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Great Wolf Lodge, Bicester

Planning Condition 16 Discharge Report

engineering a better society

		Remarks:	Planning Condition 16 Discharge				
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Contents

Appendices

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Executive Summary

Elliott Wood Partnership Ltd has been appointed by Great Lakes UK Limited to design the sustainable drainage strategy for proposed Great Wolf Lodge Resort and Aquapark in Bicester, Oxfordshire.

This report has been prepared address and discharge planning condition 16 for the Oxfordshire County Council approved appeal planning application 21/04158/F. The sustainable drainage strategy contained within this report is compliant with Appendix F - Information required for discharge of standard conditions of "Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire".

Great Wolf Lodge Hotel and Aquapark is to be constructed on part of the existing golf course associated with the Bicester Hotel, Golf and Spa. The site currently resides as land used for holes 10 – 18 of the existing golf course.

The developments redline boundary is subdivided in to two areas:

1. Resort Area - 13,0666m^2 (13.07 hectares)
2. Northern Park – 55,181m^2 (5.52 hectares)

The resort area consists of three main building zones:

- Family Entertainment Centre & Conference Centre
- Hotel, Reception & Porte Cochère
- Waterpark & Bunker

The Northern Park is a landscaped area comprising of footpaths, existing and proposed ponds with no buildings.

Card Geotechnics Limited (CGL) have undertaken intrusive site investigation. The ground conditions were found to consist of topsoil underlain by the Cornbrash Formation, which is in turn underlain by the Forest Marble Formation. Shallow 'perched' surface water was encountered across the site at depths of between 1.05mbgl and 2.31mbg). This perched surface water is caused by the low permeability of the clay, mudstone, and limestone superficial layers. Continuous groundwater monitoring data loggers continue to monitor the perched ground water levels onsite.

There are no public foul, surface or combined water sewers located on site or in the immediate vicinity. Holes 10-18 of the existing golf course currently manage surface water run-off via a network of ditches that ultimately discharge to a 300mm diameter pipe. This pipe continues under the Bicester Hotel, Golf and Spa to an existing pond to the south of the hotel. From there, surface water continues via a network of ditches, ultimately discharging to the Wendlebury Brook. It is proposed to re-use this 300mm diameter pipe as the point of outfall for the development. Surface Water run-off will be attenuated by the sustainable drainage strategy to Greenfield Rates (QBar). This will be achieved using living roofs, swales, pervious paving, detention basins, ponds, rain gardens and below ground attenuation tanks.

John Sisk & Son Limited will be the Principal Contractor, responsible for the construction of the development. In the early stages of construction John Sisk & Son Limited intend to manage surface water during construction through the construction of temporary surface water drainage systems. As construction progresses, they will build, use and remediate the permeant surface water drainage system in a phased manner.

Pollution control and treatment has been developed in line with the SuDS Manual and Pollution Prevention Guidance 3 (PPG3). Sufficient treatment is provided to the surface water run-off to allows its safe discharge to the ordinal watercourse.

All drainage will remain private, Great Wolf Lodge will be responsible for its ongoing maintenance. An Operation & Maintenance Manual is included within this report.

One

Introduction

Elliott Wood Partnership Ltd has been appointed by Great Lakes UK Limited to provide structural and civil engineering consultancy services on the proposed development of The Great Wolf Lodge Resort and Aquapark in Bicester, Oxfordshire.

This report has been prepared to address and discharge planning condition 16 for the Oxfordshire County Council approved appeal planning application 21/04158/F.

The proposed surface water drainage strategy has been developed as an evolution of the Curtins surface water drainage strategy (Reference: 068535-CUR-00-XX-RP-C-00002) that was submitted and approved at planning.

Two

Planning Condition 16

Planning condition 16 for the above planning application is worded as follows:

No development shall commence until a detailed surface water drainage scheme for the site, has been submitted to and approved in writing by the local planning authority. The scheme shall be implemented in accordance with the approved details before the development is completed. The scheme shall include:

a) *a compliance report to demonstrate how the scheme complies with the "Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire";*
b) *full micro drainage calculations for all events up to and including the 1 in 100 year plus 40% climate change;*
c) *a Flood Exceedance Conveyance Plan;*
d) *Comprehensive groundwater monitoring and modelling to understand the groundwater flows across the site;*
e) *detailed design drainage layout drawings of the SuDS proposals including cross-section details;*
f) *detailed maintenance management plan in accordance with Section 32 of CIRIA C753 including maintenance schedules for each drainage element; and*
g) *details of how water quality will be managed during construction.*

The scheme shall also include the following details of the tank proposed for the storage of surface water:

h) *full details of the design and proposed location of the tank and the pipes and the conduits to be installed to convey water to and from the tank, such details to include the materials from which the tank, pipes and conduits are to be made;;*
i) *full details of the proposals for the installation of the tank, including the means by which the tank will be anchored;*
j) *full details of the proposed means of operation of the tank, including the control of discharge;*
k) *full details of on-going maintenance of the tank and the pipes and conduits to be installed to convey water to and from the tank and a scheme for on-going monitoring of its operation.*

Prior to first occupation, a record of the installed SuDS and site wide drainage scheme shall be submitted to and approved in writing by the Local planning authority for deposit with the Lead Local Flood Authority in its Asset Register. The details shall include:

l) *as built plans in both .pdf and .shp file format.*
m) *photographs to document each key stage of the drainage system when installed on site;*
n) *photographs to document the completed installation of the drainage structures on site;*
o) *the name and contact details of any appointed management company information.*

This report looks to discharge points a – k of the above condition. Points l – o will be discharged prior to first occupation of the development.

Three

Compliance Report

The following table demonstrates compliance with Appendix F - Information required for discharge of standard conditions of:

"Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire"

Detail Required for Standard Detailed Design Condition	Provided?
Details (i.e. designs, diameters, invert and cover levels, gradients, dimensions, materials and so on) of all elements of the proposed drainage system, to include pipes, inspection chambers, ACO drains, storage tanks, outfalls/inlets and swales. These must be supported by calculations.	Yes, refer to drawings provided in Appendix E and G
Cross sections of the control chambers (including site specific levels m AOD) and manufacturers' hydraulic curves should be submitted for all hydro brakes and other flow control devices.	Yes, refer to details provided in Appendix E and G
Full specification for any permeable paving.	Yes, refer to details provided in Appendix E and G
Details of the attenuation pond dimensions, to include bank levels in relation to 'normal' and design water levels and surrounding land levels, plus cross sections through any raised sections of bank. This should demonstrate that adequate attenuation storage volume has been provided above 'normal' water level, providing an appropriate residual uncertainty allowance (freeboard) between top design water level and bank level of at least 300mm or that determined as being appropriate by a qualified engineer for safety and other factors, following the Environment Agency's revised guidance at https://www.gov.uk/government/publications/accounting-for-residual-uncertainty-an-update-to-the- fluvial-freeboard-guide. The available storage volume should account for any ballast or other permanent features within the pond.	Yes, refer to details provided in Appendix E and G

Site Context

3.1 Site Location

Great Wolf Lodge Hotel and Aquapark is to be constructed on part of the existing golf course associated with the Bicester Hotel, Golf and Spa. The site is located to the west of Chesterton which is an outlying village to the west of Bicester.

Figure 1: Site Location Plan (© Google Earth)

The site boundary is triangular in shape, bound by the M40 to the west, A4095 to the east and Bicester Hotel, Golf and Spa to the south.

The site is located within the county of Oxfordshire who are also the Lead Local Flood Authority (LLFA).

3.2 Existing Development

The site currently resides as land used for holes 10 – 18 of the existing golf course.

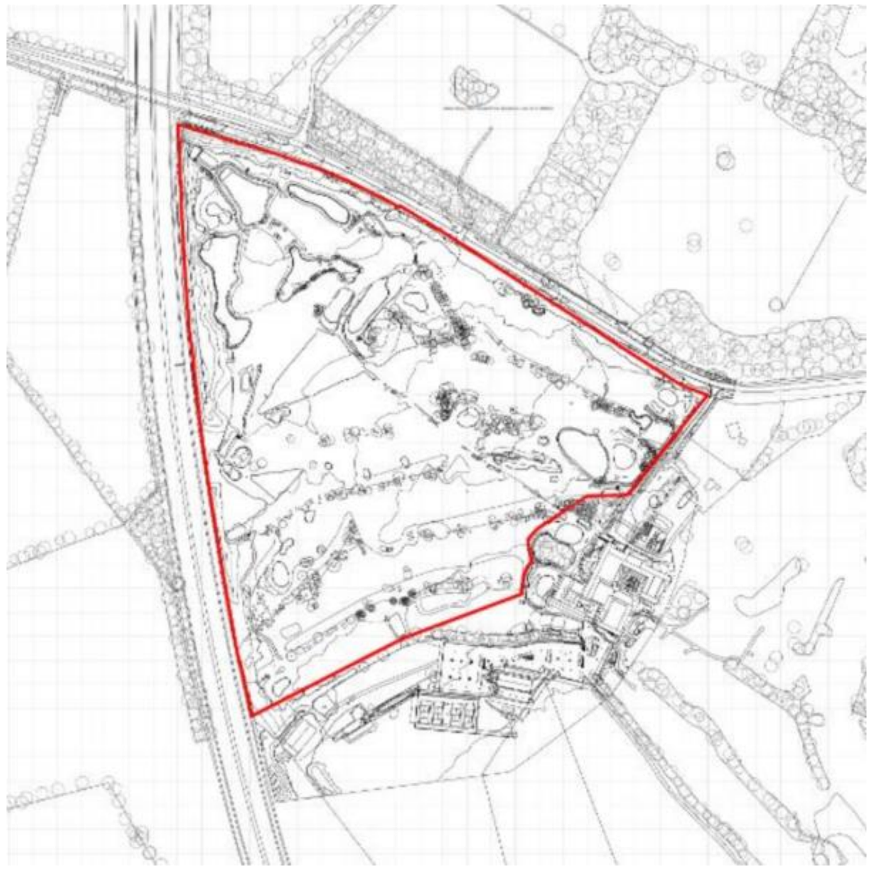

Figure 2: Existing Site Layout

The site centred OS grid reference is 454923E; 221686N.

The total site area is bound in red is approximately 186,000m^2 (18.6 hectares).

3.3 Topography

The existing site comprises of a combination of managed golf fairways, greens, bunkers, footpaths, ditches and ponds with pockets of existing trees. Figure 3 illustrates the key topographical features.

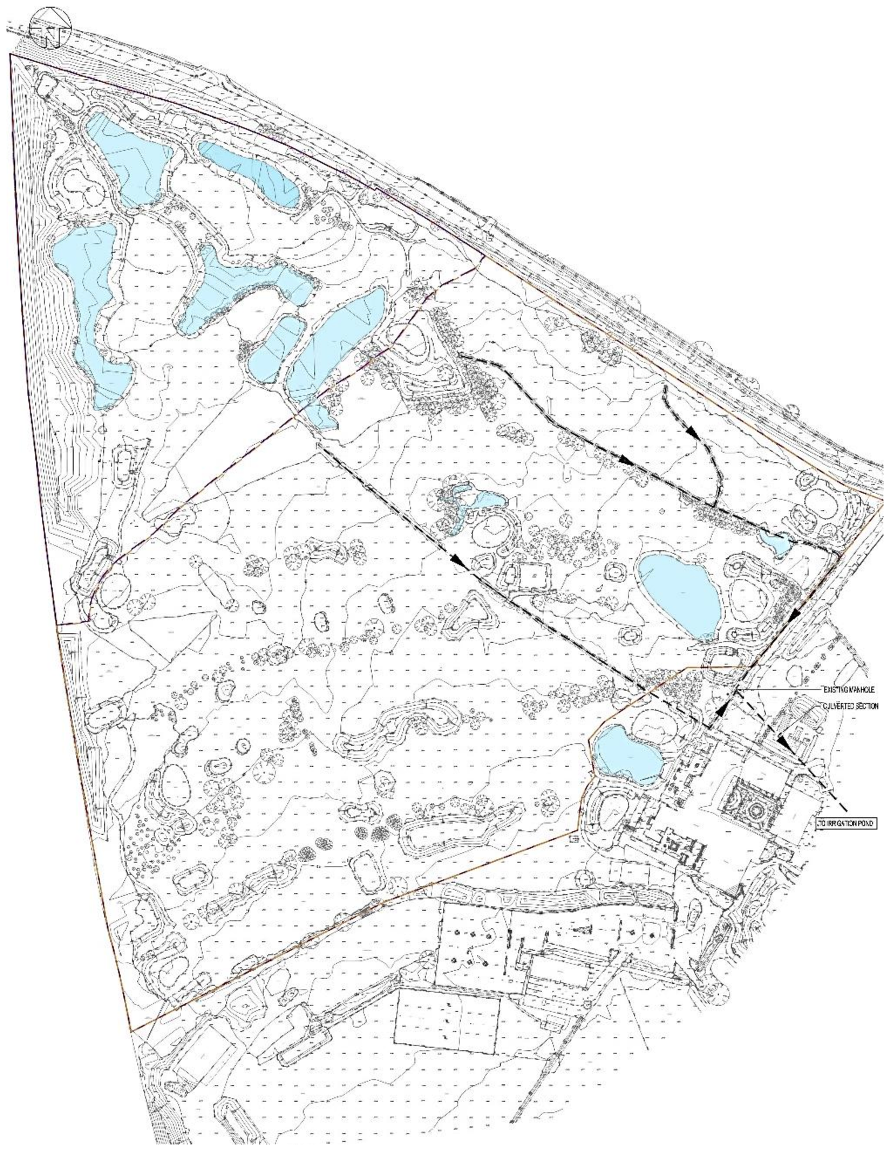

Figure 3: Existing Site Topographical Features

It can be seen from the contours in Figure 3 that the existing site gently falls in elevation from north to south from around 84.700m AOD to 80.400m AOD over around 500m.

The topographical survey is presented in Appendix A.

Four

Underlying Geology

Card Geotechnics Limited (CGL) were appointed to undertake ground investigation works at the existing site. CGL concluded their final site investigation report in March 2022, their report is presented in Appendix B.

The site geology consists of topsoil, made ground, and clays over mudstone and limestone (Cornbrash formation) at shallow depth. Due to the low permeability of the clay, mudstone and limestone layers, perched surface water is encountered at shallow depth.

4.1 Site Investigation

The ground investigation works comprised the following:

- Twelve rotary boreholes to depths between 3mbgl and 20mbgl:
  - 1 x 20m deep borehole
  - 1 x 15m deep borehole
  - 5 x 5m deep boreholes
  - 5 x 3m deep boreholes
- In-situ Standard Penetration Tests in soils, and recovery of samples of rocks in boreholes.
- Installation of groundwater monitoring standpipes to varying depths in all locations, reinstated with a flush metal cover.
- Installation of water monitoring divers in 7 out of the 12 boreholes.
- Completion of four return monitoring visit for groundwater monitoring and recovering data from water monitoring divers.

Figure 4: Borehole Locations

4.2 Ground Conditions

The ground conditions at Bicester Golf Club consist of topsoil underlain by the Cornbrash Formation, which is in turn underlain by the Forest Marble Formation, as summarised below:

- Topsoil was encountered at all locations with a thickness of between 0.1 and 0.4 m. The elevation of the base of the topsoil ranged from 84.65 – 80.39 m AOD.

<u>Cornbrash Formation:</u>

- Residual soils of the Weathered Cornbrash Formation were encountered at all borehole locations and consisted of dark to light brown sandy gravelly clay or clayey gravel. The elevation of the base of these soils ranged from 84.15 –78.59 m AOD, and the thickness ranged from 0.50 m in BH02 to 2.20 m in BH06.
- Marl of the Cornbrash Formation was encountered beneath the residual soils in three boreholes (BH04, BH05, and BH07). Generally, the marl was described as clayey gravelly sand with oolitic limestone lithorelics or weak grey mottled orangish brown fine to medium grained limestone with spherical nodules, and sand sized grains of oolites and calcite crystals. The elevation of the base of the marls ranged from 81.57 m AOD in BH04 to 79.93 m AOD in BH07, and the thickness ranged from 1.25 m to 1.40m.
- Limestone of the Cornbrash Formation was encountered in eight exploratory hole locations across the site (boreholes BH02 to BH07, BH10 and BH11. The limestone was described as light brown and light grey medium grained thinly bedded slightly fractured fossiliferous limestone. The elevation of the base of the limestone ranged from 81.79 m AOD in BH03 and 78.08 m AOD in BH10, and the thickness ranged from 0.20 m to 1.70 m.

<u>Forest Marble Formation:</u>

The Forest Marble Formation was encountered in all boreholes, except BH10, and typically comprises interbedded clay, mudstone, and limestone.

- Stiff to very stiff dark grey to bluish grey clay of the Forest Marble Formation was encountered in nine boreholes (BH01, BH02, BH04, BH05, BH06, BH07, BH08, BH09 and BH12) with the shallowest elevation of 78.59 m AOD in BH12. The clay beds range in thickness from 0.05 m to 1.20 m, with and average thickness of 0.30 m. Generally, the thickness of the beds decreases with depth.
- Dark grey to blue grey slightly silty fine-grained mudstone was encountered in eight boreholes (BH01 to BH07 and BH11) with the shallowest elevation of 79.11 m AOD in BH11. The beds of mudstone range in thickness from 0.05 m to 1.25 m with an average thickness of 0.35 m.
- Limestone was encountered in seven borehole locations (BH01 to BH06 and BH09) with the shallowest elevation of 78.49 m AOD in BH06. Generally, the limestone was described as being light grey to dark grey fine to medium grained thinly bedded fossiliferous limestone. The thickness of the bands of limestone ranged from 0.04 to 1.10 m with an average thickness of 0.4m.

4.3 Groundwater

Shallow 'perched' surface water was encountered across the site at shallow depths during monitoring visits at elevations ranging from 83.63 to 78.28m AOD (depths of between 1.05mbgl and 2.31mbgl). This perched surface water is caused by the low permeability of the clay, mudstone and limestone superficial layers.

Continuous groundwater monitoring data loggers were installed in BH01, BH04, BH05, BH07m BH08, BH10 and BH 11 on 11th November 2021. Data has been collected between 11th November 2021 and 7th February 2022. Groundwater monitoring continues, CGL will revisit site periodically to download the continuous monitoring. A summary of their data collected to date against precipitation is presented in Figure 6.

When compared to the daily rainfall data, the groundwater shows quite a fast response to a rainfall event – the levels rise quickly immediately after the rainfall event. The water levels then stay at a higher level for an extended period, indicating that the groundwater is not freely draining away due to the bands of clay within the Forest Marble Formation.

As precipitation struggles to infiltrate in the superficial deposits, the existing golf course manages potential waterlogging of the course with a series of ditches and ponds that drain the course, keeping play possible all year round.

A deeper water horizon, considered to be the true groundwater level was found between 4.3m and 4.72mbgl in the lower limestone. This water horizon is separated from the shallower groundwater by a bed of clay/mudstone.

Whist the perched water monitoring is continuing, Figures 5 illustrate the ground water variation over a 3-month duration.

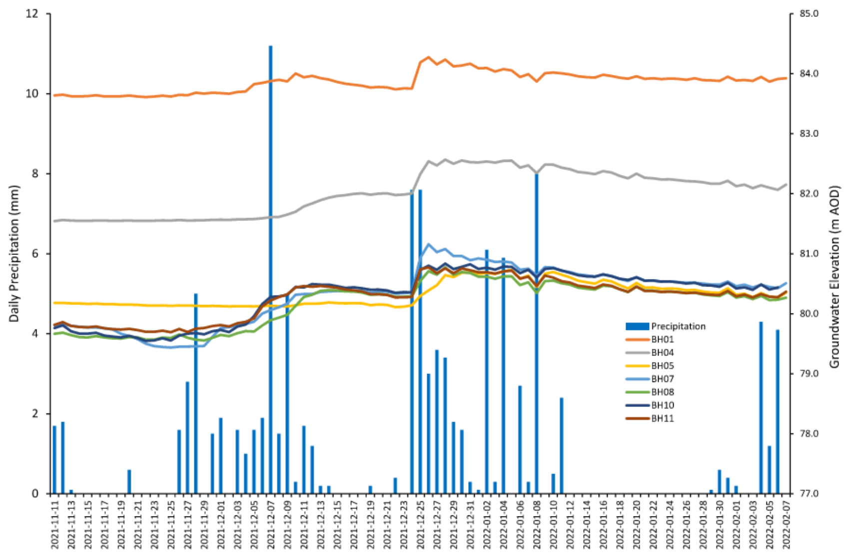

Figure 5: Groundwater Monitoring Summary Results (10/11/21–08/02/22)

CGL has mapped the perched groundwater levels across the site, an extract of this mapping is presented in Figure 6 and in full in Appendix B.

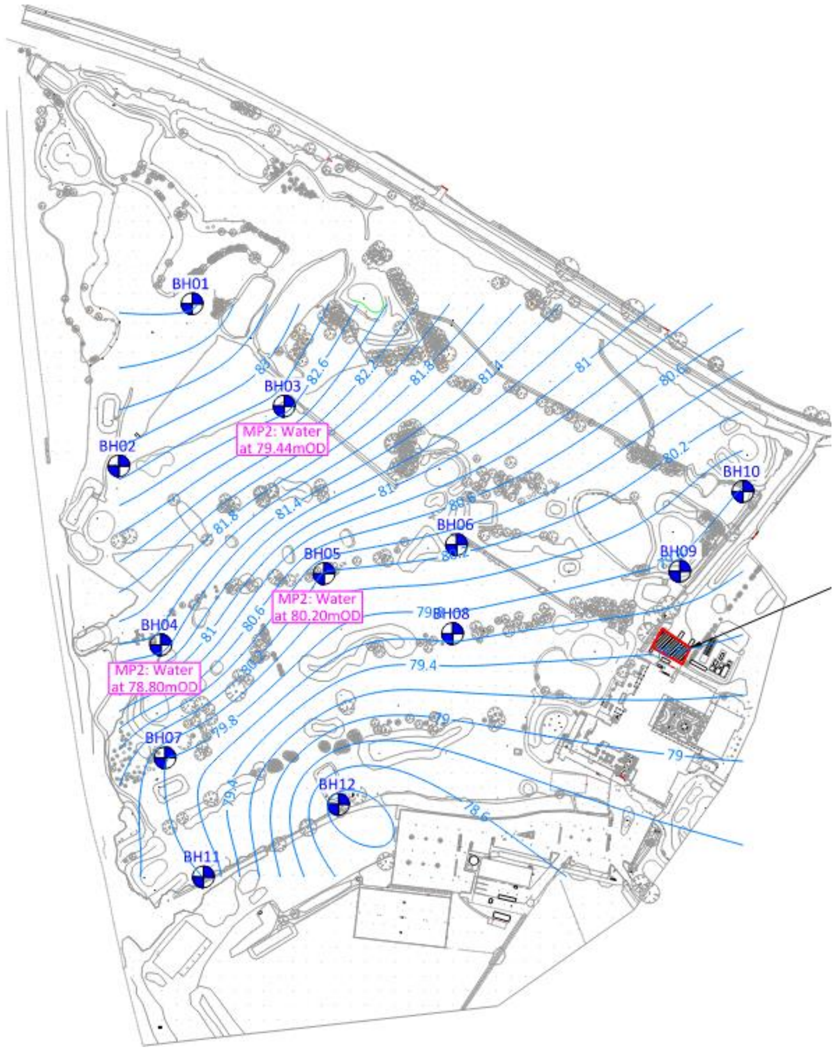

Figure 6: Mapped Groundwater Contours (Oct-Nov 2021)

Five

Existing Drainage

5.1 Thames Water Sewers

There are no public foul, surface or combined water sewers located on site or in the immediate vicinity. The closest public sewer is a Thames Water foul sewer located around 450m to the east, along the A4095, manhole reference 7601.

This manhole is the head of the foul water sewer that serves Chesterton, it is also the outfall for the rising rain from the Bicester Hotel Golf and Spa.

The location of manhole 7601 can be seen in Figure 7. Thames Water sewer records are contained within Appendix C.

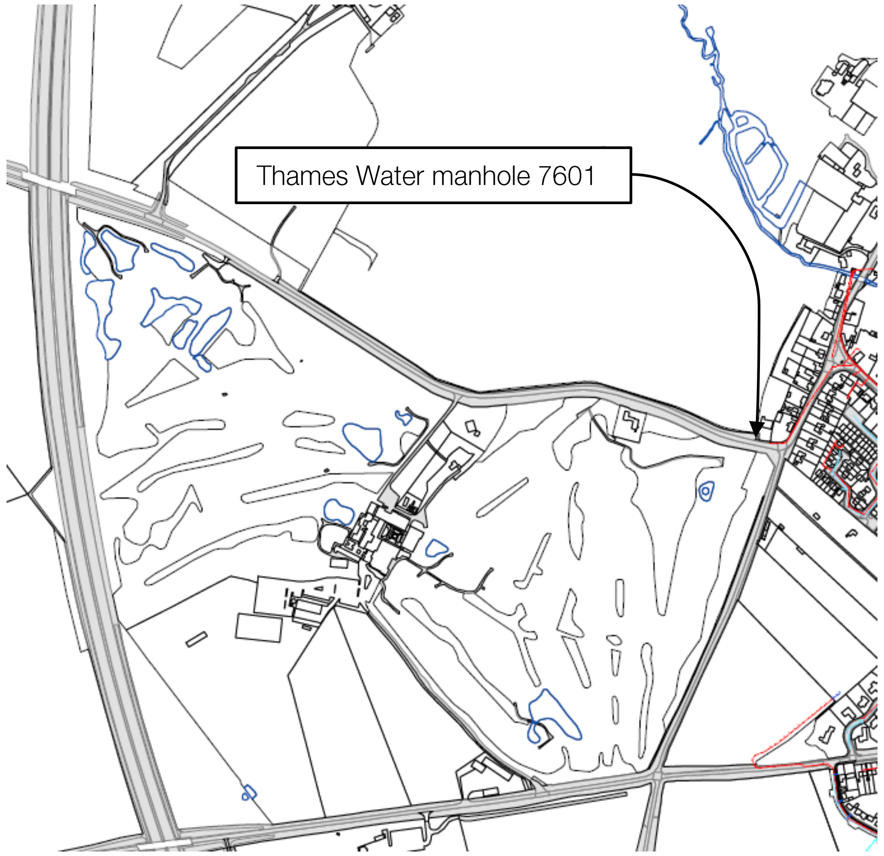

Figure 7: Extract from Thames Water sewer records © Thames Water

5.2 Existing Surface Water Drainage

The existing site, while comprised of extensive areas of soft landscaping, is considered to be a brownfield site due to previous developments undertaken to create suitable grounds for a golf course. All surface water run-off from across the existing golf course is managed with a series of ditches and ponds that drain the course, to manage waterlogging and keep play possible all year round.

5.3 Ordinary Watercourses

Existing ponds and ditches across the development site are illustrated on Figure 8 and presented on drawing numbered 2180501-EWP-ZZ-XX-DR-C-0010 contained with Appendix D.

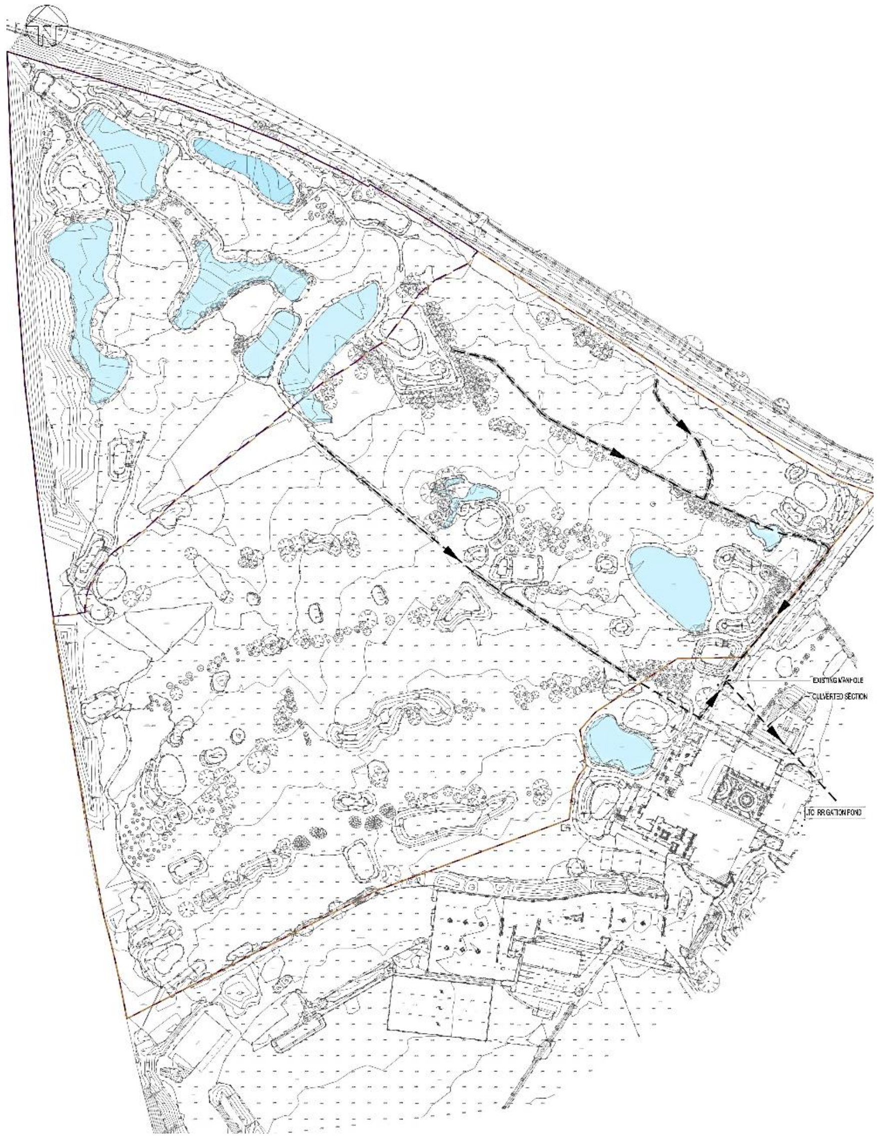

Figure 8: Existing Topographical Features within Site Boundary

The two existing ditches illustrated by a black dashed line in the Figure above outfall via a 300mm diameter pipe to an existing pond to the south of Bicester Hotel, golf and spa.

It is understood that Bicester Hotel, golf and spa use this pond in the summer months for a source of irrigation water for the golf course. This existing irrigation pond has a high-level outfall discharging to a network of ditches that ultimately discharges to the Wendlebury Brook. Figure 9 illustrates the approximate route of this downstream ditch network to the brook.

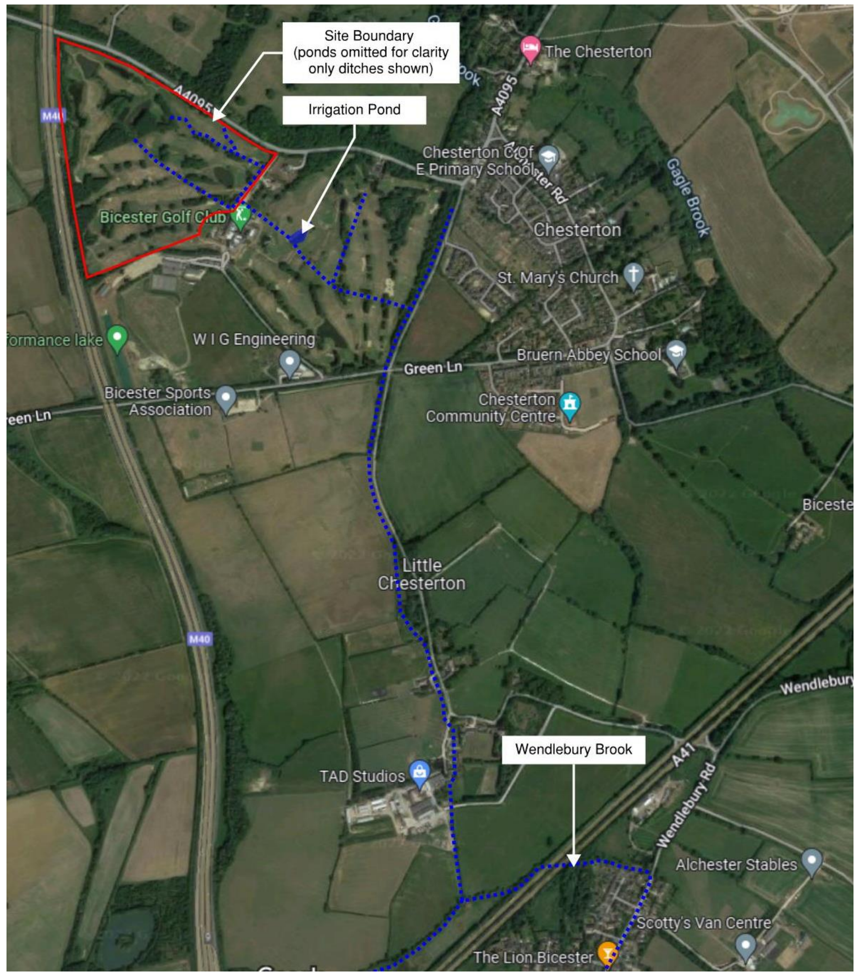

Figure 9: Ordinary Watercourse Routing to the Wendlebury Brook (shown in blue dashed)

Six

Proposed Development

It is proposed to construct a new 498 room hotel and aquapark with associated parking and servicing. The development also offers indoor activities, conferencing facilities, food and beverage offering for guests and public nature trails.

The developments redline boundary is subdivided in to two areas:

3. Resort Area - 13,0666m^2 (13.07 hectares)
4. Northern Park – 55,181m^2 (5.52 hectares)

The resort area consists of three main building zones:

- Family Entertainment Centre & Conference Centre
- Hotel, Reception & Porte Cochère
- Waterpark & Bunker

These building zones are identified in Figure 10.

The Northern Park is a landscaped area comprising of footpaths, existing and proposed ponds with no buildings.

Figure 10: Proposed Development Layout

Seven

Proposed Surface Water Drainage

The sustainable drainage strategy builds on the Curtins strategy that was agreed at planning. The sustainable drainage strategy uses a series of techniques to manage surface water run-off as close to the source as possible. Managing surface water in this manner provides water quality improvements, reduces future maintenance requirements and enhances amenity value for the end user.

Surface water will be managed on site using sustainable drainage techniques in accordance with:

- National Planning Policy Framework (NPPF)
- Cherwell Local Plan
- Oxfordshire County Council - Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire
- Curtins Drainage & SuDS Strategy (as approved at planning)

It is proposed to re-use the existing outfall to the south of the site boundary as described in Section 5.3 of this report.

The proposed surface water drainage strategy can be separated into the following areas:

1. Northern Park
2. Main Resort

Each area is discussed in the following sections.

7.1 Northern Park

The northern park area of the site is to remain undeveloped except for new informal pedestrian paths, landscape enhancements and the introduction of new newt ponds forming a new area of parkland.

Self-binding gravel trails and mown grass routes will provide pedestrians access through the parkland, offering the opportunity for guests and the general public to explore this new ecologically rich area.

The proposed self-binding gravel path will not be positively drained. Instead, the 1.8m wide path will be laid to shed surface water onto the adjacent soft landscaping.

The area that encompasses the proposed northern park currently has six existing ponds. It is proposed to supplement these six existing ponds with three further proposed ponds.

The existing topography of the northern park area provides an overland flow route that interconnects the existing ponds in an exceedance event flowing with the general topography from north to south. Pre-development, exceedance conveyance route and cascading nature of one pond to another, continued all the way to the existing outfall on the southern boundary referenced in Section 5.3 via ditches and culverts.

However, with the construction of the main resort, these exceedance conveyance routes through the main resort area are severed.

The proposed ponds have been incorporated into the landscape so complement the existing ponds and to ensure exceedance conveyance route and the cascading nature of one pond to another is maintained.

Northern Park Drainage, Exceedance and Details Drawings

The Northern Park ponds and their overland exceedance routes are presented on our proposed drainage drawings contained with Appendix E.

Northern Park Micro Drainage Modelling

Whilst the water level in the ponds vary throughout the year, for the purposes of the Cascade modelling, a permanent water level of 1mm below the exceedance level has conservatively been assumed as a worst-case scenario.

Micro Drainage Cascade and the simulation results are presented in Appendix F for storms up to and including the 1 in 100-year event + 40% climate change.

Beyond the terminal ponds in the Northern Park (Ponds 8 and 9), exceedance is conveyed to a below ground 300mm pipe that run south, through the proposed resort to the existing outfall to the south of the main resort.

7.2 Main Resort

Proposed Main Resort Drained Areas

The approximate proposed positively drained areas within the resort boundary are summarised as follows:

Table 1: Approximate Proposed Positively Drained Areas

	m^2	Hectares (ha)
Proposed Buildings	27,322	2.732
Proposed Hardstanding	37,198	3.720
Total	64,520	6.452

Proposed Main Resort Surface Water Discharge Rate

It has been agreed at planning to limit the surface water discharge rate offsite to QBar for up to and including the 1 in 100-year event + 40% climate change as noted in Section 7.1 of this report.

The ICP SuDS method of rural run-off calculator in Micro Drainage has been used to calculate the QBar rate which is set based on the proposed positively drained area.

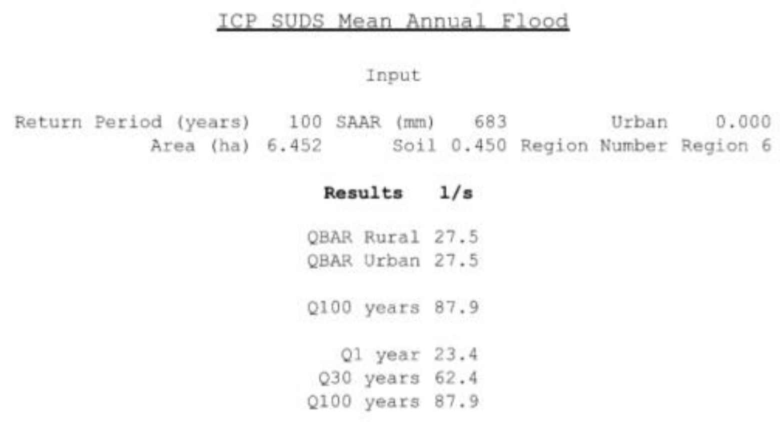

Figure 11: QBar Calculation

As can be seen in Figure 11, the QBar rate for the development is 27.5l/s. this flow restriction will be achieved using a vortex flow control device that will be located on the final manhole prior to discharge to the existing outfall.

Further flow control will be proposed with the resort site; however, these are to manage upstream surface water flows and maximise the use of the upstream attenuation volume.

7.3 Main Resort Sustainable Drainage Hierarchy

The following drainage hierarchy has been considered when developing the surface water drainage philosophy for the proposed development.

1. rainwater harvesting (including a combination of living and blue roofs).
2. infiltration techniques
3. rainwater attenuation in green infrastructure
4. rainwater discharge direct to a watercourse (unless not appropriate).
5. rainwater attenuation below ground.
6. rainwater discharge to a surface water sewer or drain.
7. rainwater discharge to a combined sewer.

In line with this hierarchy, Table 2 details the SuDS techniques that have been considered suitable together with supporting rationale.

Table 2: SuDS Evaluation

SUDS Technique	Y/N	Comment
Rainwater reuse	Y	The buried attenuation tank to the south of the proposed resort is to be an active attenuation tank to double as a rainwater harvesting tank. Harvested rainwater will be reused within the resort for WC flushing.
Infiltration devices	N	High ground water and low infiltration characteristics of the sub-soil has precluded the use of infiltration techniques
Attenuation in green infrastructure (i.e. living roofs & rain gardens)	Y	Living roofs are proposed in areas across the FEC. Swales, pervious paving, basins, ponds and rain gardens are proposed throughout the resort.
Attenuation below ground	Y	An attenuation tank is proposed to the south of the proposed resort and is to be an active attenuation tank. This means it will double as a rainwater harvesting tank. Harvested rainwater will be reused within the resort for WC flushing.
Rainwater discharge direct to a watercourse	Y	It is proposed to outfall to the existing ordinary watercourse network that ultimately discharges to the Wandlebury Brook
Controlled rainwater discharge to a surface water sewer or drain	N	No surface water sewers or drains exist in the vicinity of the development.
Controlled rainwater discharge to a combined sewer	N	No combined sewers or drains exist in the vicinity of the development.

The following sustainable drainage features are proposed as part of the Main Resort at Great Wolf Lodge, Bicester.

Living Roofs

Approximately 2,950m^2 of living roof will cover parts of the FEC roof. The living roofs will increase time of entry for surface water run-off entering the below ground drainage network, reduce the volume of water discharged off site, increase biodiversity and the urban greening effect. While there will be an element of attenuation of surface water run-off within the green roof construction, the attenuated volume cannot be quantified as the design of the roof assumes the planted medium is saturated. Run-off from roof areas is considered to have a 'very low' pollution hazard level.

Figure 12: Example Image of Living Roof

Swales

The perimeter access road to the south and west of the hotel will be impermeable and shed surface water into the proposed swale located adjacent to the access road. Part of the northern hotel tower also discharges to a length of swale. These swales will convey surface water run-off whilst also providing treatment to improve water quality.

As well as providing a conveyance method for surface water run-off, the proposed swales will provide surface water treatment, increase in biodiversity as well as an element of attenuation. The swales will need to be coordinated with other surface water treatment devices to ensure the offsite surface water discharge is suitably treated.

Figure 13: Example Image of Roadside Swale

Pervious Paving

Pervious paving is used extensively across the development. All proposed parking bays are to be constructed with permeable concrete block paving. Surrounding circulatory roads will be constructed in impermeable asphalt with their levels designed in such a manner so they shed surface water on to these bays. The geomembrane lined 4/20mm coarse graded aggregate subbase and geocellular attenuation will provide source control to these areas. Orifice plate flow controls will restrict the rate at which the run-off is discharged from the subbase to the wider below ground drainage network.

The northern emergency access route will be permeable by nature as it is proposed to be constructed from a Grasscrete system. Surface water run-off from this area will infiltrate into the ground and mimic the existing undeveloped situation.

As well as attenuation, permeable paving provides treatment of surface water run-off through filtration, adsorption, bioretention and sedimentation. This will ensure that surface water run-off from these areas will be suitably treated to for re-use in the rainwater harvesting system.

Figure 14: Example Image of Permeable Concrete Block Parking Bays

Detention Basins

Two basins are proposed adjacent to the entrance to the hotel tower entrance. These basins will be grassy depressions drying dry weather, filling with water during a rainfall event and draining down within a short period following. The primary purpose of these basins is for the attenuation of surface water run-off, however, the ponds will also increase biodiversity and improve water quality.

Figure 15: Example Image of Detention Basin

Pond

A feature pond is proposed in front of the Porte Cochère, this will contain permanent water all year round. The roof of the Porte Cochère is drained to this pond which will see a small increase in the ponds water level during rainfall events, but, a min 300mm freeboard will be maintained.

Figure 16: Illustration of proposed feature pond at Porte Cochère

Rain Gardens

The main entrance road leading from the A4095 to the Porte Cochère will drain toward the central reservation. Within the central reservation will be a raingarden which will receive surface water run-off via regular dropped kerbs.

As well as providing a conveyance method for surface water run-off, the proposed swales will provide surface water treatment, increase in biodiversity as well as an element of attenuation. The swales will need to be coordinated with other surface water treatment devices to ensure the offsite surface water discharge is suitably treated.

Figure 17: Example Image of Roadside Swale

Below Ground Attenuation Tank

The final primary surface water drainage feature is the below ground attenuation tank. The attenuation tank will operate in conjunction with the Rainwater Harvesting System.

Figure 18: Example Image of Pre-cast Concrete Below Ground Attenuation Tank

Rainwater Harvesting System

The rainwater harvesting system will utilise the surface water run-off from the below ground attenuation tank. In order to ensure there is a sufficient volume of water within the below ground attenuation tank for re-use, a smart outflow control is proposed in addition to the primary flow control. This system connects to the UK Meteorological Office predicted weather data to restrict the offsite discharge when forthcoming weather indicates that there will be spare capacity in the attenuation tank. This water is then re-used for the flushing of WCs throughout the hotel. When the tank is full or a future storm event is predicted to occur, the smart outflow control will be open and flow control will be provided by a HydroBrake Flow Control chamber which will act as the primary flow control.

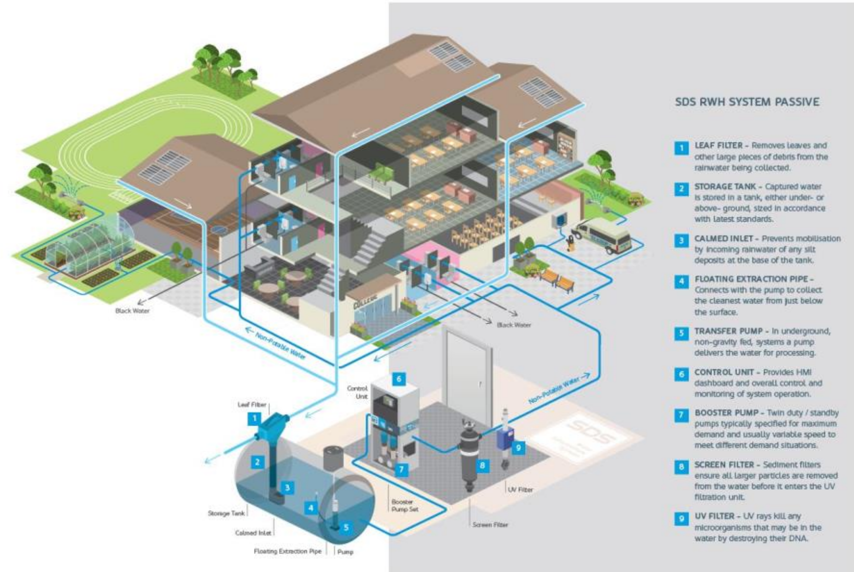

Figure 19: SDS Active Attenuation Diagram © SDS Limited

Main Resort Drainage, Exceedance and Details Drawings

The proposed Main Resort drainage strategy drawings, overland flood conveyance plan and associated details are contained with Appendix G.

Main Resort Micro Drainage Modelling

Micro Drainage network and simulation results are presented in Appendix H for the Main Resort drainage network for storms up to and including the 1 in 100-year event + 40% climate change.

The proposed rain garden in the central reservation of the main entrance has been modelled as a separate cascade model. The model details and simulation results for storms up to and including the 1 in 100-year event + 40% climate change have been included with Appendix H.

For the purposes of the main Micro Drainage Network model and simulation, a placeholder tank and flow control has been used that has the same catchment and flow control in lieu of the rain garden.

Eight

Management of Surface Water during Construction

8.1 Roles and Responsibilities

John Sisk & Son Limited will be the Principal Contractor, responsible for the construction of the development.

8.2 Managing Surface Water during Construction

In the early stages of construction John Sisk & Son Limited intend to manage surface water during construction through the construction of temporary surface water drainage systems.

As construction progresses, they will build, use and remediate the permeant surface water drainage system in a phased manner.

John Sisk & Son Limited have prepared a series of plans contained within Appendix I of this report that briefly outlines their surface water management plan.

The Project Manager will also sign up to receive Met Office weather warning alerts to allow sufficient time and preparations to be made in advance of extreme rainfall.

8.3 Legislation & Guidance

Below is a list of legislation and guidance the Principal Contractor is to adhere to:

- The Water Environment (England & Wales) regulation 2009
- Land Drainage Act 1991
- SEPA Engineering in the Water Environment Good Practice Guide Temporary Construction Methods
- Control of Water pollution from Construction Sites – Guide to Good Practice (SP156)
- Control of Water Pollution from Linear Construction Projects – Technical Guidance (C648)
- Control of Water Pollution from Linear Construction Projects – Site Guide (C649)
- Environmental Good Practice – Site Guide (C650)
- The SuDS Manual (C753)
- BS 8582: 2013 Code of Practice for Surface Water Management for Development Sites
- BS 8582: 2013 Code of Practice for Surface Water Management for Development Sites

Nine

Rainwater Harvesting Tank

9.1 Full details of the design, proposed location of the tank, the pipes and conduits to be installed to convey water to and from the tank. Such details to include the materials from which the tank, pipes and conduits are to be made.

The size of the proposed tank and its location is indicated on the relevant drainage drawing contained with Appendix G. The tank is to be constructed in pre-cast concrete by FP McCann.

The pipework, cables, hoses and ducts to be installed between the tank and the plant room for the active attenuation are as follows:

Table 3 – Active Attenuation pipework, cables, hoses and ducts

Pipe / duct	Size
Transfer rising main from tank to water reuse plant room	80mm fusion welded MDPE rising main
Power supply to transfer pumps in the tank	2 no. cables in 1 no. 100mm dia. duct
Level Sensor & Switch Cables	4 no. cables in 1 no. 100mm dia. duct
Power, Control Cables & hydraulic hoses to active attenuation valve	2 no. cables and 1 no. hose in 100mm dia. duct

9.2 Full details of the proposals for the installation of the tank, including the means by which the tank will be anchored;

The FP McCann pre-cast brochure has been included in Appendix J.

The following calculation demonstrates that the self-weight of the tank and soil above will be sufficient to overcome any buoyancy even if the tank is empty.

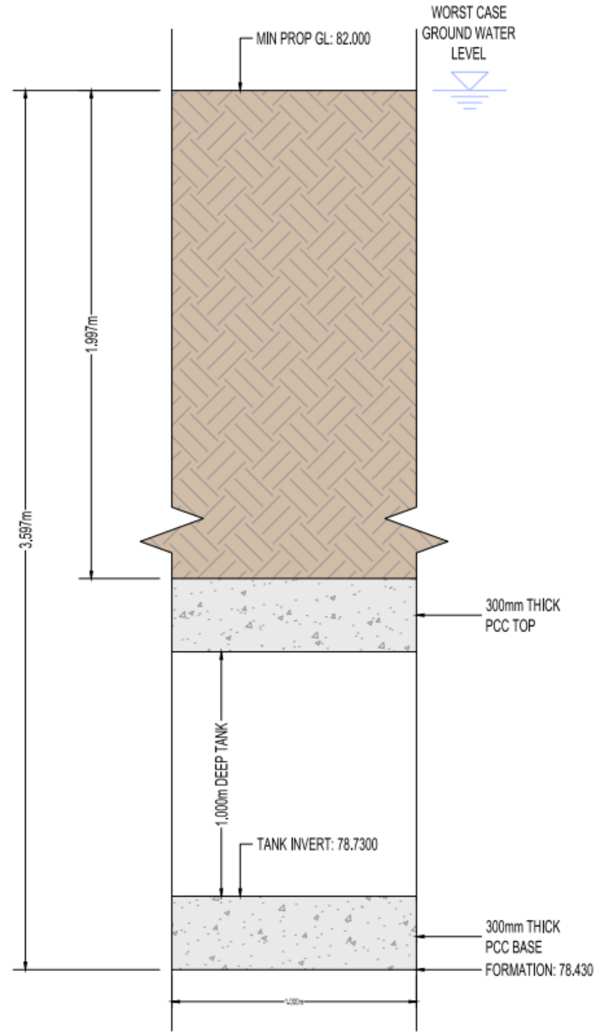

Figure 20: Typical section of attenuation tank at mid-span

Conservatively taking the tank at mid-span, the resistance to buoyancy forces is calculated as follows:

$W_{CONC} = (24 \cdot 0.3) \cdot 2 = 14.4kN/m^2$

$W_{SOIL} = 18 \cdot 1.997 = 35.946kN/m^2$

$\therefore W = W_{CONC} + W_{SOIL} = 14.4 + 35.9 = 50.3kN/m^2$

Conservatively taking the perched water level at ground level, the uplift created by the perched water is calculated as follows:

$B = 10 \cdot 3.597 = 35.97kN/m^2$

$\therefore \boldsymbol{B < W \rightarrow OK}$

9.3 Full details of the proposed means of operation of the tank, including the control of discharge

Contrary to a traditional attenuation tank, an active attenuation tank receives surface water run-off and holds it for re-use within the building. It allows for the dual purposing of the tank, as attenuation and rainwater harvesting.

Between the tank and the downstream hydro-brake flow control is an active attenuation valve. The "active" element of the system is its control. The tank is installed with an intelligent attenuation controller which is the nerve centre of the installation and that controls the active attenuation valve.

The valve in conjunction with the live tank readout provided via the hydrostatic level sensor. The system is designed to discharge the appropriate volume of water from the tank through the active attenuation valve and via the hydro-brake flow control in line with any predicted rainfall volume in the following 24-hours. This process creates sufficient tank volume for the storm event but retaining the maximum available rainwater for re-use.

The supply of reclaimed water to the internal break tank within the water re-use plant room, will be made via a submersible transfer pump located in the tank.

The water will then be treated in the water re-use plant room and made available for reuse for WC flushing.

The intelligent attenuation controller receives a daily SMS alert direct from the weather forecasting data service, providing a value for the next 24 hours projected rainfall in mm. This will trigger a calculation based on projected rainfall, surface collection area and current tank volume, in turn actuating the attenuation valve to create sufficient volume within the tank to accommodate the following days rainfall.

For example:

SMS input states 20mm of rainfall for the following day (period 9am-9am). At 6am the tank will note current tank volume, for example 250m^3 of a max capacity of 360m^3. Based on the site surface area and projected rainfall, a predicted 200m^3 of rainfall will occur during the next measured period. The tank will therefore actuate the active attenuation valve, draining the tank volume via the hydro-brake to 110m^3 (with a 50m^3 safety margin). Should the rainfall continue more than the anticipated 200m^3, the system will trigger the discharge to re-achieve the required volume aligning with the following days forecast when received. The above can additionally be operated on a manual override basis and a high-level overflow is also installed that bypasses the active attenuation valve.

System performance is reported to the developments building management system to allow for real-time monitoring and manual adjustment if required.

9.4 Full details of on-going maintenance of the tank and the pipes and conduits to be installed to convey water to and from the tank and a scheme for on-going monitoring of its operation

All elements of the active attenuation system will have a maintenance plan implemented by the manufacture of the system for the Client.

The active attenuation system elements that require on-going maintenance in and around the vicinity of the tank are as follows:

Transfer Pumps

The submersible pumps that transfer the harvest rainwater to the re-use plant room will be mounted on guide rails within the tank. This will enable the pumps to be removed when required for maintenance.

Active Attenuation Valves

The submersible valves are fixed into position within their chamber, these would require confined space access for physical maintenance, however this access requirement can be limited by remote monitoring, testing, and maintenance via the Intellistorm & SDS SYMBiotIC system whereby the valves can be tested and monitored with requiring physical inspection.

Tank Sensors / Switches

Much like the transfer pumps, the nature of the items mean that they are removable and adjustable from ground level via access chambers within the lid of the pre-cast concrete tank.

Ten

Pollution Prevention Surface Water Treatment

Pollution control and treatment has been developed in line with the SuDS Manual and Pollution Prevention Guidance 3 (PPG3).

Surface water run-off from the roofs of the development is considered to be clean.

The external hardstanding areas comprising the carpark and associated access roads primarily drain to the drainage network via pervious paving and raingardens. This approach will provide filtration of silt and attached pollutants, biodegradation, absorption and retention for silts and potential contaminants suspended within the surface water run-off.

Levels for the external hardstanding areas comprising the service yards to the south and west of the aquapark have been set to direct runoff to permeable paving where feasible. Where the levels don't permit runoff to discharge to permeable paving, runoff will be treated via petrol interceptors before discharging to the wider conveyance network, ensuring all pollutants, oils and suspended solids are extracted from the runoff and treated at source. The southern access road will discharge to the swale adjacent to the road, providing filtration, absorption, biological uptake by vegetation and subsoil biota, and contaminants will be removed through photolysis and volatilisation.

The below ground drainage network ultimately discharges to a watercourse which is a high-risk receptor.

In accordance with the SuDS Manual Chapter 4 *'Table 4.3 - Minimum water quality management requirements for discharges to receiving surface waters and groundwater'*, car parking bays for non-residential sites with frequent change, commercial yard and delivery areas are considered to have a medium pollution hazard level, as such the simple index approach should be followed.

TABLE 4.3 Minimum water quality management requirements for discharges to receiving surface waters and groundwater

Land use	Pollution hazard level	Requirements for discharge to surface waters, including coasts and estuaries[2]	Requirements for discharge to groundwater
Residential roofs	Very low	Removal of gross solids and sediments only	
Individual property driveways, roofs (excluding residential), residential car parks, low traffic roads (eg cul de sacs, home zones, general access roads), non-residential car parking with infrequent change (eg schools, offices)	Low	Simple index approach[3] *Note: extra measures may be required for discharges to protected resources*[1]	
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	Simple index approach[3] *Note: extra measures may be required for discharges to protected resources*[1]	Simple index approach[3] *Note: extra measures may be required for discharges to protected resources1* In England and Wales, Risk Screening[4] must be undertaken first to determine whether consultation with the environmental regulator is required. In Northern Ireland, the need for risk screening should be agreed with the environmental regulator.
Trunk roads and motorways	High	Follow the guidance and risk assessment process set out in HA (2009)	
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured, industrial sites	High	Discharges may require an environmental licence or permit[3]. Obtain pre-permitting advice from the environmental regulator. Risk assessment is likely to be required[5].	

Figure 21: **Table 4.3 extract from C753** identifying the pollution hazard indices for different land uses with non-residential carparks and general access road use highlighted.

TABLE 26.2 Pollution hazard indices for different land use classifications

Land use	Pollution hazard level	Total suspended solids (TSS)	Metals	Hydro-carbons
Residential roofs	Very low	0.2	0.2	0.05
Other roofs (typically commercial/ industrial roofs)	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1]	Medium	0.7	0.6	0.7
Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1]	High	0.8[2]	0.8[2]	0.9[2]

Figure 22: Table 26.2 extract from C753 identifying the pollution hazard indices for different land use classifications

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TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters

	Mitigation indices[1]		
Type of SuDS component	**TSS**	**Metals**	**Hydrocarbons**
Filter strip	0.4	0.4	0.5
Filter drain	0.4[2]	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention system	0.8	0.8	0.8
Permeable pavement	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6
Pond[4]	0.7[3]	0.7	0.5
Wetland	0.8[3]	0.8	0.8
Proprietary treatment systems[5,6]	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Figure 23: Table 26.3 highlights the mitigation indices achieved by different SuDS techniques

The schematic presented in Figure 23 illustrates the pollution hazard indices for each area of the Main Report with reference to Figure 21.

The schematic also illustrates the mitigation achieved through the proposed SuDS techniques with reference to Figure 22 to demonstrate that appropriate pollution prevention is achieved for discharge to the watercourse.

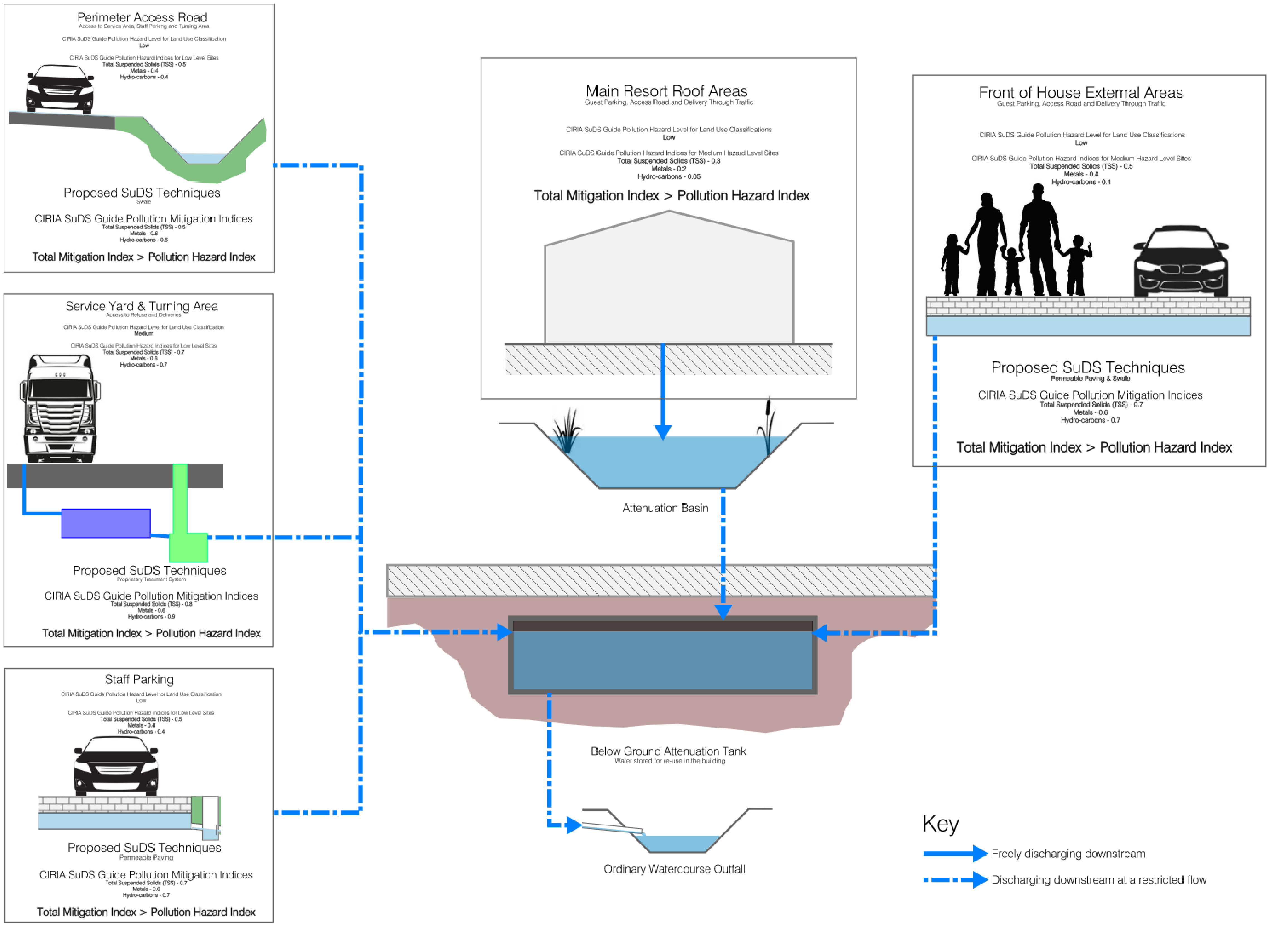

Figure 24: SuDS pollution mitigation schematic

Eleven

Twelve

Operation and Maintenance Manual

12.1 Introduction

SuDS are different from conventional drainage and require different maintenance regimes. This manual details the following:

- Location of all SuDS components on the site
- Summary of the design intent, how the SuDS components work, their purpose and potential performance risks
- Specific indicators that may trigger intervention
- Maintenance Plan and Maintenance Record Pro-forma
- Explanation of the consequences of not carrying out the maintenance that is specified
- Identification of areas where certain activities are prohibited (for example stockpiling materials on pervious surfaces)
- An action plan for dealing with accidental spillages
- Advice on what to do if alterations are to be made to a development or if service companies need to undertake excavations or other similar works that could affect the SuDS

12.2 Location of all SuDS Components

The location of all SuDS components are indicated on the below ground drainage drawings contained in Appendix E and G.

12.3 SuDS component Summary

Table 4: Living Roof SuDS Component Details

SuDS Component:	Living Roof
How it works:	Living roofs comprise a multi-layered system that covers the roof with vegetation cover. The roof consists of an impermeable layer, a substrate or growing medium and a drainage layer. Living roofs are designed to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows.
Performance:	Peak flow reduction: Medium Volume reduction: Medium Water quality treatment: Good Amenity potential: Good Ecology potential: Good
Potential Performance Risks:	Irrigation maybe needed during establishment of vegetation. Inspection for bare patches and replacement of plants will be required on a regular basis. Inspection of roof outlets to prevent blockages / flooding.

Table 5: Swale SuDS Component Details

SuDS Component:	Swale
How it works:	Swales are shallow, broad, and vegetated channels designed to store and/or convey runoff and remove pollutants. They are used as conveyance structures to pass the runoff to the next stage of the SuDS treatment train.
Performance:	Peak flow reduction: Medium Volume reduction: Medium Water quality treatment: Good Amenity potential: Medium/Good Ecology potential: Medium
Potential Performance Risks:	Litter/debris removal to avoid blockages of inlets / outlets Grass cutting and removal of cuttings Clearing of inlets, culverts and outlets from debris and sediment Repair of eroded or damaged areas.

Table 6: Pervious Surfacing SuDS Component Details

SuDS Component:	Pervious Surfaces
How it works:	Pervious surfaces can be either porous (grasscrete) or permeable (permeable concrete block paving). The important distinction between the two is: • Porous surfacing is a surface that infiltrates water across the entire surface. • Permeable surfacing is formed of material that is itself impervious to water but, by virtue of voids formed through the surface, allows infiltration through the pattern of voids. Pervious surfaces provide a surface suitable for pedestrian and/or vehicular traffic, while allowing rainwater to be temporarily stored in the subbase prior to discharge downstream or infiltration into the sub-soil.
Performance:	Peak flow reduction: Good Volume reduction: Good Water quality treatment: Good Amenity potential: Poor Ecology potential: Poor
Potential Performance Risks:	Risk of clogging if debris and/or weeds are allowed to establish / accumulate.

Table 7: Detention Basin SuDS Component Details

SuDS Component:	Detention Basin
How it works:	Detention basins are surface storage basins or facilities that provide flow control through attenuation of stormwater runoff. They also facilitate some settling of particulate pollutants. Detention basins are normally dry and in certain situations the land may also function as a recreational facility.
Performance:	Peak flow reduction: Good Volume reduction: Poor Water quality treatment: Medium Amenity potential: Good Ecology potential: Medium
Potential Performance Risks:	Litter/debris removal to avoid blockages of inlets / outlets Vegetation management and removal of cuttings. Sediment monitoring and removal when required to avoid blockages of inlets / outlets.

Table 8: Pond SuDS Component Details

SuDS Component:	Pond
How it works:	Ponds can provide both stormwater attenuation and treatment. They are designed to support emergent and submerged aquatic vegetation along their shoreline. Runoff from each rain event is detained and treated in the pool. The retention time promotes pollutant removal through sedimentation and the opportunity for biological uptake mechanisms to reduce nutrient concentrations.
Performance:	Peak flow reduction: Good Volume reduction: Poor Water quality treatment: Good Amenity potential: Good Ecology potential: Good
Potential Performance Risks:	Litter/debris removal to avoid blockages of inlets / outlets Vegetation management and removal of cuttings. Sediment monitoring and removal when required to avoid blockages of inlets / outlets.

Table 9: Rain Garden SuDS Component Details

SuDS Component:	Rain Garden
How it works:	Rain gardens are relatively small depressions in the ground that can act as infiltration / collection points for run off. Rain gardens should be planted up with native vegetation that is happy with occasional inundations.
Performance:	Peak flow reduction: Good Volume reduction: Medium Water quality treatment: Medium Amenity potential: Good Ecology potential: Good
Potential Performance Risks:	Litter/debris removal to avoid blockages of inlets / outlets Vegetation management and removal of cuttings.

Table 10: Below Ground Attenuation Tank SuDS Component Details

SuDS Component:	Below Ground Attenuation Tank
How it works:	Attenuation tanks are used to control and manage rainwater surface water runoff as a storage tank.
Performance:	Peak flow reduction: Good Volume reduction: Poor (storage only) Volume reduction: Poor Water quality treatment: Poor Amenity potential: Poor Ecology potential: Poor
Potential Performance Risks:	Regular inspection of silt traps, manholes and pipework, with removal of sediment and debris as required.

12.4 Specific indicators that may trigger intervention

- Witness of waterlogged areas / standing water / poorly drainage areas / stagnant water, indicating a blockage
- Autumn and the removal of fallen leaves/ debris
- Following extreme rainfall events. Typically classified as MET Office weather alert Amber and above.

12.6 Operation and Maintenance Activity Schedule

There are likely to be three categories of maintenance activities:

1. Regular maintenance (including inspections and monitoring).
2. Occasional maintenance.
3. Remedial maintenance.

Regular maintenance consists of basic tasks done on a frequent and predictable schedule, including vegetation management, litter and debris removal, and inspections.

Occasional maintenance comprises tasks that are likely to be required periodically, but on a much less frequent and predictable basis than the regular tasks (eg sediment removal or filter replacement). Table 2 summarises the likely maintenance activities required for each SuDS component and guidance on specific maintenance activities is given in the following sections.

Remedial maintenance describes the intermittent tasks that may be required to rectify faults associated with the system, although the likelihood of faults can be minimised by good design, construction, and regular maintenance activities. Where remedial work is found to be necessary, it is likely to be due to site-specific characteristics or unforeseen events, and so timings are difficult to predict. Remedial maintenance can comprise activities such as:

- inlet/outlet repairs
- erosion repairs
- reinstatement or realignment of edgings, barriers, rip-rap or other erosion control
- infiltration surface rehabilitation
- replacement of blocked filter fabrics
- construction stage sediment removal (although this activity should have been undertaken before the start of the maintenance contract)
- system rehabilitation immediately following a pollution event.

It is important to note that these remedial activities will not be required for all systems, but for the purpose of estimating whole life maintenance costs, a contingency sum of 15-20% should be added to the annual regular and occasional maintenance costs to cover the risk of these activities being required.

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				□	□	□	□		□	□	□		

Figure 25: SuDS component operation and maintenance activities

■ Will be required

□ May be required

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

Geocellular/Modular Systems

Regular inspection and maintenance is required to ensure the effective long-term operation of below ground modular storage systems. Maintenance responsibility for systems should be placed with a responsible organization. Maintenance requirements for modular systems are described in the table below. Maintenance plans and schedules should be developed during the design phase. Specific maintenance needs of the system should be monitored, and maintenance schedules adjusted to suit requirements.

Maintenance Schedule	Required Actions	Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then six monthly
	Debris removal from catchment surface (where may cause risks to performance)	Monthly
	Where rainfall infiltrates into blocks from above, check surface of filter for blockage by silt, algae or other matter. Remove and replace surface infiltration medium as necessary.	Monthly (and after large storms)
	Remove sediment from pre-treatment structures	Annually, or as required
Remedial actions	Repair/rehabilitation of inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually and after large storms

Silt Traps and Catchpits

Regular inspection and maintenance is required to ensure the effective long-term operation of below ground silt traps and catchpits systems. Maintenance responsibility for systems should be placed with a responsible organization. Maintenance requirements are described in the table below. Maintenance plans and schedules should be developed during the design phase. Specific maintenance needs of the system should be monitored, and maintenance schedules adjusted to suit requirements.

Maintenance Schedule	Required Actions	Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then six monthly
	Debris removal from catchment surface (where may cause risks to performance)	Monthly
	Inspection of silt traps and catchpits to assess silt accumulation	Monthly (and after large storms)
	Removal of accumulated silt from silt trap and catchpit sumps	Annually, or as required
Remedial actions	Repair/rehabilitation of inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, and overflows to ensure that they are in good condition and operating as designed	Annually and after large storms

Permeable Paving

Regular inspection and maintenance is important for the effective operation of pervious pavements. Maintenance responsibility for a pervious pavement and its surrounding area should be placed with an appropriate responsible organisation. The facility should be inspected regularly, preferably during and after heavy rainfall to check effective operation and to identify any areas of ponding.

Pervious surfaces need to be regularly cleaned of silt and other sediments to preserve their infiltration capability. Experience in the UK is limited, but advice issued with permeable precast concrete paving has suggested a minimum of three surface sweepings per year. Manufacturers' recommendations should always be followed.

A brush and suction cleaner, which can be a lorry-mounted device or a smaller precinct sweeper, should be used and the sweeping regime should be as follows:

- End of winter (April) – to collect winter debris.
- Mid-summer (July/August) – to collect dust, flower and grass-type deposits.
- After autumn leaf fall (November).

Care should be taken in adjusting vacuuming equipment to avoid removal of jointing material. Any lost material should be replaced.

Operation and maintenance requirements for permeable paving are described below.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Brushing and vacuuming.	Three times/year at end of winter, mid-summer, after autumn leaf fall, or as required based on site-specific observations of clogging or manufacturers' recommendations.
Occasional maintenance	Stabilise and mow contributing and adjacent areas.	As required.
	Removal of weed.	As required.
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving.	As required.
	Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users.	As required.
	Rehabilitation of surface and upper sub-structure.	As required (if infiltration performance is reduced as a result of significant clogging).
Monitoring	Initial inspection.	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth. If required take remedial action.	3-monthly, 48 h after large storms.
	Inspect silt accumulation rates and establish appropriate brushing frequencies.	Annually.
	Monitor inspection chambers.	Annually.

Living Roofs

Intensive living roofs will require regular maintenance. Lawns will require mowing weekly or fortnightly, plant beds may require weeding on a weekly or fortnightly basis during the growing season, and wildflower meadows may require annual mowing with the cuttings removed. Extensive living roofs should normally only require bi-annual or annual visits to remove litter, check fire breaks and drains and, in some cases, remove unwanted colonising plants. The most maintenance is generally required in the first three years, and usually this should be made the responsibility of the living roof provider.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth.	Six monthly/ Annually or as required.
	During establishment (ie one year), replace dead plants as required.	Monthly (but usually responsibility of manufacturer)
	Post establishment, replace dead plants as required.	Annually (in autumn)
	Remove fallen leaves and debris form deciduous plant foliage.	Six monthly or as required.
	Remove nuisance and invasive vegetation, including weeds.	Six monthly or as required.
	Mow grasses (if appropriate) as required. Clippings must be removed and not allowed to accumulate.	Six monthly or as required.
Occasional maintenance	-	-
Remedial Actions	If erosion channels are evident, these should be stabilised with additional soil substrate similar to the original material. Sources of erosion damage must be identified and controlled.	As required.
	If drain inlet has settled, cracked or moved, investigate and repair as appropriate.	As required.
Monitoring	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes, and roof structure for proper operation, integrity if waterproofing and structural stability.	Annually/after severe storms.
	Inspect soils substrate for evidence of erosion channels and identify any sediment sources.	Annually/after severe storms.
	Inspect drain inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system.	Annually/after severe storms.
	Inspect underside of roof for evidence of leakage	Annually/after severe storms.

Ponds

Regular inspection and maintenance is important for the effective operation of ponds as designed. Maintenance responsibility for a pond and its surrounding area should always be placed with a responsible organisation.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Litter removal.	As required
	Grass cutting – public areas.	Monthly (during growing season)
	Grass cutting – meadow grass.	Half yearly (spring, before nesting season, and autumn)
	Inspect vegetation to pond edge and remove nuisance plants (for first 3 years).	Monthly (at start, then as required)
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1 m above pond base. Include max 25% of pond surface).	Annually
	Remove 25% of bank vegetation from waters edge to a minimum of 1 m above water level.	Annually
	Tidy all dead growth before start of growing season.	Annually
	Remove sediment from forebay.	1–5 years, or as required.
	Remove sediment from one quadrant of the main body of ponds without sediment forebays.	2–10 years.
Occasional Maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%.	>25 years (usually).
Remedial actions	Repair of erosion or other damage.	As required.
	Aerate pond when signs of eutrophication are detected.	As required.
	Realignment of rip-rap or other damage.	As required.
	Repair/rehabilitation of inlets, outlets and overflows.	As required.
Monitoring	Inspect structures for evidence of poor operation.	Monthly/after large storms.
	Inspect banksides, structures, pipework etc for evidence of physical damage.	Monthly/after large storms.
	Inspect water body for signs of eutrophication.	Monthly (May–October).
	Inspect silt accumulation rates and establish appropriate removal, frequencies.	Half yearly.
	Check penstocks and other mechanical devices.	Half yearly.

Sediments excavated from ponds or forebays that receive runoff from residential or standard road and roof areas are generally not toxic or hazardous material and can be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on site if there is an appropriate safe and acceptable location to do so.

New ponds may become rapidly dominated by invasive native plants, particularly Common Bulrush *(Typha latifolia)*. As it is not desirable for all new ponds to be bulrush dominated, it should be ensured that in the first five years, while vegetation is establishing, certain plant growth is controlled. After this period, ponds can usually be allowed to develop naturally, recognising that, unless the margins are occasionally managed, they are likely to become dominated by trees and shrubs.

Eutrophication of SuDS ponds can occur during the summer months. Eutrophication is best alleviated by controlling the nutrient source or providing a continuous baseflow to the pond. Unless eutrophication is severe, aeration can be used as a stop-gap measure to save aquatic animal species and reduce risks to receiving waters. However, the addition of barley straw bales, dredging or rendering the nutrients inactive by chemical means can also be successful.

Specific maintenance needs of the pond should be monitored and maintenance schedules adjusted to suit requirements.

Swales

Regular inspection and maintenance is important for the effective operation of swales as designed. Maintenance responsibility for a swale should always be placed with an appropriate organisation.

Adequate access must be provided to all swale areas for inspection and maintenance, including for appropriate equipment and vehicles.

Operation and maintenance requirements for swales are described below.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Litter and debris removal	
	Grass cutting – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
Occasional maintenance	Check for poor vegetation growth due to lack of sunlight or dropping of leaf litter, and cut back adjacent vegetation where possible	Annually
	Re-seed areas of poor vegetation growth. Alter plant types to better suit conditions, if required	Annually, or if bare soil is exposed over 10% or more of the filter strip area
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required.
	Re-level uneven surfaces and reinstate design levels	As required.
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required.
	Remove build up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required.
	Remove and dispose of oils or petrol residues using safe standard practices	As required.
Monitoring	Inspect filter strip surface to identify evidence of erosion, compaction, ponding, sedimentation and contamination (eg oils)	Half yearly
	Check flow spreader and filter strip surface for even gradients	Half yearly
	Inspect gravel diaphragm trench upstream of filter strip for clogging	Half yearly
	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly

Sediments excavated from swales that receive runoff from residential or standard road and roof areas are generally not toxic or hazardous material and can be safely disposed of by either land application or landfilling. However, consultation should take place with the environmental regulator to confirm appropriate protocols. Sediment testing may be required before sediment excavation to determine its classification and appropriate disposal methods. For industrial site runoff, sediment testing will be essential. In the majority of cases, it will be acceptable to distribute the sediment on site if there is an appropriate safe and acceptable location to do so.

Many of the specific maintenance activities for swales can be undertaken as part of a general landscaping contract. If landscape management is already required at site, this should have marginal cost implications.

Proprietary Treatment System

Proprietary treatment systems will require routine maintenance to ensure continuing operation to design performance standards. Because of the wide range of different designs and performance, all manufacturers should provide detailed specifications and frequencies for the required maintenance activities along with the likely machinery requirements and typical annual costs for any given site. The treatment performance of proprietary treatment systems is strongly dependent on maintenance, and robust management plans will be required to ensure that maintenance is carried out in the long term. Different proprietary treatment devices will have different operation and maintenance requirements, but this section gives some generic guidance. Ease of access for maintenance and inspection is essential. In particular, access lids and covers should be kept as lightweight as practicable.

Many proprietary systems are beneath the ground, and malfunctioning is not easy to detect, and it is therefore often ignored unless alarms are provided or the system is designed to cause localised surface ponding if full. If systems lead to other surface features, early warning of maintenance being required may be easily observed at the inlet to the feature (which should be designed to prevent it entering the main part of the component).

Lack of routine maintenance is more likely to cause poor outflow water quality than with other SuDS due to resuspension of solids and anaerobic conditions developing within the device. For example, anaerobic conditions can develop in deep sumps and catchpits that result in nutrients and metals being released from captured sediments. During the first few months after installation, subsurface treatment units should be visually inspected after rainfall events, and the amount of depositions measure to give the operator an idea of the expected rate of sediment and oil deposition. After this initial period, systems should be inspected every six months to verify the appropriate level of maintenance. During these inspections, the floating debris and any floating oils should normally be removed. This may be done using a van-mounted system, without the need for a large tanker. Silt should be removed when it reaches 75% of the capacity of the sump. In most situations, the units should be fully cleaned out at least annually.

Harmful vapours may develop in sub-surface filtration or hydrodynamic separation units, as hydrocarbons may remain there for extended periods of time. Appropriate testing for harmful vapours and venting should be undertaken whenever access for

maintenance is required. Removal of oil, silt and other pollutants must be in accordance with the appropriate waste management legislation.

Operation and maintenance requirements for oil separator are described below.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Removal of litter and debris and inspect for sediment, oil and grease accumulation	Six monthly
	Change the filter media	As recommended by the manufacturer
	Remove sediment, oil, grease and floatables	As necessary – indicated by system inspections or immediately following a significant spill.
Remedial actions	Replacement of malfunctioning parts or structures	As required.
Monitoring	Inspection for evidence or poor operation	Six monthly
	Inspect filter media and establish appropriate replacement frequencies	Six monthly
	Inspection sediment accumulation rates and establish appropriate removal frequencies.	Monthly during first half of operation, then every six months.

Maintenance activities for all activities should be placed with an appropriate organisation, and Maintenance plans and schedules should be developed during the design phase.

Rainwater Harvesting

Rainwater systems should be designed so that use of the systems can be temporarily discontinued, for example if maintenance is required. Most systems require periodic checking and maintenance to ensure trouble-free and reliable operation. There are wide differences in the extent of maintenance required for different systems and manufacturers guidelines should always be followed.

Operation and maintenance requirements for rainwater harvesting systems are described below.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Cleaning of tank, inlets, outlets, gutetrs, withdrawal devices and roof drain filters of silts and other debris.	Annually (or following poor performance)
Occasional maintenance	Replacement of any filters.	As required.
Remedial actions	Repair of erosion damage, or damage to tank.	As required.
	Pump repairs.	As required.
Monitoring	Inspection of the tank for debris and sediment build up.	Annually (or following poor performance)
	Inspection of inlets, outlets and withdrawal devices	Annually (or following poor performance)
	Inspection of areas receiving overflow, for evidence of erosion.	Annually (or following poor performance)
	Inspection of any pumps – check function and wiring.	Annually.
	Inspection of roof drain filters.	Annually (or following poor performance)

Rain Garden

Regular inspection and maintenance is important for the effective operation of rain gardens as designed. Maintenance responsibility for a rain garden should always be placed with an appropriate organisation.

Adequate access must be provided to all filter strip areas for inspection and maintenance, including for appropriate equipment and vehicles.

Operation and maintenance requirements for filter strips are described below.

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Litter and debris removal	
	Grass cutting – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)
Occasional maintenance	Check for poor vegetation growth due to lack of sunlight or dropping of leaf litter, and cut back adjacent vegetation where possible	Annually
	Re-seed areas of poor vegetation growth. Alter plant types to better suit conditions, if required	Annually, or if bare soil is exposed over 10% or more of the filter strip area
Remedial actions	Repair erosion or other damage by re-turfing or reseeding	As required.
	Re-level uneven surfaces and reinstate design levels	As required.
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required.
	Remove build up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required.
	Remove and dispose of oils or petrol residues using safe standard practices	As required.
Monitoring	Inspect filter strip surface to identify evidence of erosion, compaction, ponding, sedimentation, and contamination (eg oils)	Half yearly
	Check flow spreader and filter strip surface for even gradients	Half yearly
	Inspect gravel diaphragm trench upstream of filter strip for clogging	Half yearly
	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly

12.7 Consequences of Lack of Maintenance

During the construction phase of the development, the responsibility for the maintenance of all SuDS components and the rate, volume and quality of surface water discharge lies with the Principal Contractor.

Post construction, it is the owner of the development, Great Wolf Lodge Resorts, who will be responsible for ensuring all SuDS components are maintained.

If maintenance is not executed as outlined in this manual and in accordance with industry best practise at the time, the risk of flooding and pollution are significantly increased. Any ensuing flooding or pollution could lead to civil litigation if damage to third-parties is incurred.

12.8 Areas where Activities are Prohibited

Heavy loads shall not be permitted in areas where buried tanks are located.

Materials shall not be stockpiled over permeable paving unless a suitable temporary membrane is provided to ensure materials do not block voids in the paving construction.

12.9 Accidental Spillages

The maintenance regime of a site also needs to consider the response to extreme pollution events. A response action plan should be developed and communicated to all those involved in the operation of a site, so that if a spillage occurs it can be prevented from causing pollution to receiving waters.

Health and safety consideration are a priority and addressing accidental spillages should only be attempted if the nature of the spillage is known and its potential hazardous properties understood. The source of the spillage should be stopped, and excess surface spillage removed by suction tank or absorption matts. Silt traps and sumps should be emptied by suction tanker. Areas of affected permeable paving should have the surface and laying course removed. The surfacing blocks should be cleaned and re-laid on new bedding material. Heavy pollution of the sub-base will require removal and replacement of the sub-base.

12.10 Future Alterations

In the event of future building or landscape alterations a suitably qualified Civil Engineer is to be appointed to access the proposals against the as-built SuDS system. This is to ensure clashes are avoided and in the event of increases in drained area, future source control or enhancement of the wider SuDS system may be required.

In the event of maintenance requiring excavation within a SuDS component, the drawings contained with Appendix E and G are to be used to assist in the reinstatement or surfaces and excavations.

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Appendices

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A Topographical Survey