Julian Parry

Flood Risk Assessment and Surface Water Management Strategy for residential development in

Land at Holme Oaks
Ocle Pychard,
Herefordshire,
HR1 3RE

Report L0032/1

December, 2016

Prepared and submitted by

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Ref: L0032

19th December 2016

Dear Julian,

FLOOD RISK ASSESSMENT AND SURFACE WATER MANAGEMENT STRATEGY: OCLE PYCHARD, HEREFORDSHIRE, HR1 3RE TWO RESIDENTIAL DWELLINGS

Thank you for instructing Hydro-Logic Services to undertake a flood risk assessment and surface water management strategy for the above development in Ocle Pychard, Herefordshire, HR1 3RE. Our findings are summarised below:

1) The proposed development is for two dwellings on agricultural land at Holme Oaks, Ocle Pychard, Herefordshire, HR1 3RE, with associated garages, access track, and vehicle parking and turning areas. The total area of the site is approximately 0.26 Ha. The total impermeable surface area of the site would be approximately 354.4 m^2.
2) In terms of the National Planning Policy Framework (NPPF), buildings used as housing are classified as "More Vulnerable".
3) The risk of fluvial flooding is regarded as very low. The proposed development is located within Flood Zone 1, beyond the limits of the 1:1,000 year flood, and therefore the Sequential and Exception Tests are not required.
4) There is a very low risk of surface water flooding and all other sources at the site.
5) Soil infiltration testing to the BRE365 standard, corroborates map evidence that soils at the site have low permeability with impeded drainage. Soil infiltration rates were as low as 0.0070 m/h indicating that the soil is not sufficiently permeable to manage runoff using infiltration alone.
6) Runoff from the 1:100 year rainfall event plus 40% 'Upper End' climate change allowance, from each of the proposed dwellings, could be managed by constructing a geocellular storage structure of the following dimensions: 4 m x 4.8 m and 1.32 m deep, with the outflow controlled by a Hydro-Brake.
7) Residual risk of a rainstorm of magnitude greater than the 1:100 year + CC event would be mitigated by construction of a small berm along the western boundary of the property. This would prevent surface water leaving the site, causing it to pool on the garden until it infiltrated naturally.
8) Rainfall on to the access track and areas for vehicle parking and turning would infiltrate into the ground through the proposed gravel access road and car parking areas.

9) Allowance is made for climate change by increasing the design rainfall by 40%, the NPPF and Environment Agency recommended upper allowance for the potential change in peak rainfall between 2070 and 2115.

10) It is recommended that the surface water management system should be checked for damage or blockage on a regular basis, such a monthly and after heavy rains. All such costs should be borne by the site owner.

In summary, the risk of flooding on site is low and surface water runoff could be managed using attenuation and infiltration to ensure that the development does not increase flood risk elsewhere. If the recommendations within this report are implemented, the proposed development would comply with the flood risk requirements of the NPPF.

Yours sincerely,

Alison Clare-Dalgleish
Principal Hydrologist

Limitation of liability and use

The work described in this report was undertaken for the party or parties stated; for the purpose or purposes stated; to the time and budget constraints stated. No liability is accepted for use by other parties or for other purposes, or unreasonably beyond the terms and parameters of its commission and its delivery to normal professional standards.

Flood Risk Assessment Template
Based on the NPPF Practice Guide[1]

1. Development description and location

1a. What type of development is proposed and where will it be located?

- A location plan at an appropriate scale should be provided with the FRA, or cross referenced to the main application when it is submitted.

The 0.24 hectare development site is located to the North West of Ocle Pychard (National Grid Reference SO 590 465), just off the A465 (Figure 1 and Figure 2). The proposed development comprises the erection of two dwellings with garages on a greenfield site at Holme Oaks, Ocle Pychard, Herefordshire, HR1 3RE, with associated access track, and hardstanding areas for vehicle parking and turning.

Figure 1 Location of the site of proposed development

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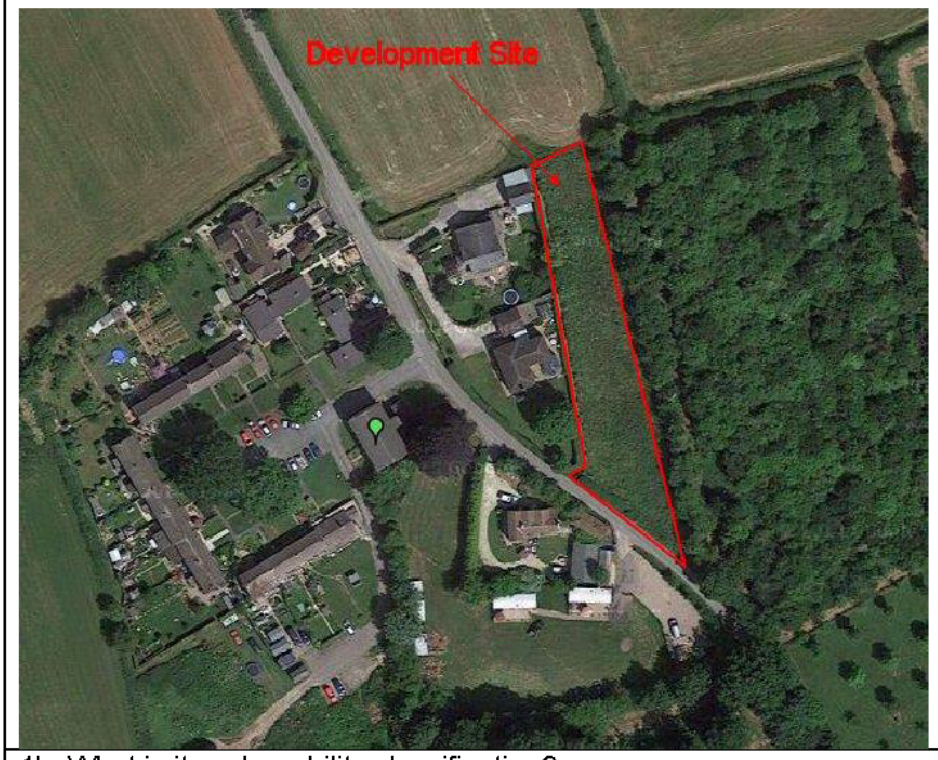
[1] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

Figure 2 Aerial photograph showing the approximate outline of the site



1b. What is its vulnerability classification?

- Vulnerability classifications are provided in Table 2, NPPF Technical Guide

In terms of the National Planning Policy Framework (NPPF), buildings with a residential use are classified as "More Vulnerable".

1c. Is the proposed development consistent with the Local Development Documents?

- Where the site is allocated in an existing LDD the allocation should be referred to. Your Local Planning Authority planning officer should be able to provide site-specific guidance on this issue.

The site of proposed development is covered by Herefordshire Local Plan Core Strategy 2011 – 2031 (Herefordshire Council, 2015). Within the core strategy, the following policies are relevant to the proposed development:

Policy SS2: Delivering new homes

Herefordshire Council aim to deliver a minimum of 16,500 new homes within Herefordshire between 2011 and 2031 to meet market and affordable housing need. Of this 16,500 target, the council have allocated 5,300 new homes to be built in rural settlements.

Policy RA2: Housing in settlements outside of Hereford and the market towns.

Ocle Pychard is listed as one of the settlements to receive new houses designated for rural settlements within the Bromyard HMA (Housing Market Area). Herefordshire Council state that they will support sustainable housing growth on land adjacent to or in the rural settlements listed within Herefordshire Local Plan Core Strategy 2011 – 2031. Bromyard HMA is assigned as providing an indicative 364 of these dwellings, representing some 7% of the total assigned to rural areas. Neighbourhood Development Plans will outline land suitable for housing development or show how housing targets can be met by indicating levels of suitable and available capacity.

Housing proposals which meet the following criteria will be permitted:

1. "Their design and layout should reflect the size, role and function of each settlement and be located within or adjacent to the main built up area. In relation to smaller settlements identified in fig 4.15 proposals will be expected to demonstrate particular attention to the form, layout, character and setting of the site and its location in that settlement and/or they result in development that contributes to or is essential to the social well-being of the settlement concerned;
2. Their locations make the best and full use of suitable brownfield sites wherever possible;
3. They result in the development of high quality, sustainable schemes which are appropriate to their context and make positive contribution to the surrounding environment and its landscape setting: and
4. They result in the delivery of schemes that generate the size, type, tenure and range of housing that is required in particular settlements, reflecting local demand."

The proposed development appears to be consistent with the Local Development Documents.

1d. Please provide evidence that the Sequential Test or Exception Test has been applied in the selection of this site for this development type?

- Evidence is required that the Sequential Test has been used in allocating the proposed land use proposed for the site and that reference has been made to the relevant Strategic Flood Risk Assessment (SFRA) in selecting development type and design (See paragraphs 100-104, NPPF and paragraphs 3-5, NPPF Technical Guide). Your Local Planning Authority planning officer should be able to provide site-specific guidance on this issue.
- Where use of the Exception Test is required, evidence should be provided that both elements of this test have been passed (see paragraphs 102, NPPF and paragraphs 4-5, NPPF Technical Guide). Your Local Planning Authority planning officer should be able to provide site-specific guidance on this issue.

The development site is located within Flood Zone 1 (Figure 4), where all types of development are appropriate with regards to flood risk. Neither the Sequential nor the Exception Tests are required for the proposed development.

1e. Will your proposal increase overall the number of occupants and/or users of the building/land; or the nature or times of occupation or use, such that it may affect the degree of flood risk to these people?

While the proposed development would increase the overall number of occupants, this would not pose any additional flood risk, as the site is located within Flood Zone 1.

2. Definition of the flood hazard

2a. What sources of flooding could affect the site? (see paragraph 2, NPPF Technical Guide).

- This may include hazards such as the sea, reservoirs or canals, which are remote from the site itself, but which have the potential to affect flood risk (see Section 1 of the NPPF Practice Guide).

The sources of flood risk that could affect the development site are summarised in Table 1. The site of proposed development is within fluvial Flood Zone 1, outside of the limits of the 1:1,000 year flood (Figure 4). The site is at 'very low' risk of surface water flooding (Figure 3). The SFRA (Herefordshire Council, 2009) shows no records of sewer or groundwater flooding at or close to the site. In general groundwater flooding is not a significant issue in Herefordshire. There is also no known flood risk associated with infrastructure failure either at or upstream of the site.

Table 1 Sources of flooding which could affect the site

Source of Flooding	*Flood Risk at Development Site*
Tidal	*N/A*
Fluvial	*Very low risk of fluvial flooding (Flood Zone 1)*
Surface water	*Very low risk of surface water flooding with a small area at low risk in the North East corner*
Groundwater	*No records found*
Infrastructure Failure	*No known infrastructure whose failure could affect the site.*
Sewers	*No records found*

Figure 3 Surface water flood risk map

Copyright Environment Agency

2b. For each identified source, describe how flooding would occur, with reference to any historic records wherever these are available.

- An appraisal of each identified source, the mechanisms that could lead to a flood occurring and the pathways that flood water would take to, and across, the site.
- Inundation plans, and textural commentary, for historic flood events showing any information available on the mechanisms responsible for flooding, the depth to which the site was inundated, the velocity of the flood water, the routes taken by the flood water and the rate at which flooding occurred.

Flood risk from all sources is considered very low.

2c. What are the existing surface water drainage arrangements for the site?

- Details of any existing surface water management measures already in place, such as sewers and drains and their capacity.

There are currently no formal drainage arrangements on site. Runoff from the site would be into a ditch, bounding the site's southern margin and separating it from the main road.

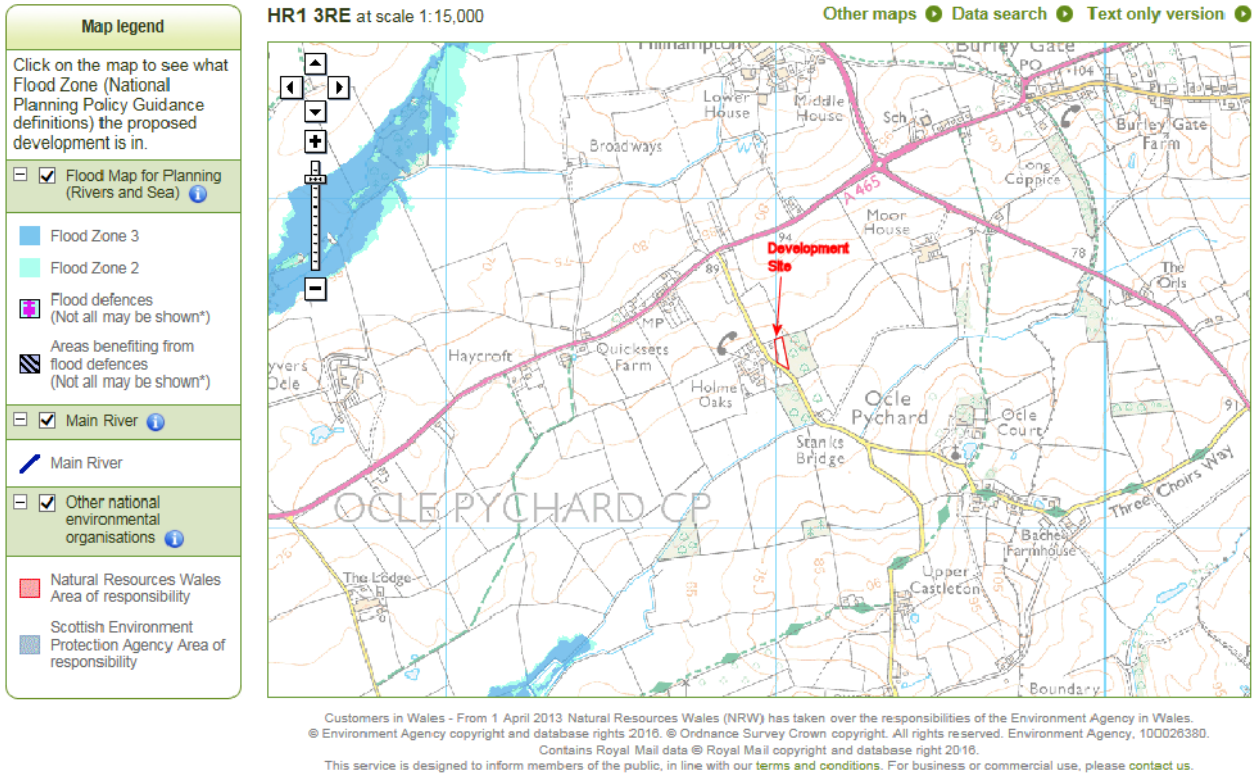
3. Probability

3a. Which flood zone is the site within?

- The flood zones are defined in Table 2, NPPF Technical Guide.

The Environment Agency Flood Map is reproduced in Figure 4. The map indicates that the site is located within fluvial Flood Zone 1, beyond the limits of the 1:1,000 year flood event.

Figure 4 Environment Agency Flood Zone map



3b. If there is a Strategic Flood Risk Assessment covering this site, what does it show?

- The planning authority can advise on the existence and status of the SFRA.

The site is covered by the Herefordshire Council SFRA (2009). There are no records of flooding at or near the site, contained within the SFRA.

3c. What is the probability of the site flooding taking account of the contents of the SFRA and of any further site-specific assessment?

This may need to include

- a description of how any existing flood risk management measures affect the probability of a flood occurring at the site.
- supporting evidence and calculations for the derivation of flood levels for events with a range of annual probability.
- inundation plans of, and cross sections through, the existing site showing flood extents and levels associated with events with a range of annual probability.
- a plan and description of any structures which may influence the probability of a flood occurring at the site. This may include bridges, pipes/ducts crossing a watercourse, culverts, screens, embankments or walls, overgrown or collapsing channels and their likelihood to choke with debris.
- details of any modelling studies completed to define the exiting degree of flood risk.

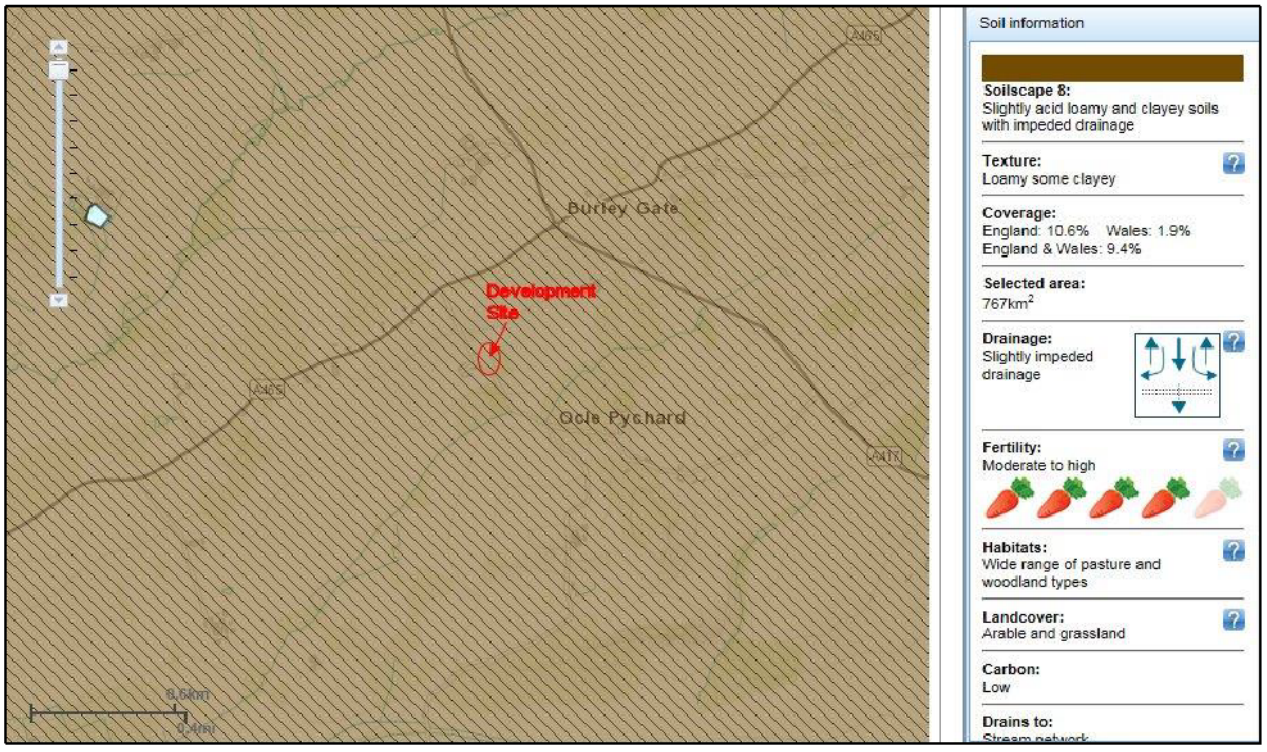
The probability of the site flooding is considered very low, since the site is located beyond the limits of the 1:1,000 year event.

3d. What are the existing rates and volumes of run-off generated by the site?

- This should generally be accompanied by calculations of run-off rates and volumes from the existing site for a range of annual probability events (see Section 21 of the NPPF Practice Guide).

Soils at the site are described on the Cranfield University website as, "loamy and clayey soils with impeded drainage" (Figure 5). Bedrock geology comprises the Raglan Mudstone formation (Figure 6), siltstone and mudstone interbedded[2]. The evidence indicates that the site and catchment are within an area underlain by poorly draining, less permeable soils with poor infiltration.

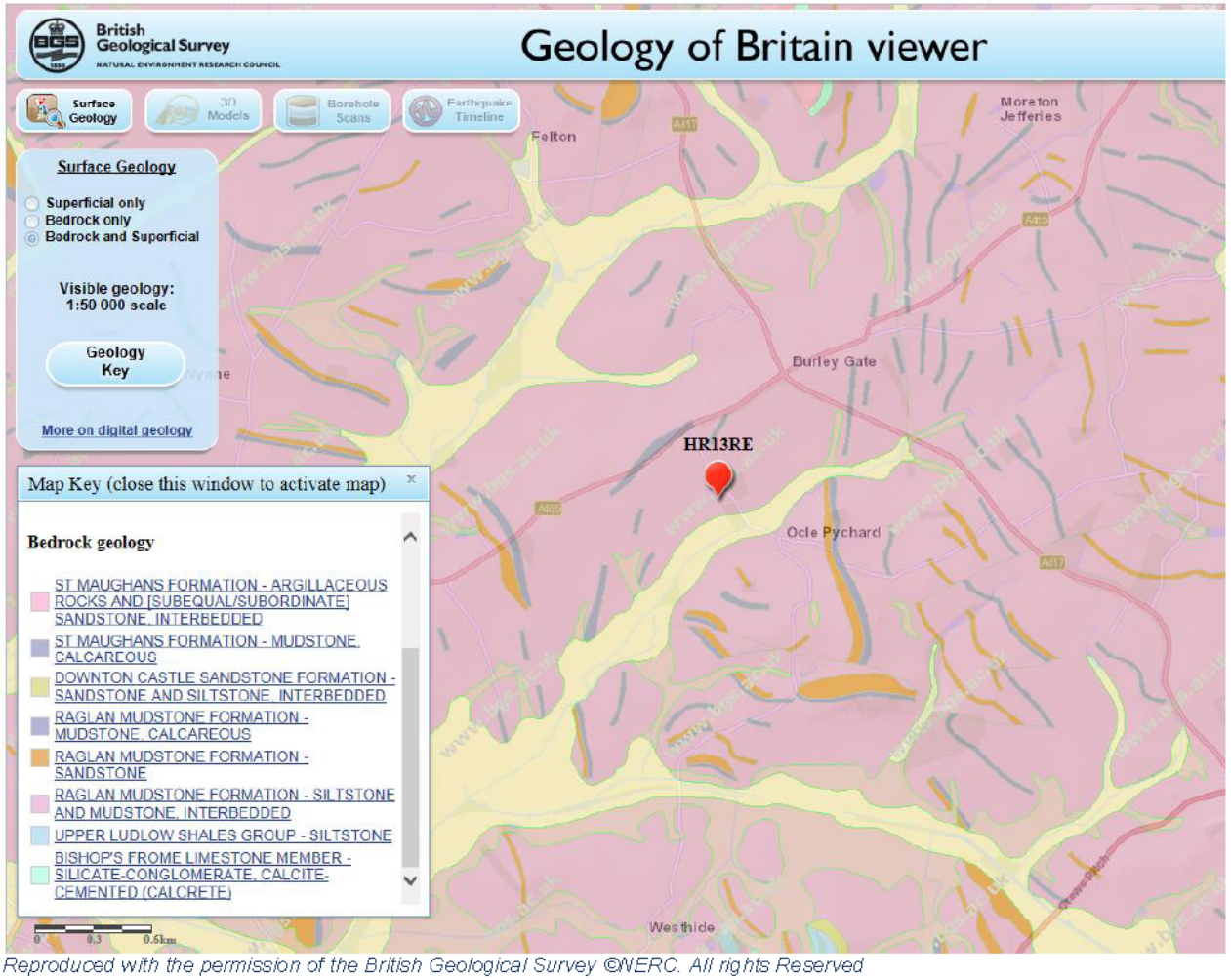
Figure 5 Soil map



Cranfield University Soil Mapping http://www.landis.org.uk/soilscapes2/

[2] http://mapapps.bgs.ac.uk/geologyofbritain/home.html

Figure 6 Geology underlying the site



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4. Climate change

4a. How is flood risk at the site likely to be affected by climate change?

- Paragraphs 11-15, of the NPPF Technical Guide provide guidance on how to assess the impacts of climate change.

In February 2016, the Environment Agency updated the climate change allowances to be used in flood risk assessments compliant with the NPPF[3]. The recommended allowances relevant to the proposed development are summarised in the following table.

Peak Rainfall Intensity Allowance (Small and Urban Catchments)

Allowance Category	Total Potential Change		
	2015 to 2039	2040 to 2069	2070 to 2115
Upper End	10%	20%	40%
Central	5%	10%	20%

Due to the site's location in the West of England, and classification of the proposed development as 'More Vulnerable', the upper estimate of 40% for the standard 100 year design life is considered appropriate.

[3] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

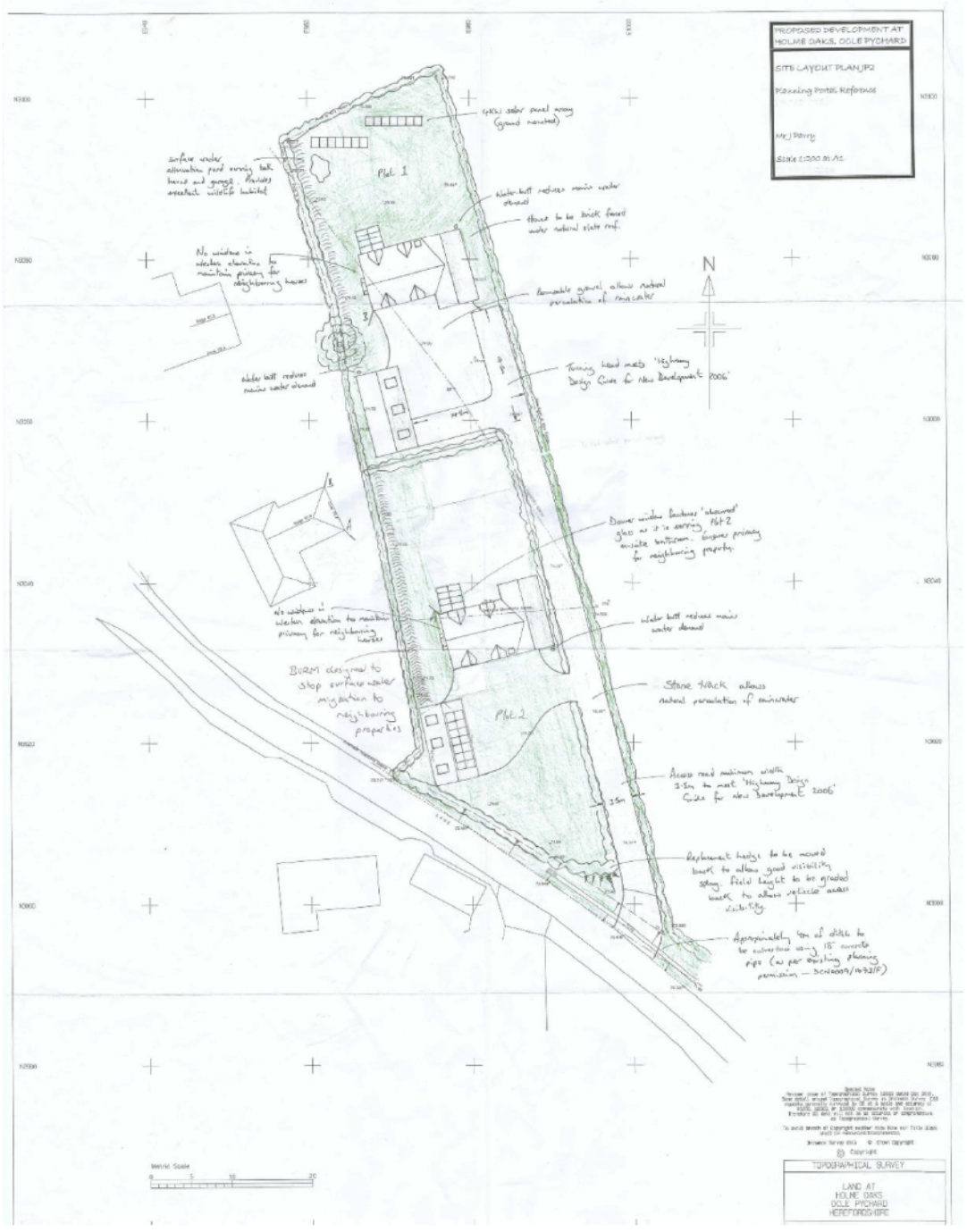
5. Detailed development proposals

5a. Where appropriate, are you able to demonstrate how land uses most sensitive to flood damage have been placed in areas within the site that are at least risk of flooding, including providing details of the development layout?

- Reference should be made to vulnerability classification, Table 2 of the NPPF Technical Guide.
- Section 4 of the NPPF Practice Guide provides guidance on how the sequential approach can be used to inform the lay-out of new development sites.

Two new detached houses are proposed for land adjacent to Holme Oaks, with associated driveway access from the C1131, car parking/turning areas and garages (Figure 7).

Figure 7 Proposed Site Layout



6. Flood risk management measures

6a. How will the site be protected from flooding, including the potential impacts of climate change, over the development's lifetime?

- This should show that the flood risk management hierarchy has been followed and that flood defences are a necessary solution. This should include details of any proposed flood defences, access/egress arrangements, site drainage systems (including what consideration has been given to the use of sustainable drainage systems) and how these will be accessed, inspected, operated and maintained over the lifetime of the development. This may need to include details of any modelling work undertaken in order to derive design flood levels for the development, taking into account the presence of any new infrastructure proposed.

Flooding is not expected to affect the proposed development, so no management measures are considered to be necessary.

7. Off Site impacts

7a. How will you ensure that your proposed development and the measures to protect your site from flooding will not increase flood risk elsewhere?

This should be over the lifetime of the development taking climate change into account. The assessment may need to include:

- Details of the design basis for any mitigation measures (for example trash screens, compensatory flood storage works and measures to improve flood conveyance). A description of how the design quality of these measures will be assured and of how the access, operation, inspection and maintenance issues will be managed over the lifetime of the development.
- Evidence that the mitigation measures will work, generally in the form of a hydrological and hydraulic modelling report.
- An assessment of the potential impact of the development on the river, estuary or sea environment and fluvial/coastal geomorphology. A description of how any impacts will be mitigated and of the likely longer-term sustainability of the proposals.

The site is located predominantly within Flood Zone 1, and beyond the extent of Flood Zone 3 due to its elevation (Figure 4). Hence, with the exception of runoff from the proposed impermeable surfaces (Section 7b), flood risk elsewhere will not be affected.

7b. How will you prevent run-off from the completed development causing an impact elsewhere?

- Evidence should be provided that drainage of the site will not result in an increase in the peak rate or in the volumes of run-off generated by the site prior to the development proceeding.

A neighbour, living to the west of the site of proposed development has stated that his property has occasionally been subject to runoff from the site. It can be seen from (Figure 8) that there appears to be a gentle slope across the site, towards the west (to the right of Figure 8). The severity of this runoff is not known but it is recommended that this development be used as an opportunity to address this issue. To prevent excess runoff water endangering the neighbouring property it is proposed to construct a berm, a low ridge, along the western boundary of the site. This will keep the water on site where it will eventually infiltrate naturally into the garden

There is concern that increased impermeable area on this green field site may exacerbate surface water flooding further down the hill towards Ocle Pychard and at the property immediately adjacent to the site. In order to not increase flood risk elsewhere in the catchment, a surface water management plan is recommended for the site.

The driveway, hardstanding and turning areas within the development are proposed to be gravel, allowing the percolation of rainwater and having a neutral or slightly beneficial impact on runoff from the site. The only increase to impermeable area due to the development would be the buildings themselves. The soils at the site are shown to have, "impeded drainage" (Figure 5) and soil infiltration testing to the BRE365 standard corroborates this (Appendix B). Soil infiltration rates were found to be as low as 0.0070 m/h.

Due to the poor infiltration at the site the preferred runoff control would be cellular infiltration/attenuation storage. Micro Drainage Design tool showed that roof runoff, from the 1:100 year rainfall event plus 40% 'Upper End' climate change allowance, could be managed using such an attenuation system. It is suggested that the site should have attenuation storage built to the following dimensions; 4 m x 4.8 m and 1.32 m deep, controlled by a Hydrobrake (see Appendix A). This would be discharged at the Greenfield runoff rate to a roadside ditch (Figure 9), itself discharging to an unnamed tributary of the Lugg, see Appendix A.

Figure 8 View South along the development site

The use of cellular storage exploits the relatively low soil permeability, allowing some limited infiltration, while most of the runoff is detained pending attenuated outflow. It can be seen from Figure 10 that the site slopes down towards the road in the south. The site itself is raised well over 1 m above the road and the ditch (Figure 9) increases that head, allowing the attenuation storage at least 1.32 m depth. If the cellular storage cannot be located beneath the drive, it is recommended that it be set within the soil bounding drive, close to the site entrance.

Figure 9 Roadside Ditch

8. Residual risks

8a. What flood-related risks will remain after you have implemented the measures to protect the site from flooding?

- Guidance on residual risks is provided in Section 14 of the NPPF Practice Guide.

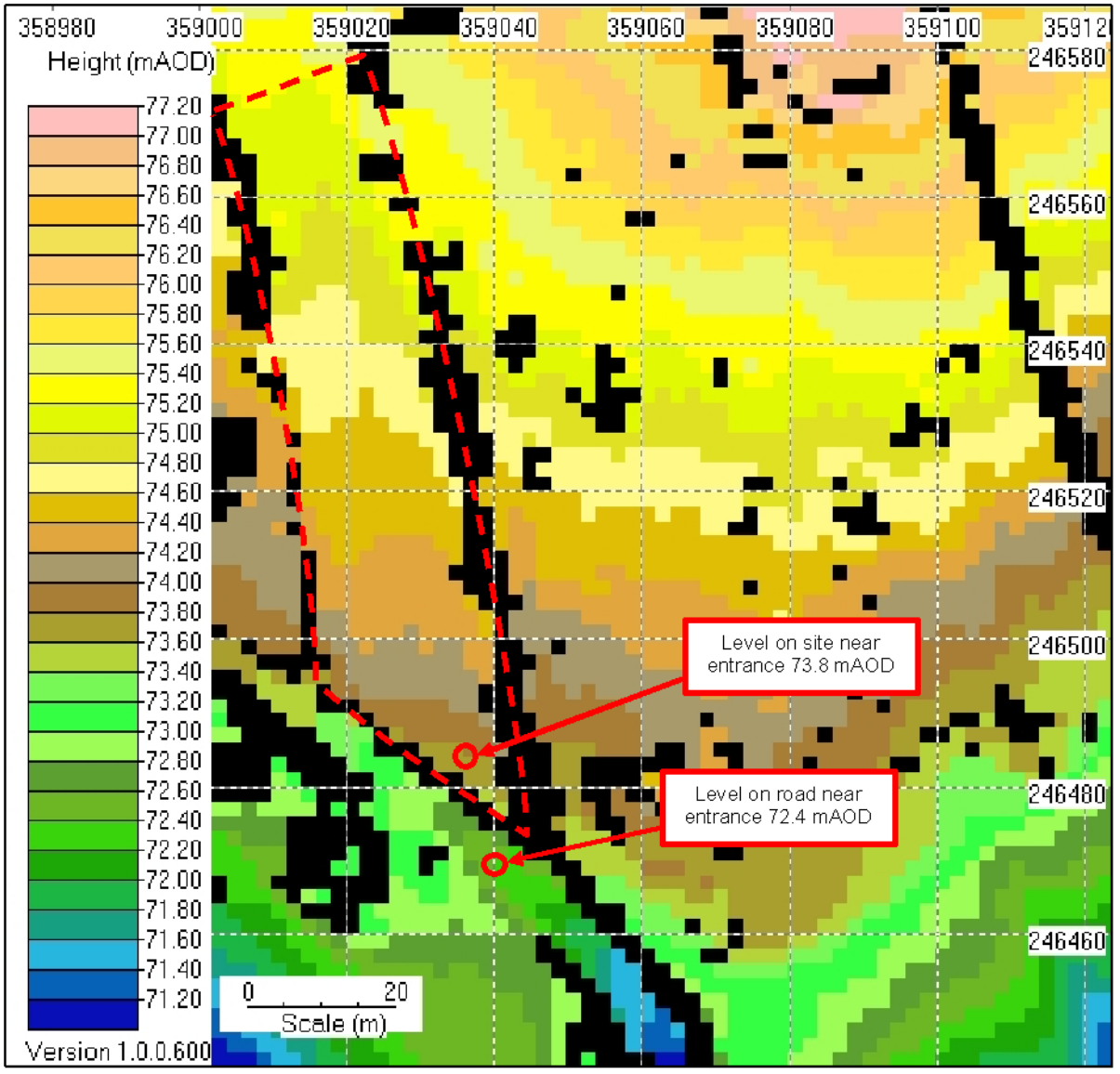
Residual risks include the possibility of a rainstorm of magnitude greater than the 1:100 year+CC event, in which the attenuation basins, recommended in Section 7b, may surcharge. A maintenance schedule, such as on a monthly basis and after heavy rainfall, should be established by the property owners to reduce the risk of blockage within the drainage / SuDS systems and ensure the systems remain in good working order. The cellular storage/soakaway system with Hydrobrake proposed includes easy maintenance components such as filters on the inflow and outflow structures.

8b. How, and by whom, will these risks be managed over the lifetime of the development?

- Reference should be made to flood warning and evacuation procedures, where appropriate, and to likely above ground flow routes should sewers or other conveyance systems become blocked or overloaded. This may need to include a description of the potential economic, social and environmental consequences of a flood event occurring which exceeds the design standard of the flood risk management infrastructure proposed and of how the design has sought to minimize these – including an appraisal of health and safety issues.

The responsibility of maintaining any surface water management features, including attenuation basins and associated structures, would be with the property owner.

Figure 10 LiDAR DTM showing levels across the site



References

Author	Date	Title/Description
Building Research Establishment (BRE)	2016	Digest 365 Soakaway Design
Centre for Ecology and Hydrology.	2016	The Flood Estimation Handbook Web Service. Available from: https://fehweb.ceh.ac.uk/GB/map [Accessed: 14/12/2016].
CIRIA	2007	The SUDS Manual - CIRIA Report C697.
Cranfield University	-	Soilscapes Map (http://www.landis.org.uk/soilscapes/)
DCLG	2012	National Planning Policy Framework
DCLG	2014	Planning Practice Guidance (http://planningguidance.communities.gov.uk/blog/guidance/)
Environment Agency	2016	Flood Risk Assessments: Climate Change Allowances (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances)
Environment Agency	-	Interactive Maps (http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e)
Herefordshire Council	March 2009	Herefordshire Strategic Flood Risk Assessment Report 1110-TR1-C. Available from: https://www.herefordshire.gov.uk/planning-and-building-control/planning-policy/local-plan-evidence-base/strategic-flood-risk-assessment-and-water-cycle-study (last accessed 12th December 2016)
Herefordshire Council	March 2013	Herefordshire Local Plan – Core Strategy Rural Housing Background Paper. Available at: https://beta.herefordshire.gov.uk/media/5749300/Rural_Housing_Background_Paper_March_2013.pdf (last accessed 7th July 2016)
Herefordshire Council	October 2015	Herefordshire Local Plan Core Strategy 2011 – 2031. Available at: https://www.herefordshire.gov.uk/media/8060294/core_strategy_combined.pdf (last accessed 19th Dec. 2016)

Appendix A Surface Water Management Plan

This section outlines a surface water management plan, designed to ensure that the proposed development (2 detached residential properties) would not lead to an increase in flood risk elsewhere. The proposed development would include a total impermeable surface area of 354.4 m^2 (Roof area of each house - 116.9 m^2 Roof area of each garage - 60.3m^2 177 m^2 per dwelling), from which runoff must be managed. In order to determine the permeability of the site, infiltration testing was completed to BRE365 standard, as described in Appendix B.

A1 Infiltration Rate

The soils for the site are shown to be 'loamy and clayey soils with impeded drainage' (Figure 5). To confirm the infiltration rates of the soil, infiltration testing to the BRE365 standard was conducted at the site. The results are summarised in Table A1, and display a range of infiltration rates between 0.00698 m/h and 0.02762 m/h. The slowest soil infiltration rate recorded was in trial pit 1, producing an infiltration rate of 0.00698 m/h. This value must be used as a conservative basis for the outline design of the surface water management plan for the site. It is extremely low and indicates that the soils at the site are unsuitable for infiltration drainage, since soakaways would not half empty in a 24 hour period, as recommended in the SuDS Manual (CIRIA C753). All the tests were terminated as the pits failed to empty in a timely manner.

Table A1 – Soil infiltration rates at proposed development site

Trial Pit 1	Trial Pit 2	Trial Pit 3
0.00698 m/h	0.02762 m/h	0.01213 m/h

A2 Outline Surface Water Drainage Strategy

Geocellular storage is considered to be a suitable SuDS structure to manage runoff from impermeable features of the proposed development. A such unit could serve the site, accepting runoff from all impermeable surfaces, while making use of the limited soil permeability by allowing infiltration. The design method in this report makes use of the Micro Drainage software.

The total impermeable area of the proposed development used for the design is 360 m², slightly more than the proposed 354.4 m^2. Details of the design analysis are presented in Figure 11 to Figure 16. Assumptions made in the analysis were as follows:

1. The attenuation system has been designed as a geocellular structure, 4 m x 4.8m and 1.32m deep;
2. Design rainfall totals were derived within Micro Drainage using the FEH methodology and catchment characteristics. The 1 in 2, 1 in 30 and 1 in 100 year events all with 40% climate change allowance, in line with NPPF and Environment Agency guidance, were analysed;
3. A factor of safety of 2 has been used as recommended by CIRIA C753;
4. The 2 properties will discharge to the same structure.

Results indicate that to ensure the tank does not surcharge during the 1:100 yr + CC event, the plan area of the structure should be 19.2 m^2. This could be achieved by constructing a tank 4 m x 4.8 m and 1.32 m deep with a hydrobrake set at the invert level and an overflow weir 0.5 m wide set at 1.2 m. A basin of these dimensions would be capable of managing the runoff from the 1:100 year rainfall event plus the 40% 'Upper End' climate change allowance. The design also complies with CIRIA, C753 (2015) regulations as it would drain from full to half full in 11

hours, within the 24 hour requirement. Figure 17, shows the proposed location of the attenuation tanks.

Figure 11 Attenuation Design Analysis (100 yr+CC critical storm)

Hydro Consultancy		Page 2
Shearwater House Clevedon BS21 7RD	L0032 FRA and SWMP Land at Holme Oaks, Ocle Pycha	Micro Drainage
Date 19/12/2016 File Ocle Pychard 100yr#12.srcx	Designed by Hydro-Logic Serv... Checked by ACD	
Micro Drainage	Source Control 2016.1	

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 Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	73.467	0.787	0.0	0.3	0.0	0.3	14.4	O K
60 min Winter	73.536	0.856	0.0	0.3	0.0	0.3	15.6	O K
120 min Winter	73.700	1.020	0.0	0.3	0.0	0.3	18.6	O K
180 min Winter	73.759	1.079	0.0	0.3	0.0	0.3	19.7	Flood Risk
240 min Winter	73.794	1.114	0.0	0.3	0.0	0.3	20.3	Flood Risk
360 min Winter	73.827	1.147	0.0	0.3	0.0	0.3	20.9	Flood Risk
480 min Winter	73.833	1.153	0.0	0.3	0.0	0.3	21.0	Flood Risk
600 min Winter	73.826	1.146	0.0	0.3	0.0	0.3	20.9	Flood Risk
720 min Winter	73.814	1.134	0.0	0.3	0.0	0.3	20.7	Flood Risk
960 min Winter	73.807	1.127	0.0	0.3	0.0	0.3	20.6	Flood Risk
1440 min Winter	73.764	1.084	0.0	0.3	0.0	0.3	19.8	Flood Risk
2160 min Winter	73.676	0.996	0.0	0.3	0.0	0.3	18.2	O K
2880 min Winter	73.594	0.914	0.0	0.3	0.0	0.3	16.7	O K
4320 min Winter	73.426	0.746	0.0	0.3	0.0	0.3	13.6	O K
5760 min Winter	73.296	0.616	0.0	0.2	0.0	0.2	11.2	O K
7200 min Winter	73.194	0.514	0.0	0.2	0.0	0.2	9.4	O K
8640 min Winter	73.112	0.432	0.0	0.2	0.0	0.2	7.9	O K
10080 min Winter	73.046	0.366	0.0	0.2	0.0	0.2	6.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
30 min Winter	98.957	0.0	14.5	0.0	41
60 min Winter	57.358	0.0	16.3	0.0	66
120 min Winter	33.246	0.0	20.1	0.0	126
180 min Winter	24.165	0.0	21.9	0.0	184
240 min Winter	19.270	0.0	23.3	0.0	242
360 min Winter	14.007	0.0	25.4	0.0	354
480 min Winter	11.170	0.0	27.0	0.0	462
600 min Winter	9.371	0.0	28.3	0.0	562
720 min Winter	8.119	0.0	29.4	0.0	590
960 min Winter	6.544	0.0	31.6	0.0	746
1440 min Winter	4.828	0.0	34.0	0.0	1052
2160 min Winter	3.562	0.0	38.8	0.0	1496
2880 min Winter	2.871	0.0	41.7	0.0	1932
4320 min Winter	2.073	0.0	45.1	0.0	2764
5760 min Winter	1.646	0.0	47.8	0.0	3528
7200 min Winter	1.376	0.0	49.9	0.0	4328
8640 min Winter	1.189	0.0	51.7	0.0	5032
10080 min Winter	1.050	0.0	53.3	0.0	5816

Figure 12 Attenuation Design Analysis (30 yr+CC critical storm)

Summary of Results for 30 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	73.209	0.529	0.0	0.2	0.0	0.2	9.6	O K
60 min Winter	73.299	0.619	0.0	0.2	0.0	0.2	11.3	O K
120 min Winter	73.391	0.711	0.0	0.3	0.0	0.3	13.0	O K
180 min Winter	73.438	0.758	0.0	0.3	0.0	0.3	13.8	O K
240 min Winter	73.466	0.786	0.0	0.3	0.0	0.3	14.3	O K
360 min Winter	73.493	0.813	0.0	0.3	0.0	0.3	14.8	O K
480 min Winter	73.498	0.818	0.0	0.3	0.0	0.3	14.9	O K
600 min Winter	73.494	0.814	0.0	0.3	0.0	0.3	14.8	O K
720 min Winter	73.491	0.811	0.0	0.3	0.0	0.3	14.8	O K
960 min Winter	73.486	0.806	0.0	0.3	0.0	0.3	14.7	O K
1440 min Winter	73.455	0.775	0.0	0.3	0.0	0.3	14.1	O K
2160 min Winter	73.395	0.715	0.0	0.3	0.0	0.3	13.0	O K
2880 min Winter	73.336	0.656	0.0	0.2	0.0	0.2	12.0	O K
4320 min Winter	73.212	0.532	0.0	0.2	0.0	0.2	9.7	O K
5760 min Winter	73.115	0.435	0.0	0.2	0.0	0.2	7.9	O K
7200 min Winter	73.039	0.359	0.0	0.2	0.0	0.2	6.5	O K
8640 min Winter	72.978	0.298	0.0	0.2	0.0	0.2	5.4	O K
10080 min Winter	72.928	0.248	0.0	0.2	0.0	0.2	4.5	O K

Figure 13 Attenuation Design Analysis (2 yr+CC critical storm)

Summary of Results for 2 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	72.898	0.218	0.0	0.1	0.0	0.1	4.0	O K
60 min Winter	72.946	0.266	0.0	0.2	0.0	0.2	4.9	O K
120 min Winter	72.996	0.316	0.0	0.2	0.0	0.2	5.8	O K
180 min Winter	73.022	0.342	0.0	0.2	0.0	0.2	6.2	O K
240 min Winter	73.037	0.357	0.0	0.2	0.0	0.2	6.5	O K
360 min Winter	73.050	0.370	0.0	0.2	0.0	0.2	6.7	O K
480 min Winter	73.056	0.376	0.0	0.2	0.0	0.2	6.9	O K
600 min Winter	73.058	0.378	0.0	0.2	0.0	0.2	6.9	O K
720 min Winter	73.057	0.377	0.0	0.2	0.0	0.2	6.9	O K
960 min Winter	73.056	0.376	0.0	0.2	0.0	0.2	6.9	O K
1440 min Winter	73.041	0.361	0.0	0.2	0.0	0.2	6.6	O K
2160 min Winter	73.010	0.330	0.0	0.2	0.0	0.2	6.0	O K
2880 min Winter	72.978	0.298	0.0	0.2	0.0	0.2	5.4	O K
4320 min Winter	72.911	0.231	0.0	0.1	0.0	0.1	4.2	O K
5760 min Winter	72.855	0.175	0.0	0.1	0.0	0.1	3.2	O K
7200 min Winter	72.748	0.068	0.0	0.1	0.0	0.1	1.2	O K
8640 min Winter	72.725	0.045	0.0	0.1	0.0	0.1	0.8	O K
10080 min Winter	72.719	0.039	0.0	0.1	0.0	0.1	0.7	O K

Figure 14 Attenuation Design Analysis (rainfall details)

Hydro Consultancy		Page 3
Shearwater House Clevedon BS21 7RD	L0032 FRA and SWMP Land at Holme Oaks, Ocle Pycha	
Date 19/12/2016 File Ocle Pychard 100yr#12.srcx	Designed by Hydro-Logic Serv... Checked by ACD	
Micro Drainage	Source Control 2016.1	

Rainfall Details

Rainfall Model	FEH	F (1km)	2.319
Return Period (years)	100	Summer Storms	Yes
Site Location	GB 359000 246300	Winter Storms	Yes
C (1km)	-0.028	Cv (Summer)	0.750
D1 (1km)	0.342	Cv (Winter)	0.840
D2 (1km)	0.379	Shortest Storm (mins)	15
D3 (1km)	0.326	Longest Storm (mins)	10080
E (1km)	0.303	Climate Change %	+40

Figure 15 Attenuation Design Analysis (cellular storage details)

Hydro Consultancy		Page 4
Shearwater House Clevedon BS21 7RD	L0032 FRA and SWMP Land at Holme Oaks, Ocle Pycha	Micro Drainage
Date 19/12/2016 File Ocle Pychard 100yr#12.srcx	Designed by Hydro-Logic Serv... Checked by ACD	
Micro Drainage	Source Control 2016.1	

Model Details

Storage is Online Cover Level (m) 74.000

Cellular Storage Structure

Invert Level (m) 72.680 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	19.2	19.2	1.320	19.2	42.4

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-CHE-0024-2000-0450-2000
Design Head (m)	0.450
Design Flow (l/s)	0.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	No
Diameter (mm)	24
Invert Level (m)	72.680
Minimum Outlet Pipe Diameter (mm)	Error (Contact Hydro International)
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.450	0.2
Flush-Flo™	0.056	0.1
Kick-Flo®	0.089	0.1
Mean Flow over Head Range	-	0.1

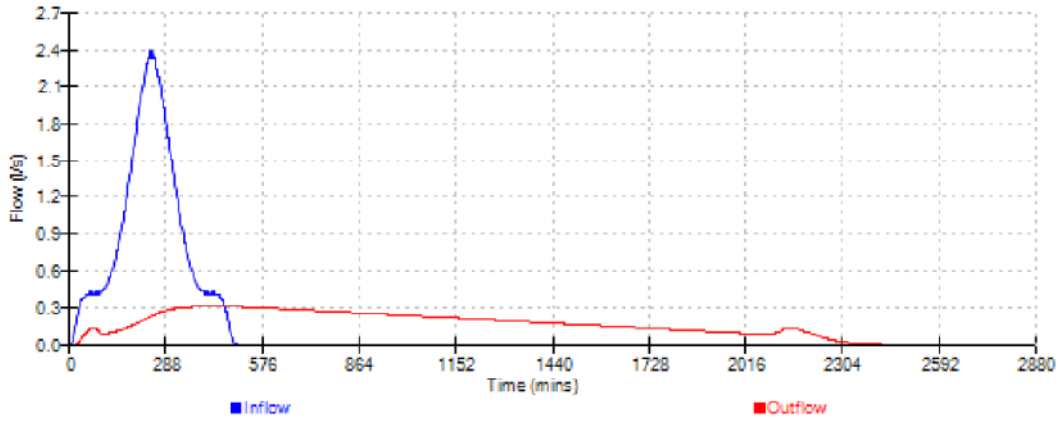
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

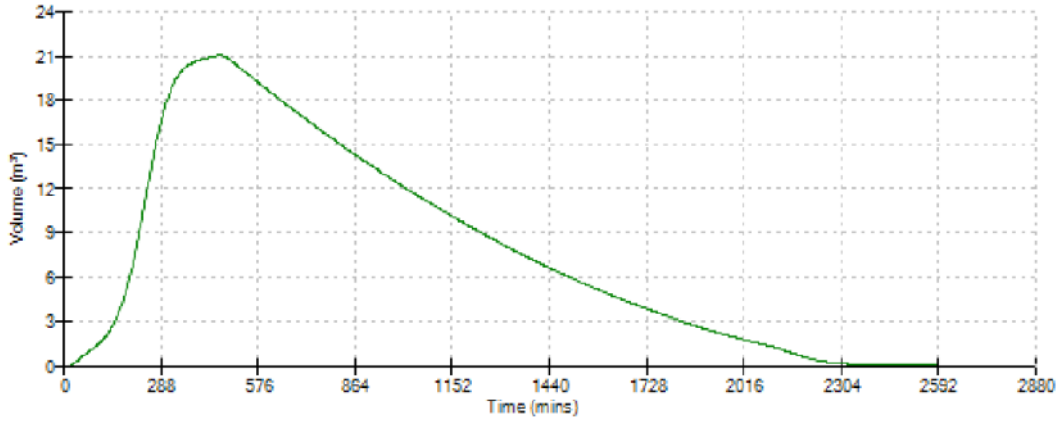
Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.1	1.200	0.3	3.000	0.5	7.000	0.8
0.200	0.1	1.400	0.3	3.500	0.5	7.500	0.8
0.300	0.2	1.600	0.4	4.000	0.6	8.000	0.8
0.400	0.2	1.800	0.4	4.500	0.6	8.500	0.8
0.500	0.2	2.000	0.4	5.000	0.7	9.000	0.9
0.600	0.2	2.200	0.4	5.500	0.7	9.500	0.9
0.800	0.3	2.400	0.5	6.000	0.7		
1.000	0.3	2.600	0.5	6.500	0.7		

Figure 16 Attenuation Design Analysis (critical storm plots)

Hydro Consultancy		Page 6
Shearwater House Clevedon BS21 7RD	L0032 FRA and SWMP Land at Holme Oaks, Ocle Pycha	
Date 19/12/2016 File Ocle Pychard 100yr#12.srcx	Designed by Hydro-Logic Serv... Checked by ACD	
Micro Drainage	Source Control 2016.1	

Event: 480 min Winter





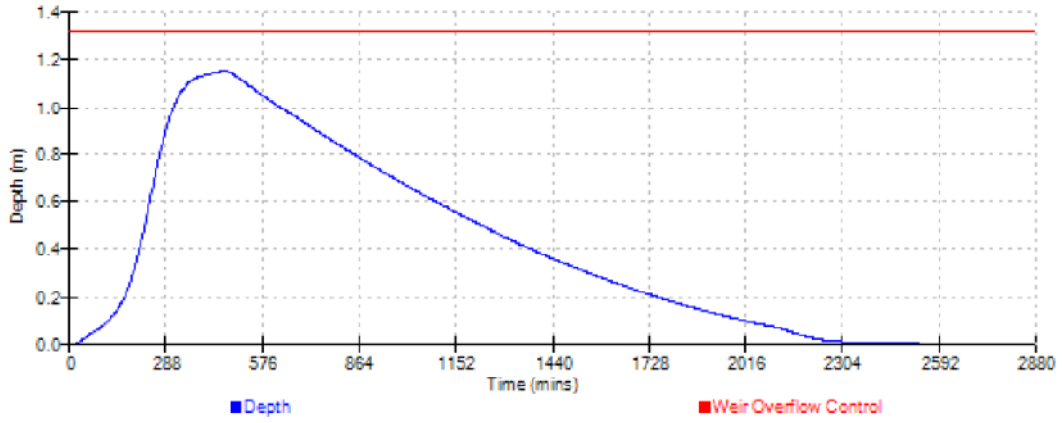
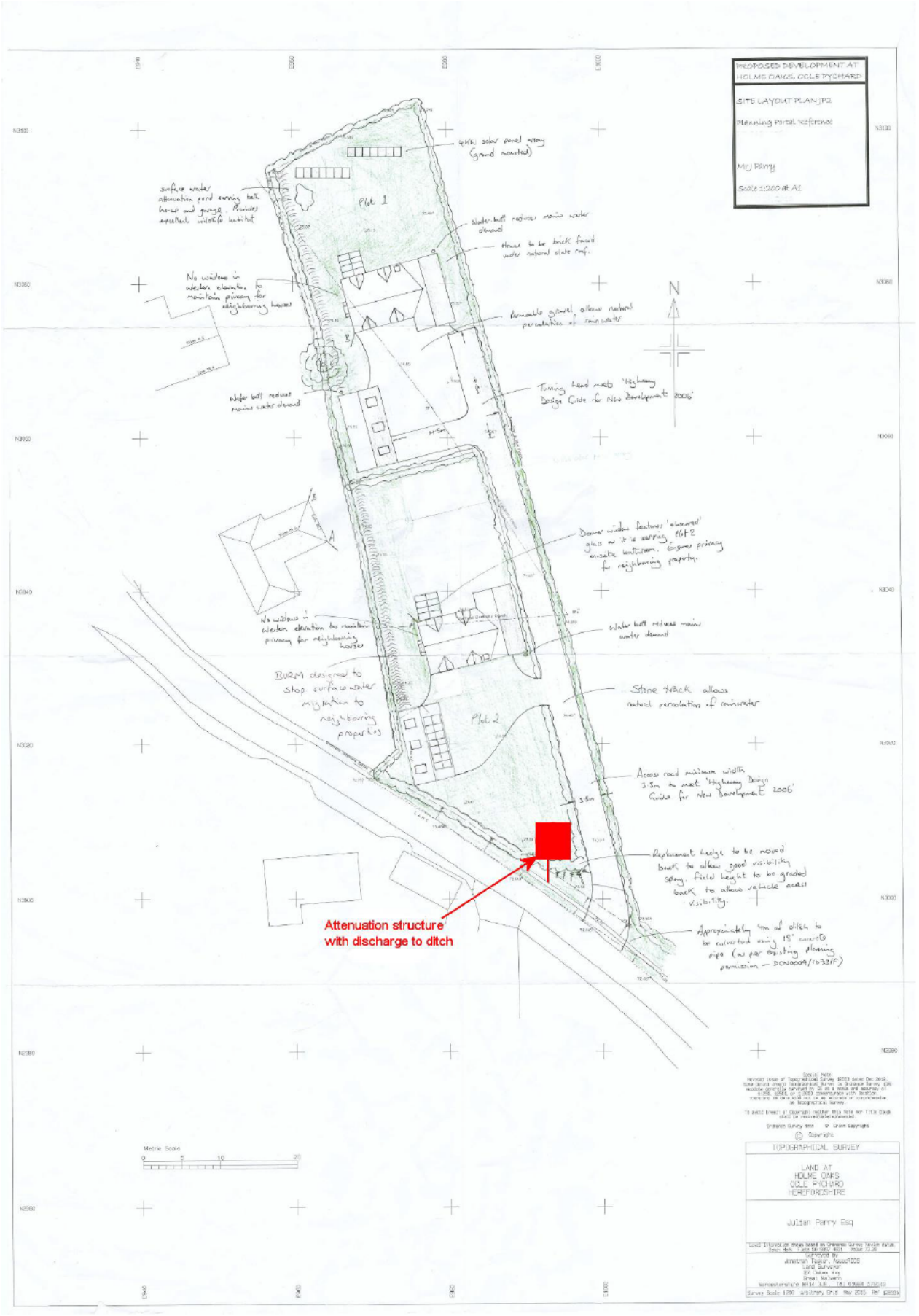


Figure 17 Outline Surface Water Drainage Strategy



A3 Design Considerations

The attenuation tanks should be located towards the south east corner of the site. This would ensure the gradient within the on-site surface water drainage system would be the same direction as the overall gradient of the site, rather than counter to it. The location would also benefit from proximity to the discharge point in the roadside ditch. The outflow control specified is a hydrobrake (specification given in Figure 15). This allows the 2yr event outflow to be attenuated to the Greenfield rate of 0.2 l/s. An orifice control for the same flow would be very small and at risk of blockage.

A4 Operation and Maintenance

The responsibility of maintaining the attenuation basin would be with the property owner. A maintenance schedule, on a monthly basis and after heavy rainfall, should be established by the property owners to reduce the risk of blockage within the systems and to ensure they remain in good working order. The cellular storage tanks and Hydrobrake system include easy maintenance features such as inflow and outflow filters.

Appendix B - Infiltration Testing Results

J Parry
Land to the East of Holme Copse House and Brick House
Ocle Pychard
Herefordshire
HR1 3RE

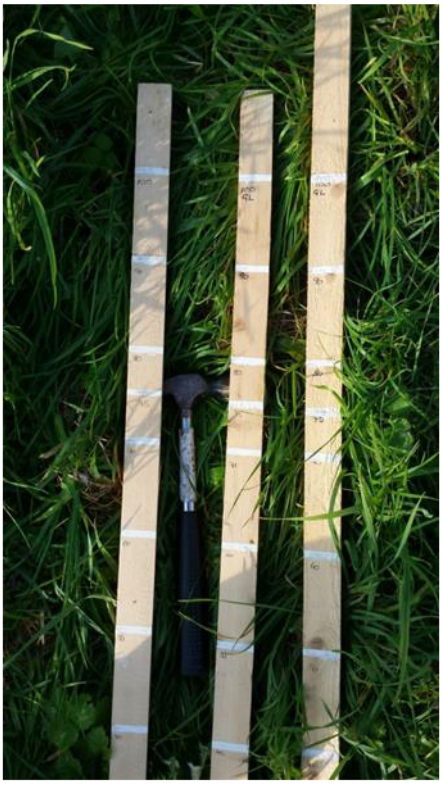
Soak Away Investigation

An investigation has been carried out to determine the infiltration rate of water into the soil. The test was carried out in accordance with BRE365 guidance.

Method

The plan below shows the location of the Trial Holes dug to evaluate soil permeability. Each hole measured 0.3m wide by 1.2m long by 1.0m deep. The investigation was carried out on Saturday 15 October 2016.

Wooden Stakes marked at 10cm intervals (with addition marks at 25cm and 75cm height)



Stake in-situ (trial hole No1)

Filling the trial hole with water from an IBC

Water level at full

Results

Trial Hole No1

Time at height (above base level)	
100	12.40
90	13.38
80	15.55
75	16.56
70	17.59
Test abandoned at 18.00hrs as results showed the percolation rate was exceptionally slow	

Trial Hole No2

Time at height (above base level)	
Initial Fill began at 12.42hrs. Approximately 0.6m3 water added but immediately drained away. Second attempt to fill commenced at 13.29hrs.	
100	13.38
90	13.48
80	14.05
75	14.17
70	14.27
60	15.07
50	15.42
40	16.29
30	17.35
Test abandoned at 18.00hrs as results showed the percolation rate was exceptionally slow	

Trial Hole No3

Time at height (above base level)	
100	13.27
90	13.33
80	13.46
75	14.25
70	15.18
60	17.45
Test abandoned at 18.00hrs as results showed the percolation rate was exceptionally slow	

Offices at

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Reading

Sheffield

Stirling

Tiverton

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