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ATKINS

Sully Sports and Social Club

Drainage Strategy Report

For St. Modwen Homes Ltd

2 June 2016

Plan Design Enable

Notice

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Document history

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1. Introduction

Atkins has been commissioned to undertake a Flood Consequence Assessment and prepare a Drainage Strategy on behalf of St. Modwen Homes Ltd (St Modwen) to support an outline planning application for the development of a residential area involving the construction of up to 200 houses and a detailed planning application for the redevelopment of a sports club and pitches in Sully. The development proposals and the implications of this development in terms of flood risk (to and from the proposed development) have been discussed separately as a part of the Flood Consequence Assessment Report [FCA] (Atkins, 2016) Ref: 5133321-DG-R&C-001 Rev 1.4

This Drainage Strategy report outlines the drainage proposals for foul and surface water and references sections of the FCA where appropriate. Therefore, this report should be read in conjunction with the FCA. A summary of the findings of the FCA is listed in Section 1.1.

1.1. Summary of the Flood Consequence Assessment Report

Sully Sports and Social Club (post code CF64 5SD) is located near South Road (B4267), Sully, between Sully and Swanbridge in the Vale of Glamorgan. The site is next to the sea on the top of the cliff. The proposed development involves construction of up to 200 new houses on the western part of the site and the provision of a clubhouse, gym, caravan site and sports pitches on the eastern site.

The Flood Consequence Assessment Report concludes that;

- The site is not subject to fluvial flooding at least up to the 0.1% AEP event, with no known watercourse in the near vicinity of the site.
- The estimated level from a 0.1% AEP tidal event plus climate change allowance of is 9.8mAOD, which around 0.6m below the lowest topographic level recorded at the southern edge of the site providing a 1 in 1000 year plus climate change standard of protection for 100% area of the site.
- The risk of groundwater flooding is expected to be low.
- The risk of surface water flooding is low, either from offsite sources or as a consequence of the proposed development. Surface water runoff from the site can be discharged to coastal waters, and therefore the potential increased peak runoff and volumes does not need to be attenuated.
- There will be an additional foul load of approximately 21l/s due to the proposed residential development and other features of the site, which will require the design of a new drainage system and is expected to connect to the existing foul network and outfall into the existing Welsh Water pumping station (subject to reviewing capacity).
- The only residual risk identified at the site is splash flooding during extreme storm events.

1.2. Topography

The existing land use at the proposed development site is greenfield (Photograph 1). The site drops approximately 10m to 15m from the northern boundary near South Road towards the southern boundary of the site near the coastline.

Photograph 1 – Existing greenfield site

Photograph 2 – Southern boundary of the site

The ground levels within the site range from 24.0mAOD (near South Road) to 11.06mAOD near the southern edge of the site. It was noted during the site visit that the site is approximately 5m higher than the beach/ bedrock formation along the coast adjacent to southern boundary (Photograph 2). The lowest tide line varies to some distance from the cliff level, approximately 2m lower than the base of the cliff.

The topographic survey of the site is included in Appendix A.

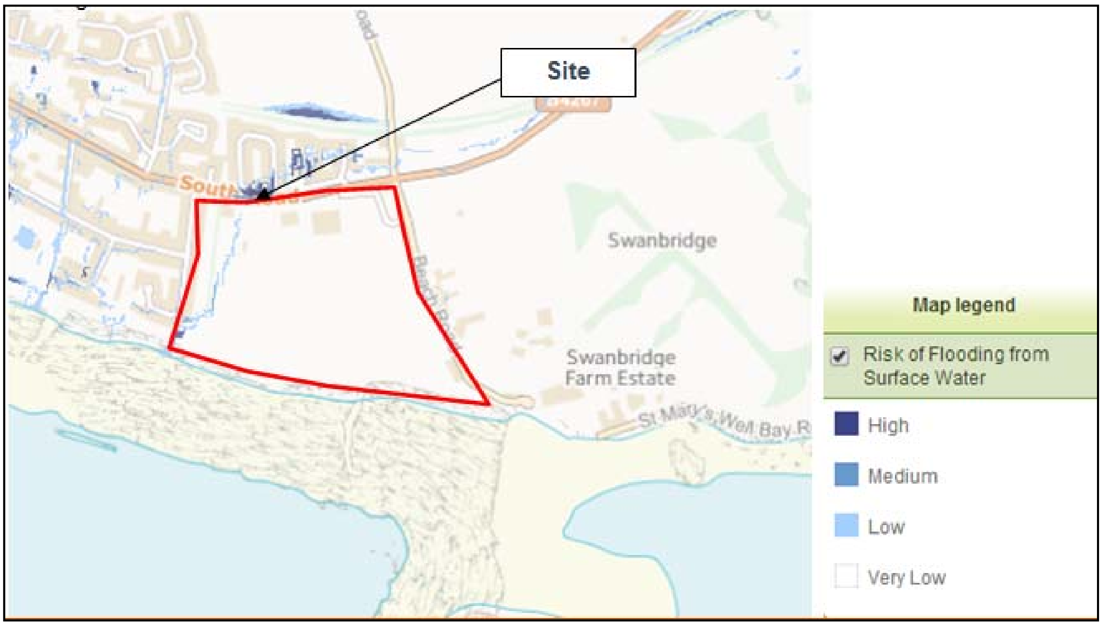
2. Surface Water Drainage Strategy

The following sections of the report assesses the quantum of the increase of the surface water runoff from the site as a result of the proposed development and subsequently recommends a drainage strategy to cater the additional load without increasing on-site and off-site flood risk.

2.1. Existing Flood Risk & Drainage

The Natural Resources Wales "Risk of Flooding from Surface Water" (or Surface Water Flooding - SWF) Map has been inspected in order to ascertain the potential level of risk posed by surface water flooding in the area. The SWF map (Figure 2-1) depicts that the development site is at low to very low risk for surface water flooding, indicating a chance of flooding of less than 1 in 1000 (0.1%) from surface water. The topographic levels on the site and the surface water flood map from Natural Resources Wales suggests that surface water flows naturally from the north-western to south-western corners on the site and a very small area on the south western edge is susceptible to high risk of surface water flooding.

Figure 2-1 Natural Resources Wales Indicative Surface Water Flood Risk Map



The existing drainage plan at Sully Sports and Social Club was procured from Welsh Water and is included in Appendix B. This plan indicates that there is no existing surface water network at the site. From the site visit, and further inspection using Google Street view, gully traps have been noticed on the South Road (Figure 2-2). The gullies are located on the far side (north) of the highway, with cross fall of the road away from the site entrance. It is assumed that this is a highway drainage asset. The South Road slopes down from 24.3mAOD at the junction of South Road and Beach Road from the eastern corner of the site to 20.78mAOD near the existing junction into the site, and continues to fall along the highway to the west.

Figure 2-2 View of the South Road adjacent to the Site depicting gully trap

Overland flows from adjacent to South Road could convey flows to the development site, however it is expected that the highway drains associated with this road will route flows parallel to the site following the down-slope towards west. This is also evident from the Natural Resources Wales Surface Water Flood Map depicting South Road at high risk of surface water flooding while the site at low risk.

The outfall from an existing surface water drain discharging to the coastal frontage has been observed adjacent to the southern boundary of the site on the cliff face. This drain is not understood to be connected to the existing site systems. From discussions with the local authority drainage officer it is believed that this drain collects runoff from part of the residential area to the north of the site, however, its exact route and details are not recorded.

Figure 2-3 Outfall headwall from unidentified surface water outfall

2.2. Impacts of development on surface water

As a result of the proposed development, involving construction of up to 200 new houses on the western site, and a gym, clubhouse, caravan site and all weather sports pitches on the eastern site; there will be a significant increase in impervious area at the site, thereby reducing the potential for infiltration at the site.

The existing surface water flow paths are expected to be altered as a result of the proposed development. It is expected that the increased surface water runoff from the site, if unobstructed, would discharge into the south-western part of the site, increasing the flood risk to the adjacent properties near Clevedon Avenue.

The increase in runoff from the site therefore needs to be managed in a manner which will not increase the risk of surface water flooding at the site or cause off-site impacts, but instead ensure that surface water flows are directed in a controlled manner to a coastal outfall to the south.

The Sustainable Development – Supplementary Planning Guidance (The Vale of Glamorgan, Adopted Unitary Development Plan, 1996-2011) states the benefits of Sustainable Urban Drainage Systems (SuDS) for providing a sustainable solution to help reduce and manage surface water runoff which might otherwise cause flooding and pollution.

With respect to the proposed development, the ultimate discharge point will be to the coastal waters, hence no escalation in flood risk is expected as a result of an increase in surface water runoff. However, consideration of SuDS will be useful in obtaining the acceptable treatment levels before discharging to coastal waters. Therefore, the following sections of the report discuss the suitability of SuDS with respect to proposed development.

2.3. SuDS Principles

SuDS are physical structures which receive surface water runoff and provide a drainage that mimics natural processes rather than piped solutions. By dealing with surface water close to its source, SuDS provide an advantage of treating polluted water, slow down flows across sites and into drainage system allowing settlement, filtering and infiltration, which have ecological benefits. SuDS should be designed to agreed standards which satisfy the hydraulic, water quality, amenity and ecology objectives.

The main principles driving the drainage design and selection criteria are:

- **Level of Service**: The standard of service provided should ensure minimum level of flood risk and health and safety of the people on the site, and should not exacerbate flood risk at any other point. The on-site flood protection includes protection of flooding against any watercourse, drainage system or from overland flows from sources within or external to the site.
- **Sustainability**: The drainage system should aim to replicate natural rainfall-runoff process occurring on the site in the predevelopment scenario, causing minimum environmental impact and maximum ecological benefits. Water quality of storm water runoff should be treated to prevent detrimental impacts to the receiving water body as a result of urban contaminants.
- **Cost-effective** to operate and maintain.
- The **amenity and ecological benefits** associated with the drainage system should be maximised, wherever feasible.

2.4. Selection criteria of sustainable drainage options

There are many different SuDS components that can be used on each site and each site has its own unique characteristics which guides the selection of the most appropriate set of SuDS techniques. Therefore it is vital to identify opportunities and constraints in the early stage of any drainage assessment. A brief description of the various SuDS components is attached as Appendix C.

Five selection criteria have been considered to confirm the applicability of SuDS techniques. These include:

a) Land use characteristics
b) Site characteristics
c) Catchment characteristics
d) Quantity and quality performance criteria, and
e) Amenity and environmental requirements.

(a) Land use characteristics

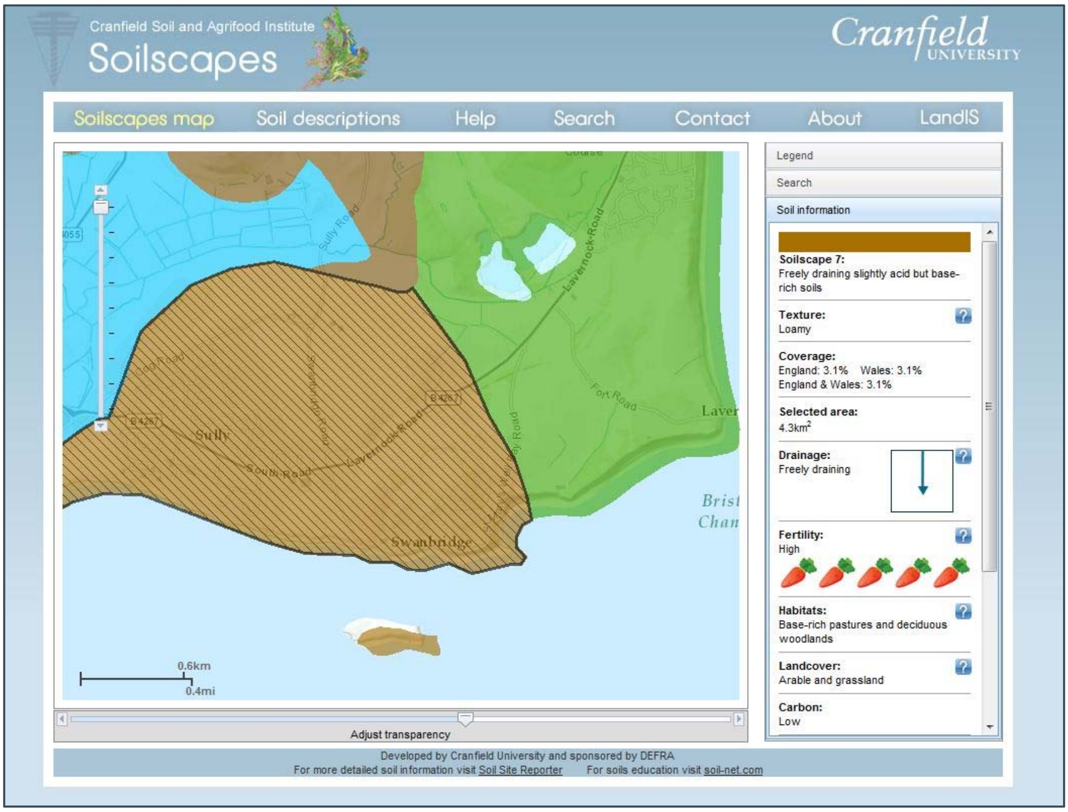
It is important to determine which SuDS component shall be suitable for the proposed land use at the site. The proposed development at Sully Sports and Social Club consists of the relocation of the existing sports field pitches, replacement of the clubhouse, a new gym as well as the provision of new low to medium density residential development related to which there will be runoff from roofs, parking zones and residential roads. According to the CIRIA SuDS Manual, any type of SuDS component (namely retention, wetland, infiltration, filtration, and detention basins) would be feasible and might require two treatment stages depending on the receiving water course sensitivity.

(b) Site characteristics

There are certain site characteristics which might favour or restrict the usage of a particular type of SuDS technique at a particular site. The site characteristics influencing the suitability of a particular SuDS technique at Sully Sports and Social Club are discussed below:

- **Soils and bedrock**: An extract from Cranfield's Soilscapes website shown in Figure 2-4 (Cranfield Soil and Agrifood Institute Soilscapes,Cranfield University) identifies the superficial layer of soil at Sully Sports and Social Club is freely draining. Therefore, the presence of permeable soil at the site suggests the suitability of infiltration SuDS. However, geotechnical investigations undertaken at the site (Sully Sports and Social Club Geo-environmental Interpretative Report, Atkins, 2016) indicate that bedrock is at shallow depths and comprises of mudstone which is not considered to be sufficiently permeable to allow soakaways. Therefore, infiltration of large volumes of surface water will not be feasible at the site.

Figure 2-4 Cranfield Institute Soils Map



- **Groundwater depths:** Infiltration systems typically require at least 1m of soil depth between the base of the infiltration unit and the maximum expected groundwater table so that the system operates efficiently, even in the case of extreme rainfall events, with a low risk of groundwater flooding. According to the geotechnical investigations undertaken at the site (Geo-environmental Interpretative Report, Atkins, 2014 Ref: 5133321 Rev 1.0), no groundwater was encountered up to the depth of 2.2m below ground level. Hence, the suitability of infiltration SuDS would be subject to the depth of the groundwater table (which is anticipated to be below 2.2m below ground level) and size of the basin required.

- **Area draining to a single SuDS component:** At this stage, the site masterplan is still to be finalised for the residential layout. However, according to the RIBA survey "The Case for Space", a typical house size in UK is 45-75m^2, indicating the total proposed hardstanding area for the construction of 250 houses as 2.0ha (noting that no more than 200 houses are proposed, hence this is over-conservative). Considering parking areas, roads and other hardstanding areas, it has been assumed that out of 7ha of the greenfield area, 3.5ha shall be hardstanding area. For the 7.95ha sports site, the total impermeable area generated from hardstanding, gym, sports pitches and the caravan site is approximately 2.8ha. Based on the CIRIA SuDS manual, the proposed impermeable area (6.3ha) required to be draining into the SuDS component is greater than 2ha, and, therefore cannot be drained into a single SuDS component. Hence, it is recommended that several smaller features are included that ultimately drain into a single site control.

- **Site Slope:** There is a drop of circa. 10-15m in a distance of approximately 350m from the northern edge of the site (near the South Road) to the southern edge (cliff edge). Therefore, the site slope is between 3.3 to 5% hence, based on the CIRIA SuDS manual all type of SuDS components are expected to be suitable at the site with regards to site slope.

(c) Catchment characteristics

The site neither encompasses any ecological designation nor any groundwater source protection zone or aquifers used for public water supply. The planned discharge for any surface water drainage system will be to the coastal waters, thereby negating the requirement of very high treatment levels. Also, there is no known constraint of the local habitat requirements. Similarly the volume and flow rates will not generally have to be constrained to the greenfield equivalent, as there will be no deterioration in downstream flood risk as a result of increased runoff.

The site is located adjacent to the coastline / cliff edge. Current guidance advises between 0 – 20m coastal erosion over the development lifetime with a "No active intervention" maintenance policy (Lavernock Point to St Ann's Head Shoreline Management Plan (SMP2), 2013).

Any discharge or features connected with the proposed development should also not affect the natural movement of beach materials along the coastline or provide a new point of weakness where erosion may occur leading to a quicker loss of the coastline / cliff features than occurs at present.

(d) Quantity and quality performance

For most sites, general water quality improvement is required across the suite of urban pollutants, however, where there are particular pollutants of concern, specific technique might be adopted. Due to the high dilution available, surface water discharges to coastal waters are generally considered low risk. The main risk is from the faecal coliforms, oil and metals which are all present in urban runoff affecting bathing and shellfish waters.

Since the proposed development is residential, it will involve runoff from roofs, parking areas and residential roads. Runoff from clean roof surfaces (i.e. not metal roofs, roofs close to polluted atmospheric discharges, or roofs close to populations of flocking birds) is classified as Low in terms of hazard status. Runoff from roads, parking and other areas of residential or commercial sites (that are not contaminated with waste, high levels of hydrocarbons, or other chemicals) is classified as Medium in terms of hazard status.

Following discussion with the local authority drainage officer, their preference would be for one treatment stage to be provided prior to discharge to manage the initial flush of pollutants from discharging directly onto the foreshore.

(e) Amenity and environmental requirements

It is important to determine whether a proposed SuDS component meets all the community and environmental requirements at the site. The major issues of concern regarding this are: maintenance regime, community acceptability, cost, public safety and habitat creation. It is recommended to analyse the whole life cost estimate of the proposed drainage system and detailed design risk assessments for the health and safety of the people should also be undertaken during the detailed design stage.

With the intended discharge direct to coastal waters there is no need to manage the increased runoff due to flood risk. However, as noted above, the local authority emphasised the requirement for initial treatment of the surface water runoff to limit the potential pollutant load of the 'first flush' runoff from storm events.

This can be managed through the provision of permeable paving, filter strips, swales, retention basins or infiltration trenches as preferred approaches depending on the planned development layout, ground conditions and available space within the development area.

2.5. Hydraulic Design Criteria

The proposed development is on a mostly greenfield site. Typically, the increased runoff from a proposed development area needs to be attenuated to the equivalent greenfield rates prior to discharge into the receiving watercourse. This is to ensure there is no increase in flood risk downstream from the site as a result of increased runoff. However, surface water from the site following development will discharge directly to coastal waters and therefore will not increase flood risk to adjacent sites. Therefore, attenuation of surface water is not required at the site, although a positive drainage system to convey surface water from the development is required.

Although attenuation is not necessary, SuDS features will be required to limit the pollutant load discharging directly to coastal waters. The key element of improving water quality through the use of SuDS is the retention time (the length of time it takes surface water to reach the outfall). An extended retention time promotes pollutant removal as the longer the water is retained the greater the treatment will be. At the detailed design stage, SuDS features should be designed to maximise their retention time and therefore their treatment benefits.

SuDS approaches that would improve water quality are identified in the CIRIA SUDS Manual. These include vegetated channels, swales or basins or a variety of filtration methods. Permeable paving or filter trenches would be suitable alternatives and discharges could outfall to the surface water drainage network as ground investigation indicated that infiltration of large volumes is not suitable at the site. The CIRIA SUDS Manual recommends that sites larger than 2ha do not drain into a single SuDS feature and therefore a selection of features forming a treatment train will be required.

An assessment of the surface water discharge from the proposed development has been undertaken in order to inform the sizing of the outfall pipe into the sea. Sewers for Adoption (7th edition) states that surface water pipework should be designed under full pipe conditions to accept a 1 in 2 year design storm without surcharging. Therefore, the 1 in 2-year post-development run-off flow rate for the site has been derived based on the assumed development characteristics. The resultant flow rates for each section of the development site are shown in Table 2-1 below.

Site:	Total impermeable area:	Surface water discharge for 2 year design storm:
Western: Residential Development	3.50ha	351l/s
Eastern: Sports and Clubhouse	2.80ha	279l/s

Table 2-1 Surface water discharges for the 2 year design storm

Assuming a pipe gradient no flatter than 1:100, the diameter of the outfall pipe would be approximately 450mm for both the western and eastern sites. This would achieve the minimum velocity of 1.0m/s that is required for self-cleansing of the sewer. If a single outfall was to be provided for both sites, an outfall pipe diameter of 600mm would be required.

During detailed design, the drainage system should be checked to ensure that no part of the site is flooded during the 1 in 30 year design storm.

2.6. Water Quality Criteria

As discussed in Section 2.4, runoff from clear roof surfaces shall be classified as Low and runoff from roads, parking and other areas shall be classified as Medium in terms of hazard status. Ideally, a low hazard runoff from residential roofs would require one treatment stage and medium hazard runoff from residential roads and parking areas would require two treatment stages before disposal.

However, it is proposed to discharge the surface water directly to coastal waters which has high dilution available. Therefore, following consultation with the local authority drainage officer, it is proposed that at least one SuDS treatment stage is provided prior to discharge to manage the initial flush of pollutants. The retention time within SuDS features should be maximised to increase the water quality of discharges.

However, if the occurrence of pollutants such as oil or metals is expected from any part of the proposed development, a higher level of treatment may be required before disposing the surface water runoff.

2.7. Proposed surface water option

The proposed option to manage the discharge of surface water from the site should consider the following:

- Provide a positively drained network with a final outfall to coastal waters
- Provide at least one SuDS treatment stage for surface water prior to discharging to the coastal outfall.
- The drainage outfall must not affect the coastal features, and should be able to adapt to the potential erosion of the coastline of up to 20m over the lifetime of the development.
- The outlet manhole should be placed 20m back from the existing coastal edge to allow for the potential erosion over the development lifetime.
- This manhole will be suitably deep to allow the final outfall drain to be bored from the seaward end back to the manhole to minimise the impact to the cliff face / existing coastal features.
- Any headwall structure should be placed as low as possible in the cliff face to allow the storm water to discharge directly onto the beach and avoid the effects of scour.
- A flap valve, or duck-bill valve should be provided to prevent tidal ingress into the system during tidal surge events.

The risk of extreme tide and rainfall at the site can affect the performance of the outfalls and the drainage system. Therefore the impact of extreme tides and the failure of the outfall should be considered.

3. Foul Water Drainage Strategy

3.1. Existing Drainage

The existing drainage plan procured from Welsh Water (Appendix B) illustrates that there are no surface water, or combined sewers on the existing site, although a foul sewer runs from the east to the west of the site and outfalls into a Welsh Water pumping station adjacent to the south-west corner of the site. Photograph 3 shows the location of manholes in the south-western part of the site.

Photograph 3 – Location of manholes near the south-western edge of the site

3.2. Proposed Drainage

The proposed development involves the construction of up to 200 houses, a new clubhouse, gym and a 46 pitch caravan site which will cause a significant increase in foul water discharge to the existing network.

The increase in domestic wastewater due to proposed residential development has been estimated using Sewers for Adoption (7th edition) which suggests the design flow rate of foul sewers should be 4000 litres per dwelling per day. This value is the design peak flow rate rather than a daily average and represents the peak flow from a number of domestic appliances. Applying this flow rate to 250 houses (following an over-conservative design approach) derives a design foul water flow rate of 11.6l/s.

The proposed development on the eastern portion of the site will also contribute foul flows to the existing network. Assessments of the foul contributions have been undertaken in accordance with an article from Surveyor (1992) which indicates the foul design flows for numerous land-uses. This calculated the design flows for the clubhouse, the gym and the caravan site and equated to a total design flow of 9.4l/s.

Therefore, an additional peak foul load of approximately 21l/s will be generated by the proposed development and would require the detailed design of a new sanitary pipework system. This new system is expected to connect to the existing foul network (Appendix B) and outfall into the Welsh Water Pumping Station, situated adjacent to the south-west corner of the site. Prior to making alterations or extensions to the existing drainage network, a survey should be undertaken to understand the type of drainage system in use, drain and sewer loading, details and positions of appliances connected to the system and a condition assessment of the existing pipework. Most importantly, the capacity of the Welsh Water pumping station to accommodate the additional load needs to be considered.

Therefore, the capacity and performance of the existing and proposed systems and the pumping station should be assessed to confirm that they continue to operate effectively and do not pose an increased flood risk due to insufficient system capacity. It is recommended to design the drainage system for a 1 in 30 year critical event for the site without causing any flooding.

If there are points in the drainage system that may be at risk of blockage then simulations should be undertaken to assess any potential consequences and minimised through appropriate design.

4. Conclusions

It is concluded that stormwater discharges from the site do not need to be attenuated as the intended discharge is to coastal waters and will not increase flood risk downstream. However, a positive drainage system will be required to convey surface water to the coastal outfall.

The local authority has advised that at least one surface water treatment stage should be provided prior to discharge to manage the initial flush of pollutants from the site. This will require the use of SuDS and could take the form of vegetated channels or basins or a variety of filtration methods such as permeable paving or filter trenches. In order to maximise the treatment benefits, the proposed drainage system and SuDS features should be designed to maximise the retention time and ecological benefits to the site.

Ground investigation has identified that bedrock at the site is at shallow depths and therefore it is not suitable for infiltration of large volumes of surface water. As the site is located adjacent to a cliff edge, soakaways should be avoided as infiltration may reduce ground stability. Therefore, we recommend that the surface water drainage network and proposed SuDS features drain to the coastal outfall at the southern end of the site.

An additional peak foul load of 21.1l/s is estimated to be generated due to the proposed residential and sports developments, thereby requiring the detailed design of a new foul sewer system. This new system is expected to connect to the existing foul network and outfall into the existing Welsh Water Pumping Station, situated adjacent to the south west corner of the site.

The capacity and performance of the existing and proposed systems and the pumping station should be assessed to confirm that they continue to operate effectively.

4.1. Recommendations

To further the value of this report, it is recommended that the following is undertaken at the next design stage:

- Geotechnical investigations should be undertaken to confirm assumptions and appropriate system design characteristics. The geotechnical investigations should investigate two aspects: (a) The stability of the cliff over the lifetime of the residential development (b) Groundwater and bedrock depths which may affect the selection of SuDS or water treatment options.
- A detailed layout for the proposed development should be provided to enable full determination of:

  - the surface water discharges;

  - the most suitable SuDS features to propose on site and;

  - foul water discharge volumes.
- The existing foul water drainage system should be checked for capacity to cater for the additional foul load generated from the new development. Furthermore, the capacity of the Welsh Water Pumping station to accommodate the additional foul flows should be investigated.

5. References

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Appendices

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Appendix A. Topographical Survey

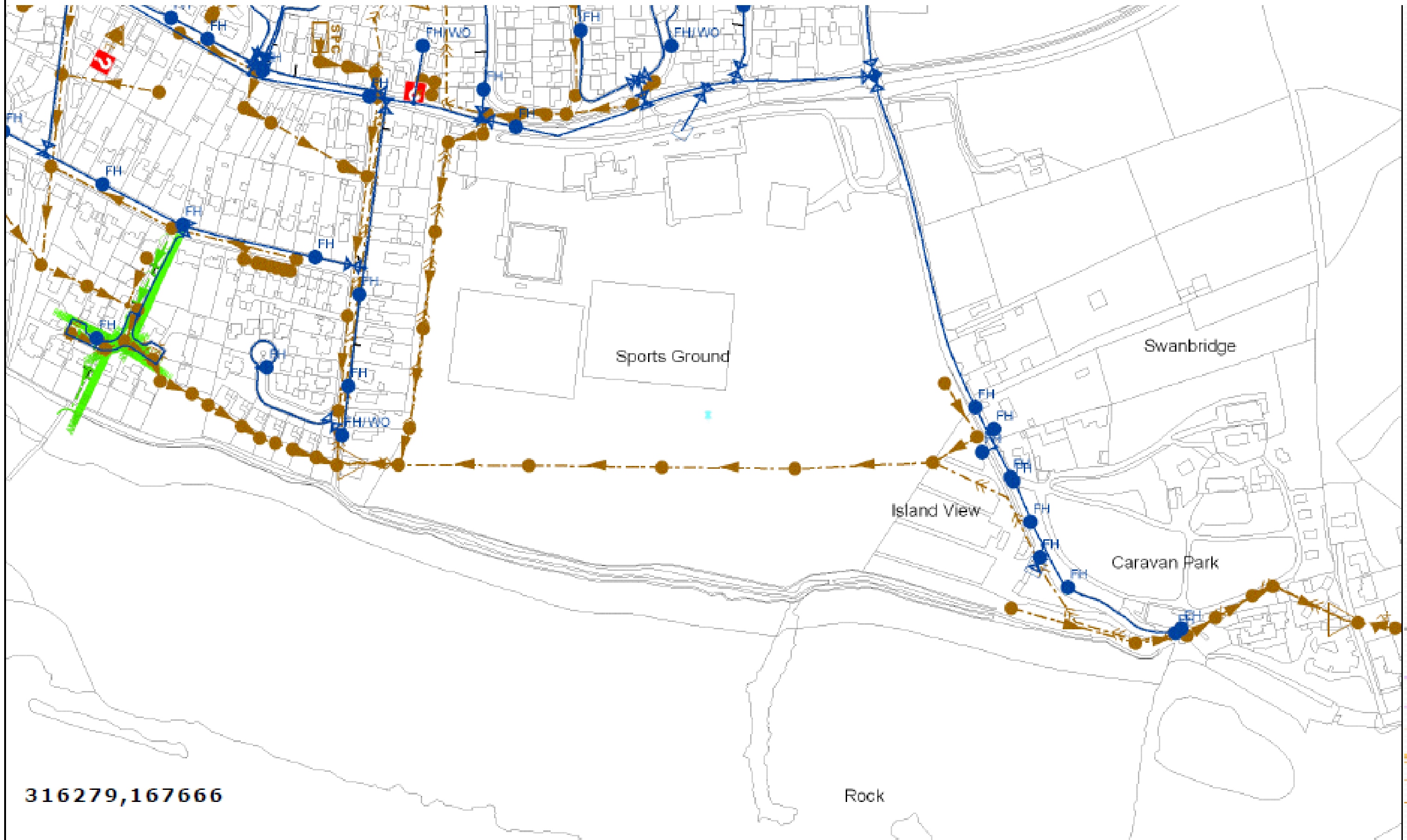
Appendix B. Welsh Water Existing Drainage Plan

Dŵr Cymru
Welsh Water

16/07/2014

Sully Sport and Social Club

Scale: 1:5000



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

Dwr Cymru Cyfyngedig ('the Company') gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the Company's apparatus and any onus of locating the apparatus before carrying out any excavations rests entirely on you. The information which is supplied hereby by the Company, is done so in accordance with statutory requirements of sections 198 and 199 of the Water Industry Act 1991 based upon the best information available and in particular, but without prejudice to the generality of the foregoing, it should be noted that the records that are available to the Company may not disclose the existence of a drain sewer or disposal main laid before 1 September 1989, or if they do, the particulars thereof including their position underground may not be accurate. It must be understood that the furnishing of this information is entirely without prejudice to the provision of the New Roads and Street Works Act 1991 and the Company's right to be compensated for any damage to its apparatus.

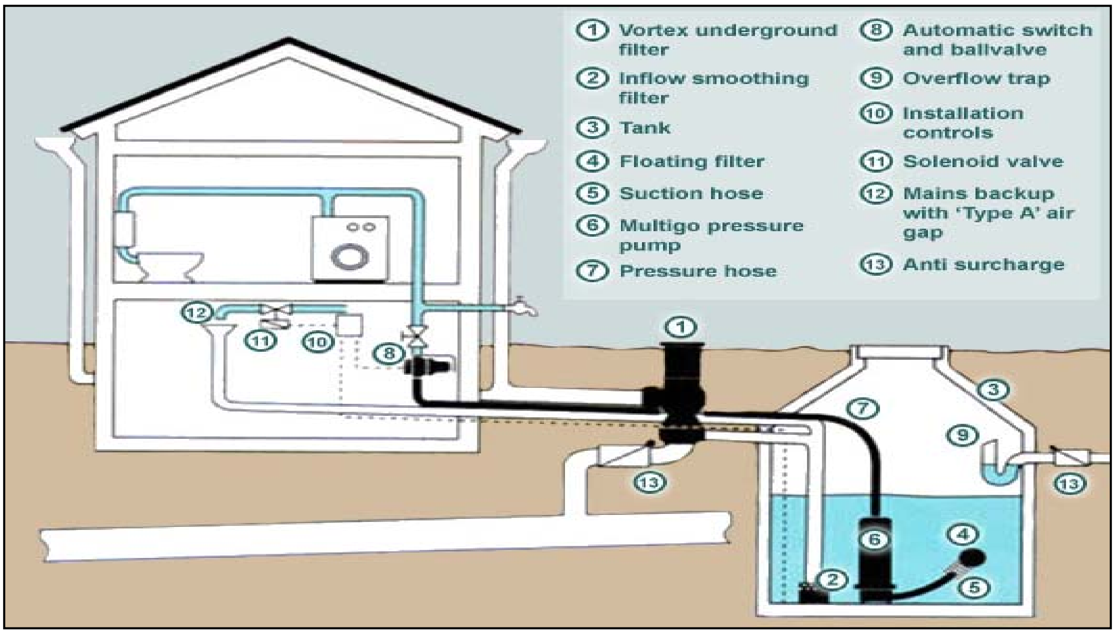
EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF) . It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

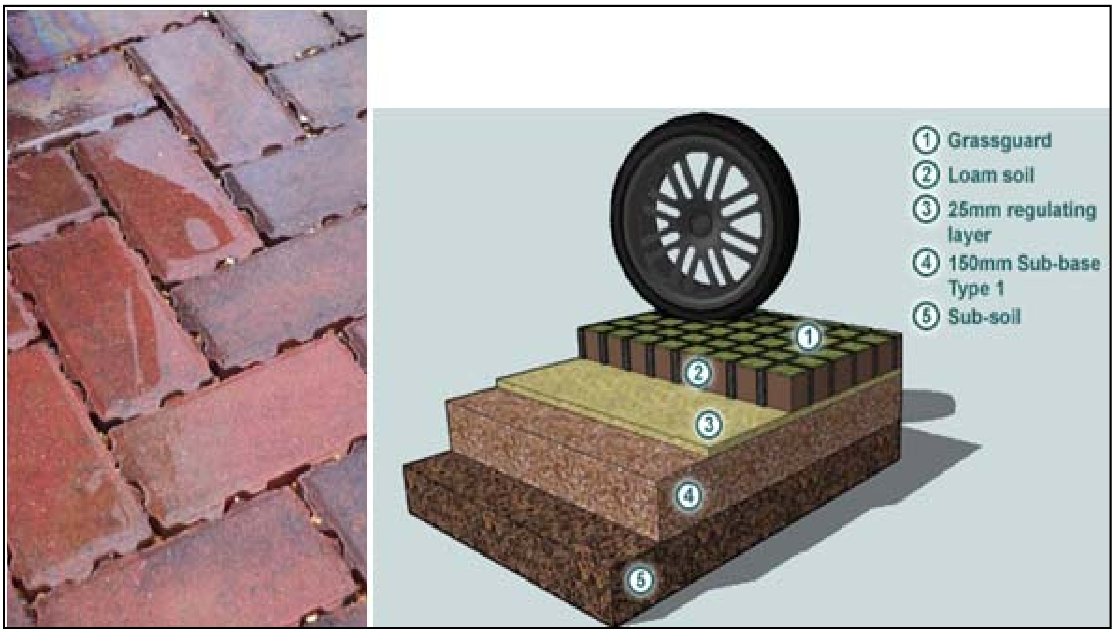
Appendix C. Various SuDS Groups

a) **Soakaways:** Soakaways are below-ground devices that store runoff and allow it to infiltrate into the surrounding soil, providing ground conditions are favourable. Soakaways can be installed at individual properties. The process provides limited treatment as the runoff passes through the filter medium. They can be used to manage water from roofs, driveways and patios for individual houses.

b) **Rainwater harvesting using Water Butts*:*** Rainwater from roofs and hard surfaces such as car parks can be stored and used in and around properties. The simple rainwater butt, used for garden watering, is a familiar method of storage. Water butts and storage tanks allow water to be collected from roofs and stored for use within and around the property. They are best placed to provide source control at an individual household/building level and are most effective as part of a management train approach. Rainwater harvesting systems can be used to effectively drain roofs and provide both water supply and storm water management benefits. Figure below shows rainwater harvesting process.



c) **Permeable pavements:** Permeable pavement is an alternative to conventional paving in which water filters through the paved structure rather than running off it. Both the surface and the sub-grade need to be designed with this function in mind. Water may infiltrate directly into the subsoil where conditions are suitable. Alternatively, it can be held in a reservoir structure under the paving for reuse, infiltration or delayed discharge. The permeable paving can be gravel, concrete or plastic webbing, concrete blocks designed for the purpose or porous asphalt. Permeable paving should be considered for use in parking and access areas, some roads and pedestrian areas to provide effective storage and treatment of surface water runoff. It is used to form source control and site control solutions. Figure below shows a typical permeable pavement.



d) **Infiltration trenches*:*** An infiltration trench is a shallow, excavated trench that has been lined with geotextile and backfilled with stone to create an underground reservoir. Storm water runoff flowing into the trench gradually infiltrates into the subsoil. An overflow may be required for extreme rainfalls that exceed the capacity of the reservoir. The performance of the trench depends largely on the permeability of the soil and the depth to the water table. Infiltration trenches usually serve small catchment areas up to 2-3 hectares in common with other source control techniques. The closer they are to the source of the runoff the more effective they will be. The operational life of the trench may be enhanced by providing pre-treatment for the inflow, such as a filter strip, gully or sump pit, to remove excessive solids. Regular maintenance will be required for most pre-treatment designs. Trenches can be used on sloping sites, where implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered.

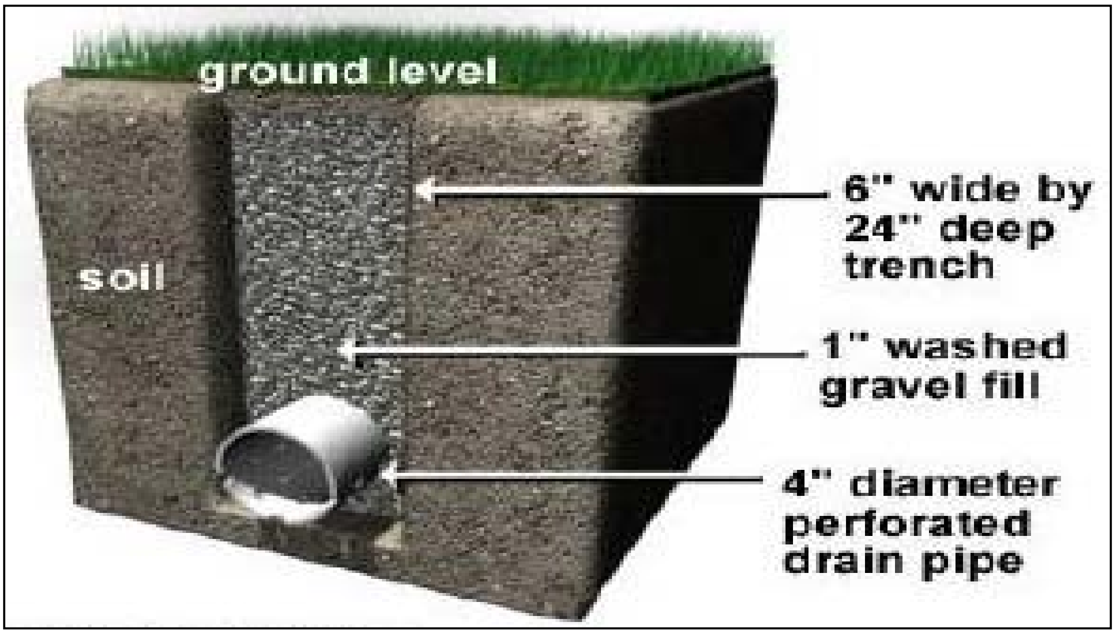
An infiltration trench is shown in figure below:

Infiltration trench

e) **Permeable Conveyance Systems:** Permeable conveyance systems move runoff water slowly towards a receiving watercourse allowing storage, filtering and some loss of runoff water through evaporation and infiltration before it reaches the discharge point. The main types of permeable conveyance systems are underground systems such as filter drains (or French drains) and surface water swales.

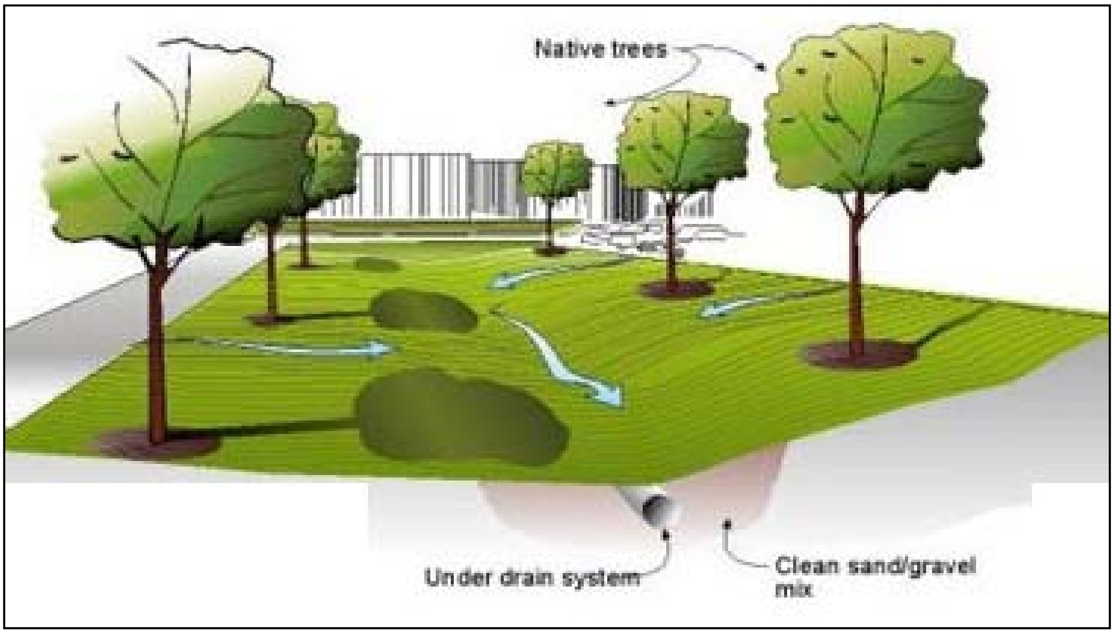
- **Filter drains:** This technique can be adopted if there is evidence of pollutants entering the runoff. A filter drain is a trench lined with a geotextile and filled with gravel into which runoff water is led, either directly from the drained surface or via a pipe system. The gravel in the filter drain provides some filtering of the runoff, trapping sediment, organic matter and oil residues that can be broken down by bacterial action through time. The runoff rate is reduced, and runoff storage is also provided. Stored water can also pass through the geotextile membrane and some filter drains need not lead to a watercourse at all.

A filter drain is shown in figure below:



- ***Swales and Filter Strips:*** Swales can be used to convey roof water to other parts of the site. Swales are grassed trapezoidal channels which are used to convey and store flows. Their gentle side slopes provide water quality improvements by filtration through the grass, and by controlling the flows they allow particulates to settle on the base. A swale is dry during dry weather but in wet weather, rainwater flows into it along its length and moves slowly through the grass area. The grass slows down and filters surface water flows. Sediment is deposited while oily residues and organic matter are retained to be broken down in the top layer soil and vegetation. The underlying aquifer can be protected, if needed, by placing an impermeable lining under the swale below the soil. Swales can be used on sloping sites, where implemented parallel to the contours. The consequences of exceedance and flood flow paths will need to be considered. The size of area that can be drained will be limited by meeting the hydraulic and water quality criteria.

- Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow. In order to be effective they should be 5-15 metres wide and they may adopt any natural vegetated form, from grassy meadow to small wood. The wider the strip and the more dense the plant cover the better the pollutant removal. Filter strips are best employed at the upstream end of the drainage system, accepting runoff from small areas (up to 2 hectares) directly, for example, before it is concentrated in a drainage system. Road runoff can also be treated in this manner, provided the road/filter strip boundary is designed so that it does not become blocked by sediment or vegetation.



f) **Passive Treatment*:*** Passive treatment systems use natural processes to remove and break down pollutants from surface water runoff. Small scale systems such as filter strips, can be easily designed into the landscape and are sited upstream of other SuDS. Larger, 'end of pipe' systems usually involve storage of water in constructed ponds. Here natural purification processes can be encouraged. Constructed wetlands and ponds also provide the opportunity to improve wildlife habitat in urban areas. Additionally, ponds can be made into amenity features for the local community and there is growing evidence of the additional value this can provide to communities.

g) **Detention basins*:*** Detention basins are designed to hold back storm runoff for a few hours to allow solids to settle. Bypasses may be included to ensure the 'first flush' is detained. Detention basins drain via an orifice plate or similar hydraulic structure into a watercourse or surface water drainage system. Detention basins are dry outside of storm periods. They are designed to retain flood events, reducing peak flows and limiting the risk of flooding.

h) **Wetlands:** These are a further enhancement of retention ponds that incorporates shallow areas planted with marsh or wetland vegetation. They provide a much greater degree of filtering and removal of nutrients by algae and, to a lesser extent, by plants. Inlet and outlet sumps will improve performance and are recommended, since excessive sediment can quickly overwhelm the shallow area. Only specially constructed wetlands should be used to treat surface water. It is not normally an acceptable practice to lead surface water into an existing natural wetland area.

Appendix D. Storm Water Flow Estimates

Maximum runoff flow Date Calculated: 13/04/2016

Western Catchment: Residential development

Catchment details				
Area	*A* =	3.485	ha	(total impermeable area)
Length	*L* =	365.0	m	(north to south boundary)
Average slope	1/	30.0		(average slope across the site from north to south)
Time of concentration (Bransby-Williams)				
Area	*A* =	0.035	km^2	
Length	*L* =	0.4	km	
Average slope	*S* =	33.333	m/km	
Time of concentration	*T* =	14.81	mins	
		0.247	hours	
Rainfall details (FSR model)				
Event return period	*T* =	2	years	(max. 100)
Critical duration	*D* =	0.247	hours	(equal to time of concentration)
Model parameters (from FSR maps):				
M5-60min		19.000	mm	(values derived from MicroDrainage WinDES)
Ratio *r*		0.339		
Location		England & Wales		
	M5-*D* =	11.3	mm	
Depth (M2-0.247hrs)	Interpolated *Z2* =	0.793		
	R =	8.9	mm	
Average intensity	*i* =	36.2	mm/hr	
Peak flow rate 2yr design storm	***Q* =**	**351.1**	**l/s**	

Maximum runoff flow Date Calculated: 12/04/2016

Eastern Catchment: Sports and retail development

Catchment details				
Area	*A* =	2.800	ha	(total impermeable area)
Length	*L* =	365.0	m	(north to south boundary)
Average slope	1/	30.0		(average slope across the site from north to south)
Time of concentration (Bransby-Williams)				
Area	*A* =	0.028	km^2	
Length	*L* =	0.4	km	
Average slope	*S* =	33.333	m/km	
Time of concentration	*T* =	15.14	mins	
		0.252	hours	
Rainfall details (FSR model)				
Event return period	*T* =	2	years	(max. 100)
Critical duration	*D* =	0.252	hours	(equal to time of concentration)
Model parameters (from FSR maps):				
M5-60min		19.000	mm	(values derived from MicroDrainage WinDES)
Ratio *r*		0.339		
Location		England & Wales		
	M5-*D* =	11.4	mm	
Depth (M2-0.252hrs)	Interpolated *Z2* =	0.793		
	R =	9.0	mm	
Average intensity	*i* =	35.8	mm/hr	
Peak flow rate 2yr design storm	***Q* =**	**278.7**	**l/s**	

Appendix E. Foul Water Design Flow Estimates

Western Development: 250 new residential properties

Item:	Estimated design flow:	Notes:
250 residences	11.57l/s	Design flow rates for dwellings based on 4000 litres per dwelling per day. This is over-conservative as no more than 200 residences are proposed.
Design flow: 11.57l/s		

Reference: Sewers for Adoption 7th Edition.

Eastern Development: Sports facilities and Clubhouse

Item:	Estimated design flow:	Notes:
Sports Clubhouse	2.31l/s	Assumed as a public house producing 150 litres per day per seat (assuming 200 seats)
Sports Changing	2.35l/s	Assumed as a sports hall producing 150 litres per day per person (assuming 205 total)
Caravan site	2.24l/s	Caravan camp with shared facilities producing 145 litres per person per day. Assuming a full occupancy of 50 pitches each with 4 persons per pitch (200 total).
Bowling Hall	0.38l/s	Assumed as a sports hall producing 50 litres per person per day (assuming 100 people)
Gym	2.29l/s	Assumed as a sports hall producing 150 litres per person per day (assuming 200 people)
Design flow: 9.57l/s		

Reference: Jones, Peter M. 1992. Foul sewer design flow. Extract from: Surveyor Magazine, 30 January 1992