TEIGNCONSULT
CONSULTING ENGINEERS

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LEVEL 2 FLOOD RISK ASSESSMENT & SUSTAINABLE URBAN DRAINAGE STRATGEY

LAND AT HARTNOLL FARM
HALBERTON
TIVERTON
DEVON

FOR
WADDETON PARK LTD

REPORT REF. NO.: 529/FRA2
V2 – 23.06.21

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1.0 INTRODUCTION

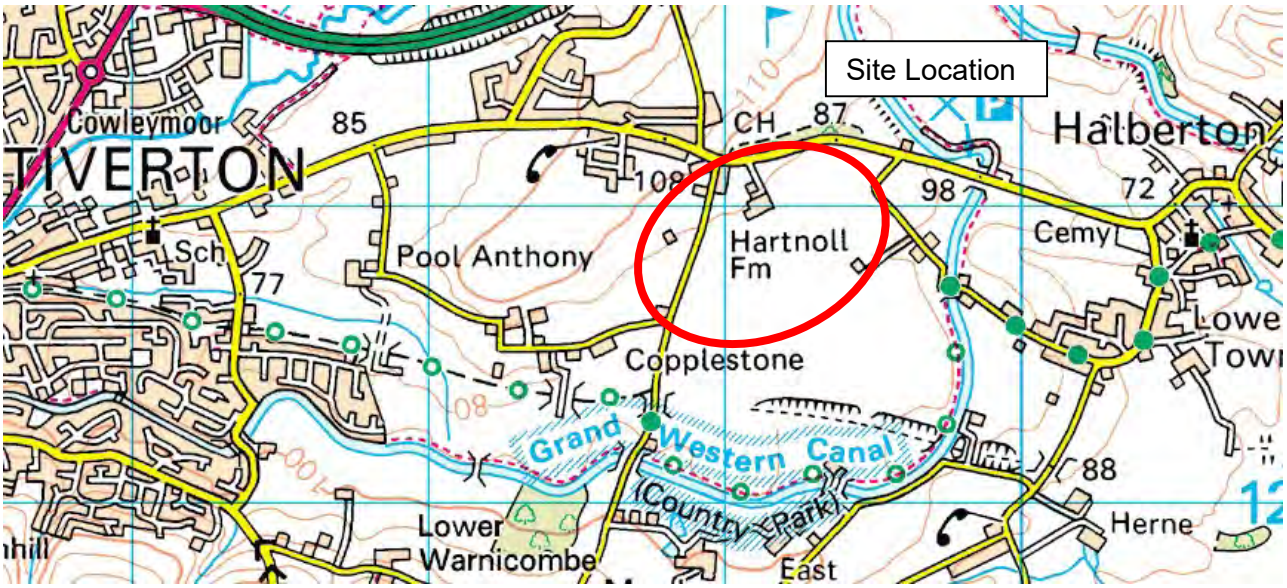
1.1 Context

TeignConsult has been retained by Waddeton Park Ltd to undertake a Flood Risk Assessment and produce a Sustainable Urban Drainage Strategy in support of a new mixed use development on land at Hartnoll Farm, Halberton. This assessment has been undertaken to ascertain any drainage constraints to the development, and to assess the impact of the proposals, with respect to flood risk.

As the increased urbanisation on the site could affect the risk of flooding downstream of the site a sustainable drainage strategy is required.

1.2 Site Location & Features

The Ordnance Survey National Grid Reference (NGR) for the centre of the site is 299045, 112915. The site location is shown below:



The whole site consisting of several fields and is a Greenfield site approximately 12.71 hectares in area.

The site is currently accessed from Tiverton Road to the north. The site is bounded as follows:

- to the north by Tiverton Road;
- to the east by agricultural land with Crown Hill and the Tiverton Canal beyond;
- to the west by Manley Lane;
- to the south by the Alsa Brook and agricultural land with the dismantled Tiverton – Tiverton Junction railway line beyond.

LIDAR Height data has been provided by the client for the site area and is included on Drawing FRA 1.

1.3 Development Proposals

The proposed site layout consists of:

- Up to 150 residential units and approximately 4.0ha of mixed use employment land with associated access roads, open space and landscaping.

The site will be accessed off Tiverton Road with links to the west into the Tiverton EUE development area.

The Architects conceptual layout plan detailing the different uses is included as Drawing FRA 2. This FRA is based on this layout which does not show full details but shows that the density and infrastructure can be delivered. Their drawing is included in the drawing section of the report.

1.4 Flood Zone Allocation

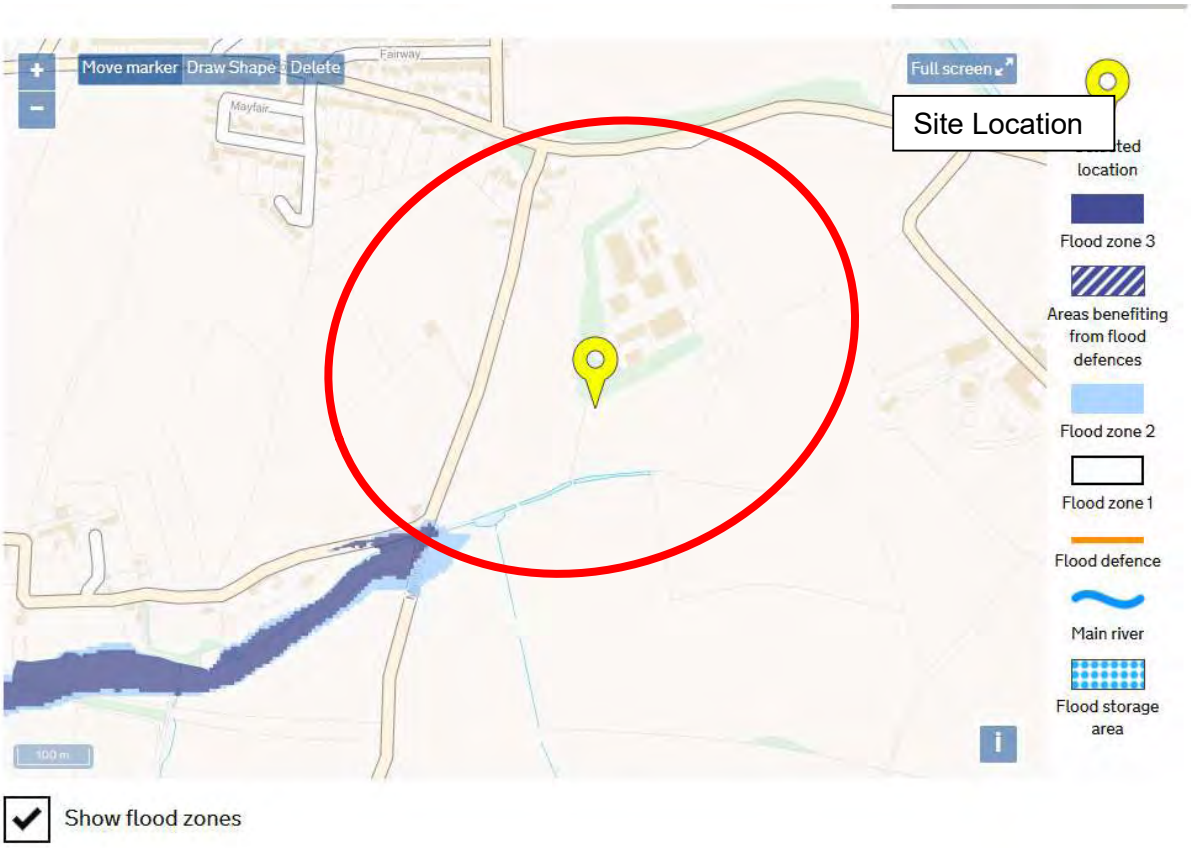
Based upon the latest Flood Zone Mapping issued by the Environment Agency (EA), the site lies within Flood Zone 1 (FZ1) except for a very small area of Flood Zone 2 (FZ2) in the southwest corner associated with the Alsa Brook. The upstream sections of the Alsa Brook have not been mapped as they fall below the catchment area at which flood zones are produced by the EA. Instead, the upstream areas are mapped as surface water flood risk areas. The area of FZ2 in the west will not be used for buildings or access routes but will be located within an area of open space.

FZ1 – Defined as being low risk comprising land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

FZ2 is defined as being at moderate risk of flooding and is land with a probability of 1%-0.1% river flooding and 0.5%-0.1% sea flooding which can include historic flood event boundaries. At the location of this site there are historic flood events which dictate the extent of FZ2;

FZ3 is defined as being high risk of flooding and comprising land assessed as having a probability of >1% river flooding and >0.5% sea flooding in any year;

An extract of the EA Flood Zone map is included below:



1.5 Appropriateness of Development Proposals

Table 2 of Planning Policy Guidance to the National Planning Policy Framework (NPPF PPG) provides information on the Vulnerability Classification of various developments. The residential element of the proposed end use of this site falls in the “more vulnerable” classification of the Table. Table 3 in NPPF PPG details compatibility of the end use with the different Flood Zone classifications. Comparing the More Vulnerable use with FZ1 shows that the “Development is appropriate”.

1.6 Sequential Test

According to NPPF PPG the Sequential Test gives preference to locating new development in Flood Zone 1 (FZ1 - least risk of flooding). However, if there is no allocated land within FZ1 which meets the policy aims of the published Local Authority Local Plan or Local Development Framework then other sites in higher flood risk categories, FZ2 or FZ3 can be considered for that development.

As the proposed development build areas of the site lies within Flood Zone 1, the sequential test is not required as the development is within an area with the lowest probability of flooding.

1.7 Exception Test

In line with Table 3 of NPPF PPG, the Exception Test need not be applied in this instance for the site.

1.8 Influences of Climate Change

The influence of Climate Change on rivers and watercourses is likely to increase the frequency of flood events and the overall volume of water that passes the site. NPPF PPG advises that an increase in watercourse flow of 40% should be considered when applying climate change over the lifetime of the development.

When considering surface water runoff from a site the increase in peak rainfall intensity varies over the lifetime of the development. For residential development with a typical lifetime of 100 years it is expected to be a 40% increase. For commercial or employment use with a 60 year lifetime 40% increase in runoff is predicted.

2.0 SOURCES OF INFORMATION

2.1 Flood Zone Maps & Flood Defence Data

Information relating to the current flood risk at the application site has been obtained from the EA website and is included earlier in the report.

2.2 Watercourse Hydrology & Surface Water Flood Risk Maps

The Alsa Brook runs from east to west along the southern boundary of the site and a tributary of the brook runs north through the site but neither of these are recorded on the Ordnance Survey mapping. The Flood Estimation Handbook (FEH) has the watercourse in its mapping. The nearest node on the western boundary in the mapping is listed as 1.99km² in area. The Standard Percentage Runoff (SPR) co-efficient for the catchment is 28.4%, low to moderate runoff, indicating the subsoils are considered reasonably permeable.

The EA have produced maps for Surface Water Flood Risk. The map shows flood risk areas running along the ditches and hedge lines through the site. When the site is built out these risk areas will not be developed. These flood risk areas will become part of the green corridors running through the site. An extract of the map is included below:

2.3 Historic Flooding

The level 1and 2 MDDC SFRA (Last updated October 2014) shows no records of historic flooding at this location. The SFRA assessed all the potential development sites within the Mid Devon boundary and this site is included in Table A-2 included below:

Sites within Flood Zone 3
Sites where it is likely that all, or part of, the site falls within the Flood Zone 3b (Functional Floodplain)
(PP) – sites with planning permission
(PPP) – sites with partial planning permission

Location	Site name	Site area (ha)	Proposed development type	Existing land use of the site	Proportion of site in Flood Zone 3	Proportion of site in Flood Zone Two	Proportion of site in Flood Zone One	uFMfSW (lowest return period of risk – years)	Canal Breach Impact Zone	Small watercourse within, or adjacent, to site?	Proportion of site flooded in the past (based on EA Historic Flood Map
Tiverton	Land at the Foundry	1.79	Commercial	Brownfield	100%	0%	0%	100	Medium	-	100%
	William Street	0.89	Mixed use	Brownfield	0%	0%	100%	1000	Medium	-	0%
	Eastern Urban Extension	108.07	Mixed use	Greenfield	3%	0%	97%	30	High	-	0%
	Phoenix Lane	1.41	Mixed use	Brownfield	0%	0%	100%	-	High	-	0%
	Blundell's School	13.13	Mixed use	Partial Brownfield	62%	18%	20%	30	Medium	-	71%
	Leat Street	0.23	Residential	Brownfield	11%	67%	22%	1000	Low	-	9%
	Town Hall/St Andrew Street	0.52	Residential	Brownfield	6%	33%	61%	1000	Medium	-	18%
	Land at Hartnoll Farm	94.8	Residential	Greenfield	0%	0%	100%	30	V High	Y	0%
	Tidcombe Hall	8.51	Residential	Partial Brownfield	0%	0%	100%	1000	V High	Y	0%
	Hay Park	0.32	Residential	Brownfield	0%	0%	100%	-	High	Y	0%
	Exeter Hill	6.26	Residential	Greenfield	0%	0%	100%	-	High	-	0%
	The Avenue	0.34	Residential	Brownfield	0%	0%	100%	1000	V High	-	0%
	Moorhayes	0.28	Residential	Greenfield	0%	0%	100%	1000	-	Y	0%
	Farleigh Meadows	11.27	Residential	Greenfield	8%	8%	84%	30	-	-	29%
	Howden Court	0.53	Residential	Greenfield	0%	0%	100%	1000	-	-	0%
	Palmerston Park	0.78	Residential	Greenfield	0%	0%	100%	-	Low	-	0%
	Roundhill	0.42	Residential	Brownfield	0%	0%	100%	-	-	-	0%
	Land at Wynnards Mead	6.53	Residential	Predominantly Greenfield	3%	0%	97%	30	-	-	0%
Crediton	Pedlerspool	24.13	Mixed use	Greenfield	2%	1%	97%	30	-	-	0%
	South of Wellparks and A377	1.33	Commercial	Greenfield	0%	8%	92%	30	-	-	0%
	Wellparks	1.36	Commercial	Brownfield	0%	0%	100%	100	-	-	0%
	Land east of Exeter Road	5.47	Commercial	Greenfield	0%	0%	100%	-	-	-	0%
	Land south of Common Marsh Lane	3.33	Commercial	Greenfield	0%	0%	100%	-	-	-	0%
	Westwood Farm	3.73	Residential	Greenfield	9%	0%	91%	100	-	-	0%
	Land at Chapel Down Farm	10.38	Residential	Greenfield	0%	0%	100%	1000	-	-	0%
	Land at Alexandra Close	0.64	Residential	Greenfield	0%	0%	100%	-	-	-	0%
	George Hill (PP)	1.18	Residential	Predominantly Greenfield	0%	0%	100%	-	-	-	0%

2.4 Public Sewer Records & Other Drainage Systems

There is no highway drainage or public sewer system within the site.

SWW records show public foul (or combined) sewers to the 250m west of the site boundary.

A copy of the SWW asset map is included in Appendix A.

The site is categorised in the table above as being “Very High risk in the Canal Breach impact Zone”. This is discussed in section 3.4.2.

2.5 Topographic Data

Current (pre-development) LIDAR height data has been provided by the Client; this is shown on Drawing 1. This survey is based on Ordnance Datum.

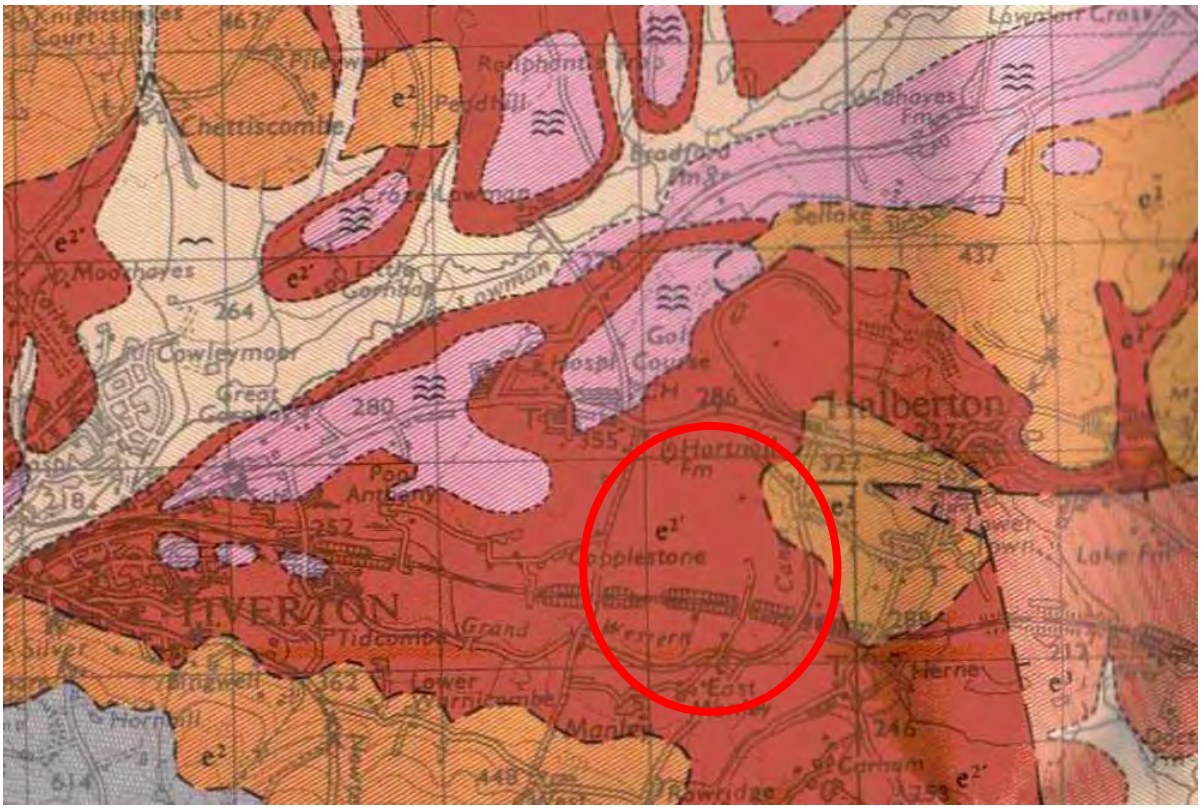
The site falls from 95m in the north to 83m in the southwest at Shamel’s End on the western boundary.

2.6 Geological Data & Soakaway Suitability

British Geological Survey Mapping has been reviewed to assess the local geological conditions. The British Geological Survey mapping indicates the site is underlain mainly by Tidcombe Sandstone with a head of sand, clay and silts. The formation can provide infiltration but becomes waterlogged after prolonged periods of rainfall.

The FSR soil maps predict a soil Type 2 or 30% SPR.

An extract of the BGS mapping is included below:



Infiltration testing has been undertaken at 4 locations (TPS1 – 4) in the southern part of the site. None of the four tests achieved a 25% drain down over a 45 – 46 hour period.

Water levels dropped by between 0.15m and 0.58m in TP1 – TP3 and water level rose in TP4 by 0.06m.

Ground water monitoring has continued since the soakaway tests were undertaken in April 2020.

At the potential location for Detention Ponds the ground water has been:

North pond and DS4 – 1.38 mbgl (maximum 90.01mAOD) and dry over all other monitoring;

South pond and TP1 – 0.33 – 2.35 mbgl (maximum 82.79mAOD) over the monitoring period.

The relative ground water levels to pond inverts are discussed in section 3.5.

The full soakaway and ground water monitoring results reported by GeoConsulting Engineers are included in Appendix A together with their location plan.

3.0 FLOOD RISK ASSESSMENT

3.1 Flood Risk Assessment Methodology & Objectives

It is recognised that developments that are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. Current guidance on development and flood risk identifies several key aims for a development to ensure that it is sustainable in flood risk terms. These aims are as follows:

- The development should not be at a significant risk of flooding and should not be susceptible to damage due to flooding;
- The development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, are threatened;
- Safe access to and from the development should be possible during flood events;
- The development should not increase flood risk elsewhere;
- The development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences;
- The development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk. The responsibility for any operation and maintenance required should be clearly defined;
- Future users of the development should be made aware of any flood risk issues relating to the development;
- The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues;
- The development should not lead to degradation of the environment; and
- The development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change.

This Flood Risk Assessment is undertaken with due consideration of these sustainability aims and has been prepared to inform the proposed scheme. A development lifetime of 100 years has been assumed in line with NPPF PPG for residential development life cycle.

3.2 Project Scope

In order to achieve the aims outlined above, this Flood Risk Assessment has been undertaken in accordance with current best-practice guidance, including NPPF PPG. A scoping study was initially undertaken to identify all potential sources of flooding at the site, which may warrant further consideration. Any potential flooding issues identified in the scoping study have subsequently been considered within this FRA. The aim of the scoping study is to review all available information and provide a qualitative assessment of the flood risk to the site and the impact of the site on flood risk elsewhere.

The report has been undertaken with due regard to the EA's National Standing Advice on Development and Flood Risk.

3.3 Level 1 – Scoping Study

All potential sources of flooding must be considered for any proposed development.

Using the EA Flood risk zone mapping, public sewer records, topographical survey, Ordnance Survey maps and data collected in a site walkover a summary of the potential sources of flooding and a review of the potential risk posed by each source on part or parts of the application site is presented in Table 1.

Table 1: Potential Risk Posed by Flooding Sources

Potential Source	Potential Flood Risk to Site?
Fluvial flooding	No
Tidal flooding	No
Surface Water Flooding	Yes
Flooding from rising / high groundwater	No
Overland flow flooding	No
Flooding from piped drainage systems	No
Flooding due to infrastructure failure (Reservoirs, canal, lakes etc)	Yes
Increase in flood risk due to urbanisation of the catchment	Yes

Following the Level 1 scoping study a more detailed Level 2 assessment has been undertaken which considers each of the potential flood risks identified above.

3.4 Level 2 - Technical Assessment of Flood Risk

3.4.1 Surface Water Flooding

This type of flooding occurs as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse or cannot enter it because the network is full to capacity. It also occurs as overland flows from groundwater springs or paved areas which initiate in rural areas but can enter urban areas because of topography, field boundaries and manmade obstructions.

At this location, the surface water flood risk areas are associated with natural valleys and ditches at the base of hedge banks or minor watercourses that do not run all year round (Winterbournes).

The development will not use land that is currently shown as surface water flood risk. These corridors will be left as ecological zones.

The masterplan is illustrative to show the scale of development.

3.4.2 Flooding due to Infrastructure Failure

An earlier scoping response from MDDC advises that the canal operates a series of sluices and weirs to discharge excess surface water to the adjoining streams.

We have contacted Mark Baker at DCC who was the point of contact mentioned by MDDC in their scoping response at the time. He advised that the Canal drainage system has no sluices or weirs along the site frontage with the application boundary. The nearest canal outfall structure is located downstream of the site near Manley Wood. There were no plans to construct any new structures along the site frontage either.

Mark did advise that there is one location where the canal has a slightly lower bank where water has overflowed in the past. This is located in Crown Hill between Lisiaux and the wood yard at the junction of Red Linhay Lane and Crown Hill. Flows from the canal enter Crown Hill and run northwest to the low point at SX 299490,113060. Flows also run from the junction of Tiverton Road and Crown Hill southwest along Crown Hill where there is no highway drainage to the same low spot. Ponding has been witnessed in this location on occasion when flows exceed the downstream watercourse capacity. The landowner is aware of this flow and ponding. It is therefore proposed to improve the watercourse capacity and flow entry conditions as part of this development during the detailed design stage to mitigate the potential overland flood flow route from the canal. The location of the overtopping is shown as a pair of blue **X** on drawing FRA 1. The flow routes and low spot are also shown.

The SFRA identified that the site was at “Very High risk in the Canal Breach impact Zone”. The canal is over 400m to the east from the application boundary. At the three potential breach locations flows head down the natural valley in the landscape before joining the Alsa Brook tributaries. We have allowed a 15m flow corridor centred on the existing watercourse through the development for the potential breach flow. No development is proposed in these areas except where a road crossing is required between development parcels within the employment area.

With these mitigation measures in place any risk from a canal breach can be managed effectively.

3.4.3 Increase in surface water runoff due to urbanisation

Based on guidance in NPPF PPG, the LLFA / Environment Agency requests that applications for development where the site may increase the amount of surface water runoff include an appropriate drainage strategy to ensure that surface water runoff discharge mimics or is less than the existing pre-development regime. This can be via a series of different methods, including infiltration, attenuation and rainwater re-use so that the potential adverse impact, i.e. increase in downstream flood risk on the fluvial system is alleviated.

The regulating authorities require that the storage requirements are based on the critical 1:100 year storm event, including allowance for potential effects of climate change, with runoff not exceeding existing rates. Assessment of the runoff regime for the existing and proposed sites considers the runoff generated by the site for the 100 year return period event, for a range of durations. Using the effective rainfall and investigation of the existing and proposed site land use characteristics, a range of allowable discharge rates relating to return period storm events can be estimated.

The following sources of data can be used to complete this assessment:

- Topographical data for the existing site;
- Land-use data for the existing and proposed sites, and
- Catchment descriptors and FEH rainfall data.

Analysis of the following has been undertaken as part of this process:

- Determination of appropriate discharge rates based on existing Greenfield runoff areas and flow rates;
- Assessment of the mitigation requirements to ensure that appropriate discharge rates and runoff volumes are maintained; and
- An outline surface water drainage strategy that demonstrates no detrimental impact on the existing receiving water bodies, or third party property.

Land Use

The site area has been assessed and the different uses categorised. The architect has produced sample layouts for the 8 residential parcels, and we have a proposed employment unit area of between 9,000 and 9,500m² floor area over one or two story buildings plus parking and yard areas. This density equates to 60% impermeable for the employment areas.

Each area block has then been measured off and a nett impermeable area estimated using the housing blocks or 60% ratio. For the SUDS ponds a design of the volume required has been calculated in MicroDrainage.

The LLFA require 10% urban creep be added to all private impermeable areas for extensions and paved areas. The figures in Table 2 below include this allowance. The table summarises the existing and proposed land uses within the site boundary:

Table 2: Land Use Summary

Land Use Type	Total Land use Area			
	Existing Site		Proposed Development	
	m²	%	m²	%
Residential areas			25333	20.0
Spine road			4770	3.7
Commercial areas			27108	21.3
Pond inverts			4617	3.6
Garden areas / Open space			65305	51.4
Grass areas	127133	100		
TOTAL	127133	100	596277	100
Approx Runoff Coefficient	30.0%		64.0%	

These are the gross areas without any SUDS factors. Runoff coefficients for the different elements of the site based on the SuDS Code of Practice are as follows:

Domestic roof areas	90%
Commercial roofs	100%
Bitumen highways or paved areas	100%
Pond areas	100%
Undeveloped greenfield areas	30%

3.4.4 Existing Greenfield Runoff Rates and Volumes

Using the land use information and catchment data from the FEH rainfall website the existing Greenfield runoff rates have been estimated at the site, using the IoH124 Method and Devon & Cornwall Regional Growth Curve factors derived from the Flood Studies Report.

The site has been split into two catchments North and south to suit potential phases of development. The north area consists of a single block of housing R1, a commercial plot Emp-North and the eastern part of the spine road. The south area includes the remaining residential blocks R2 – R8, commercial areas East, South and West, and the western part of the spine road.

A catchment area of 6.183ha including the 10% urban creep has been considered for the design of the surface water drainage strategy. If Greenfield or landscaped areas are drained positively in some areas of the development site the increase in allowable runoff and the attenuation volumes can be adjusted as the detailed design progress. The results of this analysis based on the average slope of the western and eastern land parcels are summarised in Table 3, below:

Table 3: Summary of Existing Greenfield Runoff Rates

Return Period (Years)	IoH 124 Method			
	Whole site 6.183ha	North 1.036ha	South 5.147ha	Or l/s/ha
2	15.1	2.5	12.5	2.4
QBAR	17.1	2.9	14.2	2.8
30	36.6	6.1	30.5	5.9
100	50.1	8.4	41.7	8.1
100+40% Climate	70.2	11.8	58.4	11.3

The full spreadsheet used to derive these figures is included in Appendix B.

3.5 Disposal of Surface Water Runoff

Development of the site will lead to an increase in impermeable area, which will have a consequential impact on the existing site runoff rates. The SPR indicates that subsoils are suitable for infiltration however the insitu soakaway test results provided do not support this.

Alsa Brook feeds the Tidcombe Lane Fen SSSI and the existing runoff rates should not be reduced greatly or there will be a negative impact on the wetland habitat that is now nationally scarce and rare in Devon. The habitat is sensitive to changes in its hydrological catchment and is dependent on a continuous water supply, high water table, occasional flooding and good water quality.

It is therefore proposed to promote wetland areas on the site and manage the flow discharge rates as close to the existing Greenfield as possible but not restrict the discharge volumes to match existing.

A series of pipes and swales will feed into the ponds. There may be opportunity for porous paving and other SuDS features in the detailed design but at this stage the proposed layout has not been developed sufficiently to identify potential locations.

The proposed wetlands can be placed in management company or offered up for adoption under the Sewage Sector Guidance.

North wetland / Pond option

The total impermeable area draining to this pond is calculated as 1.036ha.

The 100 year 360 minute winter Greenfield runoff volume for this is 211.5m^3.

The contributing area of 1.036ha has been input into MicroDrainage and a wetland basin designed to discharge up to the QBAR flow rate of 2.9l/s in the 1 in 100 year + 40% climate change storm. It is envisaged a sump of 400mm permanent water will be retained below the design outfall level for diversity. The invert of the pond has been included in the area calculations for this reason.

Usable pond storage of 1600mm depth is proposed to attenuate flows with an invert area of 643m² at 89.00mAOD, rim area of 1305m² at 90.60mAOD and 1 in 3 side slopes. The pond has a maximum volume of 1539m³. A maximum volume of 911m³ at 1.07m depth is stored in the CC40% storm. The pond has been designed with a 69mm diameter Crown vortex flow control device (2.9l/s at 1.05m head) at the invert. The additional storage volume will be available should the density of commercial development be increased.

The highest groundwater level that has been recorded is 90.01m on one instance with all other readings dry over a 14 month period. This means the pond may need lining, but further monitoring is continuing to inform this.

In an exceedance event the pond would overtop and flow southwest into the new outfall swale leading to the southern pond. The table below summaries the design:

Table 4: Summary of North Pond Design

Return Period (Years)	Greenfield flow (l/s)	Design flow (l/s)	Design volume (m³)	Design depth (m)
2	2.5	1.8	290	0.40
30	6.1	2.2	481	0.63
100	8.4	2.5	617	0.78
100+40% Climate	11.8	2.9	911	1.07

In the 100 year 360 minute winter storm the discharge volume is 321.3m^3 and this will help balance the flows into Tidcombe Lane Fen SSSI.

The illustrative surface water drainage design can be found on drawing FRA 3.

The output MicroDrainage files for the 2yr, 30yr, 100yr and 100 year plus 40% climate change scenario are included in Appendix C.

South wetland / Pond option

The total impermeable area draining to this pond is calculated as 5.147ha.

The 100 year 360 minute winter Greenfield runoff volume for this is 1050.6m^3.

In addition, the north pond will drain through this pond via the outfall swale, this means the maximum discharge flow can be up to 17.1l/s in the 1 in 100 year + 40% climate change storm and the total Greenfield discharge volume is 1262.1m^3.

The contributing area of 5.147ha has been input into MicroDrainage with the northern basin connected as an upstream cascade. A wetland basin designed to discharge up to the QBAR flow rate of 17.1l/s in the 1 in 100 year + 40% climate change storm.

Some of the flows from the upstream residential and highway catchment areas will arrive at the pond using the outfall swale from the northern pond.

It is envisaged a sump of 400mm permanent water will be retained below the design outfall level for diversity. The invert of the pond has been included in the area calculations for this reason.

Usable pond storage of 1400mm depth is proposed to attenuate flows with an invert area of 3974m² at 82.60mAOD, rim area of 5502m² at 84.00mAOD and 1 in 3 side slopes. The pond has a maximum volume of 6619m³. A maximum volume of 4560m³ at 1.01m depth is stored in the CC40% storm. The pond has been designed with a 130mm diameter Crown vortex flow control device (17.0l/s at 1.00m head) at the invert. The additional storage volume will be available should the density of commercial development be increased.

The highest groundwater level that has been recorded is 82.79m on one instance with all other readings below the pond invert over a 14 month period. This means the pond may need lining, but further monitoring is continuing to inform this.

In an exceedance event the pond would overtop and flow southwest into the Alsa Brook.

The table below summaries the design:

Table 5: Summary of South Pond Design

Return Period (Years)	Greenfield flow (l/s)	Design flow (l/s)	Design volume (m³)	Design depth (m)
2	15.1	12.8	1347	0.33
30	36.6	12.8	2415	0.57
100	50.1	14.4	3105	0.71
100+40% Climate	70.2	17.0	4560	1.01

In the 100 year 360 minute winter storm the discharge volume is 1998.3m^3 and this included the northern pond flows. This will help balance the flows into Tidcombe Lane Fen SSSI.

The illustrative surface water drainage design can be found on drawing FRA 3.

The output MicroDrainage files for the 2yr, 30yr, 100yr and 100 year plus 40% climate change scenario are included in Appendix C.

3.6 Other SuDS systems

The employment area could utilise rainwater harvesting systems for their toilets. An example calculation has been undertaken for a 1000m² roof area building. This shows that for 5 employees in an employment unit a tank of 1972m^3 would be required to serve toilet flushing over 21 days.

The calculation sheet for this is included in Appendix C.

3.7 Off-Site Impact: Sustainable Drainage Design Statement

It can be demonstrated that with the input of mitigation measures, the proposed development of the site can deliver similar runoff rates to maintain the flows that feed the Tidcombe Lane Fen SSSI.

The illustrative design shown is one of many SUDS solutions which can be developed further in the detailed design. Further BRE365 soakaway tests will be completed as part of the detailed design, however the roll out of huge infiltration areas in the detailed design will have an impact on the SSSI.

In the detailed design the adopted highway areas may require a different attenuation system. This can include a separate pond or basin areas, whichever is preferred by the adopting authority.

3.8 Maintenance and Management

The continued maintenance of any site piped drainage systems will be by the Local Authority County Council (Highway areas), whilst piped drainage will be offered up to SWW under a S104 agreement. The SuDS ponds will also be offered up to SWW or could be placed in a management company if SWW decline to adopt the open wetlands.

A draft Operation & Maintenance Manual has been prepared and is included in Appendix D.

It is considered that with these measures, the potential residual flood risks can be managed.

4.0 SUMMARY AND CONCLUSIONS

TeignConsult has been retained by Waddeton Park Ltd to undertake a Flood Risk Assessment and produce a Sustainable Urban Drainage Strategy to support the planning application for the proposed mixed use development at Hartnoll Farm, Halberton and to ascertain the constraints to the development of the site and assess the impact of the proposals with regard to flood risk.

The development site area is currently agricultural use.

An area of FZ2 is located on the western boundary. No buildings are proposed in this area.

Areas of surface water flood risk run through the site centred on the existing ditches, winterbournes, and hedge banks. These areas will not be developed and will remain as ecological corridors and flow routes through which the canal can discharge excess flows when required.

Mitigation measures are proposed to reduce any flood risk from a canal breach or minor overtopping.

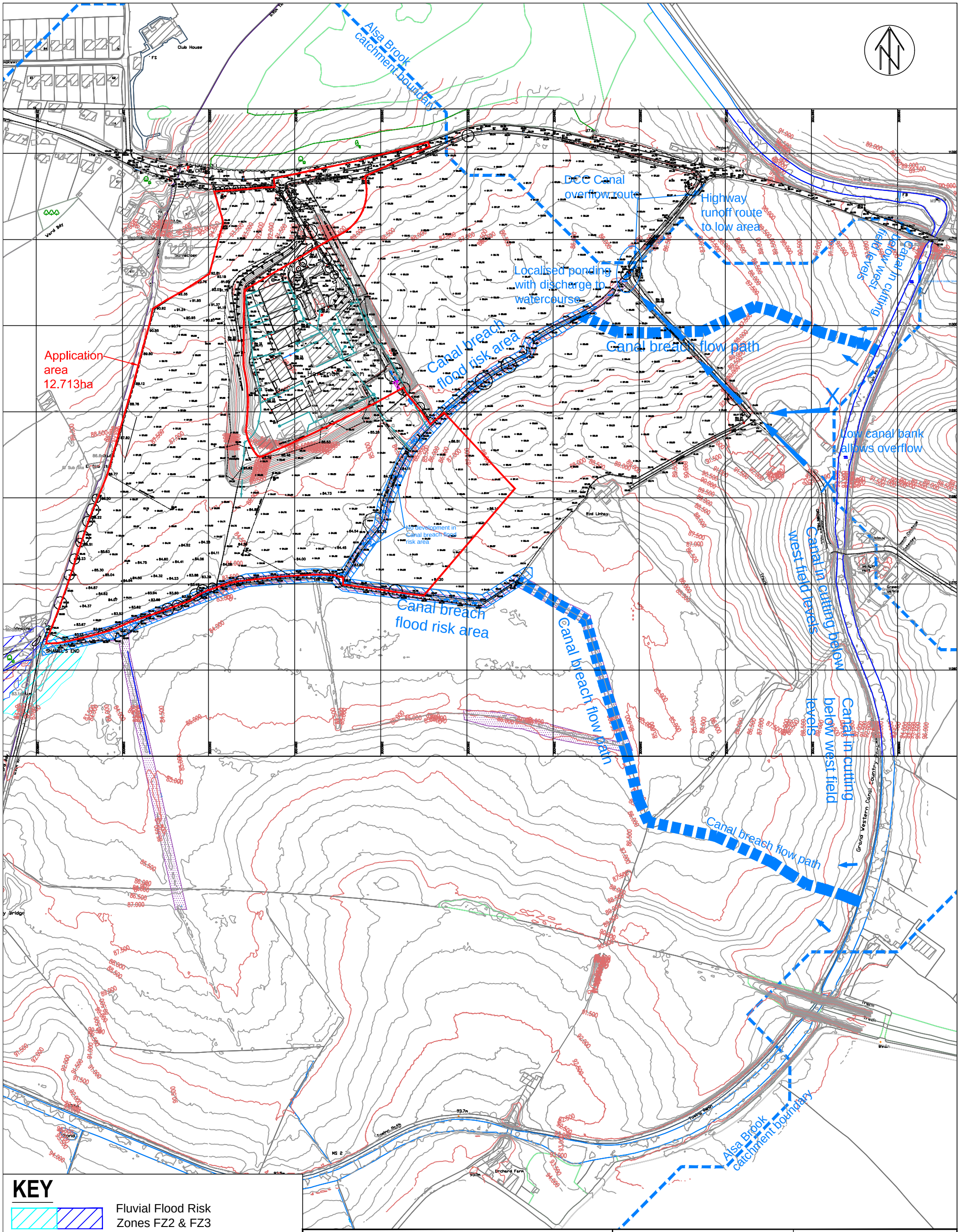
The site surface water runoff from the proposed development will drain via wetland ponds and the discharge rates to the Alsa Brook will be maintained as close as possible to existing Greenfield rates.

The Architects conceptual layout plan includes large areas of public open space and these areas provide suitable locations to include swales and surface water attenuation ponds or basins.

There is no reason why this site cannot be developed based on the assessment of existing and potential flood risk.

DRAWINGS

1.	FRA1	Existing Site Layout, LIDAR Height Data and Flood Risk Areas
2.	FRA2	Architects Masterplan
3.	FRA3	Illustrative Surface Water Drainage Strategy



KEY

- Fluvial Flood Risk Zones FZ2 & FZ3
- Surface Water Flood Risk Areas (Pluvial Risk)
- Watercourse catchment boundaries from FEH & topgraphy
- Canal breach flow route & Flood risk area

TEIGNCONSULT
9 Higher Kingsdown Road
Teignmouth
Devon
TQ14 9AT

Project: Hartnolls Farm, Halberton, Tiverton		Client: Waddeton Park	
Subject: Flood Zones & Canal Breach Route on LIDAR Height Data		Date: March 2021	Scale: 1:4000 @ A3
		Drawn: NAS	Checked: NAS
Project No: 529	Drawing No: FRA1		Rev.: A

DEFINE

Legend

- Red Line Site Boundary
- Primary Road
- Secondary Road
- Tertiary Road
- Pedestrian/Cycle Route
- Vehicular Link to TEUE
- Vehicular Site Access
- Employment Access Point
- Residential Access Point
- Pedestrian/Cycle Access Point
- Proposed Bridge - Vehicular Access
- Canal Breach - No build
- Open Space (incl. SuDS)
- New Woodland Planting
- Development / New Homes
- Development / Employment

N

10 30
0m 20 50 100

D	Rev
DE_425_SK11	Drg No
Waddeton Park LTD	Client
425 Hartnoll Park, Tiverton	Project
Framework Plan	Title
1:2500@A3	Scale

North Attenuation Pond
Earthworks area 1830m²
Rim area 1305m² @ 90.60
Invert 643m² @ 89.00
1:3 side slopes
Maximum volume 1539m3
Flow controlled by 69mm
Crown vortex 2.9l/s at
1.05m head. Outfall via
swale to southern pond

Swale collects development drainage and discharges into southern pond

Application area 12.713ha

Swale collects development drainage and discharges into southern pond

0.6m deep Swale 1-4 side slopes

Swale collects development drainage and discharges into southern pond

0.8m deep Swale 1-4 side slopes

Swale collects development drainage and discharges into southern pond

Bed level 82.13
Water level 82.35
450 dia culvert
US IL 82.15
DS IL 82.08

F IL 82.60

Emp - N 3569m2

Emp - W 8806m2

Emp - S 12219m2

Emp - E 12211m2

R1 R2 R3 R4 R5 R6 R7 R8

Illustrative spine road

Illustrative acess road

No development in Canal breach flood risk area

Canal breach flood risk area

Canal breach flood risk area

Hartnoll Farm

The Gamble

Ward Bay

Woodleigh House

Barnsclose

HARTNOLL CROSS

SHANGELS END

Pond

KEY

- Employment areas
- Residential units
- Canal breach Flood Risk Areas

Catchment areas

North catchment

South catchment

TEIGNCONSULT
9 Higher Kingsdown Road
Teignmouth
Devon
TQ14 9AT

Project: Hartnolls Farm, Halberton, Tiverton		Client: Waddeton Park	
Subject: Illustrative Surface Water Drainage Strategy		Date: March 2021	Scale: 1:2000 @ A3
		Drawn: NAS	Checked: NAS
Project No: 529	Drawing No: FRA3		Rev.: -

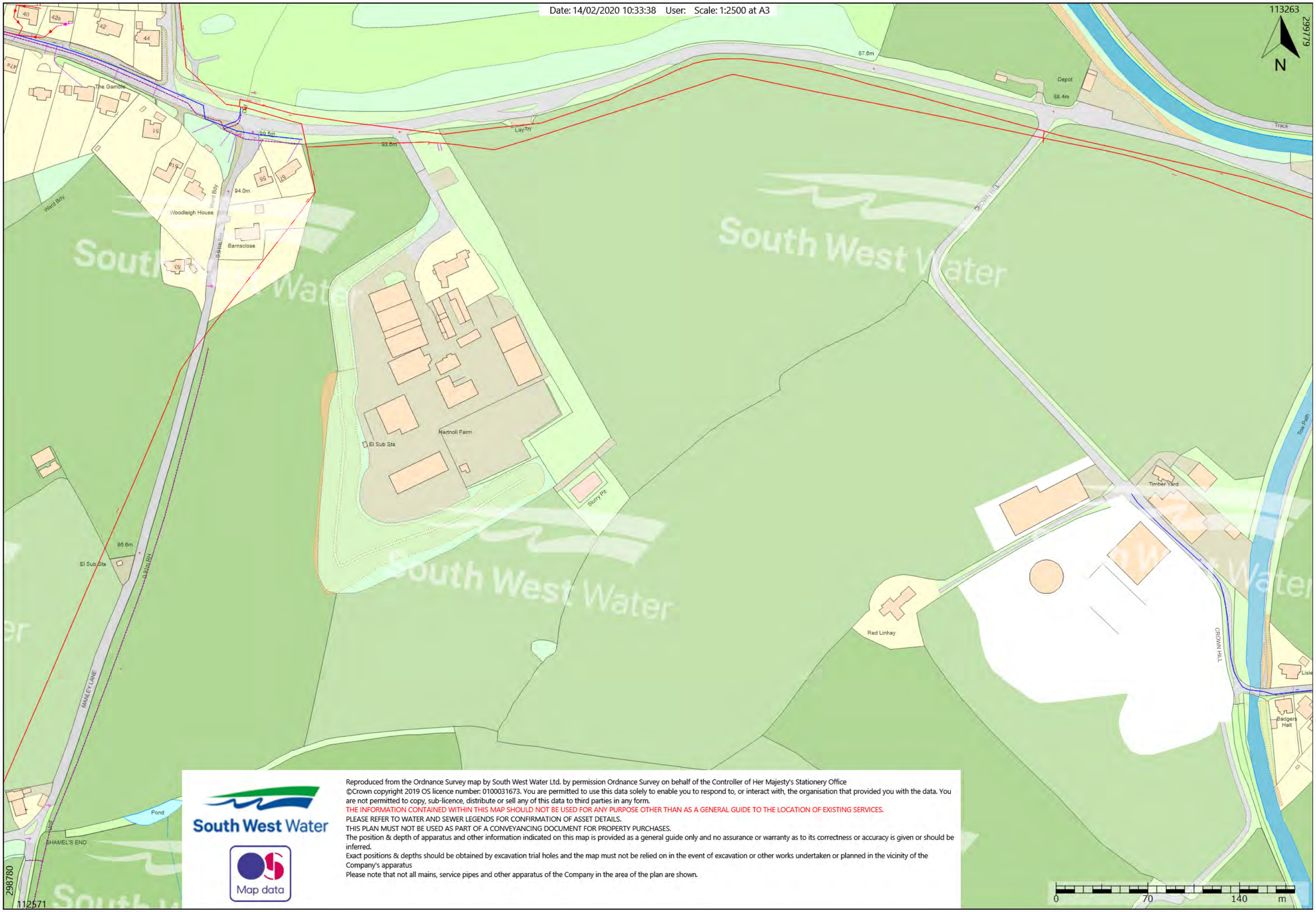
APPENDIX A

Third party data

1. South West Water sewer records
2. Soakaway test locations & results
3. Ground water monitoring data

Date: 14/02/2020 10:33:38 User: Scale: 1:2500 at A3

113263
299779
N



South West Water

Map data

Reproduced from the Ordnance Survey map by South West Water Ltd. by permission Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office
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THE INFORMATION CONTAINED WITHIN THIS MAP SHOULD NOT BE USED FOR ANY PURPOSE OTHER THAN AS A GENERAL GUIDE TO THE LOCATION OF EXISTING SERVICES.
PLEASE REFER TO WATER AND SEWER LEGENDS FOR CONFIRMATION OF ASSET DETAILS.
THIS PLAN MUST NOT BE USED AS PART OF A CONVEYANCING DOCUMENT FOR PROPERTY PURCHASES.
The position & depth of apparatus and other information indicated on this map is provided as a general guide only and no assurance or warranty as to its correctness or accuracy is given or should be inferred.
Exact positions & depths should be obtained by excavation trial holes and the map must not be relied on in the event of excavation or other works undertaken or planned in the vicinity of the Company's apparatus
Please note that not all mains, service pipes and other apparatus of the Company in the area of the plan are shown.

0 70 140 m

298780
112571

From: Howard Mallett
Sent: 08 June 2020 12:28
To: David Jackson; nigel smith
Cc: Gerry; Margaret
Subject: GCE In 2020 06 08 Hartnoll Soaks & GWM results
Attachments: GW levels.pdf

Nigel,

Large-scale infiltration testing was carried out in TP01, TP02, TP03 and TP4. The following table summarises the results of the testing:

Location	Test Range (mbgl)	Infiltration Rate (ms^{-1})
		Test 1
TP1	0.90-2.60m	Water level dropped from 0.90m at 9.30am 22/04/20 to 1.05m at 7.45am 24/04/20.
TP2	0.91-2.50m	Water level dropped from 0.91m at 10.00am 22/04/20 to 1.35m at 8.10am 24/04/20.
TP3	0.90-2.40m	Water level dropped from 0.90m at 10.30am 22/04/20 to 1.48m at 8.05am 24/04/20.
TP4	0.85-2.50m	Water level dropped from 0.85m at 11.00am 22/04/20 to 0.79m at 7.55am 24/04/20.

None of the test pits passed the first test, with all tests failing to reach 25% effective depth in 24hours.

GW levels attached for recent monitoring.

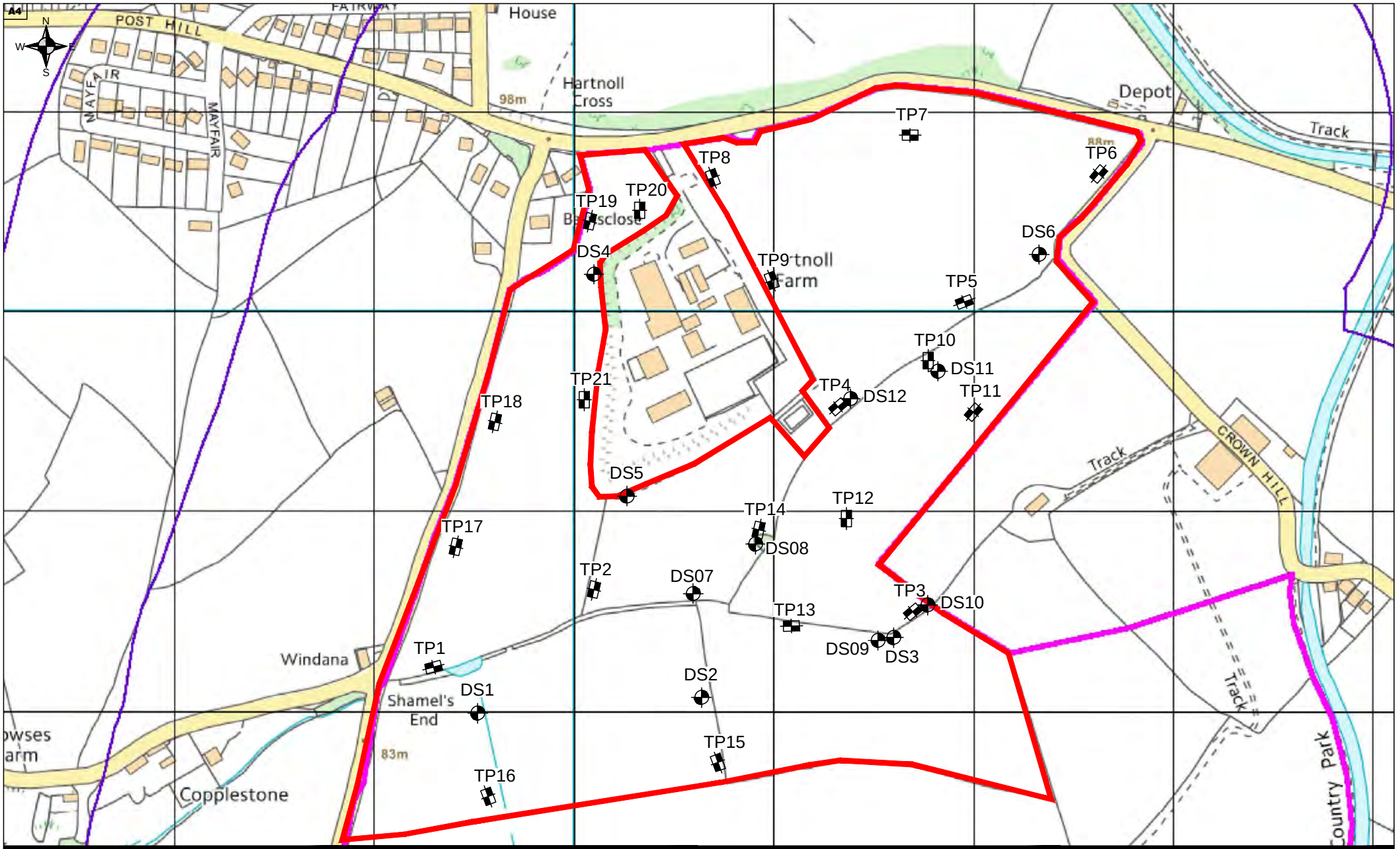
Let me know if you need any more information.

Regards

Howard Mallett
Principal Engineering Geologist
Geo Consulting Engineering Ltd

w: www.geoconsultingeng.co.uk

The Studio, Woodmanton Barns, Woodbury, Exeter, EX5 1HQ



Geo Consulting Engineering Ltd
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E: mail@geoconsultingeng.co.uk
W: www.geoconsultingeng.co.uk

geo consulting engineering ltd

Client: Waddeton Park Ltd

Drawing Status: For Information

Job Title: Hartnoll Farm, Tiverton, Devon

Dwg Title: Exploratory Hole Location Plan

Scale 1:5000 Drawn HM

Date Apr 2020 Checked DLJ

Drawing no: GCE00528-Fig3 Rev P1

Hartnoll Farm - Groundwater Monitoring data

June 2021

DS/TP	level m AOD	well depth m bgl	GW m bgl 23/04/20	GW m AOD 23/04/20	GW m bgl 01/05/20	GW m AOD 01/05/20	GW m bgl 07/05/20	GW m AOD 07/05/20	GW m bgl 14/05/20	GW m AOD 14/05/20	
DS1	83.556	5.00	1.70	81.86	1.85	81.71	1.93	81.63	2.06	81.50	
DS2	84.226	2.79	1.36	82.87	1.40	82.83	1.45	82.78	1.51	82.72	
DS3	84.009	2.02	2.08	81.93	1.57	82.44	1.85	82.16	dry		
DS4	91.394	3.52	dry		dry		dry		dry		North pond invert 89.00
DS5	85.136	3.00	1.60	83.54	1.68	83.46	1.87	83.27	2.00	83.14	
DS6	85.323	2.49	dry		2.47	82.85	dry		dry		
TP1	83.115	2.54	1.00	82.12	1.03	82.09	1.19	81.93	1.31	81.81	South pond invert 82.60
TP2	83.977	2.35	1.42	82.56	1.44	82.54	1.52	82.46	1.63	82.35	South pond
TP3	84.311	1.59	1.48	82.83	1.61	82.70	dry		dry		
TP4	84.872	2.31	0.93	83.94	0.89	83.98	0.97	83.90	1.05	83.82	

81.81 GWL below pond invert

90.01 GWL above pond invert

ADJUSTED DATUM TO PIPE TOP

DS/TP	level m AOD	well depth m bgl	pipe AGL	GW m btop 30/06/20	GW m AOD 30/06/20	GW m btop 22/07/20	GW m AOD 22/07/20	GW m btop 20/08/20	GW m AOD 20/08/20	GW m btop 28/09/20	GW m AOD 28/09/20	GW m btop 21/10/20	GW m AOD 21/10/20	GW m btop 24/11/20	GW m AOD 24/11/20	GW m btop 09/12/20	GW mbgl 9/12/20	GW m AOD 09/12/20	
DS1	83.556	5.00	1.04	3.44	81.16	3.63	80.97	3.80	80.80	4.18	80.42	3.53	81.07	3.06	81.54	3.19	2.15	81.41	
DS2	84.226	2.79	0.89	2.62	82.50	2.91	82.21	3.02	82.10	3.35	81.77	2.52	82.60	2.23	82.89	2.29	1.40	82.83	
DS3	84.009	2.02																	
DS4	91.394	3.52	0.88	dry		dry		dry		dry		dry		4.44	87.83	dry			North pond invert 89.00
DS5	85.136	3.24	0.86	1.60	84.40	3.67	82.33	3.62	82.38	3.80	82.20	dry		3.29	82.71	3.38	2.52	82.62	
DS6	85.323	2.49	0.78	dry		dry		dry		dry		dry		2.54	83.56	2.56	1.78	83.54	
DS7	83.333	2.00								dry		dry		1.48	81.85	1.52	1.52	81.81	
DS8	83.860	2.00								dry		dry		2.04	81.82	2.17	2.17	81.69	
DS9	83.950	2.00								dry		dry		2.28	81.67	dry			
DS10	84.110	1.80								dry		dry		2.17	81.94	dry			
DS11	86.523	3.00								dry		dry		2.33	84.19	2.41	2.41	84.11	
DS12	84.785	2.60								2.27	82.52	0.67	84.12	0.87	83.92	0.88	0.88	83.91	
TP1	83.115	2.54	0.77	2.46	81.43	dry		2.80	81.09	3.13	80.76	2.76	81.13	2.16	81.73	2.33	1.56	81.56	South pond invert 82.60
TP2	83.977	2.35	1.00	3.07	81.91	2.69	82.29	3.35	81.63	dry		dry		2.80	82.18	dry			South pond
TP3	84.311	1.59		dry		2.29	82.02	2.31	82.00	dry		dry							
TP4	84.872	2.31	0.94	2.47	83.34	2.70	83.11	2.71	83.10	dry		2.65	83.16	1.76	84.05	1.86	0.92	83.95	

DS/TP	level m AOD	well depth m bgl	Pipe AGL	GW m btop 15/01/21	GW mbgl 15/01/21	GW m AOD 15/01/21	GW m btop 18/02/21	GW m bgl 18/02/21	GW m AOD 18/02/21	GW m btop 23/03/21	GW m bgl 23/03/21	GW m AOD 23/03/21	GW m btop 21/04/21	GW m bgl 21/04/21	GW m AOD 21/04/21	GW m btop 19/05/21	GW m bgl 19/05/21	GW m AOD 19/05/21	GW m btop 22/06/21	GW m bgl 22/06/21	GW m AOD 22/06/21
DS1	83.556	5.00	1.04	1.87	0.83	82.73	1.18	0.14	83.42	2.19	1.15	82.41	2.86	1.82	81.74	1.85	0.81	82.75	3.07	2.03	81.53
DS2	84.226	2.79	0.89	1.79	0.90	83.33	1.25	0.36	83.87	2.07	1.18	83.05	2.35	1.46	82.77	1.75	0.86	83.37	2.49	1.60	82.63
DS3	84.009	2.02															0.00	84.01	dry		
DS4	91.394	3.52	0.88	dry			2.26	1.38	90.01	dry			dry			dry			dry		
DS5	85.136	3.24	0.86	1.51	0.65	84.49	0.87	0.01	85.13	1.65	0.79	84.35	2.57	1.71	83.43	2.00	1.14	84.00	2.82	1.96	83.18
DS6	85.323	2.49	0.78	1.96	1.18	84.14	1.23	0.45	84.87	2.18	1.40	83.92	3.10	2.32	83.00	2.06	1.28	84.04	2.51	1.73	83.59
DS7	83.333	2.00	0.28	0.80	0.52	82.81	0.49	0.21	83.12	0.27	-0.01	83.34	0.64	0.36	82.97	0.76	0.48	82.85	2.25	1.97	81.36
DS8	83.860	2.00	0.35	0.48	0.13	83.73	0.27	-0.08	83.94	0.00	-0.35	84.21	1.40	1.05	82.81	0.97	0.62	83.24	1.89	1.54	82.32
DS9	83.950	2.00	0.31	0.84	0.53	83.42	0.72	0.41	83.54	0.67	0.36	83.59	1.95	1.64	82.31	1.74	1.43	82.52	dry		
DS10	84.110	1.80	0.32	1.46	1.14	82.97	1.15	0.83	83.28	1.11	0.79	83.32	dry			0.62	0.30	83.81	dry		
DS11	86.523	3.00	0.33	1.62	1.29	85.23	0.93	0.60	85.92	1.84	1.51	85.01	2.41	2.08	84.44	2.47	2.14	84.38	2.50	2.17	84.35
DS12	84.785	2.60	0.30	0.45	0.15	84.64	0.24	-0.06	84.85	0.94	0.64	84.15	1.17	0.87	83.92	0.68	0.38	84.41	1.17	0.87	83.92
TP1	83.115	2.54	0.77	1.10	0.33	82.79															
TP2	83.977	2.35	1.00	1.95	0.95	83.03															
TP3	84.311	1.59																			
TP4	84.872	2.31	0.94	1.50	0.56	84.31															

APPENDIX B

Greenfield runoff calculations

1. IoH 124 Greenfield runoff for site
2. Greenfield run off volume north catchment
3. Greenfield run off volume south catchment

IoH 124

$QBAR_{rural} = 0.00108\ AREA^{0.89}\ SAAR^{1.17}\ SOIL^{2.17}$

Area (m2)	127133	500000	
AREA (km^2) =	0.127	0.50	
Area (ha)	12.713	50.000	ha from SUDS ICOP
SAAR =	1000		
SOIL =	0.3		

Co-Ords
E 299050
N 112920
M5-60 19.4
r 0.322
Soil Index 0.3
SPR % 30
SAAR mm 1000

QBAR for 50 Ha = 0.138 m^3/s

Return Periods	Growth factors for Region 8A		ICOP (ha) 50	Total site (ha) 12.713	North area 1.036	South area 5.147		Cascade pond option	or l/s/ha
Mean Annual Flood (QBAR)	1.00	=	138.3	35.2	2.9	14.2	l/s	17.1	2.8
1 yr	0.78	=	107.9	27.4	2.2	11.1	l/s	13.3	2.2
2 yr	0.88	=	121.7	30.9	2.5	12.5	l/s	15.1	2.4
5 yr	1.28	=	177.0	45.0	3.7	18.2	l/s	21.9	3.5
10 yr	1.58	=	218.5	55.6	4.5	22.5	l/s	27.0	4.4
25 yr	2.03	=	280.8	71.4	5.8	28.9	l/s	34.7	5.6
30 yr	2.14	=	296.0	75.3	6.1	30.5	l/s	36.6	5.9
50 yr	2.45	=	338.9	86.2	7.0	34.9	l/s	41.9	6.8
100 yr	2.93	=	405.3	103.0	8.4	41.7	l/s	50.1	8.1
Climate Change	100yr+ 40%	=	567.4	144.3	11.8	58.4	l/s	70.2	11.3

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 298999 112899 SS 98999 12899
Data Type	Point
Areal Reduction Factor	1.00
Area (ha)	1.036
SAAR (mm)	1000
CWI	123.365
SPR Host	30.000
URBEXT (2000)	0.0000

Results

Percentage Runoff (%)	33.40
Greenfield Runoff Volume (m^3)	211.462

Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	2013
Site Location	GB 298999 112899 SS 98999 12899
Data Type	Point
Areal Reduction Factor	1.00
Area (ha)	5.147
SAAR (mm)	1000
CWI	123.365
SPR Host	30.000
URBEXT (1990)	0.0000

Results

Percentage Runoff (%)	33.40
Greenfield Runoff Volume (m^3)	1050.576

APPENDIX C

Outline surface water drainage strategy

1. Site area take off for roads, roofs and impermeable areas
2. Micro Drainage Results: - North – South cascade pond sizing for 2yr, 30yr, 100yr & CC40% storms
3. Rainwater harvesting tank sizing for 1000m² roof area building

Location			Highway	Ponds
Spine Road				
East			3394.7	
West			1375.4	
Housing	Roofs	Paving / parking		
R1	1341.5	645.0	1781.9	
R2	866.6	416.6		
R3	921.7	443.1		
R4	894.1	429.9		
R5	840.1	403.9		
R6	1155.1	555.3		
R7	1301.1	625.5		
R8	510.4	245.4		
Roads 2 - 8			10795.8	
North Pond invert				643.0
Employment	Gross area	@ 60% impermeable area		
North	3568.8	2141.3		
West	8806.4	5283.8		
East	12210.9	7326.5		
South	12218.8	7331.3		
Access Road			2816.9	
South Pond invert				3974.0

Total to each pond	**North**	9947	m²
	add 10% urban creep private areas	413	
	Total to MicroDrainage	**10360**	m²
	South	48513	m²
	add 10% urban creep private areas	2955	
	Total to MicroDrainage	**51468**	

Cascade Summary of Results for N Pond 2yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	S Pond 2yr V1.SRCX	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	89.103	0.103	1.0	68.3	O K
30 min Summer	89.134	0.134	1.2	89.5	O K
60 min Summer	89.167	0.167	1.2	112.4	O K
120 min Summer	89.210	0.210	1.3	143.5	O K
180 min Summer	89.236	0.236	1.4	162.0	O K
240 min Summer	89.253	0.253	1.4	174.8	O K
360 min Summer	89.276	0.276	1.5	191.8	O K
480 min Summer	89.291	0.291	1.5	203.0	O K
600 min Summer	89.301	0.301	1.5	210.9	O K
720 min Summer	89.309	0.309	1.6	216.7	O K
960 min Summer	89.319	0.319	1.6	224.1	O K
1440 min Summer	89.331	0.331	1.6	233.8	O K
2160 min Summer	89.345	0.345	1.7	244.2	O K
2880 min Summer	89.354	0.354	1.7	251.4	O K
4320 min Summer	89.367	0.367	1.7	261.1	O K
5760 min Summer	89.375	0.375	1.7	267.3	O K
7200 min Summer	89.380	0.380	1.7	271.9	O K
8640 min Summer	89.385	0.385	1.7	275.7	O K
10080 min Summer	89.390	0.390	1.8	279.3	O K
15 min Winter	89.115	0.115	1.1	76.5	O K
30 min Winter	89.149	0.149	1.2	100.3	O K
60 min Winter	89.186	0.186	1.2	126.1	O K
120 min Winter	89.234	0.234	1.4	161.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	35.545	0.0	47.3	22
30 min Summer	23.394	0.0	63.4	36
60 min Summer	14.811	0.0	101.3	64
120 min Summer	9.593	0.0	130.8	124
180 min Summer	7.326	0.0	148.7	184
240 min Summer	6.015	0.0	161.4	244
360 min Summer	4.523	0.0	178.5	362
480 min Summer	3.690	0.0	189.9	482
600 min Summer	3.151	0.0	197.7	602
720 min Summer	2.769	0.0	202.9	720
960 min Summer	2.261	0.0	207.7	952
1440 min Summer	1.708	0.0	207.6	1180
2160 min Summer	1.302	0.0	344.6	1560
2880 min Summer	1.083	0.0	373.2	1984
4320 min Summer	0.848	0.0	390.7	2812
5760 min Summer	0.722	0.0	533.4	3640
7200 min Summer	0.643	0.0	591.1	4472
8640 min Summer	0.588	0.0	644.0	5280
10080 min Summer	0.547	0.0	687.8	6152
15 min Winter	35.545	0.0	53.6	22
30 min Winter	23.394	0.0	71.0	36
60 min Winter	14.811	0.0	113.6	64
120 min Winter	9.593	0.0	146.0	122

Cascade Summary of Results for N Pond 2yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	89.263	0.263	1.4	182.0	O K
240 min Winter	89.282	0.282	1.5	196.5	O K
360 min Winter	89.308	0.308	1.6	215.9	O K
480 min Winter	89.325	0.325	1.6	229.0	O K
600 min Winter	89.338	0.338	1.6	238.5	O K
720 min Winter	89.347	0.347	1.7	245.7	O K
960 min Winter	89.359	0.359	1.7	255.4	O K
1440 min Winter	89.372	0.372	1.7	265.6	O K
2160 min Winter	89.385	0.385	1.7	275.6	O K
2880 min Winter	89.393	0.393	1.8	281.9	O K
4320 min Winter	89.401	0.401	1.8	288.2	O K
5760 min Winter	89.403	0.403	1.8	290.1	O K
7200 min Winter	89.404	0.404	1.8	290.3	O K
8640 min Winter	89.403	0.403	1.8	289.7	O K
10080 min Winter	89.402	0.402	1.8	289.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	7.326	0.0	165.3	180
240 min Winter	6.015	0.0	178.7	240
360 min Winter	4.523	0.0	196.1	356
480 min Winter	3.690	0.0	207.0	472
600 min Winter	3.151	0.0	213.7	586
720 min Winter	2.769	0.0	217.7	700
960 min Winter	2.261	0.0	220.9	922
1440 min Winter	1.708	0.0	223.0	1330
2160 min Winter	1.302	0.0	383.2	1664
2880 min Winter	1.083	0.0	411.5	2132
4320 min Winter	0.848	0.0	421.3	3068
5760 min Winter	0.722	0.0	597.2	3968
7200 min Winter	0.643	0.0	661.5	4832
8640 min Winter	0.588	0.0	719.3	5704
10080 min Winter	0.547	0.0	763.1	6552

Cascade Rainfall Details for N Pond 2yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 1.036

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.900	4	8	0.136

Cascade Model Details for N Pond 2yr V1.SRCX

Storage is Online Cover Level (m) 90.600

Tank or Pond Structure

Invert Level (m) 89.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	643.7	1.200	1126.0	2.400	0.0	3.600	0.0	4.800	0.0
0.200	718.4	1.400	1214.3	2.600	0.0	3.800	0.0	5.000	0.0
0.400	795.0	1.600	1304.9	2.800	0.0	4.000	0.0		
0.600	874.7	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	956.2	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	1040.0	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.050 Vortex Valve® Type R1 SW Only Invert Level (m) 89.000
Design Flow (l/s) 2.9 Diameter (mm) 69

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.0	0.800	2.5	2.000	4.0	4.000	5.6	7.000	7.4
0.200	1.3	1.000	2.8	2.200	4.2	4.500	6.0	7.500	7.7
0.300	1.5	1.200	3.1	2.400	4.4	5.000	6.3	8.000	8.0
0.400	1.8	1.400	3.3	2.600	4.5	5.500	6.6	8.500	8.2
0.500	2.0	1.600	3.6	3.000	4.9	6.000	6.9	9.000	8.4
0.600	2.2	1.800	3.8	3.500	5.3	6.500	7.2	9.500	8.7

Cascade Summary of Results for S Pond 2yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
N Pond 2yr V1.SRCX	(None)	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	82.685	0.085	3.4	341.4	O K
30 min Summer	82.711	0.111	5.0	447.4	O K
60 min Summer	82.739	0.139	6.7	561.5	O K
120 min Summer	82.776	0.176	8.8	714.1	O K
180 min Summer	82.797	0.197	9.9	803.3	O K
240 min Summer	82.811	0.211	10.6	863.9	O K
360 min Summer	82.830	0.230	11.4	940.9	O K
480 min Summer	82.841	0.241	11.8	989.0	O K
600 min Summer	82.849	0.249	12.0	1020.7	O K
720 min Summer	82.854	0.254	12.1	1043.0	O K
960 min Summer	82.863	0.263	12.4	1080.4	O K
1440 min Summer	82.876	0.276	12.6	1136.2	O K
2160 min Summer	82.889	0.289	12.8	1191.2	O K
2880 min Summer	82.897	0.297	12.8	1225.7	O K
4320 min Summer	82.906	0.306	12.8	1265.0	O K
5760 min Summer	82.910	0.310	12.8	1282.4	O K
7200 min Summer	82.912	0.312	12.8	1289.4	O K
8640 min Summer	82.912	0.312	12.8	1291.1	O K
10080 min Summer	82.912	0.312	12.8	1290.3	O K
15 min Winter	82.695	0.095	4.0	382.2	O K
30 min Winter	82.724	0.124	5.8	500.9	O K
60 min Winter	82.755	0.155	7.6	628.5	O K
120 min Winter	82.796	0.196	9.9	800.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	35.545	0.0	200.2	27
30 min Summer	23.394	0.0	280.3	41
60 min Summer	14.811	0.0	518.4	70
120 min Summer	9.593	0.0	686.1	128
180 min Summer	7.326	0.0	790.9	186
240 min Summer	6.015	0.0	867.2	246
360 min Summer	4.523	0.0	975.6	364
480 min Summer	3.690	0.0	1054.9	482
600 min Summer	3.151	0.0	1117.1	600
720 min Summer	2.769	0.0	1167.8	674
960 min Summer	2.261	0.0	1245.4	784
1440 min Summer	1.708	0.0	1340.4	1040
2160 min Summer	1.302	0.0	1978.6	1456
2880 min Summer	1.083	0.0	2157.5	1876
4320 min Summer	0.848	0.0	2399.3	2720
5760 min Summer	0.722	0.0	3139.6	3520
7200 min Summer	0.643	0.0	3472.2	4328
8640 min Summer	0.588	0.0	3772.4	5104
10080 min Summer	0.547	0.0	4024.1	5864
15 min Winter	35.545	0.0	230.7	26
30 min Winter	23.394	0.0	321.1	41
60 min Winter	14.811	0.0	587.6	68
120 min Winter	9.593	0.0	775.1	126

Cascade Summary of Results for S Pond 2yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	82.820	0.220	11.0	900.9	O K
240 min Winter	82.837	0.237	11.6	969.8	O K
360 min Winter	82.858	0.258	12.2	1059.0	O K
480 min Winter	82.871	0.271	12.5	1116.6	O K
600 min Winter	82.881	0.281	12.7	1156.8	O K
720 min Winter	82.887	0.287	12.7	1185.8	O K
960 min Winter	82.896	0.296	12.8	1223.2	O K
1440 min Winter	82.908	0.308	12.8	1275.8	O K
2160 min Winter	82.919	0.319	12.8	1322.0	O K
2880 min Winter	82.924	0.324	12.8	1342.1	O K
4320 min Winter	82.925	0.325	12.8	1347.2	O K
5760 min Winter	82.921	0.321	12.8	1328.0	O K
7200 min Winter	82.914	0.314	12.8	1299.9	O K
8640 min Winter	82.907	0.307	12.8	1269.3	O K
10080 min Winter	82.900	0.300	12.8	1239.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	7.326	0.0	891.6	184
240 min Winter	6.015	0.0	976.1	242
360 min Winter	4.523	0.0	1095.7	356
480 min Winter	3.690	0.0	1182.5	470
600 min Winter	3.151	0.0	1250.3	582
720 min Winter	2.769	0.0	1305.2	692
960 min Winter	2.261	0.0	1388.1	896
1440 min Winter	1.708	0.0	1483.0	1118
2160 min Winter	1.302	0.0	2213.3	1588
2880 min Winter	1.083	0.0	2408.5	2052
4320 min Winter	0.848	0.0	2668.3	2944
5760 min Winter	0.722	0.0	3518.1	3800
7200 min Winter	0.643	0.0	3889.9	4616
8640 min Winter	0.588	0.0	4224.8	5440
10080 min Winter	0.547	0.0	4504.8	6168

Cascade Rainfall Details for S Pond 2yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	2	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 5.147

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	2.000	4	8	2.000	8	12	1.147

Cascade Model Details for S Pond 2yr V1.SRCX

Storage is Online Cover Level (m) 84.000

Tank or Pond Structure

Invert Level (m) 82.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3973.8	1.200	5276.7	2.400	0.0	3.600	0.0	4.800	0.0
0.200	4185.3	1.400	5501.7	2.600	0.0	3.800	0.0	5.000	0.0
0.400	4399.0	1.600	0.0	2.800	0.0	4.000	0.0		
0.600	4615.1	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	4833.3	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	5053.9	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.000 Vortex Valve® Type C1 Invert Level (m) 82.600
Design Flow (l/s) 17.0 Diameter (mm) 130

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	15.2	2.000	24.1	4.000	34.1	7.000	45.1
0.200	10.1	1.000	17.0	2.200	25.3	4.500	36.2	7.500	46.7
0.300	12.8	1.200	18.7	2.400	26.4	5.000	38.1	8.000	48.2
0.400	10.8	1.400	20.2	2.600	27.5	5.500	40.0	8.500	49.7
0.500	12.1	1.600	21.6	3.000	29.5	6.000	41.8	9.000	51.1
0.600	13.2	1.800	22.9	3.500	31.9	6.500	43.5	9.500	52.6

Cascade Summary of Results for N Pond 30yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	S Pond 30yr V1.SRCX	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	89.213	0.213	1.3	145.3	O K
30 min Summer	89.278	0.278	1.5	193.5	O K
60 min Summer	89.347	0.347	1.7	245.7	O K
120 min Summer	89.397	0.397	1.8	284.7	O K
180 min Summer	89.426	0.426	1.8	308.4	O K
240 min Summer	89.447	0.447	1.9	325.2	O K
360 min Summer	89.475	0.475	1.9	348.4	O K
480 min Summer	89.495	0.495	2.0	364.3	O K
600 min Summer	89.508	0.508	2.0	375.8	O K
720 min Summer	89.519	0.519	2.0	384.5	O K
960 min Summer	89.533	0.533	2.1	396.2	O K
1440 min Summer	89.545	0.545	2.1	407.0	O K
2160 min Summer	89.555	0.555	2.1	415.6	O K
2880 min Summer	89.562	0.562	2.1	421.4	O K
4320 min Summer	89.569	0.569	2.1	427.4	O K
5760 min Summer	89.573	0.573	2.1	430.7	O K
7200 min Summer	89.579	0.579	2.1	435.7	O K
8640 min Summer	89.585	0.585	2.2	441.0	O K
10080 min Summer	89.591	0.591	2.2	446.5	O K
15 min Winter	89.237	0.237	1.4	162.8	O K
30 min Winter	89.309	0.309	1.6	216.9	O K
60 min Winter	89.385	0.385	1.7	275.4	O K
120 min Winter	89.440	0.440	1.9	319.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	75.348	0.0	95.3	22
30 min Summer	50.335	0.0	109.9	37
60 min Summer	32.133	0.0	209.1	66
120 min Summer	18.843	0.0	233.3	124
180 min Summer	13.763	0.0	244.8	184
240 min Summer	11.009	0.0	251.7	244
360 min Summer	8.039	0.0	261.5	364
480 min Summer	6.438	0.0	268.7	482
600 min Summer	5.425	0.0	273.5	602
720 min Summer	4.721	0.0	276.7	722
960 min Summer	3.797	0.0	279.9	960
1440 min Summer	2.808	0.0	278.4	1372
2160 min Summer	2.089	0.0	513.4	1712
2880 min Summer	1.703	0.0	520.6	2104
4320 min Summer	1.290	0.0	513.4	2940
5760 min Summer	1.071	0.0	789.1	3752
7200 min Summer	0.940	0.0	858.3	4608
8640 min Summer	0.851	0.0	912.6	5448
10080 min Summer	0.787	0.0	927.3	6256
15 min Winter	75.348	0.0	101.9	22
30 min Winter	50.335	0.0	115.2	36
60 min Winter	32.133	0.0	227.5	64
120 min Winter	18.843	0.0	249.3	124

Cascade Summary of Results for N Pond 30yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	89.473	0.473	1.9	346.3	O K
240 min Winter	89.496	0.496	2.0	365.4	O K
360 min Winter	89.528	0.528	2.0	392.2	O K
480 min Winter	89.549	0.549	2.1	410.6	O K
600 min Winter	89.565	0.565	2.1	424.4	O K
720 min Winter	89.578	0.578	2.1	434.9	O K
960 min Winter	89.595	0.595	2.2	449.9	O K
1440 min Winter	89.613	0.613	2.2	465.9	O K
2160 min Winter	89.621	0.621	2.2	472.9	O K
2880 min Winter	89.627	0.627	2.2	478.3	O K
4320 min Winter	89.630	0.630	2.2	480.6	O K
5760 min Winter	89.628	0.628	2.2	478.5	O K
7200 min Winter	89.627	0.627	2.2	477.9	O K
8640 min Winter	89.626	0.626	2.2	477.6	O K
10080 min Winter	89.627	0.627	2.2	477.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	13.763	0.0	260.1	182
240 min Winter	11.009	0.0	268.4	240
360 min Winter	8.039	0.0	280.1	358
480 min Winter	6.438	0.0	287.5	474
600 min Winter	5.425	0.0	292.4	590
720 min Winter	4.721	0.0	295.6	706
960 min Winter	3.797	0.0	298.7	934
1440 min Winter	2.808	0.0	296.6	1374
2160 min Winter	2.089	0.0	552.1	1948
2880 min Winter	1.703	0.0	561.6	2224
4320 min Winter	1.290	0.0	551.7	3156
5760 min Winter	1.071	0.0	882.1	4088
7200 min Winter	0.940	0.0	955.9	4976
8640 min Winter	0.851	0.0	1003.1	5880
10080 min Winter	0.787	0.0	1010.8	6752

Cascade Rainfall Details for N Pond 30yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 1.036

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.900	4	8	0.136

Cascade Model Details for N Pond 30yr V1.SRCX

Storage is Online Cover Level (m) 90.600

Tank or Pond Structure

Invert Level (m) 89.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	643.7	1.200	1126.0	2.400	0.0	3.600	0.0	4.800	0.0
0.200	718.4	1.400	1214.3	2.600	0.0	3.800	0.0	5.000	0.0
0.400	795.0	1.600	1304.9	2.800	0.0	4.000	0.0		
0.600	874.7	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	956.2	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	1040.0	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.050 Vortex Valve® Type R1 SW Only Invert Level (m) 89.000
Design Flow (l/s) 2.9 Diameter (mm) 69

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.0	0.800	2.5	2.000	4.0	4.000	5.6	7.000	7.4
0.200	1.3	1.000	2.8	2.200	4.2	4.500	6.0	7.500	7.7
0.300	1.5	1.200	3.1	2.400	4.4	5.000	6.3	8.000	8.0
0.400	1.8	1.400	3.3	2.600	4.5	5.500	6.6	8.500	8.2
0.500	2.0	1.600	3.6	3.000	4.9	6.000	6.9	9.000	8.4
0.600	2.2	1.800	3.8	3.500	5.3	6.500	7.2	9.500	8.7

Cascade Summary of Results for S Pond 30yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
N Pond 30yr V1.SRCX	(None)	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	82.777	0.177	8.9	721.4	O K
30 min Summer	82.834	0.234	11.5	959.5	O K
60 min Summer	82.894	0.294	12.8	1216.0	O K
120 min Summer	82.939	0.339	12.8	1407.8	O K
180 min Summer	82.966	0.366	12.8	1525.8	O K
240 min Summer	82.986	0.386	12.8	1612.2	O K
360 min Summer	83.014	0.414	12.8	1735.0	O K
480 min Summer	83.033	0.433	12.8	1819.2	O K
600 min Summer	83.047	0.447	12.8	1881.1	O K
720 min Summer	83.057	0.457	12.8	1928.4	O K
960 min Summer	83.072	0.472	12.8	1994.2	O K
1440 min Summer	83.087	0.487	12.8	2059.6	O K
2160 min Summer	83.097	0.497	12.8	2106.7	O K
2880 min Summer	83.104	0.504	12.8	2139.5	O K
4320 min Summer	83.112	0.512	12.8	2173.1	O K
5760 min Summer	83.115	0.515	12.8	2188.6	O K
7200 min Summer	83.120	0.520	12.8	2209.1	O K
8640 min Summer	83.124	0.524	12.8	2229.3	O K
10080 min Summer	83.129	0.529	12.8	2250.3	O K
15 min Winter	82.798	0.198	10.0	808.0	O K
30 min Winter	82.861	0.261	12.3	1075.1	O K
60 min Winter	82.929	0.329	12.8	1364.2	O K
120 min Winter	82.979	0.379	12.8	1583.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	75.348	0.0	486.9	26
30 min Summer	50.335	0.0	661.2	41
60 min Summer	32.133	0.0	1179.6	70
120 min Summer	18.843	0.0	1372.5	130
180 min Summer	13.763	0.0	1487.4	188
240 min Summer	11.009	0.0	1566.1	248
360 min Summer	8.039	0.0	1667.2	366
480 min Summer	6.438	0.0	1728.5	486
600 min Summer	5.425	0.0	1764.4	606
720 min Summer	4.721	0.0	1781.5	724
960 min Summer	3.797	0.0	1774.1	962
1440 min Summer	2.808	0.0	1664.0	1430
2160 min Summer	2.089	0.0	3058.1	1756
2880 min Summer	1.703	0.0	3185.2	2136
4320 min Summer	1.290	0.0	3095.3	2948
5760 min Summer	1.071	0.0	4642.2	3808
7200 min Summer	0.940	0.0	5038.3	4616
8640 min Summer	0.851	0.0	5374.9	5456
10080 min Summer	0.787	0.0	5606.0	6352
15 min Winter	75.348	0.0	550.7	26
30 min Winter	50.335	0.0	741.5	40
60 min Winter	32.133	0.0	1318.1	70
120 min Winter	18.843	0.0	1521.4	128

Cascade Summary of Results for S Pond 30yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	83.010	0.410	12.8	1719.7	O K
240 min Winter	83.032	0.432	12.8	1817.2	O K
360 min Winter	83.063	0.463	12.8	1953.3	O K
480 min Winter	83.084	0.484	12.8	2048.1	O K
600 min Winter	83.100	0.500	12.8	2119.0	O K
720 min Winter	83.112	0.512	12.8	2174.0	O K
960 min Winter	83.130	0.530	12.8	2253.1	O K
1440 min Winter	83.149	0.549	12.8	2340.5	O K
2160 min Winter	83.158	0.558	12.8	2382.4	O K
2880 min Winter	83.163	0.563	12.8	2404.7	O K
4320 min Winter	83.165	0.565	12.8	2415.1	O K
5760 min Winter	83.162	0.562	12.8	2399.3	O K
7200 min Winter	83.159	0.559	12.8	2388.6	O K
8640 min Winter	83.157	0.557	12.8	2377.3	O K
10080 min Winter	83.155	0.555	12.8	2368.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	13.763	0.0	1634.2	186
240 min Winter	11.009	0.0	1709.7	244
360 min Winter	8.039	0.0	1801.7	362
480 min Winter	6.438	0.0	1848.0	478
600 min Winter	5.425	0.0	1865.7	594
720 min Winter	4.721	0.0	1863.2	710
960 min Winter	3.797	0.0	1822.3	938
1440 min Winter	2.808	0.0	1711.8	1386
2160 min Winter	2.089	0.0	3360.6	1996
2880 min Winter	1.703	0.0	3453.5	2256
4320 min Winter	1.290	0.0	3249.3	3200
5760 min Winter	1.071	0.0	5189.6	4104
7200 min Winter	0.940	0.0	5618.7	5040
8640 min Winter	0.851	0.0	5960.0	5960
10080 min Winter	0.787	0.0	6134.1	6848

Cascade Rainfall Details for S Pond 30yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 5.147

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	2.000	4	8	2.000	8	12	1.147

Cascade Model Details for S Pond 30yr V1.SRCX

Storage is Online Cover Level (m) 84.000

Tank or Pond Structure

Invert Level (m) 82.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3973.8	1.200	5276.7	2.400	0.0	3.600	0.0	4.800	0.0
0.200	4185.3	1.400	5501.7	2.600	0.0	3.800	0.0	5.000	0.0
0.400	4399.0	1.600	0.0	2.800	0.0	4.000	0.0		
0.600	4615.1	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	4833.3	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	5053.9	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.000 Vortex Valve® Type C1 Invert Level (m) 82.600
Design Flow (l/s) 17.0 Diameter (mm) 130

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	15.2	2.000	24.1	4.000	34.1	7.000	45.1
0.200	10.1	1.000	17.0	2.200	25.3	4.500	36.2	7.500	46.7
0.300	12.8	1.200	18.7	2.400	26.4	5.000	38.1	8.000	48.2
0.400	10.8	1.400	20.2	2.600	27.5	5.500	40.0	8.500	49.7
0.500	12.1	1.600	21.6	3.000	29.5	6.000	41.8	9.000	51.1
0.600	13.2	1.800	22.9	3.500	31.9	6.500	43.5	9.500	52.6

Cascade Summary of Results for N Pond 100yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	S Pond 100yr V1.SRCX	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	89.265	0.265	1.5	183.9	O K
30 min Summer	89.348	0.348	1.7	246.8	O K
60 min Summer	89.437	0.437	1.9	316.7	O K
120 min Summer	89.492	0.492	2.0	362.3	O K
180 min Summer	89.527	0.527	2.0	391.7	O K
240 min Summer	89.553	0.553	2.1	413.5	O K
360 min Summer	89.589	0.589	2.2	445.1	O K
480 min Summer	89.615	0.615	2.2	467.9	O K
600 min Summer	89.635	0.635	2.2	485.1	O K
720 min Summer	89.650	0.650	2.3	498.4	O K
960 min Summer	89.670	0.670	2.3	516.9	O K
1440 min Summer	89.689	0.689	2.3	533.9	O K
2160 min Summer	89.695	0.695	2.3	539.3	O K
2880 min Summer	89.696	0.696	2.3	540.5	O K
4320 min Summer	89.690	0.690	2.3	534.5	O K
5760 min Summer	89.682	0.682	2.3	527.5	O K
7200 min Summer	89.681	0.681	2.3	526.7	O K
8640 min Summer	89.683	0.683	2.3	528.3	O K
10080 min Summer	89.687	0.687	2.3	531.9	O K
15 min Winter	89.295	0.295	1.5	206.1	O K
30 min Winter	89.386	0.386	1.7	276.6	O K
60 min Winter	89.483	0.483	2.0	355.0	O K
120 min Winter	89.545	0.545	2.1	406.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	95.335	0.0	107.9	22
30 min Summer	64.116	0.0	123.5	37
60 min Summer	41.351	0.0	248.0	66
120 min Summer	23.908	0.0	266.7	124
180 min Summer	17.408	0.0	279.6	184
240 min Summer	13.922	0.0	288.8	244
360 min Summer	10.186	0.0	301.1	364
480 min Summer	8.182	0.0	309.1	482
600 min Summer	6.910	0.0	314.4	602
720 min Summer	6.022	0.0	317.9	722
960 min Summer	4.850	0.0	321.0	962
1440 min Summer	3.574	0.0	317.5	1440
2160 min Summer	2.629	0.0	596.4	1816
2880 min Summer	2.117	0.0	599.9	2192
4320 min Summer	1.559	0.0	576.9	2984
5760 min Summer	1.267	0.0	930.1	3808
7200 min Summer	1.096	0.0	991.7	4680
8640 min Summer	0.982	0.0	1024.7	5528
10080 min Summer	0.901	0.0	1025.4	6352
15 min Winter	95.335	0.0	113.0	22
30 min Winter	64.116	0.0	131.4	36
60 min Winter	41.351	0.0	263.7	66
120 min Winter	23.908	0.0	285.6	124

Cascade Summary of Results for N Pond 100yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	89.583	0.583	2.2	439.8	O K
240 min Winter	89.612	0.612	2.2	464.6	O K
360 min Winter	89.653	0.653	2.3	500.8	O K
480 min Winter	89.682	0.682	2.3	527.2	O K
600 min Winter	89.704	0.704	2.4	547.3	O K
720 min Winter	89.721	0.721	2.4	563.2	O K
960 min Winter	89.746	0.746	2.4	586.0	O K
1440 min Winter	89.771	0.771	2.5	609.7	O K
2160 min Winter	89.779	0.779	2.5	617.4	O K
2880 min Winter	89.777	0.777	2.5	615.2	O K
4320 min Winter	89.765	0.765	2.5	604.4	O K
5760 min Winter	89.750	0.750	2.4	590.5	O K
7200 min Winter	89.742	0.742	2.4	582.9	O K
8640 min Winter	89.737	0.737	2.4	577.8	O K
10080 min Winter	89.734	0.734	2.4	575.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	17.408	0.0	299.1	182
240 min Winter	13.922	0.0	308.6	240
360 min Winter	10.186	0.0	321.3	358
480 min Winter	8.182	0.0	329.5	476
600 min Winter	6.910	0.0	334.8	592
720 min Winter	6.022	0.0	338.3	708
960 min Winter	4.850	0.0	341.2	940
1440 min Winter	3.574	0.0	337.1	1386
2160 min Winter	2.629	0.0	641.9	2028
2880 min Winter	2.117	0.0	643.8	2304
4320 min Winter	1.559	0.0	617.5	3204
5760 min Winter	1.267	0.0	1037.2	4144
7200 min Winter	1.096	0.0	1095.5	5048
8640 min Winter	0.982	0.0	1114.4	5960
10080 min Winter	0.901	0.0	1114.2	6848

Cascade Rainfall Details for N Pond 100yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 1.036

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.900	4	8	0.136

Cascade Model Details for N Pond 100yr V1.SRCX

Storage is Online Cover Level (m) 90.600

Tank or Pond Structure

Invert Level (m) 89.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	643.7	1.200	1126.0	2.400	0.0	3.600	0.0	4.800	0.0
0.200	718.4	1.400	1214.3	2.600	0.0	3.800	0.0	5.000	0.0
0.400	795.0	1.600	1304.9	2.800	0.0	4.000	0.0		
0.600	874.7	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	956.2	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	1040.0	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.050 Vortex Valve® Type R1 SW Only Invert Level (m) 89.000
Design Flow (l/s) 2.9 Diameter (mm) 69

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.0	0.800	2.5	2.000	4.0	4.000	5.6	7.000	7.4
0.200	1.3	1.000	2.8	2.200	4.2	4.500	6.0	7.500	7.7
0.300	1.5	1.200	3.1	2.400	4.4	5.000	6.3	8.000	8.0
0.400	1.8	1.400	3.3	2.600	4.5	5.500	6.6	8.500	8.2
0.500	2.0	1.600	3.6	3.000	4.9	6.000	6.9	9.000	8.4
0.600	2.2	1.800	3.8	3.500	5.3	6.500	7.2	9.500	8.7

Cascade Summary of Results for S Pond 100yr V1.SRCX

Upstream Structures	Outflow To	Overflow To
N Pond 100yr V1.SRCX	(None)	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	82.823	0.223	11.1	912.5	O K
30 min Summer	82.896	0.296	12.8	1223.1	O K
60 min Summer	82.977	0.377	12.8	1571.1	O K
120 min Summer	83.029	0.429	12.8	1801.2	O K
180 min Summer	83.062	0.462	12.8	1949.5	O K
240 min Summer	83.087	0.487	12.8	2060.3	O K
360 min Summer	83.123	0.523	12.8	2221.8	O K
480 min Summer	83.148	0.548	12.8	2339.1	O K
600 min Summer	83.168	0.568	12.8	2428.3	O K
720 min Summer	83.183	0.583	13.0	2498.0	O K
960 min Summer	83.205	0.605	13.3	2596.6	O K
1440 min Summer	83.225	0.625	13.5	2692.8	O K
2160 min Summer	83.232	0.632	13.6	2724.9	O K
2880 min Summer	83.234	0.634	13.6	2733.8	O K
4320 min Summer	83.228	0.628	13.5	2707.0	O K
5760 min Summer	83.221	0.621	13.4	2672.5	O K
7200 min Summer	83.219	0.619	13.4	2665.5	O K
8640 min Summer	83.220	0.620	13.4	2668.7	O K
10080 min Summer	83.223	0.623	13.5	2680.6	O K
15 min Winter	82.849	0.249	12.0	1022.2	O K
30 min Winter	82.931	0.331	12.8	1371.3	O K
60 min Winter	83.020	0.420	12.8	1763.4	O K
120 min Winter	83.078	0.478	12.8	2020.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	95.335	0.0	626.8	26
30 min Summer	64.116	0.0	837.7	41
60 min Summer	41.351	0.0	1499.0	70
120 min Summer	23.908	0.0	1682.8	130
180 min Summer	17.408	0.0	1786.6	190
240 min Summer	13.922	0.0	1851.7	248
360 min Summer	10.186	0.0	1917.3	368
480 min Summer	8.182	0.0	1932.7	486
600 min Summer	6.910	0.0	1920.7	606
720 min Summer	6.022	0.0	1896.8	724
960 min Summer	4.850	0.0	1850.5	964
1440 min Summer	3.574	0.0	1815.1	1440
2160 min Summer	2.629	0.0	3648.3	1860
2880 min Summer	2.117	0.0	3631.7	2224
4320 min Summer	1.559	0.0	3330.2	3028
5760 min Summer	1.267	0.0	5470.0	3864
7200 min Summer	1.096	0.0	5830.4	4688
8640 min Summer	0.982	0.0	6104.9	5536
10080 min Summer	0.901	0.0	6196.6	6360
15 min Winter	95.335	0.0	704.4	26
30 min Winter	64.116	0.0	921.1	41
60 min Winter	41.351	0.0	1647.5	70
120 min Winter	23.908	0.0	1826.1	128

Cascade Summary of Results for S Pond 100yr V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	83.115	0.515	12.8	2187.6	O K
240 min Winter	83.143	0.543	12.8	2312.5	O K
360 min Winter	83.183	0.583	13.0	2495.8	O K
480 min Winter	83.212	0.612	13.3	2629.8	O K
600 min Winter	83.234	0.634	13.6	2732.8	O K
720 min Winter	83.251	0.651	13.8	2814.2	O K
960 min Winter	83.277	0.677	14.0	2932.0	O K
1440 min Winter	83.303	0.703	14.3	3057.8	O K
2160 min Winter	83.313	0.713	14.4	3104.8	O K
2880 min Winter	83.310	0.710	14.4	3091.4	O K
4320 min Winter	83.299	0.699	14.3	3038.7	O K
5760 min Winter	83.284	0.684	14.1	2966.6	O K
7200 min Winter	83.275	0.675	14.0	2923.7	O K
8640 min Winter	83.268	0.668	13.9	2892.2	O K
10080 min Winter	83.264	0.664	13.9	2871.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	17.408	0.0	1915.1	186
240 min Winter	13.922	0.0	1961.4	244
360 min Winter	10.186	0.0	1988.3	362
480 min Winter	8.182	0.0	1976.9	478
600 min Winter	6.910	0.0	1959.0	596
720 min Winter	6.022	0.0	1949.6	712
960 min Winter	4.850	0.0	1959.8	942
1440 min Winter	3.574	0.0	1941.4	1394
2160 min Winter	2.629	0.0	3898.8	2036
2880 min Winter	2.117	0.0	3804.8	2336
4320 min Winter	1.559	0.0	3586.6	3244
5760 min Winter	1.267	0.0	6102.1	4160
7200 min Winter	1.096	0.0	6476.1	5112
8640 min Winter	0.982	0.0	6720.8	5968
10080 min Winter	0.901	0.0	6676.7	6864

Cascade Rainfall Details for S Pond 100yr V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 5.147

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	2.000	4	8	2.000	8	12	1.147

Cascade Model Details for S Pond 100yr V1.SRCX

Storage is Online Cover Level (m) 84.000

Tank or Pond Structure

Invert Level (m) 82.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3973.8	1.200	5276.7	2.400	0.0	3.600	0.0	4.800	0.0
0.200	4185.3	1.400	5501.7	2.600	0.0	3.800	0.0	5.000	0.0
0.400	4399.0	1.600	0.0	2.800	0.0	4.000	0.0		
0.600	4615.1	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	4833.3	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	5053.9	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.000 Vortex Valve® Type C1 Invert Level (m) 82.600
Design Flow (l/s) 17.0 Diameter (mm) 130

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	15.2	2.000	24.1	4.000	34.1	7.000	45.1
0.200	10.1	1.000	17.0	2.200	25.3	4.500	36.2	7.500	46.7
0.300	12.8	1.200	18.7	2.400	26.4	5.000	38.1	8.000	48.2
0.400	10.8	1.400	20.2	2.600	27.5	5.500	40.0	8.500	49.7
0.500	12.1	1.600	21.6	3.000	29.5	6.000	41.8	9.000	51.1
0.600	13.2	1.800	22.9	3.500	31.9	6.500	43.5	9.500	52.6

Cascade Summary of Results for N Pond 100yrCC40% V1.SRCX

Upstream Structures	Outflow To	Overflow To
(None)	S Pond 100yrCC40% V1.SRCX	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	89.362	0.362	1.7	257.8	O K
30 min Summer	89.472	0.472	1.9	346.0	O K
60 min Summer	89.589	0.589	2.2	444.3	O K
120 min Summer	89.662	0.662	2.3	509.1	O K
180 min Summer	89.708	0.708	2.4	551.3	O K
240 min Summer	89.742	0.742	2.4	583.0	O K
360 min Summer	89.792	0.792	2.5	629.7	O K
480 min Summer	89.828	0.828	2.6	664.0	O K
600 min Summer	89.855	0.855	2.6	690.5	O K
720 min Summer	89.877	0.877	2.6	711.7	O K
960 min Summer	89.908	0.908	2.7	742.7	O K
1440 min Summer	89.941	0.941	2.7	776.7	O K
2160 min Summer	89.956	0.956	2.8	791.2	O K
2880 min Summer	89.960	0.960	2.8	795.8	O K
4320 min Summer	89.958	0.958	2.8	794.0	O K
5760 min Summer	89.956	0.956	2.8	791.5	O K
7200 min Summer	89.962	0.962	2.8	797.4	O K
8640 min Summer	89.970	0.970	2.8	806.3	O K
10080 min Summer	89.981	0.981	2.8	817.7	O K
15 min Winter	89.402	0.402	1.8	288.8	O K
30 min Winter	89.522	0.522	2.0	387.7	O K
60 min Winter	89.649	0.649	2.3	498.1	O K
120 min Winter	89.730	0.730	2.4	571.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	133.469	0.0	126.7	22
30 min Summer	89.763	0.0	148.0	37
60 min Summer	57.892	0.0	300.9	66
120 min Summer	33.471	0.0	325.4	126
180 min Summer	24.371	0.0	339.8	184
240 min Summer	19.491	0.0	349.9	244
360 min Summer	14.261	0.0	363.2	364
480 min Summer	11.454	0.0	371.6	484
600 min Summer	9.674	0.0	376.9	602
720 min Summer	8.431	0.0	380.2	722
960 min Summer	6.790	0.0	382.7	962
1440 min Summer	5.004	0.0	377.1	1440
2160 min Summer	3.681	0.0	735.0	2052
2880 min Summer	2.963	0.0	733.3	2368
4320 min Summer	2.183	0.0	698.7	3116
5760 min Summer	1.774	0.0	1262.4	3968
7200 min Summer	1.534	0.0	1293.0	4824
8640 min Summer	1.374	0.0	1303.4	5624
10080 min Summer	1.262	0.0	1291.0	6456
15 min Winter	133.469	0.0	134.8	22
30 min Winter	89.763	0.0	157.0	37
60 min Winter	57.892	0.0	321.5	66
120 min Winter	33.471	0.0	346.8	124

Cascade Summary of Results for N Pond 100yrCC40% V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	89.781	0.781	2.5	618.9	O K
240 min Winter	89.818	0.818	2.5	654.8	O K
360 min Winter	89.873	0.873	2.6	708.0	O K
480 min Winter	89.912	0.912	2.7	747.5	O K
600 min Winter	89.943	0.943	2.7	778.3	O K
720 min Winter	89.967	0.967	2.8	803.1	O K
960 min Winter	90.003	1.003	2.8	840.3	O K
1440 min Winter	90.045	1.045	2.9	883.7	O K
2160 min Winter	90.068	1.068	2.9	908.1	O K
2880 min Winter	90.070	1.070	2.9	911.2	O K
4320 min Winter	90.063	1.063	2.9	903.7	O K
5760 min Winter	90.056	1.056	2.9	895.6	O K
7200 min Winter	90.056	1.056	2.9	895.6	O K
8640 min Winter	90.058	1.058	2.9	898.0	O K
10080 min Winter	90.063	1.063	2.9	903.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	24.371	0.0	361.7	182
240 min Winter	19.491	0.0	372.0	242
360 min Winter	14.261	0.0	385.5	360
480 min Winter	11.454	0.0	394.0	476
600 min Winter	9.674	0.0	399.4	594
720 min Winter	8.431	0.0	402.7	710
960 min Winter	6.790	0.0	404.9	942
1440 min Winter	5.004	0.0	398.5	1400
2160 min Winter	3.681	0.0	784.8	2056
2880 min Winter	2.963	0.0	781.4	2680
4320 min Winter	2.183	0.0	743.3	3328
5760 min Winter	1.774	0.0	1372.7	4264
7200 min Winter	1.534	0.0	1402.1	5192
8640 min Winter	1.374	0.0	1407.2	6136
10080 min Winter	1.262	0.0	1390.3	7056

Cascade Rainfall Details for N Pond 100yrCC40% V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.036

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.900	4	8	0.136

Cascade Model Details for N Pond 100yrCC40% V1.SRCX

Storage is Online Cover Level (m) 90.600

Tank or Pond Structure

Invert Level (m) 89.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	643.7	1.200	1126.0	2.400	0.0	3.600	0.0	4.800	0.0
0.200	718.4	1.400	1214.3	2.600	0.0	3.800	0.0	5.000	0.0
0.400	795.0	1.600	1304.9	2.800	0.0	4.000	0.0		
0.600	874.7	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	956.2	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	1040.0	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.050 Vortex Valve® Type R1 SW Only Invert Level (m) 89.000
Design Flow (l/s) 2.9 Diameter (mm) 69

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.0	0.800	2.5	2.000	4.0	4.000	5.6	7.000	7.4
0.200	1.3	1.000	2.8	2.200	4.2	4.500	6.0	7.500	7.7
0.300	1.5	1.200	3.1	2.400	4.4	5.000	6.3	8.000	8.0
0.400	1.8	1.400	3.3	2.600	4.5	5.500	6.6	8.500	8.2
0.500	2.0	1.600	3.6	3.000	4.9	6.000	6.9	9.000	8.4
0.600	2.2	1.800	3.8	3.500	5.3	6.500	7.2	9.500	8.7

Cascade Summary of Results for S Pond 100yrCC40% V1.SRCX

Upstream Structures	Outflow To	Overflow To
N Pond 100yrCC40% V1.SRCX	(None)	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	82.909	0.309	12.8	1278.3	O K
30 min Summer	83.010	0.410	12.8	1718.2	O K
60 min Summer	83.120	0.520	12.8	2208.3	O K
120 min Summer	83.191	0.591	13.1	2532.7	O K
180 min Summer	83.236	0.636	13.6	2744.1	O K
240 min Summer	83.270	0.670	14.0	2903.3	O K
360 min Summer	83.320	0.720	14.5	3138.4	O K
480 min Summer	83.357	0.757	14.8	3311.9	O K
600 min Summer	83.385	0.785	15.1	3446.6	O K
720 min Summer	83.407	0.807	15.3	3554.3	O K
960 min Summer	83.440	0.840	15.6	3712.9	O K
1440 min Summer	83.476	0.876	16.0	3889.3	O K
2160 min Summer	83.492	0.892	16.1	3968.4	O K
2880 min Summer	83.496	0.896	16.1	3990.8	O K
4320 min Summer	83.494	0.894	16.1	3981.3	O K
5760 min Summer	83.492	0.892	16.1	3968.2	O K
7200 min Summer	83.497	0.897	16.2	3995.4	O K
8640 min Summer	83.505	0.905	16.2	4035.1	O K
10080 min Summer	83.516	0.916	16.3	4087.9	O K
15 min Winter	82.945	0.345	12.8	1432.7	O K
30 min Winter	83.057	0.457	12.8	1925.8	O K
60 min Winter	83.178	0.578	13.0	2475.2	O K
120 min Winter	83.257	0.657	13.8	2839.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	133.469	0.0	870.4	27
30 min Summer	89.763	0.0	1015.4	41
60 min Summer	57.892	0.0	1924.6	72
120 min Summer	33.471	0.0	2036.5	130
180 min Summer	24.371	0.0	2059.6	190
240 min Summer	19.491	0.0	2062.9	248
360 min Summer	14.261	0.0	2087.1	368
480 min Summer	11.454	0.0	2136.6	488
600 min Summer	9.674	0.0	2170.4	606
720 min Summer	8.431	0.0	2192.1	726
960 min Summer	6.790	0.0	2210.4	964
1440 min Summer	5.004	0.0	2184.4	1442
2160 min Summer	3.681	0.0	4271.9	2096
2880 min Summer	2.963	0.0	4267.3	2400
4320 min Summer	2.183	0.0	4078.8	3160
5760 min Summer	1.774	0.0	7492.4	3976
7200 min Summer	1.534	0.0	7786.0	4832
8640 min Summer	1.374	0.0	7719.4	5632
10080 min Summer	1.262	0.0	7579.5	6464
15 min Winter	133.469	0.0	951.1	27
30 min Winter	89.763	0.0	1007.9	41
60 min Winter	57.892	0.0	2029.9	70
120 min Winter	33.471	0.0	2086.3	128

Cascade Summary of Results for S Pond 100yrCC40% V1.SRCX

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	83.308	0.708	14.3	3078.2	O K
240 min Winter	83.345	0.745	14.7	3258.3	O K
360 min Winter	83.401	0.801	15.3	3525.6	O K
480 min Winter	83.442	0.842	15.6	3724.3	O K
600 min Winter	83.474	0.874	15.9	3879.7	O K
720 min Winter	83.499	0.899	16.2	4005.0	O K
960 min Winter	83.537	0.937	16.5	4192.9	O K
1440 min Winter	83.581	0.981	16.9	4413.7	O K
2160 min Winter	83.606	1.006	17.1	4541.3	O K
2880 min Winter	83.610	1.010	17.1	4560.3	O K
4320 min Winter	83.602	1.002	17.1	4520.3	O K
5760 min Winter	83.594	0.994	17.0	4479.1	O K
7200 min Winter	83.594	0.994	17.0	4476.7	O K
8640 min Winter	83.596	0.996	17.0	4486.2	O K
10080 min Winter	83.600	1.000	17.0	4507.7	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
180 min Winter	24.371	0.0	2103.8	186
240 min Winter	19.491	0.0	2139.7	246
360 min Winter	14.261	0.0	2222.6	362
480 min Winter	11.454	0.0	2276.1	480
600 min Winter	9.674	0.0	2311.0	598
720 min Winter	8.431	0.0	2333.3	714
960 min Winter	6.790	0.0	2351.4	946
1440 min Winter	5.004	0.0	2322.5	1402
2160 min Winter	3.681	0.0	4576.5	2072
2880 min Winter	2.963	0.0	4567.1	2684
4320 min Winter	2.183	0.0	4360.9	3336
5760 min Winter	1.774	0.0	8247.2	4272
7200 min Winter	1.534	0.0	8381.6	5192
8640 min Winter	1.374	0.0	8273.4	6136
10080 min Winter	1.262	0.0	8191.4	7056

Cascade Rainfall Details for S Pond 100yrCC40% V1.SRCX

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 298999 112899 SS 98999 12899	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 5.147

Time From: (mins)	To:	Area (ha)	Time From: (mins)	To:	Area (ha)	Time From: (mins)	To:	Area (ha)
0	4	2.000	4	8	2.000	8	12	1.147

Cascade Model Details for S Pond 100yrCC40% V1.SRCX

Storage is Online Cover Level (m) 84.000

Tank or Pond Structure

Invert Level (m) 82.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3973.8	1.200	5276.7	2.400	0.0	3.600	0.0	4.800	0.0
0.200	4185.3	1.400	5501.7	2.600	0.0	3.800	0.0	5.000	0.0
0.400	4399.0	1.600	0.0	2.800	0.0	4.000	0.0		
0.600	4615.1	1.800	0.0	3.000	0.0	4.200	0.0		
0.800	4833.3	2.000	0.0	3.200	0.0	4.400	0.0		
1.000	5053.9	2.200	0.0	3.400	0.0	4.600	0.0		

Crown Vortex Valve® Outflow Control

Design Head (m) 1.000 Vortex Valve® Type C1 Invert Level (m) 82.600
Design Flow (l/s) 17.0 Diameter (mm) 130

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	15.2	2.000	24.1	4.000	34.1	7.000	45.1
0.200	10.1	1.000	17.0	2.200	25.3	4.500	36.2	7.500	46.7
0.300	12.8	1.200	18.7	2.400	26.4	5.000	38.1	8.000	48.2
0.400	10.8	1.400	20.2	2.600	27.5	5.500	40.0	8.500	49.7
0.500	12.1	1.600	21.6	3.000	29.5	6.000	41.8	9.000	51.1
0.600	13.2	1.800	22.9	3.500	31.9	6.500	43.5	9.500	52.6

Hartnoll Farm Employment

TANK SIZE CALCULATOR

Insert your building's data in the yellow boxes. Change the red box to suit your needs.
From the roof area of your property, you assess the amount of water available, and equate it to the amount you will use.

1	**Main Building area**			
	Building width (metres)		20	
	Building depth(metres)		50	
	Rain Collection Area 1			1,000
2	**First extension/conservatory/porch/garage/shed etc**			
	width (metres)			
	Depth (metres)			
	Rain Collection Area 2			0
3	**Second extension/conservatory/porch/garage/shed etc**			
	width (metres)			
	Depth (metres)			
	Rain Collection Area 3			0
4	**Third extension/conservatory/porch/garage/shed etc**			
	width (metres)			
	Depth (metres)			
	Rain Collection Area 4			0
5	***Calculate the area of any remaining useful roofs as a figure***			
	in square metres and enter directly in the yellow box to the right			0
6	**TOTAL of collectable roof areas (square metres)**			**1,000**
7	**Maximum rainwater which could be collected**			
	Rainfall per year in your area (cms). Use rainfall chart on sheet 2, a figure between 60 and 170.		105	
8	**Collectable rainwater per annum (in litres - discounted by 20% to account for water loss)**			**840,000**
9	**Use of water in the building**			
	Washing machine and toilet flushing are the main usage for rain water in domestic systems. Add an allowance for daily garden use.			
	Number of people in the house (eg 4 bedrooms = 5 people)		0	people
	Number of clothes washing cycles per day (50 litres each)		0.00	0
	Number employees based on 1 per 200m² employment area		5.00	
	Number of toilet flushes per day (4.42 flushes per perso, average 5 litres each)		19	94
	Outdoor use per day (min 5 litres per person per day)	*or adjust till F46 = F35 more or less*		0.00
10	**Amount of water you require every day or in a year**			
		every day		94
		Rainwater DEMAND per annum		34,283
11	**How many days drought protection do you need?**			
	In the Summer of 2006 in SE England there was almost no rain for 77 days between June 1 and August 18. Enter a number of days in the red box.	*Optimal is 18 to 21 days.*		21
12				1,972
	The lesser of YIELD or DEMAND per annum			34,283
	Therefore, volume of rainwater storage required			**1,972**

Sufficient roof water available (CONCLUSION):	**YES**

APPENDIX D

Draft Operation & Maintenance Manual

Land at Hartnoll Farm, Halberton – Operation & Maintenance Plan (Draft)

Background:
Attenuation ponds / wetlands and swales are proposed to capture existing catchment runoff and balance the flows and volumes of runoff created by the proposed development.

The attenuation features and swales are located within open areas with access available from adjoining public roads.

A management company will be formed by the developer prior to development commencing on site if SWW will not adopt the storage structures as part of the Sewage Sector Guidance. Each dwelling will have a clause within their title deeds that requires it to contribute to the annual upkeep of the SUDS features. Once the residential site is completed the developer will transfer the management company to the successors who consist of a group of resident householders.

The basin / ponds will be managed in accordance with the guidelines in CIRIA C753, Chapter 32. This is an outline application so the final details of the SUDS devices, ponds and exact maintenance requirements are not yet fully known. There are however a few fundamental issues that can be specified now, these are noted below:

Routine Maintenance:-
The maintenance will occur during daylight, week day hours. Routine maintenance will include but not be limited to:

a) Mowing of the bank slopes and area around the ponds on a monthly basis during the growing season and as needed during the cooler months;
b) Checking the pipe inlets at the silt chamber above the ponds to ensure flows are running through the chamber rather than down the adjoining earth slopes on a monthly basis;
c) The outfall structure from the ponds and other areas will be inspected monthly for debris which could inhibit the proper flow of discharge. Any debris will be removed immediately and disposed of or placed in a location to prevent future maintenance and to not cause impact up or downstream of the structure;
d) Additional visual inspections will be undertaken after a prolonged rainfall event;
e) Litter and windblown debris will be removed from around the ponds on a weekly basis to prevent it entering the ponds. The site will be kept free of loose litter which could be carried off site by wind or rain or block any flow control structures;
f) Inspection of the ponds and outfall structures for non-routine maintenance needs will be undertaken every 6 months.

Periodic or Non-Routine Maintenance:-
The routine inspection of the pond areas and discharge/outfall structures will identify repairs and non-routine maintenance. These items may include but not be limited to:

a) Re-growth of windblown seedlings on or around the pond bank will be cut and removed from the pond area on an annual basis;
b) Sediment from the site may accumulate in the pond bottom and reduce the value of the wetland. Once the silt build up reaches 25% of the wetland depth the silt will be excavated and disposed off;
c) Stabilisation or re-grading of side slopes may be required periodically or after excessive rain events. Any disturbance of slopes will be reseeded or may require installation of erosion control materials until seeding can re-establish adequate grass to prevent future erosion;
d) Any other maintenance or repairs which would minimise other maintenance to the pond or outfall structures.

If the ponds are significantly impaired such that the pond is incapable of properly functioning to meet the storm water discharge requirements, the management company will notify the Local Flood Authority.

SUDS Guidance:-
Additional information can be found in Part E: Supporting Guidance – Section 32 Operation and Maintenance of the CIRIA SuDS Manual 2015. An extract of the document detailing the potential maintenance activities is included below:

TABLE 32.1 Typical key SuDS components operation and maintenance activities (for full specifications, see Chapters 11–23)

Operation and maintenance activity	SuDS component												
	Pond	Wetland	Detention basin	Infiltration basin	Soakaway	Infiltration trench	Filter drain	Modular storage	Pervious pavement	Swale/bioretention/ trees	Filter strip	Green roofs	Proprietary treatment systems
Regular maintenance													
Inspection	■	■	■	■	■	■	■	■	■	■	■	■	■
Litter and debris removal	■	■	■	■	□	■	■	□	■	■	■		□
Grass cutting	■	■	■	■	□	■	■	□	□	■	■		
Weed and invasive plant control	□	□	□	□		□	□		□		□	■	
Shrub management (including pruning)	□	□	□	□					□	□	□		
Shoreline vegetation management	■	■	□										
Aquatic vegetation management	■	■	□										
Occasional maintenance													
Sediment management[1]	■	■	■	■	■	■	■	■	■	■	■		■
Vegetation replacement	□	□	□	□						□	□	■	
Vacuum sweeping and brushing									■				
Remedial maintenance													
Structure rehabilitation /repair	□	□	□	□	□	□	□	□	□	□	□	□	
Infiltration surface reconditioning				□	□	□	□		□	□	□		

Key
■ will be required
□ may be required

Notes
1 Sediment should be collected and managed in pre-treatment systems, upstream of the main device.

The full chapter from the SUDS Manual (C753) can be found at this link:
http://www.ciria.org/Memberships/The_SuDs_Manual_C753_Chapters.aspx