Drainage and High Level Hydrological Review

Land West of Wigginton Road, York

Presented to **Airedon Planning and Design**

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Delta-Simons Project No. 20-0683.01

Delta-Simons Environmental Consultants Limited
Head Office: 3 Henley Office Park, Doddington Road, Lincoln, LN6 3QR
Tel: 01522 882555 | www.deltasimons.com

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Report Details

Client	Airedon Planning and Design
Report Title	Drainage and High Level Hydrological Review
Site Address	Land West of Wigginton Road, York YO32 2RH
Project No.	20-0683.01
Delta-Simons Contact	Josh Rigby (Joshua.Rigy@deltasimons.com)

Quality Assurance

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1	Final	26th June 2020	-	Andrew Coe Consultant	Josh Rigby Associate	Josh Rigby Associate

About us

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1.0 Introduction

1.1 Appointment

1.1.1 Delta-Simons Environmental Consultants Limited ("Delta-Simons") was instructed by Airedon Planning and Design (the "Client") to carry out a Drainage and High Level Hydrological Review of the land west of Wigginton Road, York YO32 2RH (the "Site") which is designated as a strategic housing allocation (ST14) in the emerging York Local Plan.

1.2 Project Understanding

1.2.1 It is understood that the Site is a proposed strategic housing allocation (ST14) for the emerging York Local Plan and is highlighted as such in the City of York Local Plan – Publication Draft, 2018. Any proposed development within the proposed development area must seek to provide a workable drainage concept to support its allocation.

1.2.2 This Drainage and High Level Hydrological Review outlines the prevailing drainage and hydrological conditions at the Site and highlights the potential constraints in relation to the future development in line with the latest planning policy and guidance.

1.3 Scope of Works

1.3.1 The scope of works has been as follows for this review:

- Review existing conditions including sewer plans, British Geological Survey information and topographical information;
- Review Lead Local Flood Authority (LLFA) drainage policies;
- Calculate existing runoff rates (excluding existing drainage system modelling);
- Assess the potential method of surface water runoff disposal (soakaway / watercourse / sewer);
- Establish the likely surface water discharge rate in consultation (where appropriate) with the Internal Drainage Board (IDB / LLFA / sewerage provider);
- Estimate required attenuation volume using MicroDrainage or similar;
- Establish the potential and approximate size of attenuation features given local constraints such as depth of outfall invert;
- Establish the local groundwater level utilising existing published data and / or recorded data from installed groundwater wells (provisional cost provided below); and
- Prepare Drainage and High Level Hydrogeological Review report.

1.3.2 This report considers the following national and local policies:

- National Planning Policy Framework (NPPF) (2019)[1];
- National Planning Practice Guidance (NPPG) (2014)[2];
- CIRIA Guidance: The SuDS Manual (C753) (2017)[3]; and
- York City Council Local Development and Planning Policies.

1.4 Sources of Information

1.4.1 The following sources of information have been reviewed and assessed for the purpose of this FRA:

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/779764/NPPF_Feb_2019_web.pdf
2 http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
3 https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

- British Geological Society (BGS) Interactive Map[4];
- MAGIC Interactive Map[5]; and
- York City Council 2013 Strategic Flood Risk Assessment, 2013 (2013 SFRA).

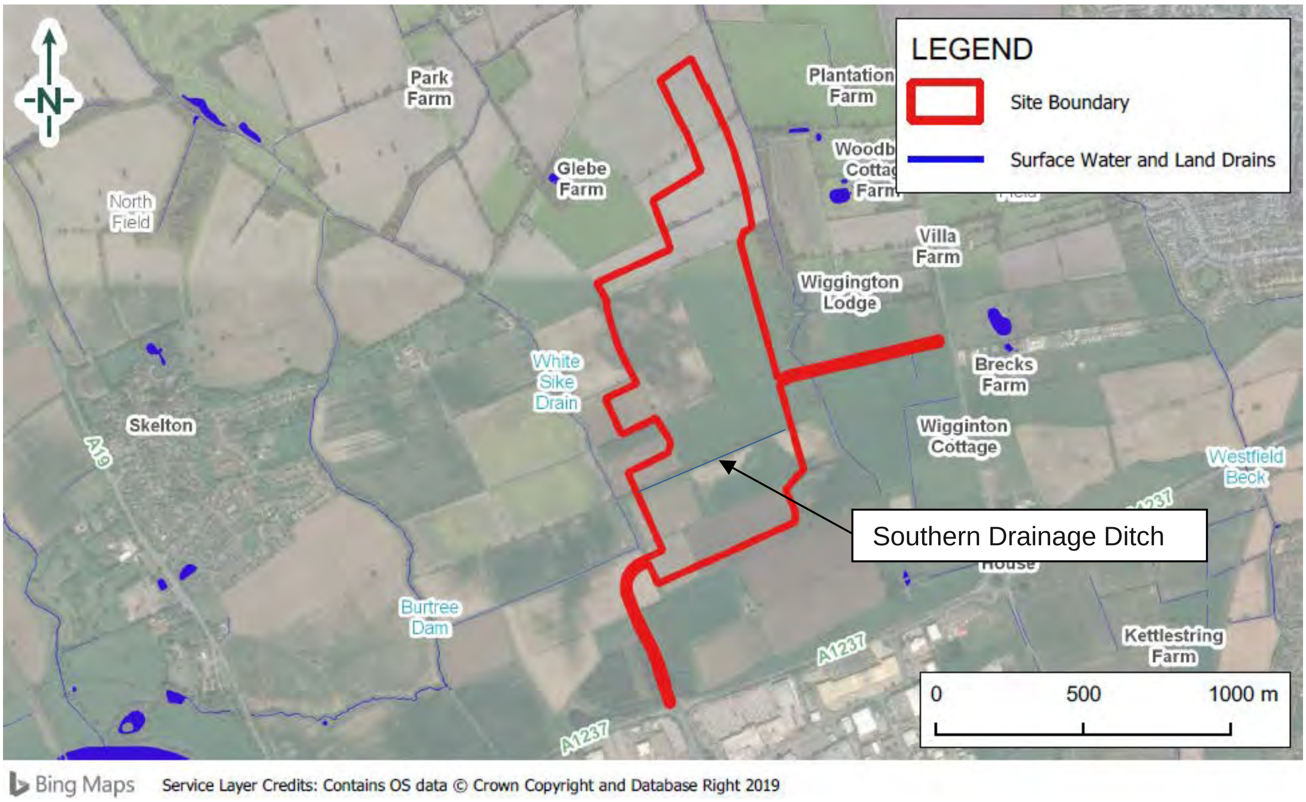
1.5 Project Limitations

1.5.1 The wider Delta-Simons limitations are contained within Appendix A.

4 http://mapapps.bgs.ac.uk/geologyofbritain/home.html
5 http://www.magic.gov.uk/

2.0 Site Description

2.1.1 The aim of this section of the report is to outline key environmental information associated with the baseline environment.



Illustrative Site Layout Plan			
Co-ordinates	Centred approximately at National Grid Reference (NGR) 458736, 456322	**Area**	Approximately 55 Ha.
Site Location	The Site is located within the City of York Greenbelt, approximately 3.7 km north from York City Centre, 1 km west from the village of Wigginton and directly north of Clifton moor Shopping park. The Site is bordered to the north and west by agricultural fields, to the east by Wigginton Road and private businesses and to the south by the A1237.		
Existing Site Conditions	Online mapping including Google Maps satellite imagery [accessed 24/06/2020] shows that the Site is entirely greenfield comprising agricultural fields and hedgerows. Access to the Site is currently provided from the south east via a farm track at Clifton Gate Farm which can be accessed from Wigginton Road.		
Topography	Topographic levels to metres Above Ordnance Datum (m AOD) have been derived from a 1 m resolution Environment Agency (EA) composite 'Light Detecting and Ranging' (LiDAR) Digital Terrain Model (DTM). A review of LiDAR ground elevation data shows that the Site is relatively flat, sloping gently from a maximum elevation of approximately 16.70		

	m AOD in the north and north east to a minimum elevation of approximately 13.5 m AOD in the south west. A LiDAR and Contour plan is included in Appendix B.
Hydrology	The Site and surrounding area is drained by land drainage managed by the Kyle and Upper Ouse Internal Drainage Board (IDB). The Kyle and Upper Ouse IDB are responsible for the management and maintenance of the Land Drains within and surrounding the Site. The following Land Drains have been identified within the vicinity of the Site: White Sike Drain flows north to south 70 m west of the Site at its nearest point. The Land Drain then changes course and flows west away from the Site following the natural topographic gradient before discharging into Burtree Dam, approximately 800 m west from the Site. Burtree Dam flows west and discharges into a series of two ponds approximately 1.5 km west of the Site which ultimately discharge into the River Ouse. An unnamed Land Drain (“Eastern Land Drain”) flows north to south along the eastern periphery of the Site before discharging into a pond approximately 410 m south east from the Site at its nearest point. An unnamed Land Drain (Northern Land Drain) flows east to west through the north of the Site. The discharge location of the Northern Land Drain cannot be confirmed based on the available online data at this time, however flows from this Land Drain are likely to follow the natural topographic gradient and ultimately discharge at the downstream end of the Site (south west) and into White Sike Drain. An unnamed Land Drain (Southern Land Drain) flows east to west through the centre of the Site before discharging into White Sike Drain to the south west corner of the Site.
Geology	Reference to the British Geological Survey (BGS) online mapping [1:50,000 scale, accessed 24/062020] indicates that the Site is underlain by superficial deposits of Sand from the Sutton Sand Formation, and Clay and Silt from the Alne Glaciolacustrine Formation. The superficial deposits are identified as being underlain by Sandstone from the Sherwood Sandstone Group. The geological mapping is available at a scale of 1:50,000 and as such may not be accurate on a Site-specific basis. Three exploratory log records made available on the BGS online mapping website have been identified approximately 300 m north west of the Site: ▲ BGS Ref: SE55NE218 Location: 458147,457294, Depth: 3 m Below Ground Level (bgl); ▲ BGS Ref: SE55NE122 Location: 458260,457290, Depth: 8.53 m bgl; and ▲ BGS Ref: SE55NE10 Location: 458293,457306; Depth: 43.28 m bgl. Tw exploratory log records made available on the BGS online mapping website have been identified approximately 450 m north east of the Site: ▲ BGS Ref: SE55NE215 Location: 459250,457390; Depth: 54 m bgl. ▲ BGS Ref: SE55NE17 Location: 459168,457596; Depth: N/A. Exploratory log records indicate the following generalised geological sequence: 1) Clayey sandy Subsoil to 0.35 m bgl; 2) Clay from 0.3 m bgl to 10.66 m bgl; 3) Cobbles from 10.66 -12.80 m bgl; 4) Clay and stones from 12.80 – 21.64 m bgl; 5) Coarse sand from 21.64- 28.04 m bgl; 6) Soft sandstones from 28.04 to 30.18 m bgl; and

	7) Sandstone from 33 m bgl - end of log records.
Hydrogeology	The Exploratory Logs identified a minimum ground water level of 3.66 m bgl. Anecdotal observations indicate that the Site is routinely waterlogged during the winter months. According to the EA's Aquifer Designation data, obtained from MAGIC Map's online mapping [accessed 24/06/2020], indicates that the Sutton Sand Formation superficial deposits are classified as a Secondary A Aquifer. Secondary A Aquifers are 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers'. The Clay and Silt superficial deposits are classified as a Secondary B Aquifer. Secondary B Aquifers are 'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers'. The underlying Sandstone bedrock is described as a Principal Aquifer. Principal Aquifers are 'layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. The EA's 'Source Protection Zones' data, obtained from MAGIC Map's online mapping [accessed 24/06/2020], indicates that the Site is not located within a Groundwater Source Protection Zone.
Local Drainage	Public sewer records have been obtained from Yorkshire Water and are included in Appendix C. The Yorkshire Water public sewer records do not identify any public sewers within the vicinity of the Site. There is unlikely to be any unrecorded private sewers within the Site boundary as the Site is undeveloped agricultural land. Based on the LiDAR plan available in Appendix B, surface water from the Site is considered to naturally drain west down the topographic gradient and into White Sike Ditch via overland flow and within the Land Drains on Site.
Proposed Site Conditions	According to the City of York Local Plan – Publication Draft, 2018 (2018 Draft local Plan) the Development of Land West of Wigginton Road (ST14) *"…will deliver approximately 1,348 dwellings, approximately 1200 units of which will be delivered within the plan period".* It is understood the proposed development may also include mixed-use development, a primary school, greenspace including woodland, allotments and outdoor sports facilities and all associated access and infrastructure. Access is proposed from the east via Wigginton Road and from the south via the A1237. No fixed development plans have been established at this stage.

3.0 Relevant Planning Policy and Guidance

3.1 Introduction

3.1.1 The aim of this section of the report is to discuss the main aspects of the local and national planning policies that are relevant to any proposed development on the Site and relevant guidance and legislation.

3.2 Local policy

The City of York Local plan – Publication Draft 2018

3.2.1 The City of York Local plan – Publication Draft 2018 has identified key Environmental Quality and Flood Risk Policies (ENV) to *"To prevent unacceptable risks from pollution, contamination, land instability and flooding…"*. Policies relating to sustainable drainage and flood risk have been identified below.

Policy ENV5: Sustainable Drainage

"For all development on brownfield sites, surface water flow shall be restricted to 70% of the existing runoff rate (i.e. 30% reduction in existing runoff), unless it can demonstrate that it is not reasonably practicable to achieve this reduction in runoff.

Sufficient attenuation and long term storage should be provided to ensure surface water flow does not exceed the restricted runoff rate. Such attenuation and storage measures must accommodate at least a 1 in 30 year storm. Any design should also ensure that storm water resulting from a 1 in 100 year event plus the recommended additional flows from the latest climate change advice, to account for climate change and surcharging the drainage system, can be stored on the site without risk to people or property and without overflowing into a watercourse or adjacent areas.

Where these surface water run-off limitations are likely to be exceeded development may be approved provided sufficient facilities for the long-term storage of surface water are installed within the development or a suitable location elsewhere. Long term surface water storage facilities must not cause detriment to existing heritage and environmental assets.

For new development on greenfield sites, surface water flows arising from the development, once it is complete (and including any intermediate stages), shall be no higher than the existing rate prior to development taking place, unless it can be demonstrated that it is not reasonably practicable to achieve this.

Sustainable Drainage System (SuDS) methods of source control and water quality improvement should be utilised for all new development, to minimise the risk of pollution and to attenuate flood volumes. Such facilities should be provided on-site, or where this is not possible, close to the site.

Where new development is proposed within or adjacent to built-up areas it should be demonstrated that retrofitting existing surface water drainage systems, in those areas for flood prevention, and SuDS within the existing built environment have been explored. Any retrofitting proposals must not damage existing environmental assets including but not limited to landscapes, trees and hedgerows and agricultural land. The authority will support applications where SuDS are enhanced for Biodiversity.

In exceptional circumstances, where SuDS methods of source control and water quality cannot be provided, it must be demonstrated that:

- *it is not possible to incorporate SuDS, either on site, or close to the site; and*
- *an acceptable means of surface water disposal is provided which does not increase the risk of flooding, does not damage existing environmental assets, and improves on the current situation.*

Measures to restrict surface water run-off rates shall be designed and implemented to prevent an unacceptable risk to contamination of groundwater. The type of SuDS used should be appropriate to the site in question and should ensure that there is no pollution of the water environment including both ground and surface waters.

New development will not be permitted to allow ground water and/or the outflow from land drainage to enter public sewers.

Existing land drainage systems should not suffer any detriment as a result of development".

City of York Council Strategic Flood Risk Assessment, 2013

3.2.2 One of the primary purposes of the 2013 SFRA is to provide a strategic assessment of flood risk issues within the York district. This will support a risk-based approach to the allocation of sustainable development sites within Local Development Framework (LDF) and will assist planners in the assessment of future planning applications in line with local and national policy.

3.2.3 The 2013 SFRA states that:

3.2.4 "*The majority of the watercourses in York has no additional capacity. Consequently, 1 in 100-year (1%) surface water runoff rates for developments in this zone should be, where practicable, restricted to either:*

- *Existing runoff rates (if a previously developed site), based on 140 l/s/ha, in accordance with The Building Regulations 2007, Part H.3, with a reduction of 30% in runoff. This is based on the predicted increased intensity in rainfall to 2115, in accordance with the NPPF. It covers the 100 year equivalent and standard lifetime for development; and*
- *Unless otherwise calculated, agricultural runoff rates (if the site has no previous development) will be based on 1.4 l/s/ha. To achieve this, additional run off volume will require balancing".*

4.0 Drainage and High level Hydrological Review

4.1 Introduction

4.1.1 The Site currently comprises undeveloped land which is not formally drained and is therefore considered to be 100% permeable.

4.1.2 The 2013 SFRA states that *"Unless otherwise calculated, agricultural runoff rates (if the site has no previous development) will be based on 1.4 l/s/ha. To achieve this, additional run off volume will require balancing".*

4.1.3 No development plans were provided and therefore proposed hardstanding has been estimated. A conservative estimate of 50% hardstanding has been utilised. This will be introduced in the form of residential dwellings, a school and mixed use buildings, along with access, parking, and associated infrastructure. The proposed development is therefore estimated to introduce approximately 27.5 Ha of hardstanding.

4.1.4 The increase in hardstanding area will result in an increase in surface water runoff rates and volumes. In order to ensure the proposed development will not increase flood risk elsewhere, surface water discharge from the Site should be controlled to the council's prescribed rate of 1.4 l/s/ha equal to 77 l/s for the entire Site.

4.2 Drainage Hierarchy

4.2.1 The recommended surface water drainage hierarchy (Paragraph 080 of the NPPG: Flood Risk and Coastal Change) is to utilise soakaway systems or infiltration as the preferred option, followed by discharging to an appropriate watercourse. If this is not feasible, the final option is to discharge to an existing public sewer.

Surface Water Discharge to Soakaway

4.2.2 The first consideration for the disposal of surface water is infiltration (soakaways and permeable surfaces). As described above exploratory log testing has identified clay from 0.3 to 10.66 m bgl, which is underlain by Sandstone bedrock.

4.2.3 The largely impermeable clay layer will likely limit the potential for infiltration solutions at the Site and it can therefore be concluded that soakaways are unlikely to be suitable for the discharge of surface water runoff.

4.2.4 With the above in mind It is recommended that year-round groundwater monitoring is undertaken including in wetter months to better establish an average groundwater level at the Site. It is also recommended that BRE 365 infiltration testing is completed to determine the suitability/ unsuitability of infiltration techniques as historic groundwater levels are limited from third party sources.

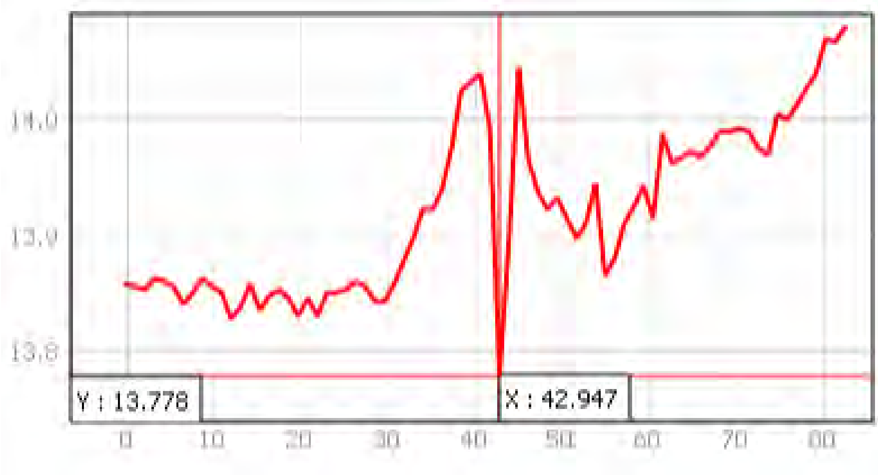
Surface Water Discharge to Watercourse

4.2.5 Where soakaways are not suitable a connection to watercourse is the next consideration.

4.2.6 The nearest watercourse is the Southern Land Drain which flows east to west through the southern half of the Site before discharging into White Sike Ditch to the south west approximately 75 m off Site. A topographical survey was not available during the production of this report and therefore invert levels of the Land Drain cannot be confirmed. However, LiDAR data indicates that the ground level at the downstream end of the Southern Land Drain (within the Site boundary) is approximately 13.78 m AOD.

4.2.7 A section, crossing the drain has been produced to highlight this level with the Y axis representing ground level in m AOD along a section of the south western boundary of the Site, incorporating the Southern Land Drain. The Land Drains invert is clearly identifiable as the lowest elevation along the cross section. See Figure 1 below. A LiDAR plan can be found in Appendix B with the wider Site levels and slope for context.

Figure 1 – Cross Sectional Levels representing the approximate invert level of the Southern Land Drain at the downstream end of the Site using 2019 1 m LiDAR data.



4.2.8 Alternatively, runoff from the Site may discharge into White Sike Ditch directly. However, White Sike Ditch is located entirely outside of the Site boundary and discharging to it potentially poses third party land issues. Therefore, in this instance discharging into the Southern Land Drain at the downstream end of the Site is deemed the most feasible option for future development.

4.2.9 A survey of the Land Drains will be required to confirm the suitable discharge location and to confirm that the Southern Land Drain discharges directly into White Sike Ditch.

Surface Water Discharge to Sewer

4.2.10 As described above, a connection to the downstream (south western end) of the Southern Land Drain is considered feasible and therefore a connection to the public surface water sewer is not required. Yorkshire Water public sewer plans have not identified any surface water sewers within the vicinity of the Site.

4.3 Surface Water Discharge

4.3.1 The existing greenfield runoff rates have been estimated using the Revitalised Flood Hydrograph Model (ReFH2) method, provided as Appendix D. The existing 1 in 2 year event greenfield rate for the 55 ha development Site is 176.6 l/s.

4.3.2 As detailed above, a review of the 2013 SFRA has indicated that surface water discharge from the Site should be controlled to 1.4 l/s/ha equivalent to 77 l/s in line with York City Council requirements. This is to ensure no increased risk in surface water runoff downstream, and to help contribute to continued flood management throughout the York City Council district in line with the existing and proposed Local Plan and the 2013 SFRA.

4.3.3 Controlling surface water discharge to 1.4 l/s/ha or 77 l/s for the entire Site provides a 43.75% betterment on the existing uncontrolled greenfield rates.

4.4 Attenuation Storage

4.4.1 In order to achieve a discharge rate of 77 l/s, attenuation storage will be required. Storage estimates have been provided using MicroDrainage and are included in Appendix E. An estimated storage volume of 21,192.5 m^3 will be required for the 1 in 100 year plus 40 % Climate Change (CC) event., and 16,143.1 m^3 will be required to accommodate the 1 in 30 year event. The storage estimates are based on a flow rate of 77 l/s, storage within a tank or pond structure, an impermeable drainage area of 275,000 m^2 (27.5 ha), a design head of 1 m and HydroBrake flow control.

4.4.2 The attenuation volumes are provided for indicative purposes only and should be verified at the detailed design stage.

4.4.3 When discharging at the required rate of 77 l/s (1.4 l/s/ha), the tank or pond structure is not predicted to half-drain within 24 hours of the peak rainfall event as required within the CIRIA SuDS manual C753. This will require designs submitted as part of a formal planning application to propose discharging surface water at a higher rate than required within 2013 SFRA to facilitate an appropriate half drain time.

4.5 Sustainable Drainage Systems

4.5.1 Attenuation storage should be provided in the form of Sustainable Drainage Systems (SuDS) where practical. The following SuDS options have been considered:

Soakaways

4.5.2 As described above, the use of soakaways is not considered to be feasible at this time and with the information available due to a largely impermeable underlying geology and a high groundwater table.

Swales, Detention Basins and Ponds

4.5.3 Sufficient space should be made available within a detailed masterplan produced for the development to utilise ponds, basins and / or swales. Theses attenuation and conveyancing features can be distributed across the Site however, in order to facilitate gravity drainage where possible, attenuation features should be located to the south eastern extent of the catchment area. The base of any open attenuation feature should be located 1m above the local ground water level. Given the anecdotal information suggesting the Site to be waterlogged, the local ground water level and therefore the invert level at which attenuation features can be placed within the ground at current site levels is anticipated to be shallow.

4.5.4 An open surface water attenuation feature such as a pond, basin or a swale in a residential area presents a safety risk; the hazards and appropriate mitigation should be considered at the detailed design stage.

4.5.5 The location of the above ground SuDS features should be considered further at the detailed design stage following the preparation of a detailed masterplan.

Rainwater Harvesting

4.5.6 The attenuation benefits provided through the use of rainwater harvesting are considered to be limited and would only be realised when the tanks were not full. However, rainwater harvesting techniques could be incorporated within the final design.

Green Roofs

4.5.7 Green roofs are not identified on development plans. The proposals could incorporate a mix of extensive and intensive green roofs as part of the development. Green roofs will provide surface water storage especially during the summer months with dry antecedent conditions prevailing a storm event. However, the reduction in the volume of runoff from a green roof for an extreme event is unlikely to impact on the downstream attenuation storage requirements, especially during winter months.

Porous/Permeable Paving

4.5.8 Permeable paving could be incorporated within private roads and driveways. Storage would be provided within the sub-grade material prior to controlled release to the receiving Land Drain. The amount of storage offered by permeable paving is subject to sub-grade depth and Site gradient. The use of permeable paving could be considered at the detailed design stage following the preparation of a detailed masterplan.

Underground Attenuation Tanks

4.5.9 Storage could be provided within underground attenuation tanks or within oversized pipes. Sufficient space for an underground tanks can be factored into a detailed masterplan on Site. In order to avoid anchoring tanks should be placed above the local groundwater level. Considering that a level of cover would be required above the tanks and the anticipated shallow ground water level tanks would be limited to areas with sufficient height above the invert level of the receiving drain.

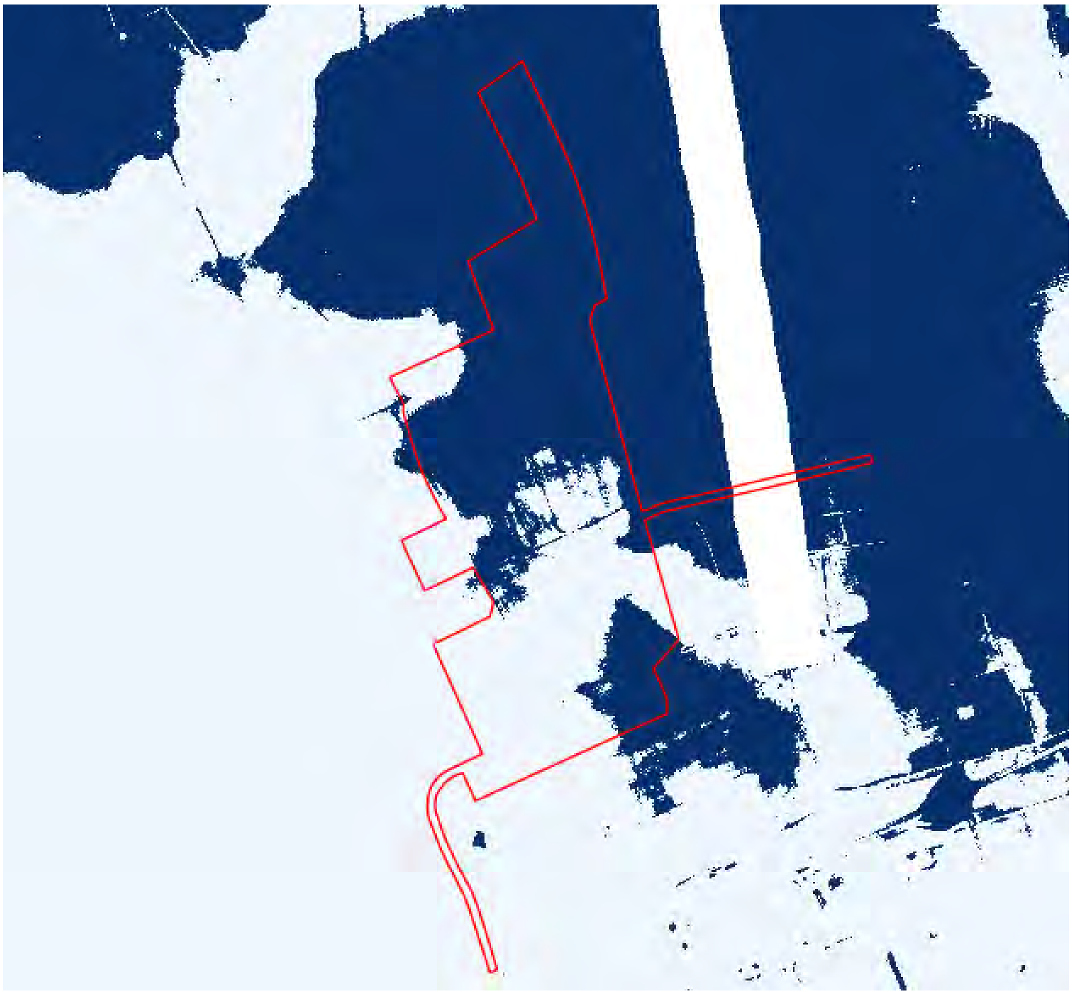
4.5.10 In accordance with the CIRIA C753 publication 'The SuDS Manual' (2015) the use of underground attenuation tanks should only be considered when infiltration solutions and above ground SuDS features such as ponds have proven to be an unfeasible attenuation storage solution at the Site.

Surface Water Pumping

4.5.11 1 m LiDAR data indicates that the invert level at the downstream end of the Southern Land Drain within the Site boundary is approximately 13.78 m AOD, however this should be confirmed by topographical survey.

4.5.12 Preliminary calculations indicate that ground levels must be at least 15.28 m AOD to allow for a gravity fed connection to the outfall at the downstream end of the Southern Land Drain. This provides a 1.5 m vertical allowance for all associated drainage infrastructure including a 1 m deep pond structure with a HydroBrake flow control, pipe invert level and a suitable pipe fall gradient to provide adequate flow velocity. This is highly likely to be conservative given the size of the Site. The area identified to be below this is shown in lighter blue in Figure 2 below.

Figure 2 – Area identified by LiDAR as being below 15.28m AOD



4.5.13 Either significant land raising or a pumped solution will be required for land located at an elevation below 15.28 m AOD to achieve a connection to the Southern Land Drain.

4.5.14 In accordance with the latest Design and Construction Guidance for foul and surface water sewers offered for adoption under the Code for adoption agreements for water and sewerage companies operating wholly or mainly in England ("the Code")" (DCG), 125 m^3 of storage should be provided per hectare of impermeable drainage area. Storage is required to reduce the risk of flooding in the event of plant or power failure. Based on an impervious drainage area of 27.5 ha (50% of the Site) a storage volume of 3,437.5 m^3 would be required.

4.5.15 The total attenuation storage volume of 21,192.5 m^3 required to accommodate the 1 in 100 year plus 40% climate change event can accommodate the 3,437.5 m^3 required in the event of pumping system failure.

4.5.16 Provision of standby pumps, an automated pump exercise regime and a pump failure alarm system would limit the risk of pump failure.

4.6 Likely Drainage Scheme

4.6.1 Surface water runoff should be discharged into the downstream end of the Southern Land Drain located to the south west of the Site at a rate of 77 l/s equivalent to 1.4 l/s/ha in line the with the LLFA requirements highlighted in the 2013 SFRA.

4.6.2 Surface water runoff up to the 1 in 100 year plus 40 % climate change allowance event should be attenuated on Site. A total attenuation volume of 21,192.5 m^3 will be required to achieve the discharge rate and will be provided in the form of above ground attenuation features such as a pond and swale system located in the south western (downstream) extent of the Site.

4.6.3 Preliminary calculations indicate that surface water generated from areas of the Site with a ground level below 15.28 m AOD will require a pumped solution to reach the outfall. This is based on an invert level of 13.78 m AOD at the downstream end of the Southern Land Drain (obtained from 1 m LiDAR data), and allows for a depth of 1.5 m for all drainage infrastructure including a pond structure with a 1 m design head, a hydrobrake flow control, pipe invert and a suitable pipe fall gradient to provide adequate flow velocity. Alternatively, significant land raising will be required across the site to facilitate a gravity fed connection.

4.7 Event Exceedance

4.7.1 Storage should be provided for the 1 in 100 year plus 40 % CC event. Storm events in excess of the 1 in 100 year plus 40 % CC event should be permitted to produce temporary shallow depth flooding within the car parks, access roads and soft landscaped areas. Finished floor levels should be set at a minimum of 150 mm above surrounding ground levels ensuring exceedance flooding will not affect the buildings. This should be considered as part of a formal planning application.

4.8 Surface Water Treatment

4.8.1 In accordance with the CIRIA C753 publication 'The SuDS Manual' (2015), residential roofs have a 'very low' pollution hazard level, commercial roofs have a 'low' pollution hazard level and moderately trafficked roads are classified as having a 'medium' pollution hazard level. Table 1 below shows the pollution hazard indices for each land use.

Table 1 – Pollution Hazard Indices

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Residential Roofs	Very Low	0.2*	0.2	0.05
Other Roofs (typically commercial/industrial roofs)	Low	0.5	0.2**	0.4
Moderately Trafficked Roads	Medium	0.7	0.6	0.7

Table extract taken from the CIRIA C753 publication 'The SuDS Manual' – Table 26.2

* Indices values range from 0-1.
** up to 0.8 where there is potential for metals to leach from the roof

4.8.2 Where practical, runoff from roofs and roads will be directed to permeable paving within private roads, carparking and driveways to be considered at the detailed master planning stages. Table 2 below demonstrates that permeable paving and above ground features including attenuation ponds and swales provide sufficient treatment.

Table 2 – SuDS Mitigation Indices

	Mitigation Indices		
Type of SuDS	**Total Suspended Solids (TSS)**	**Metals**	**Hydrocarbons**
Permeable Pavement	0.7	0.6	0.7
Swale	0.5	0.6	0.6
Pond	0.7	0.7	0.5

Table extract taken from the CIRIA C753 publication 'The SuDS Manual' – Table 26.3

4.8.3 It can be concluded that the inclusion of swales, ponds and permeable paving will provide sufficient treatment. Where attenuation is provided in a below ground system (tank storage), treatment will need to be provided by a suitably sized separator.

4.9 Foul Water Discharge

4.9.1 As detailed in Section 2.0, Yorkshire Water foul sewer plans have been obtained and made available in Appendix C. There are no public foul sewers located within the vicinity of the Site based on the plans available. However, no plans were made available showing further west along the A1237 where foul sewers may be found along the A1237 serving the Clifton Moor shopping centre to the south of the Site.

4.9.2 It appears that a new trunk foul sewer along the A1237 will be required to serve the development.

4.9.3 Consultations must be made with Yorkshire Water as part of a formal planning application, and a drainage survey completed to assess existing public sewer coverage to the south of the Site beyond that provided in the plans in Appendix C.

4.9.4 Due to the size of the Site, consultations must be made with Yorkshire Water to assess the current capacity of the foul network within the vicinity of the Site to accept additional flow from the proposed development. Where capacity is not available upgrades to the sewage treatment plant and supporting infrastructure would be required.

4.10 Other Considerations

4.10.1 The Kyle and Upper Ouse IDB are responsible for the management and maintenance of the Land Drains within and surrounding the Site. A consent will be required to discharge surface water from the Site into the Southern Land Drain;

4.10.2 A topographic survey should be completed to confirm on-Site ground levels and the invert levels of the Southern Land Drain flowing through the Site;

4.10.3 This desk study has assessed that the Southern Land Drain is likely to discharge directly into White Sike Ditch to the south west of the Site. An appropriate survey of the Land Drains will be required to confirm this;

4.10.4 Maintenance access to the Land Drains should be retained. Maintenance access can be ensured by providing an 8m buffer either side of the drains.

4.10.5 Maintenance to proposed surface water pumping systems should be ensured by providing a 15 m buffer between the pumping system and any raised development; and

4.10.6 Yorkshire water should be contacted to assess the coverage and capacity of any nearby foul sewer network to the south of the Site.

4.11 Constraints

4.11.1 There are multiple constraints to consider whilst designing a suitable drainage scheme at the Site:

- A thick impermeable clay layer from approximately 0.3 m to 10.66 m bgl is identified in historic exploratory log records. This indicates that infiltration solutions are unlikely to be a feasible option for the discharge of surface water at from the Site;
- When discharging at the required rate of 77 l/s (1.4 l/s/ha) from a tank or pond structure, the structure is not predicted in MicroDrainage to half-drain within 24 hours of the peak rainfall event as required within the CIRIA SuDS manual C753. The only foreseeable way to mitigate this is either to reduce the scale of the development or increase the run-off rate generated by the Site, contradicting local policy;
- Hydrological conditions may not allow for an above ground attenuation feature with an invert depth of 1 m bgl as calculated within this report;
- As detailed in Section 4.5.10, preliminary calculations indicate that surface water generated in areas of the Site above 15.28 m AOD will require a pumped solution to discharge into the Southern land Drain outfall;
- A 15 m easement zone should be maintained from any pumping system;
- The Land Drain invert levels have been estimated using 1 m LiDAR data. A topographical survey is required to confirm the Land Drain inverts. It may be the case that the Land Drain invert level is located above the minimum required invert of the proposed surface water pond or other above ground SuDS feature. This will significantly constrain the ability to discharge flows from the Site to the Land Drain and may require considerable land raising and/or additional pumping beyond that outlined in this report;
- Local groundwater levels are thought to be shallow, given the site is routinely waterlogged as proven by anecdotal information corroborated by historical groundwater records. Above ground surface water attenuation features such as ponds, basins and swales should be sited at least 1m above local groundwater levels, therefore without significant land raising, above ground attenuation features may have to be shallow to ensure no interaction with local groundwater. Preliminary MicroDrainage calculations considering a pond structure with an invert depth of 0.5 m bgl will require a storage volume in a tank or pond structure in excess of 30,000 m3 potentially covering an area of 6 ha. Given that attenuation features are likely to occupy a large surface area of the Site, it may become a limiting factor to meet the housing requirements for ST14 as detailed in the City of York Local Plan – Publication Draft, 2018;
- No foul sewers have been located within the vicinity of the Site and therefore a new public foul sewer may require construction along the A1237; and
- There is no evidence to suggest that the existing foul drainage network to the south of the Site has sufficient capacity to accept the foul flows from the proposed development.

5.0 Conclusions and Recommendations

5.1 Conclusions from the Review

5.1.1 A Drainage and High level Hydrological Review has been undertaken at the Site to assess the prevailing hydrological and drainage conditions, and to provide an overview of the requirements and potential constraints involved in a future SuDS scheme proposed for the strategic housing allocation (ST14) within the emerging York Local Plan. The review has considered the latest policy and guidance.

5.1.2 The City of York Local Plan – Publication Draft, 2018 indicates that the proposed Development of Land West of Wigginton Road (ST14) *"…will deliver approximately 1,348 dwellings, approximately 1200 units of which will be delivered within the plan period".*

5.1.3 The proposed development will introduce impermeable drainage area in the form of buildings, access, and associated infrastructure. This will result in an increase in surface water runoff. In order to ensure the increase in surface water runoff will not increase flood risk elsewhere, flow control should be used, and attenuation provided on Site to accommodate storm events up to and including the 1 in 100 year plus 40% climate change event.

5.1.4 All methods of surface water discharge have been assessed. Where soakaways are not possible, discharge of surface water to the Southern Land Drain at the south west (downstream) end of the Site at a rate of 77 l/s equivalent to 1.4 l/s/ha in line with IDB and LLFA requirements appears to be the most practical option.

5.1.5 Attenuation storage will be required on Site in order to restrict surface water discharge to 77 l/s. Attenuation should be provided within the sub-grade of permeable paving and in the form of above ground attenuation features including a pond structure and swales located to the south western extent of the Site.

5.1.6 Foul flows should discharge south along the southern access road to the A1237 in line with local topography to facilitate a gravity fed discharge. No foul sewers have been located within the vicinity of the Site and therefore a new public foul sewer may require construction along the A1237, in addition to those on the Site itself.

5.1.7 There are a significant number of constraints to be considered at the planning stage which are detailed in Section 4.11.1.

Appendix A – Limitations

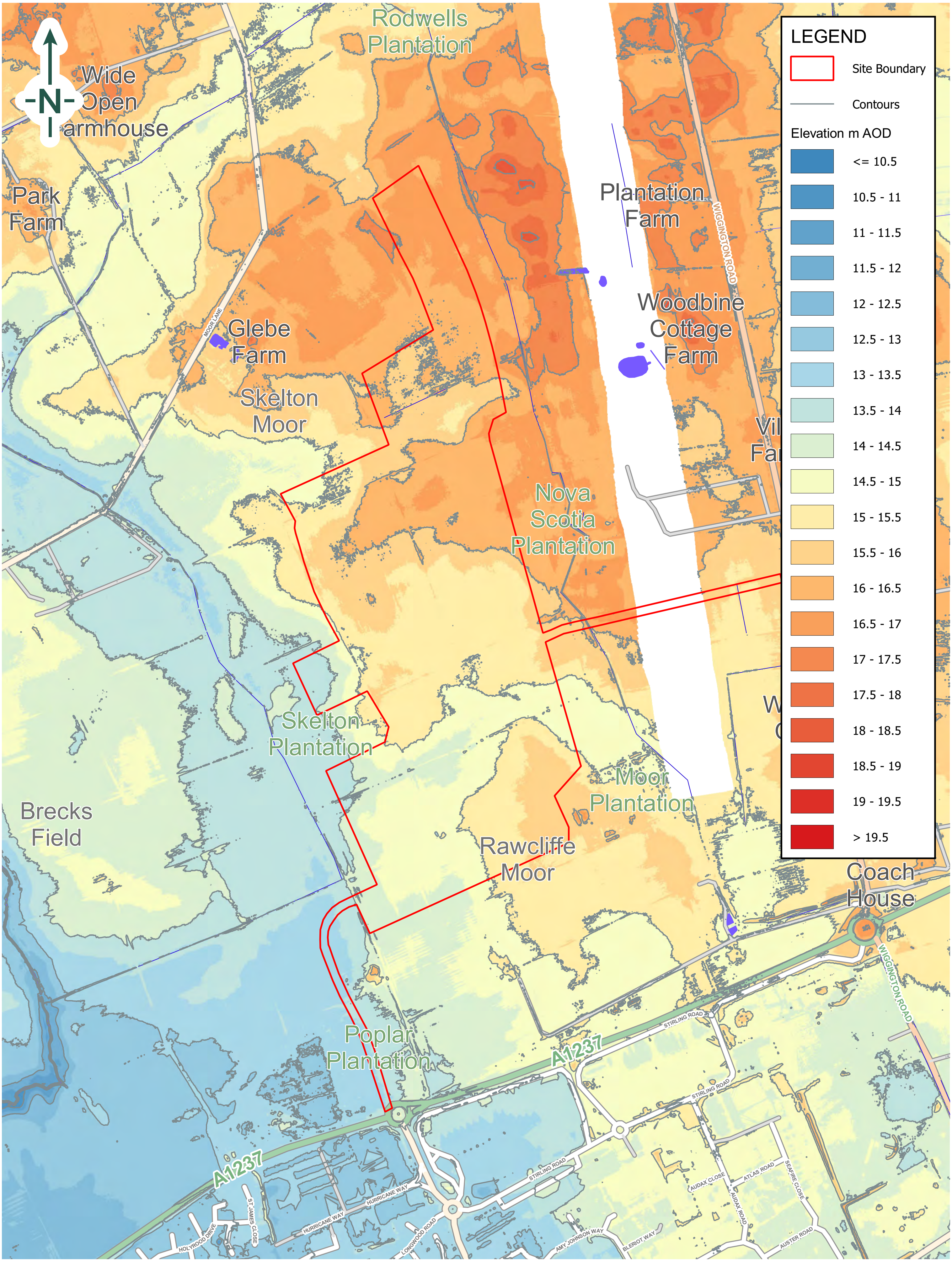
Limitations

The recommendations contained in this Report represent Delta-Simons professional opinions, based upon the information listed in the Report, exercising the duty of care required of an experienced Environmental Consultant. Delta-Simons does not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions.

Delta-Simons obtained, reviewed, and evaluated information in preparing this Report from the Client and others. Delta-Simons conclusions, opinions and recommendations has been determined using this information. Delta-Simons does not warrant the accuracy of the information provided to it and will not be responsible for any opinions which Delta-Simons has expressed, or conclusions which it has reached in reliance upon information which is subsequently proven to be inaccurate.

This Report was prepared by Delta-Simons for the sole and exclusive use of the Client and for the specific purpose for which Delta-Simons was instructed. Nothing contained in this Report shall be construed to give any rights or benefits to anyone other than the Client and Delta-Simons, and all duties and responsibilities undertaken are for the sole and exclusive benefit of the Client and not for the benefit of any other party. In particular, Delta-Simons does not intend, without its written consent, for this Report to be disseminated to anyone other than the Client or to be used or relied upon by anyone other than the Client. Use of the Report by any other person is unauthorised and such use is at the sole risk of the user. Anyone using or relying upon this Report, other than the Client, agrees by virtue of its use to indemnify and hold harmless Delta-Simons from and against all claims, losses and damages (of whatsoever nature and howsoever or whensoever arising), arising out of or resulting from the performance of the work by the Consultant.

Appendix B – LiDAR and Contour Plan



Service Layer Credits: Contains OS data @ Crown Copyright and Database Right 2019

deltasimons
Environment - Health & Safety - Sustainability

TITLE:	DRAWN BY: AC	SCALE (@A4): 1:11000	PROJECT NO: 20-0683
Land west of Wigginton Road, York LiDAR Elevtion Plan 1m Resolution DTM	CHECKED BY: JR	REVISION: -	FIGURE NO: X
	DATE: 24 June 2020		

Appendix C – Yorkshire Water Public Sewer Plans

Date Requested : 25/06/2020, 10:24:36
Date Generated : 25/06/2020, 10:24:51
Scale : 1:2000
The position and depth of any YW apparatus shown on this map are approximate only.

UPN: Undefined
Originator: S P Midgley, Waste Water Technical, 75 4486

Appendix D – ReFH2 Runoff Calculations

ReFH2 Runoff Rates

Inputs	
Site Area	55 Ha
Proposed Hardstanding	27.5 Ha
BFI Host	0.456

ReFH2 RUNOFF RATES	
Return Period (Years)	**As-rural Peak Flow (l/s)**
1	154.17
2	176.6
5	252.47
10	309.01
30	407.11
50	459.17
75	504.81
100	540.1
200	638.51
1000	972.51

Appendix E – MicroDrainage Attenuation Storage Calculations

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.362	0.362	75.1	0.0	75.1	5845.2	O K
30 min Summer	9.469	0.469	76.9	0.0	76.9	7566.9	O K
60 min Summer	9.579	0.579	77.0	0.0	77.0	9341.1	O K
120 min Summer	9.673	0.673	77.0	0.0	77.0	10861.4	O K
180 min Summer	9.725	0.725	77.0	0.0	77.0	11703.6	Flood Risk
240 min Summer	9.760	0.760	77.0	0.0	77.0	12272.3	Flood Risk
360 min Summer	9.806	0.806	77.0	0.0	77.0	13018.2	Flood Risk
480 min Summer	9.835	0.835	77.0	0.0	77.0	13479.4	Flood Risk
600 min Summer	9.854	0.854	77.0	0.0	77.0	13780.1	Flood Risk
720 min Summer	9.866	0.866	77.0	0.0	77.0	13977.3	Flood Risk
960 min Summer	9.878	0.878	77.0	0.0	77.0	14178.1	Flood Risk
1440 min Summer	9.878	0.878	77.0	0.0	77.0	14173.8	Flood Risk
2160 min Summer	9.866	0.866	77.0	0.0	77.0	13988.2	Flood Risk
2880 min Summer	9.854	0.854	77.0	0.0	77.0	13784.5	Flood Risk
4320 min Summer	9.825	0.825	77.0	0.0	77.0	13314.0	Flood Risk
5760 min Summer	9.791	0.791	77.0	0.0	77.0	12765.2	Flood Risk
7200 min Summer	9.758	0.758	77.0	0.0	77.0	12243.6	Flood Risk
8640 min Summer	9.727	0.727	77.0	0.0	77.0	11744.0	Flood Risk
10080 min Summer	9.699	0.699	77.0	0.0	77.0	11285.0	O K
15 min Winter	9.406	0.406	76.1	0.0	76.1	6550.5	O K
30 min Winter	9.526	0.526	77.0	0.0	77.0	8485.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	114.656	0.0	3732.0	0.0	30
30 min Summer	74.461	0.0	4955.9	0.0	45
60 min Summer	46.241	0.0	7916.3	0.0	74
120 min Summer	27.203	0.0	9290.0	0.0	134
180 min Summer	19.764	0.0	10042.3	0.0	192
240 min Summer	15.713	0.0	10538.8	0.0	252
360 min Summer	11.347	0.0	11147.8	0.0	370
480 min Summer	8.992	0.0	11459.1	0.0	490
600 min Summer	7.504	0.0	11591.9	0.0	608
720 min Summer	6.473	0.0	11592.6	0.0	726
960 min Summer	5.127	0.0	11314.4	0.0	964
1440 min Summer	3.701	0.0	10544.8	0.0	1382
2160 min Summer	2.680	0.0	18145.1	0.0	1716
2880 min Summer	2.139	0.0	18909.2	0.0	2088
4320 min Summer	1.571	0.0	19080.1	0.0	2912
5760 min Summer	1.273	0.0	24552.8	0.0	3744
7200 min Summer	1.088	0.0	26160.6	0.0	4544
8640 min Summer	0.962	0.0	27602.8	0.0	5360
10080 min Summer	0.871	0.0	28794.4	0.0	6152
15 min Winter	114.656	0.0	4250.6	0.0	30
30 min Winter	74.461	0.0	5506.1	0.0	45

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	9.649	0.649	77.0	0.0	77.0	10482.1	O K
120 min Winter	9.756	0.756	77.0	0.0	77.0	12202.6	Flood Risk
180 min Winter	9.815	0.815	77.0	0.0	77.0	13165.2	Flood Risk
240 min Winter	9.856	0.856	77.0	0.0	77.0	13817.2	Flood Risk
360 min Winter	9.909	0.909	77.0	0.0	77.0	14670.9	Flood Risk
480 min Winter	9.941	0.941	77.0	0.0	77.0	15197.8	Flood Risk
600 min Winter	9.963	0.963	77.0	0.0	77.0	15547.9	Flood Risk
720 min Winter	9.978	0.978	77.0	0.0	77.0	15784.8	Flood Risk
960 min Winter	9.994	0.994	77.0	0.0	77.0	16049.4	Flood Risk
1440 min Winter	10.000	1.000	77.2	0.0	77.2	16143.1	Flood Risk
2160 min Winter	9.978	0.978	77.0	0.0	77.0	15786.4	Flood Risk
2880 min Winter	9.959	0.959	77.0	0.0	77.0	15481.2	Flood Risk
4320 min Winter	9.912	0.912	77.0	0.0	77.0	14724.1	Flood Risk
5760 min Winter	9.859	0.859	77.0	0.0	77.0	13865.3	Flood Risk
7200 min Winter	9.802	0.802	77.0	0.0	77.0	12948.2	Flood Risk
8640 min Winter	9.744	0.744	77.0	0.0	77.0	12015.7	Flood Risk
10080 min Winter	9.691	0.691	77.0	0.0	77.0	11161.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	46.241	0.0	8875.6	0.0	74
120 min Winter	27.203	0.0	10319.4	0.0	132
180 min Winter	19.764	0.0	11055.6	0.0	190
240 min Winter	15.713	0.0	11498.8	0.0	248
360 min Winter	11.347	0.0	11955.4	0.0	364
480 min Winter	8.992	0.0	12074.0	0.0	480
600 min Winter	7.504	0.0	11991.0	0.0	596
720 min Winter	6.473	0.0	11837.9	0.0	712
960 min Winter	5.127	0.0	11510.1	0.0	940
1440 min Winter	3.701	0.0	10846.6	0.0	1382
2160 min Winter	2.680	0.0	20144.8	0.0	1936
2880 min Winter	2.139	0.0	20804.8	0.0	2224
4320 min Winter	1.571	0.0	19938.6	0.0	3160
5760 min Winter	1.273	0.0	27503.9	0.0	4088
7200 min Winter	1.088	0.0	29296.1	0.0	4968
8640 min Winter	0.962	0.0	30922.8	0.0	5792
10080 min Winter	0.871	0.0	32310.8	0.0	6560

Rainfall Details

Rainfall Model	FEH
Return Period (years)	30
FEH Rainfall Version	2013
Site Location	GB 458668 456501 SE 58668 56501
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 27.500

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	6.875	4	8	6.875	8	12	6.875	12	16	6.875

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	16144.0	0.500	16144.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0353-7700-1000-7700
Design Head (m)	1.000
Design Flow (l/s)	77.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	353
Invert Level (m)	8.995
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.000	77.0
Flush-Flo™	0.509	77.0
Kick-Flo®	0.823	70.1
Mean Flow over Head Range	-	59.9

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

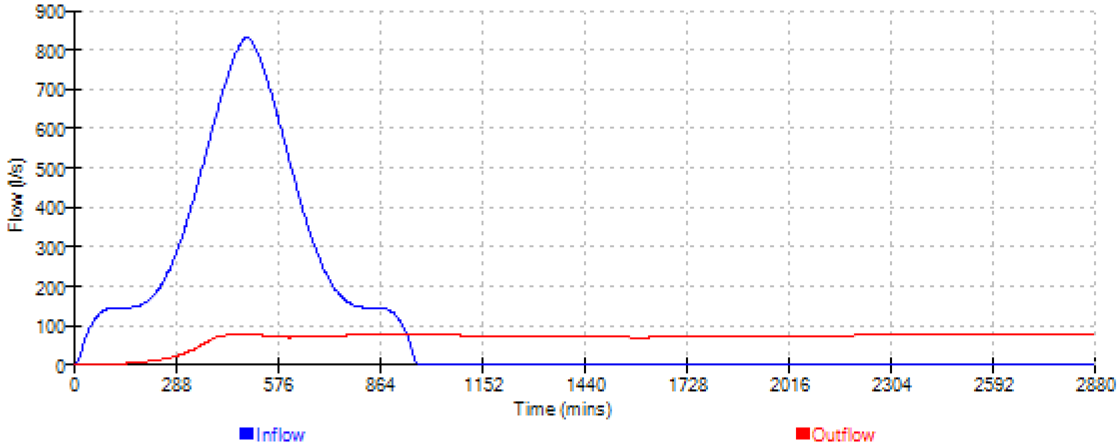
Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	10.2	1.200	84.1	3.000	131.3	7.000	198.7
0.200	35.7	1.400	90.6	3.500	141.6	7.500	205.6
0.300	65.9	1.600	96.7	4.000	151.1	8.000	212.2
0.400	75.9	1.800	102.4	4.500	160.1	8.500	218.6
0.500	77.0	2.000	107.8	5.000	168.5	9.000	224.8
0.600	76.4	2.200	112.9	5.500	176.6	9.500	230.9
0.800	71.2	2.400	117.8	6.000	184.3		
1.000	77.0	2.600	122.4	6.500	191.7		

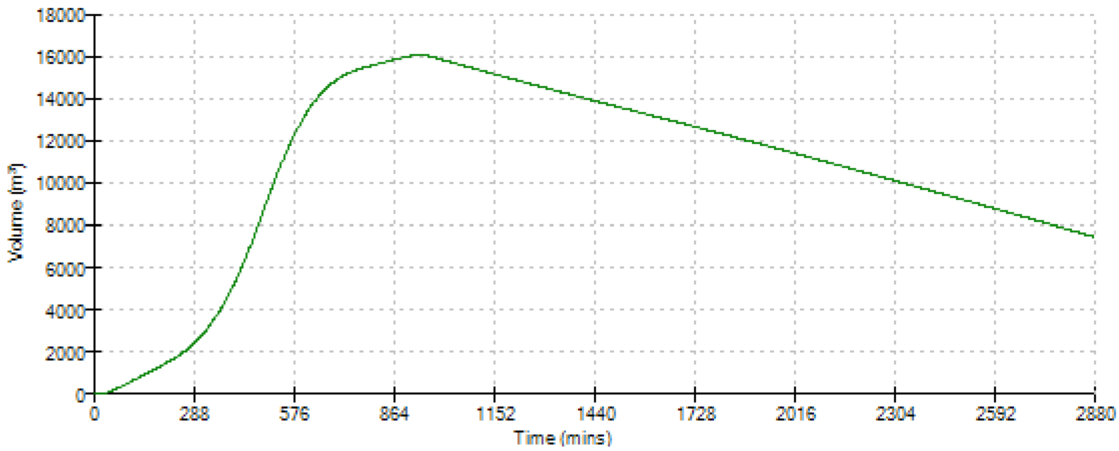
Weir Overflow Control

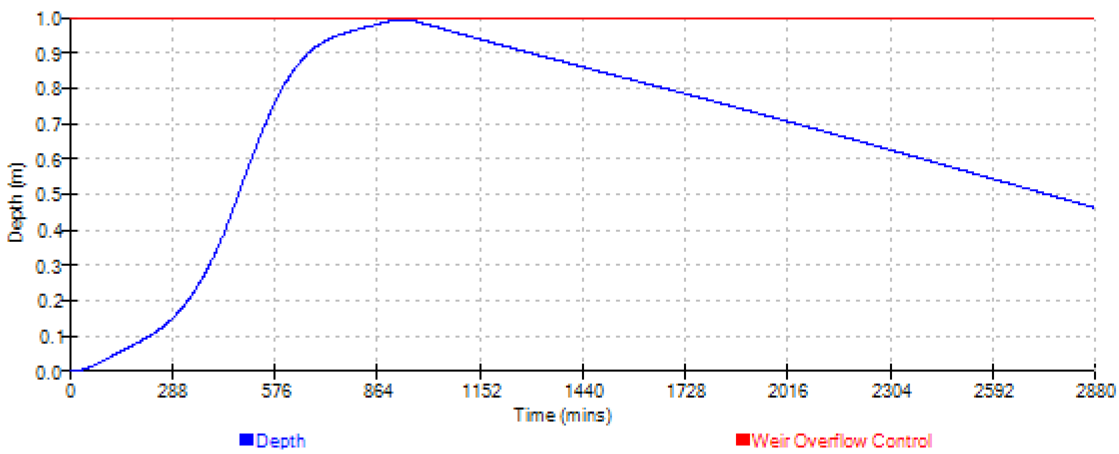
Discharge Coef 0.544 Width (m) 5.000 Invert Level (m) 10.000

Delta-Simons		Page 5
Suite 4A Portland Street Manchester, M1 3BE	1 in 30 Land off Wigginton Road 20-0683.01	
Date 25/06/2020 File	Designed by AC Checked by JR	
Innovyze	Source Control 2019.1	

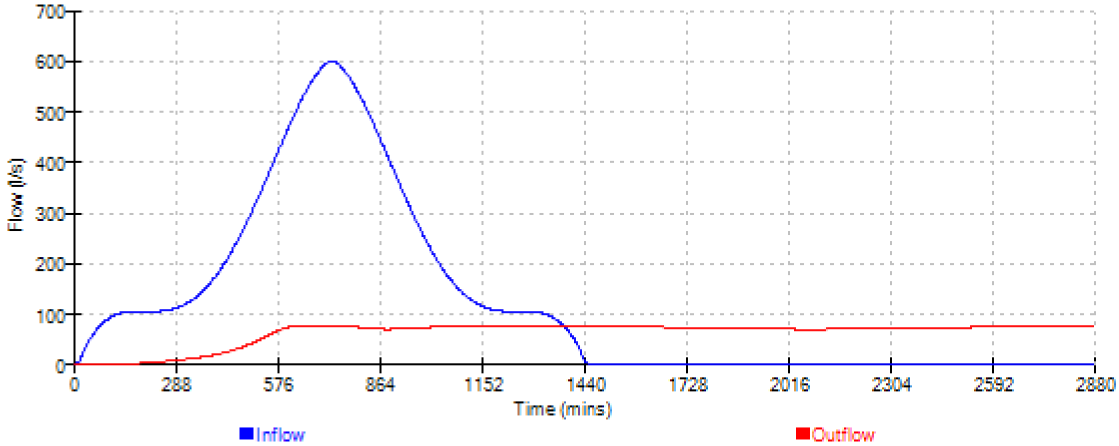
Event: 960 min Winter

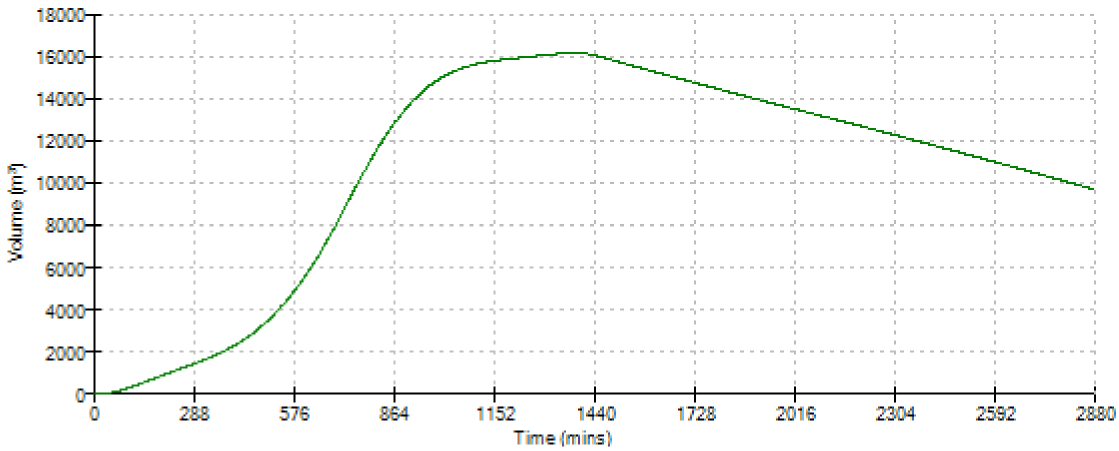


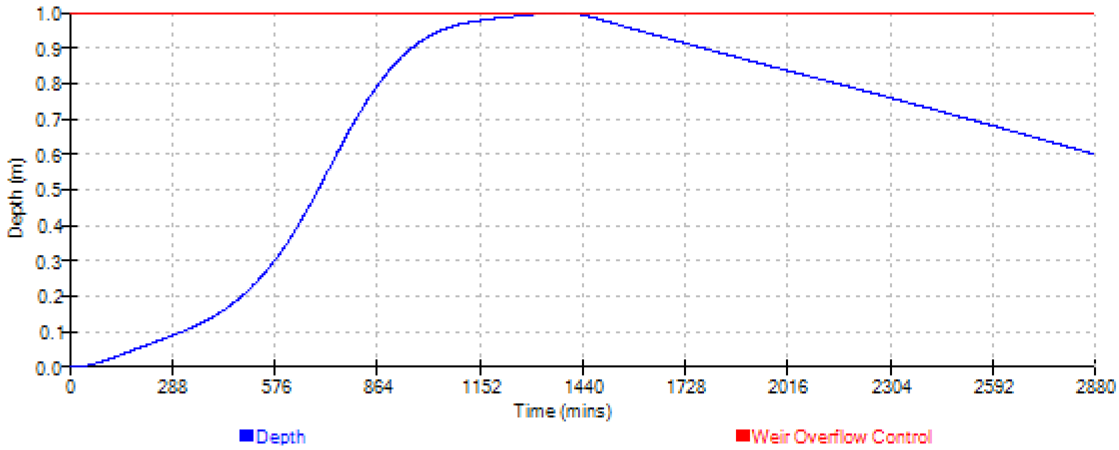




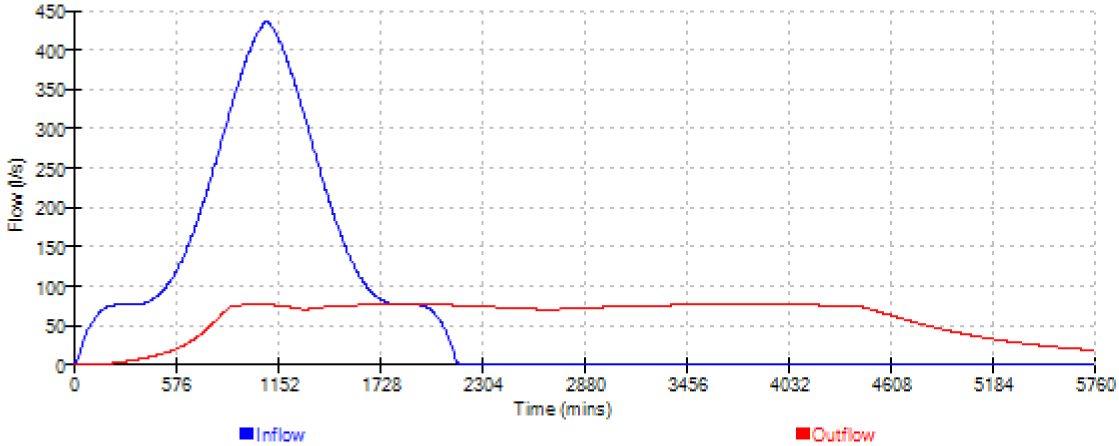
Event: 1440 min Winter

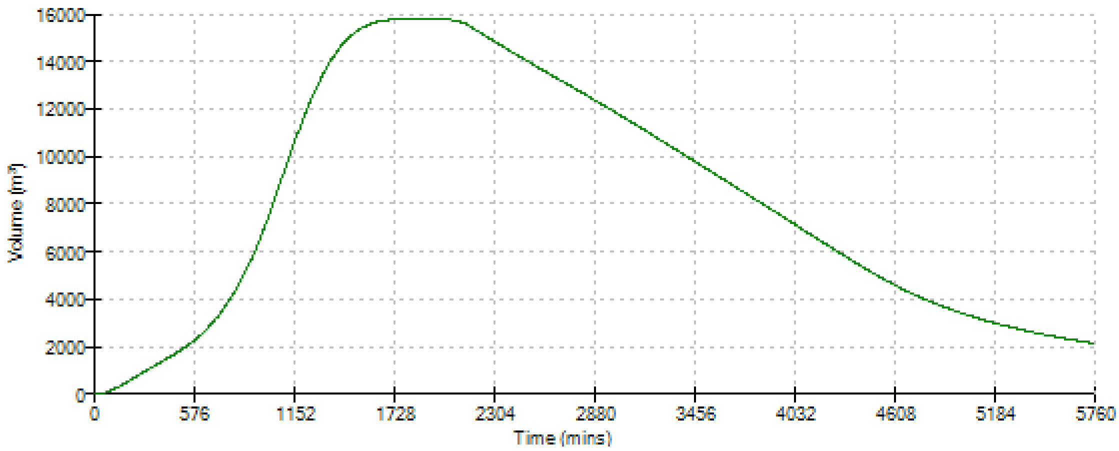


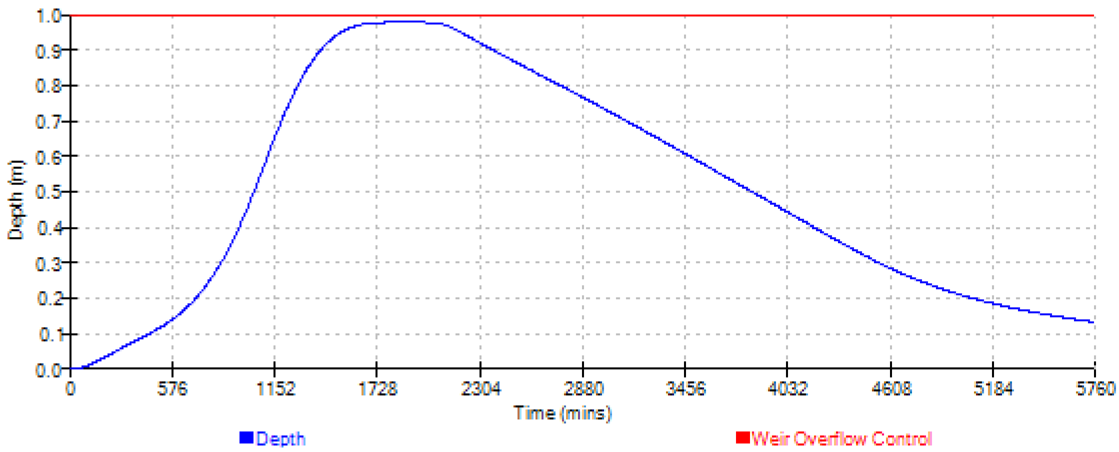




Event: 2160 min Winter







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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.367	0.367	75.2	0.0	75.2	7771.9	O K
30 min Summer	9.482	0.482	77.0	0.0	77.0	10209.0	O K
60 min Summer	9.600	0.600	77.0	0.0	77.0	12707.4	O K
120 min Summer	9.684	0.684	77.0	0.0	77.0	14486.4	O K
180 min Summer	9.729	0.729	77.0	0.0	77.0	15458.7	Flood Risk
240 min Summer	9.760	0.760	77.0	0.0	77.0	16110.3	Flood Risk
360 min Summer	9.800	0.800	77.0	0.0	77.0	16963.1	Flood Risk
480 min Summer	9.826	0.826	77.0	0.0	77.0	17505.4	Flood Risk
600 min Summer	9.844	0.844	77.0	0.0	77.0	17879.9	Flood Risk
720 min Summer	9.856	0.856	77.0	0.0	77.0	18145.9	Flood Risk
960 min Summer	9.872	0.872	77.0	0.0	77.0	18480.0	Flood Risk
1440 min Summer	9.882	0.882	77.0	0.0	77.0	18692.4	Flood Risk
2160 min Summer	9.875	0.875	77.0	0.0	77.0	18539.8	Flood Risk
2880 min Summer	9.869	0.869	77.0	0.0	77.0	18409.1	Flood Risk
4320 min Summer	9.857	0.857	77.0	0.0	77.0	18159.0	Flood Risk
5760 min Summer	9.842	0.842	77.0	0.0	77.0	17849.6	Flood Risk
7200 min Summer	9.825	0.825	77.0	0.0	77.0	17487.2	Flood Risk
8640 min Summer	9.807	0.807	77.0	0.0	77.0	17095.7	Flood Risk
10080 min Summer	9.788	0.788	77.0	0.0	77.0	16700.6	Flood Risk
15 min Winter	9.411	0.411	76.2	0.0	76.2	8707.9	O K
30 min Winter	9.540	0.540	77.0	0.0	77.0	11444.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	152.040	0.0	4348.6	0.0	31
30 min Summer	100.100	0.0	5718.1	0.0	45
60 min Summer	62.580	0.0	9875.5	0.0	74
120 min Summer	35.995	0.0	11136.9	0.0	134
180 min Summer	25.835	0.0	11715.6	0.0	194
240 min Summer	20.367	0.0	12018.2	0.0	252
360 min Summer	14.535	0.0	12213.2	0.0	372
480 min Summer	11.431	0.0	12110.8	0.0	490
600 min Summer	9.489	0.0	11897.1	0.0	610
720 min Summer	8.153	0.0	11680.3	0.0	728
960 min Summer	6.425	0.0	11252.2	0.0	966
1440 min Summer	4.610	0.0	10436.4	0.0	1442
2160 min Summer	3.327	0.0	20872.6	0.0	1920
2880 min Summer	2.654	0.0	20988.1	0.0	2280
4320 min Summer	1.950	0.0	19095.8	0.0	3040
5760 min Summer	1.581	0.0	29915.3	0.0	3880
7200 min Summer	1.351	0.0	31688.4	0.0	4752
8640 min Summer	1.193	0.0	33154.4	0.0	5536
10080 min Summer	1.078	0.0	34162.2	0.0	6360
15 min Winter	152.040	0.0	4928.5	0.0	30
30 min Winter	100.100	0.0	6189.9	0.0	45

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
60 min Winter	9.673	0.673	77.0	0.0	77.0	14254.4	O K
120 min Winter	9.767	0.767	77.0	0.0	77.0	16262.4	Flood Risk
180 min Winter	9.820	0.820	77.0	0.0	77.0	17370.1	Flood Risk
240 min Winter	9.855	0.855	77.0	0.0	77.0	18115.2	Flood Risk
360 min Winter	9.901	0.901	77.0	0.0	77.0	19091.0	Flood Risk
480 min Winter	9.930	0.930	77.0	0.0	77.0	19711.9	Flood Risk
600 min Winter	9.951	0.951	77.0	0.0	77.0	20144.2	Flood Risk
720 min Winter	9.965	0.965	77.0	0.0	77.0	20457.0	Flood Risk
960 min Winter	9.985	0.985	77.0	0.0	77.0	20865.8	Flood Risk
1440 min Winter	10.000	1.000	77.2	0.0	77.2	21192.5	Flood Risk
2160 min Winter	9.996	0.996	77.0	0.0	77.0	21111.5	Flood Risk
2880 min Winter	9.980	0.980	77.0	0.0	77.0	20768.7	Flood Risk
4320 min Winter	9.959	0.959	77.0	0.0	77.0	20319.2	Flood Risk
5760 min Winter	9.931	0.931	77.0	0.0	77.0	19731.5	Flood Risk
7200 min Winter	9.900	0.900	77.0	0.0	77.0	19067.5	Flood Risk
8640 min Winter	9.867	0.867	77.0	0.0	77.0	18368.9	Flood Risk
10080 min Winter	9.833	0.833	77.0	0.0	77.0	17647.3	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	62.580	0.0	10936.2	0.0	74
120 min Winter	35.995	0.0	12068.8	0.0	132
180 min Winter	25.835	0.0	12422.9	0.0	190
240 min Winter	20.367	0.0	12479.9	0.0	248
360 min Winter	14.535	0.0	12308.5	0.0	366
480 min Winter	11.431	0.0	12113.5	0.0	482
600 min Winter	9.489	0.0	11924.3	0.0	598
720 min Winter	8.153	0.0	11741.2	0.0	716
960 min Winter	6.425	0.0	11392.8	0.0	946
1440 min Winter	4.610	0.0	10756.5	0.0	1400
2160 min Winter	3.327	0.0	22531.3	0.0	2052
2880 min Winter	2.654	0.0	21976.8	0.0	2400
4320 min Winter	1.950	0.0	19963.2	0.0	3280
5760 min Winter	1.581	0.0	33456.7	0.0	4208
7200 min Winter	1.351	0.0	35340.5	0.0	5120
8640 min Winter	1.193	0.0	36770.5	0.0	6048
10080 min Winter	1.078	0.0	37420.7	0.0	6952

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 458668 456501 SE 58668 56501
Data Type	Point
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time Area Diagram

Total Area (ha) 27.500

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	6.875	4	8	6.875	8	12	6.875	12	16	6.875

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	**Area (m²)**	**Depth (m)**	**Area (m²)**
0.000	21193.0	0.500	21193.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0353-7700-1000-7700
Design Head (m)	1.000
Design Flow (l/s)	77.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	353
Invert Level (m)	8.995
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	**Head (m)**	**Flow (l/s)**
Design Point (Calculated)	1.000	77.0
Flush-Flo™	0.509	77.0
Kick-Flo®	0.823	70.1
Mean Flow over Head Range	-	59.9

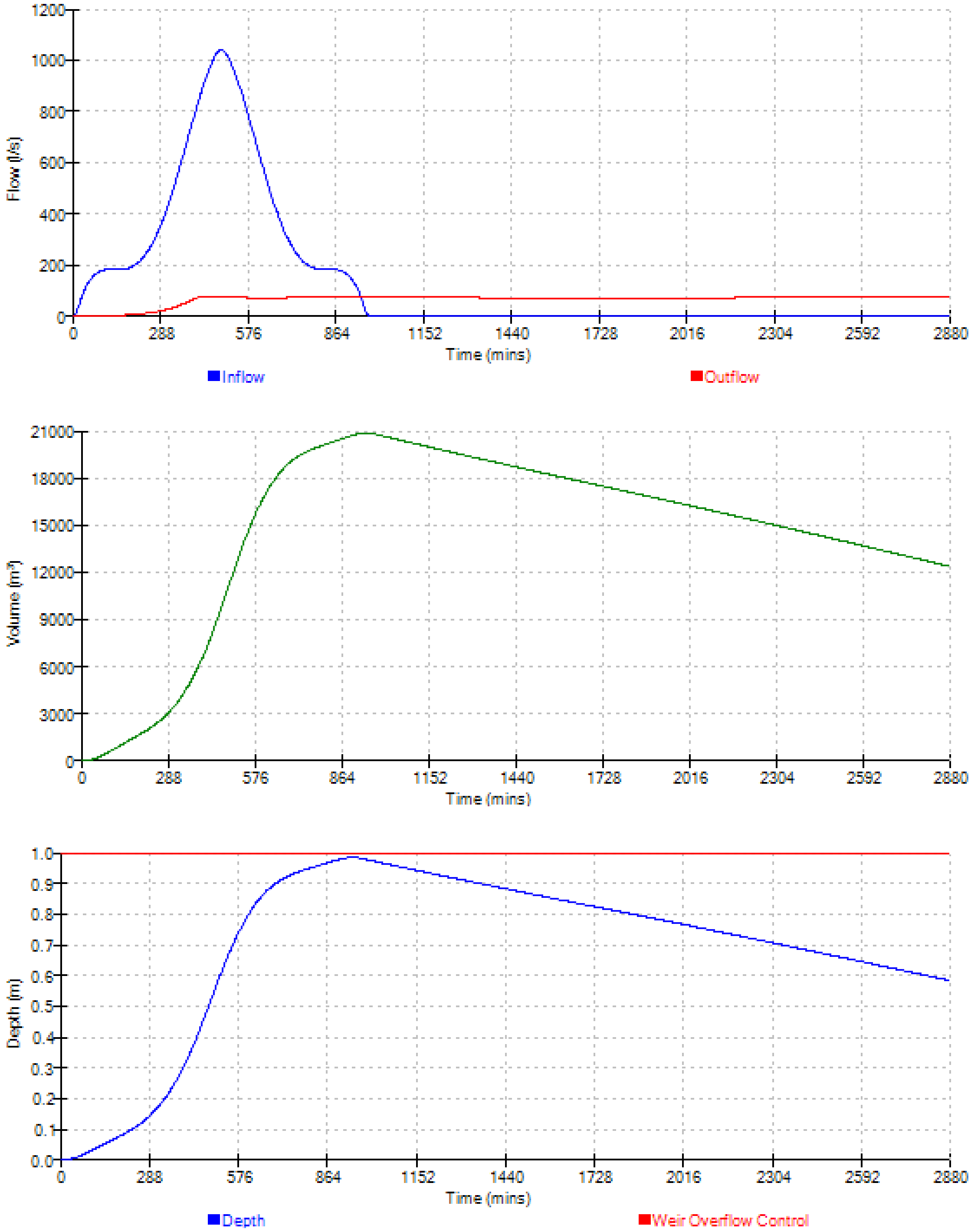
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**	**Depth (m)**	**Flow (l/s)**
0.100	10.2	1.200	84.1	3.000	131.3	7.000	198.7
0.200	35.7	1.400	90.6	3.500	141.6	7.500	205.6
0.300	65.9	1.600	96.7	4.000	151.1	8.000	212.2
0.400	75.9	1.800	102.4	4.500	160.1	8.500	218.6
0.500	77.0	2.000	107.8	5.000	168.5	9.000	224.8
0.600	76.4	2.200	112.9	5.500	176.6	9.500	230.9
0.800	71.2	2.400	117.8	6.000	184.3		
1.000	77.0	2.600	122.4	6.500	191.7		

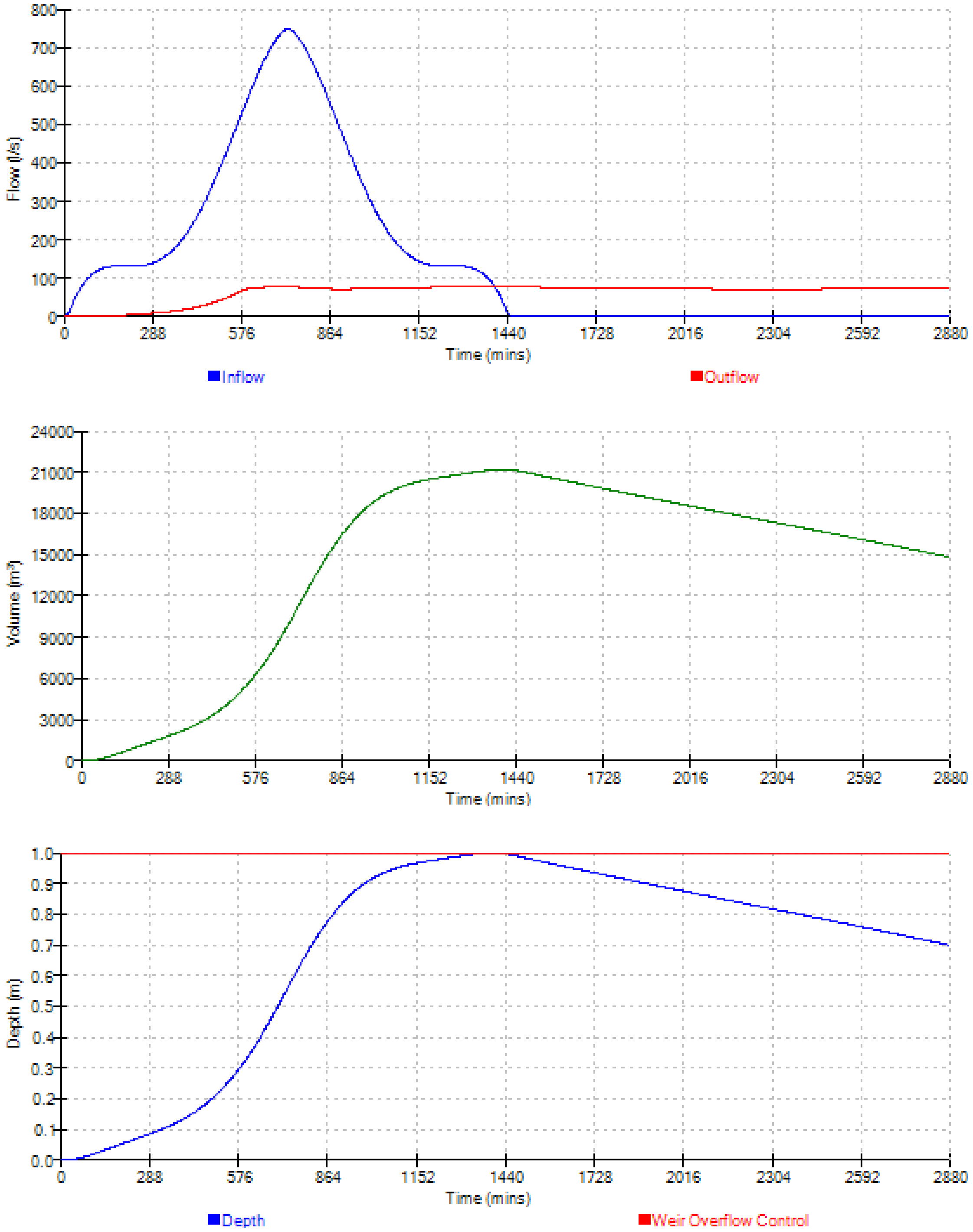
Weir Overflow Control

Discharge Coef 0.544 Width (m) 5.000 Invert Level (m) 10.000

Event: 960 min Winter



Event: 1440 min Winter



Event: 2160 min Winter