road, Packington. The model results are being used to support a planning application for expansion of the Mushroom Farm.

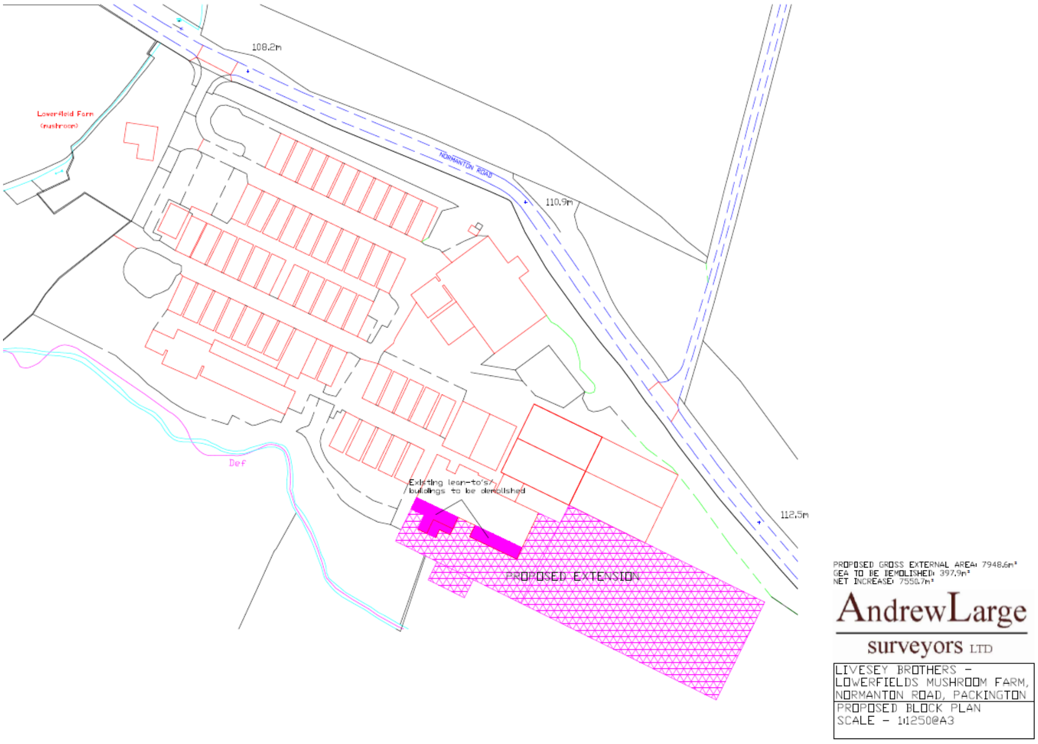

Figure 1 – Proposed Extension

1 Your requirements

The EA Flood Map for Planning (FMfP) shows the proposed site of the extension is located in Flood Zone 3/2. The FMfP in this area consists of output generated by broadscale modelling techniques and is deemed not suitable for Flood Risk Assessments.

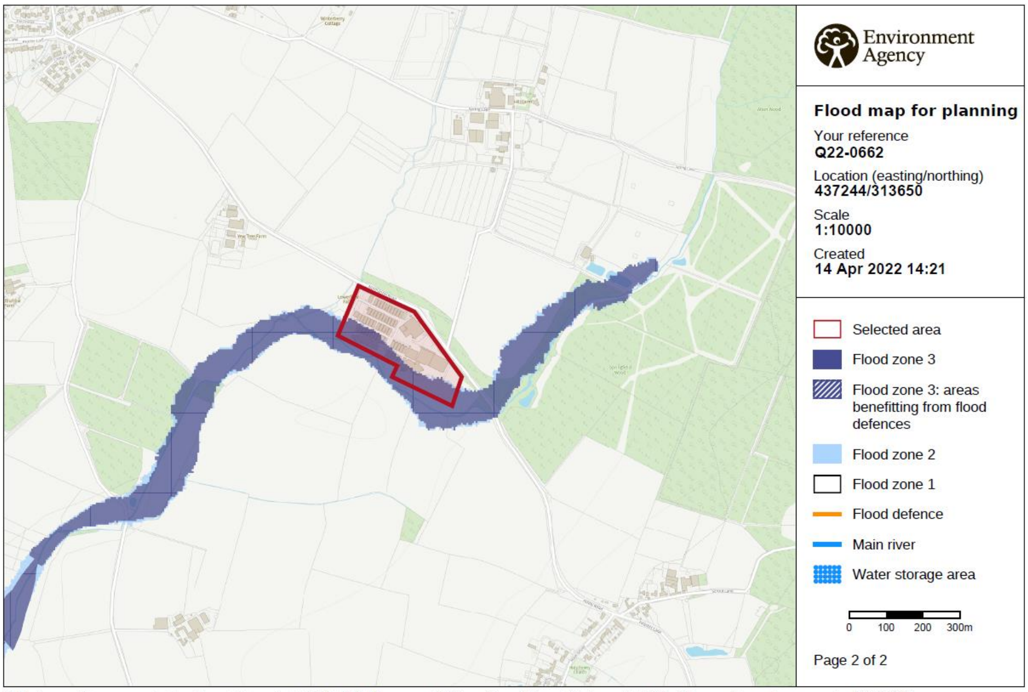

Figure 2 – EA Flood Map for Planning

2 Study scope

There are four distinct elements to the study that are outlined below.

2.1 Topographic survey

In order to build a hydraulic model to fully assess flood risk on Gilwiskaw Brook, channel cross sections are required. We understand survey is to be undertaken by yourselves. Therefore, we have outlined the required specification for modelling.

Survey spec

We estimate 17 cross sections are required (Figure 3). In order to confirm we will undertake a site visit upon contract award to fully assess survey requirements.

Therefore, we recommend the following scope for collection of topographic survey to develop the model:

- Obtain topographic cross sections, including details of any structures such as culverts and bridges to EA specification (version 5.1).
    - *Deliverables include:*
        - *Computer Aided Design (CAD) drawings include cross sections, long sections and key plan.*
        - *Hydraulic model datafiles (EA approved software) – Alternatively we have provided an example of .csv format that can be read into hydraulic modelling software.*
        - *Photographs of cross section locations and structures*
        - *Control and survey report.*

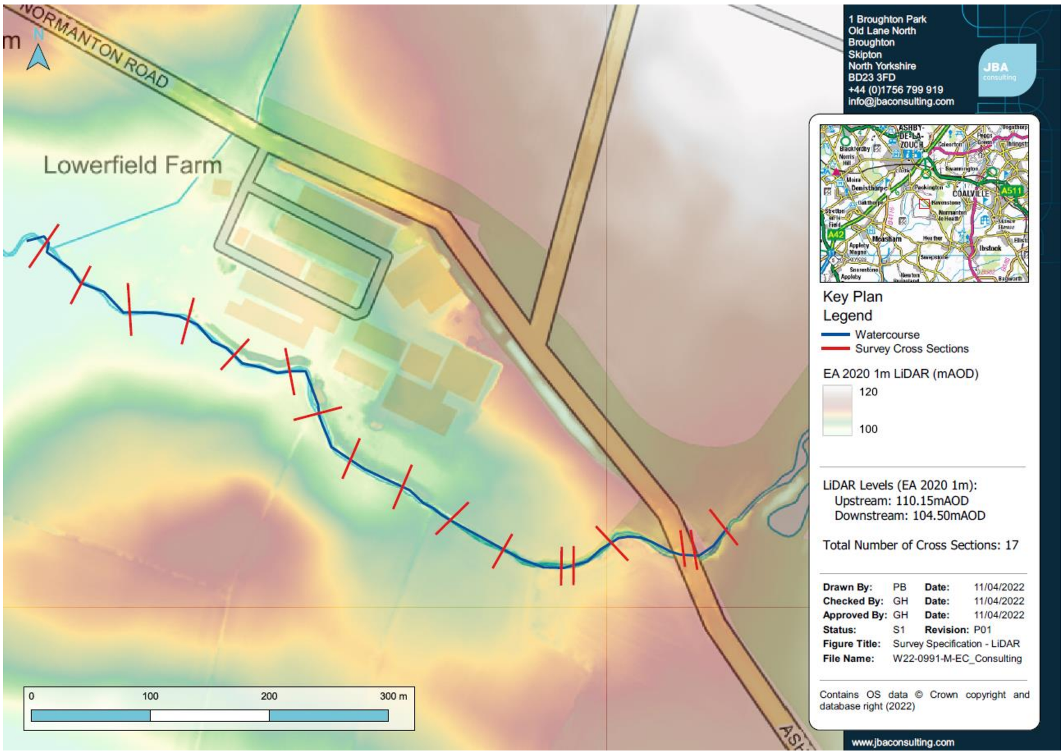

Figure 3 – Proposed survey locations

2.2 Hydrological analysis

The hydrological analysis will be undertaken using EA approved methods and consist of the following tasks:

- Review of Flood Estimation Handbook (FEH) data and definition of the Colburn Brook catchment
- Calculate design flows for range of design events:
    - 2, 5, 10, 20, 50, 75, 100 and 1,000-year
    - 2 x climate change allowances based on latest predictions
- Produce FEH calculation record (industry standard document) detailing assumptions made.

2.3 Hydraulic modelling

Hydraulic modelling will be conducted using latest EA guidance and using approved software. The following tasks will be undertaken:

Baseline Modelling

- Construct 1D-2D model using EA approved software (in this case either HEC-RAS or Flood Modeller-TuFLOW). The following tasks are included:
    - Representation of all channel structures surveyed.
- Run model for range of design events as outlined in Section 3.2. This includes allowances for climate change on the 1% AEP design event
- Undertake sensitivity tests using the model (required as part of EA review process and for 1% AEP only). Tests to include:
    - Roughness
    - Downstream boundary
    - Blockage (culvert/bridge located on Normanton Road).

Compensatory Storage Modelling

If proposed development location is shown to be at flood risk, compensatory storage may be required. The EA will require storage to be provided on a level for level basis. Modelling task will include:

- Identify suitable location and adapt terrain and introduce lower ground elevations.
- Optimisation of compensatory storage based on EA level for level requirements.

2.4 Reporting and flood mapping

The modelling process and results will be summarised a in concise report. This will be delivered in pdf format.

2.5 Meetings and review comments

We have included for one meeting with the EA and model update based on review comments.

3 Cost and timescales

3.1 Cost

Our cost for producing a hydraulic model as outlined in the scope is set out in the table below (All values are exclusive of VAT at prevailing rate).

Activity	Cost (£) (Exc VAT)
Project Management	450
Topographic Survey (Data and management only (Survey cost outlined below))	300
Hydrological analysis	1,580
Hydraulic Modelling	2,985
Reporting, flood mapping and meetings	1,545
Total	**6,860**

3.2 Timescales

We have based our timescales on best available knowledge and factoring in staff availability. We are aware that our suppliers for topographic survey currently have a 4–5 weeks lead time. This will be confirmed on award of contract. On receipt of topographic survey, we envisage the study will take 6-8 weeks. Therefore, the total project will take approximately 10-13 weeks to complete. Upon award we will provide a more robust project programme.

4 Contractual information

4.1 Terms and conditions

We enclose a copy of our terms and conditions of contract (see attached). We would require a formal written instruction to proceed. The enclosed proposal acceptance form may be used for this purpose. If you wish to commission us under an alternative set of T&Cs we would be willing to consider this however, we would reserve the right to revise our fees should these terms provide to be more onerous. We also assume that we would be commissioned directly via yourselves and not a third party.

4.2 Payment

Invoices will be issued on the first working day of each calendar month. Payment of invoices is due within 28 days of the date of issue. Until payment is received in full for all work completed, we retain ownership and intellectual property rights on all documents, drawings, calculations and databases produced by the company. All invoices should be settled in full before the project deliverables are issued as final and Property Intellectual Rights (PIR) will be held by ourselves.

4.3 Professional indemnity

The Professional Indemnity Insurance (PII) cover offered would be £100,000 and the limit of our liability is set at the same amount. We can provide higher cover however for a contract of this value we believe this to be reasonable. If additional cover is required, we reserve the right to review our fees.

We trust this proposal is of interest to you and should you have any queries please do not hesitate to contact the undersigned.

Yours faithfully,
For **Jeremy Benn Associates Limited**

Gavin Hodson MCIWEM C.WEM
Project Manager (Hydraulic Modelling)
gavin.hodson@jbaconsulting.com

Encs. Activity Schedule

Acceptance form

Proposal ref: Q22-0660

Project name: Mushroom Farm, Packington (HM)

Project type: Hydraulic modelling

I confirm I wish JBA to proceed with the following work as outlined in proposal Q22-0660-001 on 14 April 2022.

The person signing below confirms acceptance of the Fee Proposal, the terms and conditions contained therein and is responsible for the payment of our fees.

Contact name:	
Company name:	
Telephone/mobile:	**Email:**

Invoicing Details (To be fully completed)		
☐ Limited Company	☐ Limited Liability Partnership	**Company No:**
☐ Sole Trader	☐ Private Individual	☐ Partnership
Full (company) name:		
Address:		
Signed:		
Name:	**Position:**	
Telephone:	**Mobile:**	
Email:		
PO number:	☐ n/a	☐ To follow
Date:		

Please return this form to the undersign on the attached letter.

JBA consulting

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United Kingdom

+44 (0) 1756 799 919
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APPENDIX 13

---------- Forwarded message ---------
From: **Cambridgeshire Geological Society** <info@cambsgeology.org>
Date: Thu, 14 Apr 2022 at 11:16
Subject: Fwd: FW: Fulbourn Forum - Flooding Consultation on Planning Appeal Teversham Road
To: fulbournforum@gmail.com <fulbournforum@gmail.com>

Hello David

We just saw the email below and had a quick look at the geology map of the site. I don't know whether this information/comment will be of any help to you in responding to the consultation (especially as the deadline is so soon) but we wanted to point out that the statement about the geology in the attached report (page 5 under background to the catchment) is misleading as it states that the 'underlying geology is free draining chalk'. This is not true.

Although the underlying geology is part of the Chalk Formation, it cannot be described as free-draining. It is the lowest of the Chalk strata, the West Melbury Marly Chalk, which has a high clay content and is relatively impermeable, particularly in some areas. It underlies much of the fen edge in this area and its lack of 'free draining' quality results in many patches of wet 'fen' - as see e.g. Teversham Fen and Fulbourn Fen to the north. Further proof of its relative impermeability is the line of springs to the south, along the outcrop of the Totternhoe Stone - a harder band of Chalk that is fissured and, therefore, allows free drainage of water through it. At its base, where it overlies the West Melbury Marly Chalk, numerous springs occur due to the water not being able to penetrate the underlying the clay-rich Chalk.

The proposed development is very near to the spring line- in fact it looks like one of the springs (at Poor's Well) is actually part of the development. This spring site is of considerable geomorphological and geological interest (as are other chalk springs along the fen edge) and may well qualify as a Local Geological Site. We are currently looking at such sites to propose their designation as they are key features in the landscape heritage of Cambridgeshire. There seems to be no mention of this spring line in the report and, therefore, no reference to the significant source of flowing water, adjacent, if not actually within the site.

I have been in touch with Dr Steve Boreham who, as you are aware, knows the area and its geology very well and he agrees that these features are significant and should be taken into account.

Attached is a geology map taken from the British Geological Survey website which shows the (light yellow) West Melbury Marly Chalk to the north of the Totternhoe Stone (the narrow band of darker green that passes through Fulbourn) and the (lighter green) Zig Zag Chalk to the south. You can see that the site is just to the north of the Totternhoe Stone.

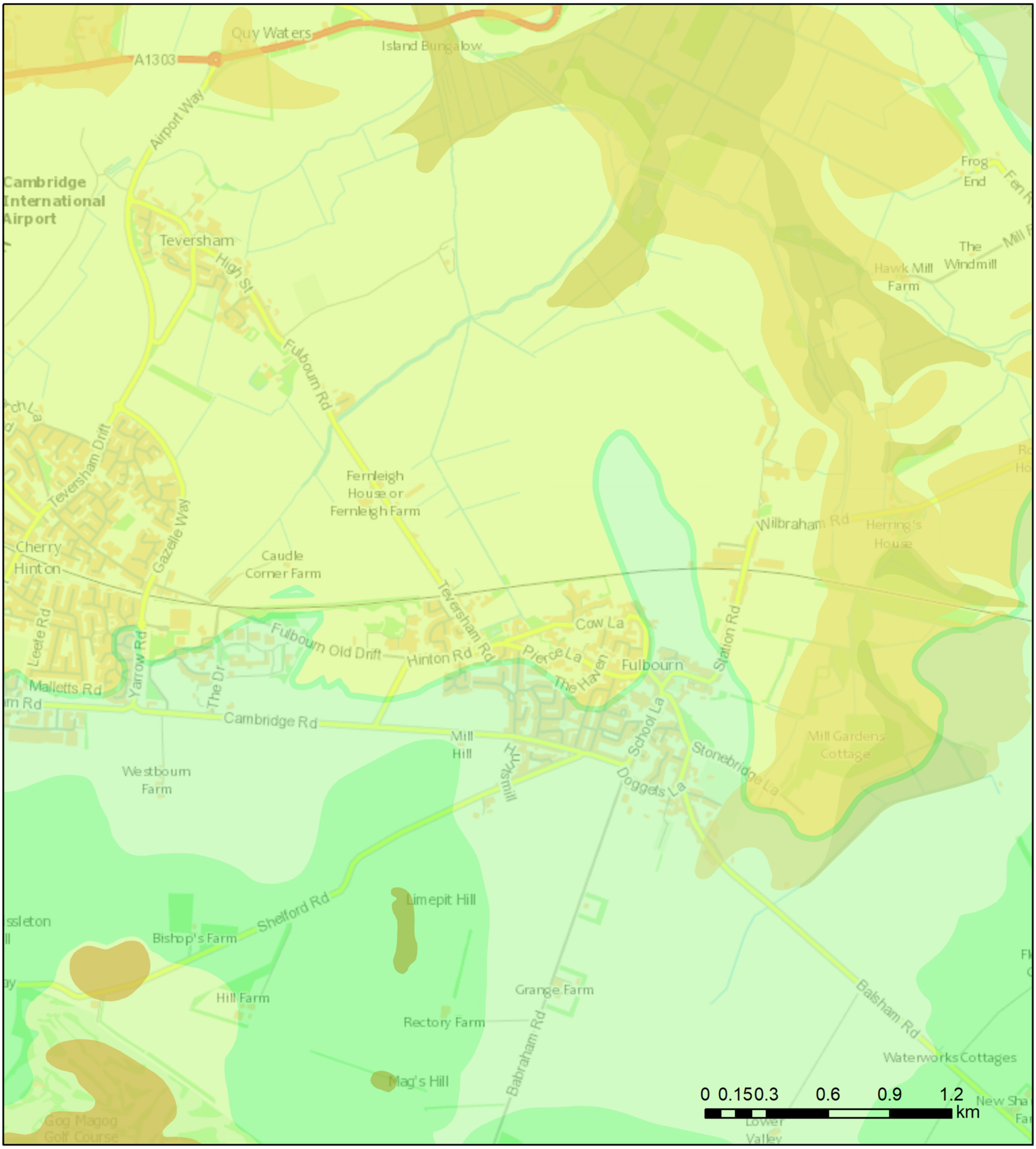
https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.259952778.1090462005.1649927734-771910022.1649927734

Chris

Christine Donnelly

CGS

GeoIndex Report



GeoIndex Onshore Data Sources: NERC, Natural England, English Heritage and Ordnance Survey

Map Key

Superficial deposits 1:50,000 scale

- HEAD - CLAY, SILT, SAND AND GRAVEL
- RIVER TERRACE DEPOSITS, 1 TO 2 - SAND AND GRAVEL
- ALLUVIAL FAN DEPOSITS - CLAY, SILT, SAND AND GRAVEL
- PEAT - PEAT
- LOWESTOFT FORMATION - SAND AND GRAVEL

Bedrock geology 1:50,000 scale

- GAULT FORMATION - MUDSTONE
- ZIG ZAG CHALK FORMATION - CHALK
- NEW PIT CHALK FORMATION - CHALK
- WEST MELBURY MARLY CHALK FORMATION - CHALK
- HOLYWELL NODULAR CHALK FORMATION - CHALK

Selection Results

APPENDIX 14

The accuracy of this Survey corresponds to accuracy band F of the Measured Surveys of Land, Buildings & Utilities RICS Guidance Note 3rd Edition (2014). Any scaling should only be undertaken using a stable media print produced using the original data.

It is for the use only of the party to whom it has been addressed and no responsibility is accepted to any third party for the whole or part of its contents. This Survey has been prepared on the basis that all information and facts, which may affect the Survey, have been disclosed to Mija Survey by all parties concerned and no liability, nor responsibility can be accepted, unless full disclosure has been made.

All ground features that were visible at the time of the Survey have been located, however there may have been items obscured. Pipe sizes and flow direction have been visually assessed from the surface and should be considered as approximate only.

Fences shown are not necessarily legal boundaries.

All data remains in the ownership of Mija Survey and any discrepancies between this Survey and any other information should be reported to Mija Survey.

Abbreviations

AV	Air Valve
ACU	Air Conditioning Unit
BB	Belisha Beacon
BK	Brick
BO	Bollard
BS	Bus Stop
BT	British Telecom cover
CBF	Close Board Fence
CLF	Chain Link Fence
CO	Column
CONC	Concrete
CP	Catch Pit
CPS	Concrete Paving Slabs
CTV	Cable Television Cover
DK	Drop Kerb
EC	Electric Cover
EP	Electricity Pole
ER	Earthing Rod
FB	Flower Bed
FE	Fire Escape
FH	Fire Hydrant
FHR	Fire Hose Reel
FP	Flag Pole
GC	Gas Cover
GP	Gate Post
GU	Gully
GV	Gas Valve
IC	Inspection Cover
IR	Iron Railings
JB	Junction Box
KO	Kerb Outlet
LB	Litter Bin
LL	Low Level
LLF	Larch Lap Fence
LP	Lamp Post
LW	Light Well
MB	Multi-Bole
MH	Manhole
MK	Marker
MT	Meter
OH	Overhead
PM	Parking Meter
PB	Post Box
P/R	Post & Rail
PT	Post
P/W	Post & Wire
RE	Rodding Eye
RET	Retaining
RS	Road Sign
RSJ	Rolled Steel Joist
RWP	Rain Water Pipe
SC	Stop Cock
TCB	Telephone Call Box
TBM	Temp. Bench Mark
TP	Telegraph Pole
TL	Traffic Light
TT	Tactile Paving
UTL	Unable To Lift
V	Vent
VP	Vent Pipe
WC	Water Cover
WM	Water Meter
WSC	Water Stop Cock
WV	Water Valve

Levels

ACL	Arch Crown Level
ASL	Arch Spring Level
CL	Cover Level
CPL	Coping Level
DCL	Door Cill Level
DHL	Door Head Level
EL	Eaves Level
FFL	Finished Floor Level
FL	Floor Level
IL	Invert Level
PL	Parapet Level
RL	Ridge Level
SSL	Structural Slab Level
TFL	Top of Fence Level
TTL	Top of Tree Level
TWL	Top of Wall Level
UBL	Underside of Beam Level
UBXL	Underside of Boxing Level
UDL	Underside of Duct Level
UJL	Underside of Joist Level
UPL	Underside of Pipe Level
URSJL	Underside of RSJ Level
USL	Generic Underside Level
WCL	Window Cill Level
WHL	Window Head Level

Heights

AC	Arch Crown
AS	Arch Spring
DC	Floor to Door Cill
DH	Door Cill to Head
HT	Height
UBX	Underside of Boxing
UD	Underside of Duct
UJ	Underside of Joist
UP	Underside of Pipe
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US	Generic Underside
WC	Floor to Window Cill
WH	Window Cill to Head

Notes

Spot Level +20.00
Arch
Gate
Contours 25.50
Hedge
Foul Pipe
Storm Pipe
Top of Bank
Bottom of Bank
DATUM 12.24 Datum Point
Photo Point
Panoramic Photo Point
ID E=XXXX.XXX N=YYYY.YYY H=ZZZ.ZZZ Survey Station
ID E=XXXX.XXX N=YYYY.YYY H=ZZZ.ZZZ Scan Target

Grid & Datum

Survey Grid

The Survey Grid is in relation to Ordnance Survey Network.

Survey Datum

The Survey is based on Ordnance Survey Datum (Newlyn).

Trees

All trees sizes and heights are approximate and species have been identified to the best of the Surveyors knowledge. Where guaranteed tree species becomes important, the services of an Arborist should be employed.

Notation : Diameter of Trunk / Height / Spread

Trees with bole diameters below the specified minimum size may have not been Surveyed.

Individual tree canopies are shown in a separate layer named RCB_CANOPY, which for presentation purposes has been turned off.

Drainage

Where drainage covers have been lifted, data has been recorded for each individual manhole from the surface and connections to other manholes, pipes or gullys are assumed. Where information is required by accessing the manhole or tracing to other manholes then a services trace will be needed.

Rev	Notes	Date	CAD
A	INSERT DESCRIPTION HERE	##/##/##	PC

Client
Liz Soilleux

Drawing Title
Level Survey

Project
Cow Lane
Fulbourn
Cambridge
CB21 5HB

Scale Bar
Scale in Metres 1:500 @ A2

Surveyor: R.A | Checked: P.C. | Status: FINAL
Issue Date: 14/04/22 | CNG Ref: 15000_01 | Rev: --

MIJA SURVEY
Geospatial Surveying Engineering

Mija Survey
Riverside Business Centre, Kings Lynn, PE30 2HD
info@mijaSurvey.com | www.mijaSurvey.uk

APPENDIX 15

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Consulting Development Engineers