

SURFACE WATER DRAINAGE STRATEGY

PROPOSED NEW LOADING BAYS & EXTERNAL WORKS
LAND NORTH OF WASHWAY ROAD, FLEET HARGATE,
HOLBEACH, LINCOLNSHIRE

PROJECT NO: SW23-269

DOCUMENT REF: SW23-269-REP-01



FOR H.Z. LOGISTICS UK LTD.



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Revision	Date	Description		
-	Sept. 2023	First Issue	Prepared	M. Barlow
			Approved	A. Wilson CEng MIStructE

1 Introduction

Under the instruction of HZ Logistics UK Ltd., the following drainage strategy report has been prepared for the proposed new loading bays and external works at land North of Washway Road, Fleet Hargate.

The object of this report is to clarify the design philosophy followed when preparing the proposed surface water drainage arrangements for the site and to outline the proposed solution in sufficient detail for all relevant parties to be able to comment. This assessment also demonstrates that the proposals are within the guidance contained within the National Planning Policy Framework (NPPF).

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2 Site Information

2.1 Location & Description

The site is approximately 1.48 hectares in size and is located North of Washway Road, National Grid reference TF385254.

2.2 Geology

2.2.1 Underlying Strata

Shields Wilson Ltd. undertook ground investigations on site during August 2023. The investigations confirmed ground conditions to be as specified by the British Geological Survey mapping, with silty Tidal Flat Deposits encountered. A photo of the trial pit is included in Appendix A.

2.2.2 Infiltration Testing

In our experience of the local area, there will be limited infiltration potential for the existing strata.

2.2.3 Ground Water Table

Ground water was found 1.7m below existing ground level, at approximately 1.45m AOD.

2.3 Drainage

2.3.1 Surface Water

The site falls within South Holland Internal Drainage Boards (SHIDB) District, specifically Catchment Number K – CMT201G, Lutton Leam (W). There is a SHIDB maintained watercourse (DRN201G1503) which runs adjacent to the sites Southern Boundary on the other side of Washway Road.

The surface water drainage infrastructure serving the existing development is to remain unchanged by the proposals.

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The topography of the field is relatively flat, with levels varying from +2.9m to 3.25m Ordnance Datum. Washway Road public highway lies approximately level with the adjacent land with levels of approximately 3.2m AOD.

2.4.1 Existing Overland Flood Flows

The existing overland flood flows are directed to the riparian Watercourse to the Western and Southern Boundaries of the site, which makes its way to the SHIDB maintained watercourse.

3 Proposed Development

This strategy is based upon G.R. Merchant Ltd. architectural site layout drawing 4162-23-01-02A (H.Z. LOGISTICS – WASHWAY ROAD).

The proposed development consists of a loading dock pod extension to an existing building and a concrete yard, together with gravel parking areas. The site is accessed via Washway Road to the South. An attenuation pond is proposed to be located West of the site connecting into the existing Dyke bounding the site.

4 Surface Water Drainage Strategy

The proposed surface water drainage strategy arrangement is shown on drawings SW23-269-010 & SW23-269-011, included within Appendix B.

4.1 SuDS Considerations

4.1.1 Hierarchy

The NPPF guidance advises that surface water discharge from proposed developments should aim to be as high up the following hierarchy as reasonably possible:

1. Into the ground (infiltration) – via soakaways or other infiltration device,
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The underlying tidal flat deposits/silty strata encountered results in the site having limited infiltration potential for large impermeable areas concentrated to a geocellular soakaway system. Therefore, draining the roof and concrete areas via this method will not be possible.

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The riparian watercourses local to the site provide a viable surface water outfall for the proposed site. These discharge to the SHIDB maintained watercourse to the South of Washway Road. This proposal achieves the second highest level of the SuDS hierarchy.

Land Drainage Consents will need to be obtained from SHIDB at the detailed design stage.

4.1.1.3 Surface Water Sewer

Surface water discharge from site via this method is not required as higher levels of the SuDS hierarchy are achievable.

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Permeable gravel surfaces are to be used for the parking areas, which will include a geotextile specifically designed to capture and degrade hydrocarbons, this will improve the water quality prior to infiltrating to ground. A bypass separator will be incorporated so all surface water run-off from the concrete yard is conveyed through the separator. The attenuation basin is to be positioned 'online', and therefore all flows are routed through this feature and will receive additional treatment through the planted vegetation to the bed.

4.2 Proposals

4.2.1 Existing Greenfield Run-off Rate

The development site is predominantly greenfield. Therefore, where possible the discharge rate from the proposed development should be restricted to the sites QBar. The site area is only 1.48 hectares, therefore as demonstrated by the following QBar calculations existing run off totals 2.16 litres per second.

Greenfield runoff rates	Default	Edited
QBAR (l/s):	2.16	2.16
1 in 1 year (l/s):	1.88	1.88
1 in 30 years (l/s):	5.3	5.3
1 in 100 year (l/s):	7.71	7.71
1 in 200 years (l/s):	9.11	9.11

Figure 1: Existing QBar Calculation Rate

The full QBar calculations are included with the drainage calculation within Appendix C.

4.2.2 Proposed Flow Control Rate

A flow control chamber incorporating a HydroBrake will be introduced into the downstream elements of the proposed drainage system to restrict flows offsite.

It will not be possible to restrict flows off site to the QBar rate established above, as the likelihood of blockage would be very high due to the small orifice required and therefore increase flood risk.

It is therefore proposed to restrict flows off site to a maximum of 5 litres per second. This is a practical minimum flow rate to ensure an orifice size greater than 100mm is achieved to reduce the risk of blockages. Although this is not an adoptable system, this is accordance with, Sewerage Sector Guidance Appendix C, Design & Construction Guidance.

4.2.3 Drainage Proposals

The proposed surface water drainage strategy arrangement is shown on drawing SW23-269-010, included within Appendix B. Typical construction details are also illustrated on drawing SW23-269-011.

The hardstanding/impermeable surfacing areas are summarised on the drainage strategy arrangement drawings and within the table below:

Ref.	Description	Area (m ²)	Discharge Method/Location
A	Proposed Building Roofs	200	Outfalling to Riparian Watercourse
B	Proposed Concrete Yard & Docks	3,160	Outfalling to Riparian Watercourse
C	Proposed Gravel Parking Area	3,110	Infiltration To Ground

Figure 2: Hardstanding/Impermeable Surface Summary

The proposed roof areas denoted as Area A, will be drained via rainwater pipes being discharged on the loading dock surface, to make its way into the drainage channel with gravity.

The proposed concrete hardstanding areas, denoted as Area B, comprise of a service yard and loading docks. Due to the level of the loading docks relative to the existing riparian dykes and therefore the proposed drainage arrangement, it will be necessary to pump the surface water catchment from this area. Surface water will be collected via a drainage channel and pumped into the downstream network which discharges to the basin. Surface water will be collected from the service yard via gullies and discharge into the basin. All surface water run-off from the concrete areas will be conveyed through a bypass separator to remove any hydrocarbons prior to discharging to the basin.

The surface water will be conveyed underground to the proposed attenuation basin to the West, a typical detail is included on drawing SW23-269-011. This basin is to be planted in accordance with The SuDS Manual, CIRIA C753 to provide treatment to the surface water.

A flow control chamber which restricts flow off site to 5 litres / second will be incorporated between the attenuation basin and SHIDB maintained watercourse.

The parking area denoted as Area C, is to be constructed with a permeable surface and to infiltrate at source. The surface water discharge from these areas will mimic the pre-development scenario, whereby water will be conveyed within the free-draining strata which has limited infiltration potential and conveyed to the existing dyke's to the Southern & Western boundaries.

The sub-base beneath the permeable gravel surface is to be an open graded stone, which is to have a minimum void ratio of 30%. The depth of the sub-base is to be designed hydraulically to accommodate the 1:100+CC event, in accordance with Interpave document 'Design and Construction of Concrete Block Permeable Pavements'. The below extract shows a minimum depth of 210mm is require:

		Infiltration rate = 1×10^{-2} m/s				
		1 in 10	1 in 30	1 in 100	1 in 100 + 20%	1 in 100 + 30%
M5-60	r	10	3.33	1	0.5	0.25
20	0.4	90	120	160	210	225
	0.3	100	140	190	240	270
	0.2	135	180	250	310	370
17	0.4	70	100	140	180	190
	0.3	80	110	160	210	225
	0.2	105	150	210	270	305
14	0.4					
	0.3	60	90	130	170	180
	0.2	75	110	160	220	245

Figure 3: Interpave Design Guidance Extract

4.3 Consultation

SHIDB have been consulted and water levels for their system have been provided.

The relevant Land Drainage consents for surface water discharge will be applied for at the detailed design stage.

4.4 Hydraulic Modelling

The system has been modelled utilising Causeway Flow+ and the calculation inputs and outputs are included within our calculation package SW23-269-CAL-C-01, contained within Appendix C.

The calculations demonstrate that the run-off will be safely conveyed and attenuated during storms up to and including the 1 in 100 year event plus climate change allowance.

The calculations show the system has no surcharging during the 1:2 year event (with the exception of the flow control chambers).

There is only very limited flooding during the 1:30 year event for the shortest most intense storms within the loading dock area. The maximum depth of flooding in the loading dock is approximately 50mm and only last for a few minutes after the peak of the storm. There is approximately 700mm freeboard within the basin for the 1:30 year event.

There is only very limited flooding during the 1:100 year event for the shortest most intense storms within the loading dock area. The maximum depth of flooding in the loading dock is approximately 100mm and last for a maximum of 20 minutes after

the peak of the storm. There is approximately 300mm freeboard within the basin for the 1:100+CC year event.

The system has been modelled using both FSR and FEH rainfall data.

The proposed hydraulic model has been reviewed in conjunction with the water level SHIDB have provided for their system for the 1:100+CC year event. Despite a high water level within the SHIDB system there is no increase in surface flooding. The freeboard during the surcharged outfall event is reduced to approximately 160mm.

4.5 Flood Exceedance

Where possible the proposed site levels have been designed to follow the existing topography, while allowing surface water to flow towards the basin. Drawing SW23-269-010 included with Appendix B demonstrates the proposed flood exceedance routes.

4.5.1 Flood Routes

The flood route plan clearly demonstrates all overland flows are safely conveyed to the basin and the riparian watercourses to the site's boundaries. This mimics the existing scenario.

4.5.2 Off-site Flood Risk Management

Proposed site levels have been sympathetic to existing levels particularly at the boundaries. The existing 1:100+CC design storm water levels within the IDB system are relatively high, higher than the existing watercourse bank line in places. Therefore, the dyke bank low spots are to be raised where required to ensure there is no flood risk to the development from the SHIDB system.

4.6 Management/Maintenance Strategy

The proposed system contains various assets which are all required to be in reasonable working order for the systems to function as a whole and operate as anticipated within the design models. These assets should generally be maintained in accordance with The SuDS Manual C753 or manufacturer guidance.

The scope/nature of inspection and maintenance is such that various facilities and structures are inspected and maintained at yearly intervals, as well as after or during use and/or heavy storms, in order that they continue to perform effectively.

The proposed surface water drainage system is to remain private and to be maintained by the site owner / appointed maintenance contractor.

Operation and maintenance requirements for ponds and wetlands		
Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut the meadow grass	Half yearly (spring, before nesting season, and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand out submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay	Every 1–5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays	Every 5 years, or as required
Occasional maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair / rehabilitate inlets, outlets and overflows	As required

Figure 4: Ponds & Wetlands Maintenance Requirements (The SuDS Manual C753)

The HydroBrake should be maintained in accordance with manufacturer guidance, please refer to the below for guidance:

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Remove sediment and debris from flow control chambers and upstream manholes	Monthly for first 12 months then 6 monthly
Remedial Actions	Replace or clean hydrobrake if performance deteriorates or failure occurs	As necessary
Monitoring	Check flow control to ensure emptying is occurring	Quarterly and post high intensity storm event

Figure 5: HydroBrake Maintenance Requirements

The loading dock pump will be maintained under a management/service agreement with the pump manufacturer to the site owner.

On completion of the above, ensure the drainage system is running freely and cleanly. If not, repeat maintenance activities. Written records should be kept of all maintenance work carried out.

5 Conclusion

In summary:

- Site investigations have been undertaken to assess the infiltration potential.
- Existing site features, topography, drainage assets, etc. have been evaluated.
- SuDS hierarchy has been explored;
- Limited infiltration is possible for wide spread hardstanding areas, infiltrating at source.
- The riparian watercourses draining to the SHIDB system are a viable outfall route.
- Various source control features have been reviewed;
- Permeable surfacing to hardstanding areas with partial infiltration are to be utilised.
- Greenfield run-off rate reviewed and discharge rate of 5 l/s specified for robustness.
- Roof water and concrete yard run-off to be attenuated within a basin and discharge to the riparian watercourse.
- Hydraulic modelling undertaking for storms ranging from 1:2 – 1:100+CC utilising both FEH and FSR data.
- Proposed flood exceedance routes have been at the forefront of design.
- Management and maintenance responsibilities explored for both the surface and foul water systems.

As illustrated by our design proposals on drawings SW23-269-010 & SW23-269-011 and the information outlined within this report, it is demonstrable that a viable and robust surface water scheme that complies with the requirements of National Planning Guidance can be provided for the proposed warehouse development.

Under the proposals outlined within the report, all the drainage features will remain private and are to be maintained by the site owner / appointed maintenance contractor and as such have suitable management and on-going maintenance.

Appendix A – Ground Investigation Report



Appendix B – Proposed Drainage Strategy Arrangement Drawing



KEY:	
	EXISTING SURFACE WATER DRAINAGE - PRIVATE
	EXISTING FOUL WATER DRAINAGE - PRIVATE
	EXISTING SURFACE WATER DRAINAGE - SOUTH HOLLAND DB
	PROPOSED SURFACE WATER DRAIN - PRIVATE
	PROPOSED SURFACE CHAMBER - PRIVATE
	PROPOSED SURFACE WATER RISING MAIN - PRIVATE
	PROPOSED SURFACE WATER DRAINAGE CHANNEL
	PROPOSED SURFACE WATER BULLY & LATERAL
	EXISTING SITE LEVEL
	PROPOSED SURFACE FALL
	AREA A - PROPOSED BUILDING ROOFS - TO DISCHARGE INTO UNDERGROUND DRAINAGE SYSTEM TOTAL AREA 200m²
	AREA B - PROPOSED CONCRETE YARD & LOADING DOCKS - TO DISCHARGE INTO UNDERGROUND DRAINAGE SYSTEM YARD AREA 1,660m² LOADING DOCK AREA 1,500m² TOTAL AREA 3,160m²
	AREA C - PROPOSED PERMEABLE GRAVEL SURFACE - TO INFILTRATE TO GROUND AT SOURCE TOTAL AREA 3,110m²
	DEMOTES PROPOSED FLOOD EXCEEDANCE ROUTE

PROPOSED ATTENUATION BASIN:
SIDE SLOPES 1:3
BWM TOP LEVEL: 3.000 (400m)
BED LEVEL: 1.785 - 1.740 (150m)
BWM STORAGE VOLUME: 340m³
1:100+00 (FDH) WATER LEVEL: 2.690 (223m)

SHD4 PROPOSED FLOW CONTROL CHAMBER:
TO BE FITTED WITH HYDROPAKE TO RESTRICT
DISCHARGE TO 5.00L/S (PRACTICAL MINIMUM RATE
MAINTAINING A 100mm CRUISE DIAMETER) DISCHARGE
RATE TO BE AGREED WITH SOUTH HOLLAND DB
CL: 3.000
IL: 1.730

SURFACE WATER DISCHARGE TO
WATERCOURSE SUBJECT TO SHD0
CONSENT UNDER BYELAW 3

EXISTING RIVER/DYKE TO BE CLEARED OF
VEGETATION WHICH IS RESTRICTING FLOWS
AND MAINTENANCE ACTIVITIES

EXISTING HEADWALL

UN-SURVEYED EXISTING PIPE
BENEATH ROAD ASSUMED TO BE
ENTERING DB SYSTEM AS SHOWN

EXISTING SOUTH HOLLAND
DB COLLECTOR

SOUTH HOLLAND DB MAINTAINED DRAIN WATER LEVELS:
1:2 YEAR = +1.64m AOD
1:10 YEAR = +1.82m AOD
1:30 YEAR = +2.04m AOD
1:100 YEAR = +2.30m AOD
1:100+00 YEAR = +2.57m AOD

EXISTING WAREHOUSE

ALL EXISTING YARD & BUILDING
SURFACE WATER DRAINAGE
TO REMAIN UNCHANGED

PUMP CHAMBER TO BE FITTED WITH 2 NO. ALTERNATING
PUMPS EACH CAPABLE OF DISCHARGING 40L/S

EXISTING 150mm TWINWALL PVC SW PIPE
L: 2.800

PROPOSED DOWNPIPER TO DISCHARGE
INTO NEW DEPRESSURED LOADING DOCK

SW02 PUMP CHAMBER

1200mm WH
CL: 1.790
IL: 1.000

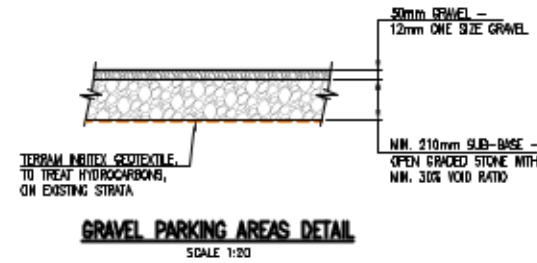
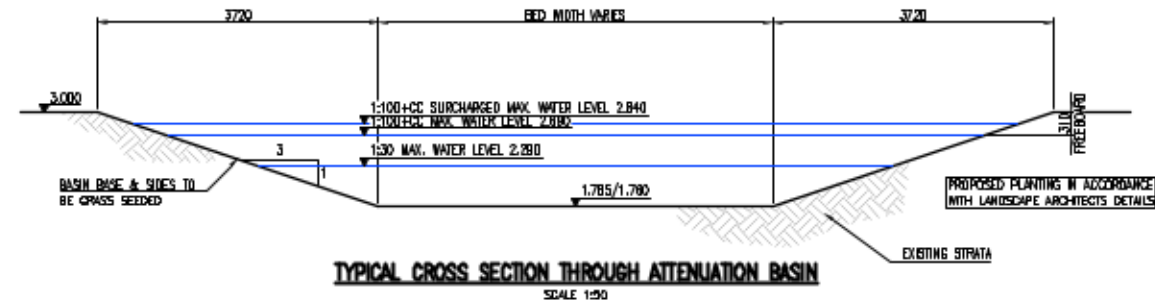
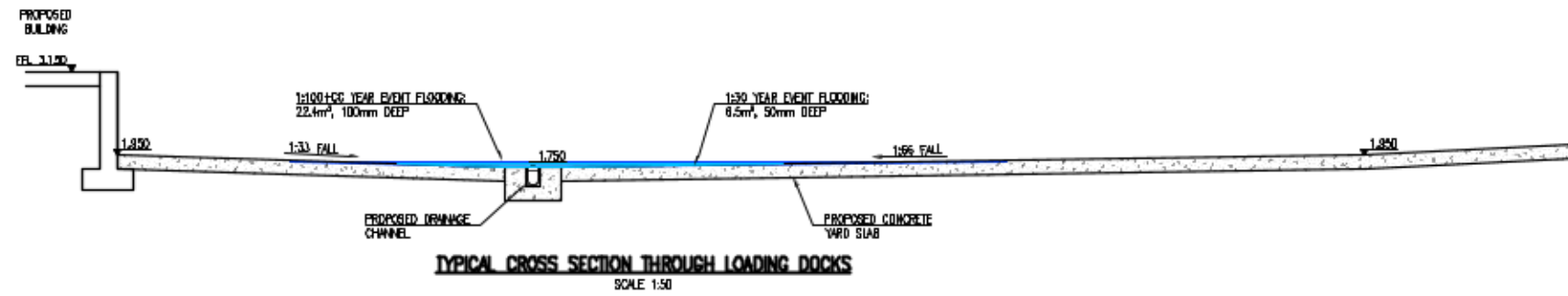
NEW DEPRESSURED
LOADING DOCK

EXISTING SW CATCHPIT CHAMBER
CL: 3.080
INCOMING 150mm IL: 2.320
OUTGOING 150mm IL: 2.480

EXISTING SW CATCHPIT CHAMBER
CL: 3.050
INCOMING 100mm IL: 2.250
OUTGOING 225mm IL: 2.190

0 2.5 5 7.5 10 15 20 25m
1:250

REVISION - ALTERED LEVELS		MRB	APV	06/08/22
PRELIMINARY - FOR INFORMATION		MRB	APV	20/08/22
REV.	DESCRIPTION	DRN	APP.	DATE
A	STATUS	FOR INFORMATION		
	CLIENT	HZ LOGISTICS UK LTD.		
	PROJECT	PROPOSED NEW LOADING BAYS & EXTERNAL WORKS WASHWAY ROAD, FLEET HARGATE, HOLBEACH Lincs, PE12 7PE		
	TITLE	PROPOSED DRAINAGE STRATEGY ARRANGEMENT		
DWG	AUG. '23	SCALE 1:500	DRAWING NO.	REV.
DRN	MRB		SW23-269-010	A



REV.	DESCRIPTION	DRN.	APP.	DATE	
SHIELDS WILSON e: info@shieldswilson.co.uk t: 01775 720252 STRUCTURAL AND CIVIL ENGINEERING					
STATUS FOR INFORMATION					
CLIENT HZ LOGISTICS UK LTD.					
PROJECT PROPOSED NEW LOADING BAYS & EXTERNAL WORKS WASHWAY ROAD, FLEET HARGATE, HOLBEACH Lincs, PE12 7PE					
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DWG	AUC. '23	SCALE 1:50	DRAWING NO.	REV.	
DRAWN	MRB	1:20	SW23-269-011	-	

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4.2 Proposals

4.2.1 Existing Greenfield Run-off Rate

The development site is predominantly greenfield. Therefore, where possible the discharge rate from the proposed development should be restricted to the sites QBar. The site area is only 1.48 hectares, therefore as demonstrated by the following QBar calculations existing run off totals 2.16 litres per second.

Greenfield runoff rates	Default	Edited
QBAR (l/s):	2.16	2.16
1 in 1 year (l/s):	1.88	1.88
1 in 30 years (l/s):	5.3	5.3
1 in 100 year (l/s):	7.71	7.71
1 in 200 years (l/s):	9.11	9.11

Figure 1: Existing QBar Calculation Rate

The full QBar calculations are included with the drainage calculation within Appendix C.

4.2.2 Proposed Flow Control Rate

A flow control chamber incorporating a HydroBrake will be introduced into the downstream elements of the proposed drainage system to restrict flows offsite.

It will not be possible to restrict flows off site to the QBar rate established above, as the likelihood of blockage would be very high due to the small orifice required and therefore increase flood risk.

It is therefore proposed to restrict flows off site to a maximum of 5 litres per second. This is a practical minimum flow rate to ensure an orifice size greater than 100mm is achieved to reduce the risk of blockages. Although this is not an adoptable system, this is accordance with, Sewerage Sector Guidance Appendix C, Design & Construction Guidance.

4.2.3 Drainage Proposals

The proposed surface water drainage strategy arrangement is shown on drawing SW23-269-010, included within Appendix B. Typical construction details are also illustrated on drawing SW23-269-011.

The hardstanding/impermeable surfacing areas are summarised on the drainage strategy arrangement drawings and within the table below:

Ref.	Description	Area (m ²)	Discharge Method/Location
A	Proposed Building Roofs	200	Outfalling to Riparian Watercourse
B	Proposed Concrete Yard & Docks	3,160	Outfalling to Riparian Watercourse
C	Proposed Gravel Parking Area	3,110	Infiltration To Ground

Figure 2: Hardstanding/Impermeable Surface Summary

The proposed roof areas denoted as Area A, will be drained via rainwater pipes being discharged on the loading dock surface, to make its way into the drainage channel with gravity.

The proposed concrete hardstanding areas, denoted as Area B, comprise of a service yard and loading docks. Due to the level of the loading docks relative to the existing riparian dykes and therefore the proposed drainage arrangement, it will be necessary to pump the surface water catchment from this area. Surface water will be collected via a drainage channel and pumped into the downstream network which discharges to the basin. Surface water will be collected from the service yard via gullies and discharge into the basin. All surface water run-off from the concrete areas will be conveyed through a bypass separator to remove any hydrocarbons prior to discharging to the basin.

The surface water will be conveyed underground to the proposed attenuation basin to the West, a typical detail is included on drawing SW23-269-011. This basin is to be planted in accordance with The SuDS Manual, CIRIA C753 to provide treatment to the surface water.

A flow control chamber which restricts flow off site to 5 litres / second will be incorporated between the attenuation basin and SHIDB maintained watercourse.

The parking area denoted as Area C, is to be constructed with a permeable surface and to infiltrate at source. The surface water discharge from these areas will mimic the pre-development scenario, whereby water will be conveyed within the free-draining strata which has limited infiltration potential and conveyed to the existing dyke's to the Southern & Western boundaries.

The sub-base beneath the permeable gravel surface is to be an open graded stone, which is to have a minimum void ratio of 30%. The depth of the sub-base is to be designed hydraulically to accommodate the 1:100+CC event, in accordance with Interpave document 'Design and Construction of Concrete Block Permeable Pavements'. The below extract shows a minimum depth of 210mm is require:

Infiltration rate = 1×10^{-2} m/s		1 in 10	1 in 30	1 in 100	1 in 100 + 20%	1 in 100 + 30%
M5-60	r	10	3.33	1	0.5	0.25
20	0.4	90	120	160	210	225
	0.3	100	140	190	240	270
	0.2	135	180	250	310	370
17	0.4	70	100	140	180	190
	0.3	80	110	160	210	225
	0.2	105	150	210	270	305
14	0.4					
	0.3	60	90	130	170	180
	0.2	75	110	160	220	245

Figure 3: Interpave Design Guidance Extract

4.3 Consultation

SHIDB have been consulted and water levels for their system have been provided.

The relevant Land Drainage consents for surface water discharge will be applied for at the detailed design stage.

4.4 Hydraulic Modelling

The system has been modelled utilising Causeway Flow+ and the calculation inputs and outputs are included within our calculation package SW23-269-CAL-C-01, contained within Appendix C.

The calculations demonstrate that the run-off will be safely conveyed and attenuated during storms up to and including the 1 in 100 year event plus climate change allowance.

The calculations show the system has no surcharging during the 1:2 year event (with the exception of the flow control chambers).

There is only very limited flooding during the 1:30 year event for the shortest most intense storms within the loading dock area. The maximum depth of flooding in the loading dock is approximately 50mm and only last for a few minutes after the peak of the storm. There is approximately 700mm freeboard within the basin for the 1:30 year event.

There is only very limited flooding during the 1:100 year event for the shortest most intense storms within the loading dock area. The maximum depth of flooding in the loading dock is approximately 100mm and last for a maximum of 20 minutes after

the peak of the storm. There is approximately 300mm freeboard within the basin for the 1:100+CC year event.

The system has been modelled using both FSR and FEH rainfall data.

The proposed hydraulic model has been reviewed in conjunction with the water level SHIDB have provided for their system for the 1:100+CC year event. Despite a high water level within the SHIDB system there is no increase in surface flooding. The freeboard during the surcharged outfall event is reduced to approximately 160mm.

4.5 Flood Exceedance

Where possible the proposed site levels have been designed to follow the existing topography, while allowing surface water to flow towards the basin. Drawing SW23-269-010 included with Appendix B demonstrates the proposed flood exceedance routes.

4.5.1 Flood Routes

The flood route plan clearly demonstrates all overland flows are safely conveyed to the basin and the riparian watercourses to the site's boundaries. This mimics the existing scenario.

4.5.2 Off-site Flood Risk Management

Proposed site levels have been sympathetic to existing levels particularly at the boundaries. The existing 1:100+CC design storm water levels within the IDB system are relatively high, higher than the existing watercourse bank line in places. Therefore, the dyke bank low spots are to be raised where required to ensure there is no flood risk to the development from the SHIDB system.

4.6 Management/Maintenance Strategy

The proposed system contains various assets which are all required to be in reasonable working order for the systems to function as a whole and operate as anticipated within the design models. These assets should generally be maintained in accordance with The SuDS Manual C753 or manufacturer guidance.

The scope/nature of inspection and maintenance is such that various facilities and structures are inspected and maintained at yearly intervals, as well as after or during use and/or heavy storms, in order that they continue to perform effectively.

The proposed surface water drainage system is to remain private and to be maintained by the site owner / appointed maintenance contractor.

Operation and maintenance requirements for ponds and wetlands		
Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter and debris	Monthly (or as required)
	Cut the grass – public areas	Monthly (during growing season)
	Cut the meadow grass	Half yearly (spring, before nesting season, and autumn)
	Inspect marginal and bankside vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Inspect inlets, outlets, banksides, structures, pipework etc for evidence of blockage and/or physical damage	Monthly
	Inspect water body for signs of poor water quality	Monthly (May – October)
	Inspect silt accumulation rates in any forebay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly
	Check any mechanical devices, eg penstocks	Half yearly
	Hand out submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level	Annually
	Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Annually
	Remove sediment from any forebay	Every 1–5 years, or as required
	Remove sediment and planting from one quadrant of the main body of ponds without sediment forebays	Every 5 years, or as required
Occasional maintenance	Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25–50 years
Remedial actions	Repair erosion or other damage	As required
	Replant, where necessary	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realign rip-rap or repair other damage	As required
	Repair / rehabilitate inlets, outlets and overflows	As required

Figure 4: Ponds & Wetlands Maintenance Requirements (The SuDS Manual C753)

The HydroBrake should be maintained in accordance with manufacturer guidance, please refer to the below for guidance:

Maintenance Schedule	Required Action	Frequency
Regular Maintenance	Remove sediment and debris from flow control chambers and upstream manholes	Monthly for first 12 months then 6 monthly
Remedial Actions	Replace or clean hydrobrake if performance deteriorates or failure occurs	As necessary
Monitoring	Check flow control to ensure emptying is occurring	Quarterly and post high intensity storm event

Figure 5: HydroBrake Maintenance Requirements

The loading dock pump will be maintained under a management/service agreement with the pump manufacturer to the site owner.

On completion of the above, ensure the drainage system is running freely and cleanly. If not, repeat maintenance activities. Written records should be kept of all maintenance work carried out.

5 Conclusion

In summary:

- Site investigations have been undertaken to assess the infiltration potential.
- Existing site features, topography, drainage assets, etc. have been evaluated.
- SuDS hierarchy has been explored;
- Limited infiltration is possible for wide spread hardstanding areas, infiltrating at source.
- The riparian watercourses draining to the SHIDB system are a viable outfall route.
- Various source control features have been reviewed;
- Permeable surfacing to hardstanding areas with partial infiltration are to be utilised.
- Greenfield run-off rate reviewed and discharge rate of 5 l/s specified for robustness.
- Roof water and concrete yard run-off to be attenuated within a basin and discharge to the riparian watercourse.
- Hydraulic modelling undertaking for storms ranging from 1:2 – 1:100+CC utilising both FEH and FSR data.
- Proposed flood exceedance routes have been at the forefront of design.
- Management and maintenance responsibilities explored for both the surface and foul water systems.

As illustrated by our design proposals on drawings SW23-269-010 & SW23-269-011 and the information outlined within this report, it is demonstrable that a viable and robust surface water scheme that complies with the requirements of National Planning Guidance can be provided for the proposed warehouse development.

Under the proposals outlined within the report, all the drainage features will remain private and are to be maintained by the site owner / appointed maintenance contractor and as such have suitable management and on-going maintenance.

Appendix A – Ground Investigation Report



Appendix B – Proposed Drainage Strategy Arrangement Drawing

PROPOSED SURFACE WATER DRAINAGE CALCULATIONS

PROPOSED NEW LOADING BAYS & EXTERNAL WORKS
LAND NORTH OF WASHWAY ROAD, FLEET HARGATE,
HOLBEACH, LINCOLNSHIRE

PROJECT NO: SW23-269

DOCUMENT REF: SW23-269-CAL-C-01



FOR H.Z. LOGISTICS UK LTD.



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Revision	Date	Description		
-	September 2023	First Issue	Prepared	M. Pett
			Approved	A.Wilson CEng MStructE

Greenfield Run-off Calculations

Calculated by:	Max Barlow
Site name:	HZ LOGISTICS
Site location:	WASHWAY ROAD

Site Details

Latitude:	52.80870° N
Longitude:	0.05322° E
Reference:	946217600
Date:	Sep 05 2023 16:35

This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (Ciria, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Runoff estimation approach IH124

Site characteristics

Total site area (ha):	1.48
-----------------------	------

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Calculate from SOIL type

Notes

(1) Is $Q_{BAR} < 2.0$ l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

Soil characteristics

	Default	Edited
SOIL type:	2	2
HOST class:	N/A	N/A
SPR/SPRHOST:	0.3	0.3

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

Hydrological characteristics

	Default	Edited
SAAR (mm):	580	580
Hydrological region:	5	5
Growth curve factor 1 year:	0.87	0.87
Growth curve factor 30 years:	2.45	2.45
Growth curve factor 100 years:	3.56	3.56
Growth curve factor 200 years:	4.21	4.21

(3) Is $SPR/SPRHOST \leq 0.3$?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates

	Default	Edited
Q_{BAR} (l/s):	2.16	2.16
1 in 1 year (l/s):	1.88	1.88
1 in 30 years (l/s):	5.3	5.3
1 in 100 year (l/s):	7.71	7.71
1 in 200 years (l/s):	9.11	9.11

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at www.uksuds.com. The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

HydroBrake Flow Control Details

Technical Specification

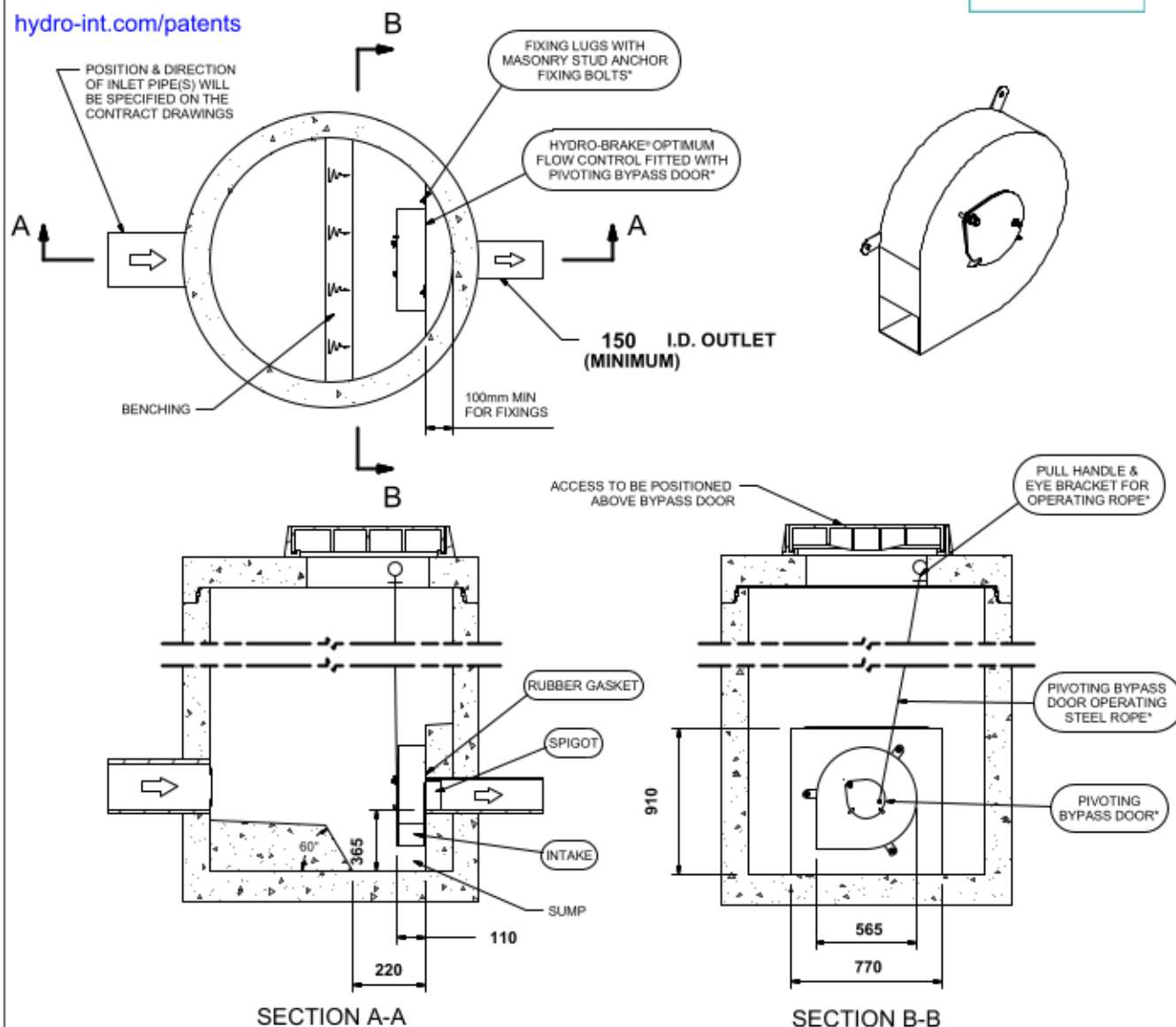
Control Point	Head (m)	Flow (l/s)
Primary Design	1.270	5.000
Flush-Flo™	0.373	4.988
Kick-Flo®	0.780	3.990
Mean Flow		4.368

Hydro-Brake® Optimum Flow Control including:

- 3 mm grade 304L stainless steel
- Integral stainless steel pivoting by-pass door allowing clear line of sight through to outlet, c/w stainless steel operating rope
- Beed blasted finish to maximise corrosion resistance
- Stainless steel fixings
- Rubber gasket to seal outlet
- Indicative Weight: 20 kg



hydro-int.com/patents



IMPORTANT:

○ LIMIT OF HYDRO INTERNATIONAL SUPPLY

THE DEVICE WILL BE HANDED TO SUIT SITE CONDITIONS
FOR SITE SPECIFIC DETAILS AND MINIMUM CHAMBER SIZE REFER TO HYDRO INTERNATIONAL
ALL CIVIL AND INSTALLATION WORK BY OTHERS

* WHERE SUPPLIED

HYDRO-BRAKE® FLOW CONTROL & HYDRO-BRAKE® OPTIMUM FLOW CONTROL ARE REGISTERED TRADEMARKS FOR FLOW CONTROLS DESIGNED AND MANUFACTURED EXCLUSIVELY BY HYDRO INTERNATIONAL

THIS DESIGN LAYOUT IS FOR ILLUSTRATIVE PURPOSES ONLY. NOT TO SCALE.

DESIGN ADVICE



The head/flow characteristics of this SHE-0101-5000-1270-5000 Hydro-Brake® Optimum Flow Control are unique. Dynamic hydraulic modelling evaluates the full head/flow characteristic curve.
The use of any other flow control will invalidate any design based on this data and could constitute a flood risk.

Hydro
International

DATE	05/09/2023 12:56
SITE	HZ Washway Road
DESIGNER	Max Barlow
REF	SW23-269

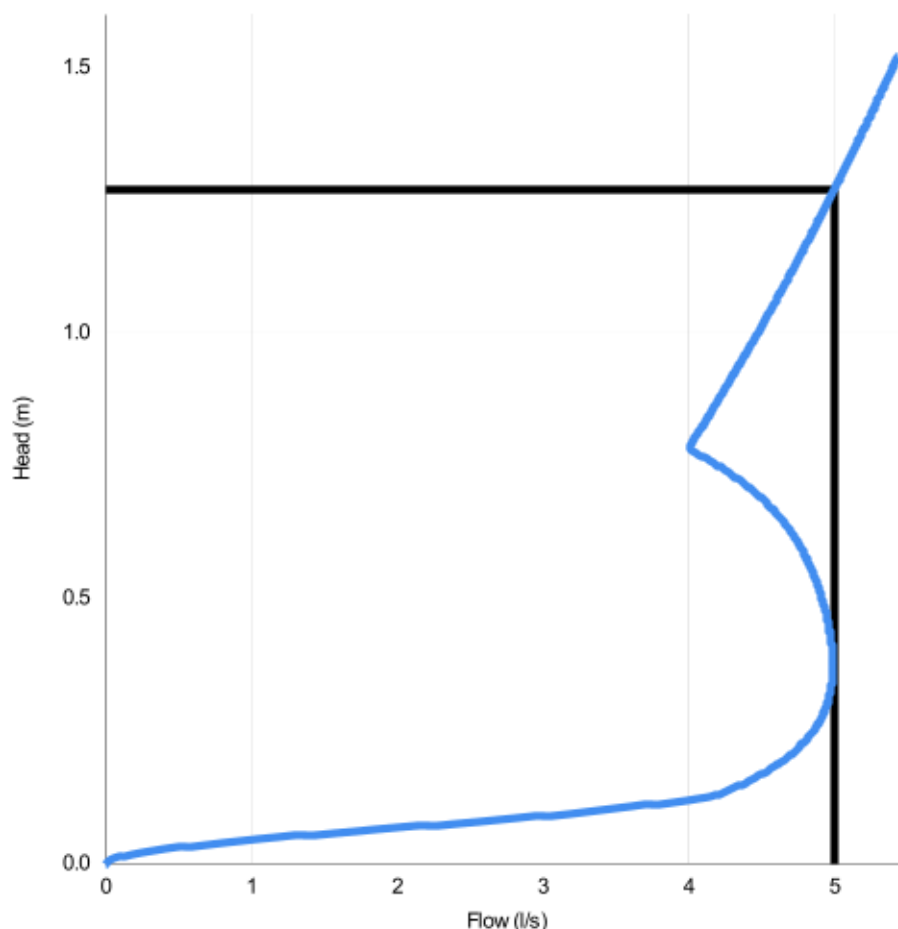
SHE-0101-5000-1270-5000
Hydro-Brake® Optimum

Technical Specification

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Primary Design	1.270	5.000
Flush-Flo	0.373	4.988
Kick-Flo®	0.780	3.990
Mean Flow		4.368



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Head (m)	Flow (l/s)
0.000	0.000
0.044	0.963
0.088	2.914
0.131	4.208
0.175	4.541
0.219	4.753
0.263	4.883
0.307	4.955
0.350	4.984
0.394	4.985
0.438	4.966
0.482	4.930
0.526	4.881
0.569	4.816
0.613	4.728
0.657	4.609
0.701	4.447
0.744	4.229
0.788	4.008
0.832	4.109
0.876	4.208
0.920	4.303
0.963	4.397
1.007	4.488
1.051	4.577
1.095	4.664
1.139	4.750
1.182	4.834
1.226	4.916
1.270	4.997

DESIGN ADVICE



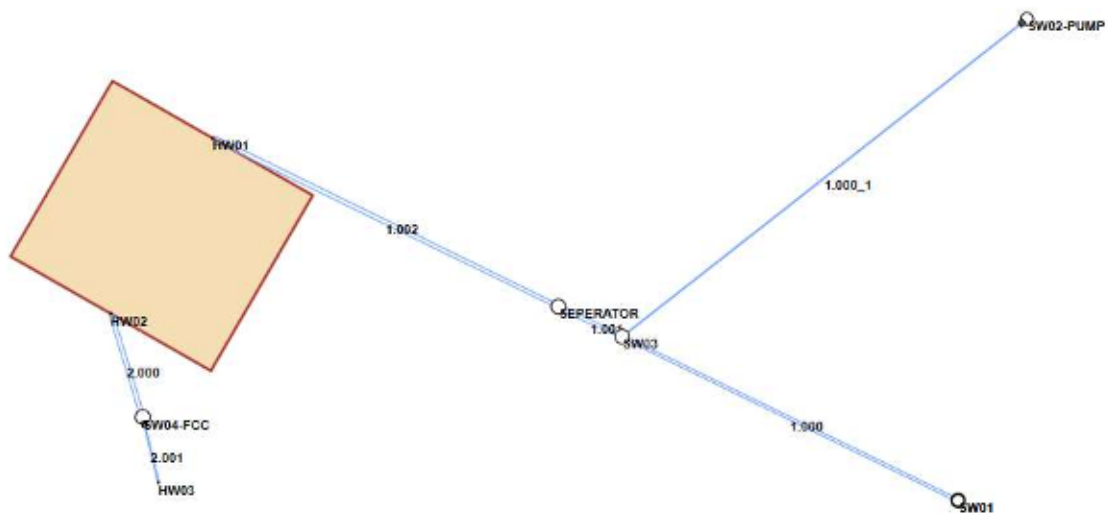
The head/flow characteristics of this SHE-0101-5000-1270-5000 Hydro-Brake Optimum® Flow Control are unique. Dynamic hydraulic modelling evaluates the full head/flow characteristic curve.

The use of any other flow control will invalidate any design based on this data and could constitute a flood risk.

Hydro
International

DATE	05/09/2023 12:56
Site	HZ Washway Road
DESIGNER	Max Barlow
Ref	SW23-269

SHE-0101-5000-1270-5000
Hydro-Brake Optimum®



Modelled Network Layout Graphic

Network Details & FEH Rainfall Data Hydraulic Model Output

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	2	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.750	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	x
Maximum Rainfall (mm/hr)	50.0		

Nodes

Name	Area (ha)	T of E (mins)	Cover Level (m)	Diameter (mm)	Easting (m)	Northing (m)	Depth (m)
SW01	0.166	5.00	3.100	1200	538529.125	325414.174	1.000
SW03			3.000	1350	538498.209	325429.382	1.045
SEPERATOR			3.000	1350	538492.328	325432.166	1.110
HW01			3.000		538460.510	325447.793	1.215
HW02		5.00	3.000		538451.128	325431.507	1.240
SW04-FCC			3.000	1350	538454.066	325421.919	1.270
HW03			3.000		538455.519	325415.834	1.315
SW02-PUMP	0.171	5.00	1.790	1200	538535.466	325458.841	0.790

Links

Name	US Node	DS Node	Length (m)	ks (mm) / n	US IL (m)	DS IL (m)	Fall (m)	Slope (1:X)	Dia (mm)	T of C (mins)	Rain (mm/hr)
1.000	SW01	SW03	34.454	0.600	2.100	1.955	0.145	237.6	300	5.57	50.0
1.001	SW03	SEPERATOR	5.000	0.600	1.955	1.940	0.015	333.3	375	5.65	50.0
1.002	SEPERATOR	HW01	33.750	0.600	1.890	1.785	0.105	321.4	375	6.13	50.0
2.000	HW02	SW04-FCC	10.028	0.600	1.760	1.730	0.030	334.3	375	5.17	50.0
2.001	SW04-FCC	HW03	6.256	0.600	1.730	1.685	0.045	139.0	150	5.29	50.0
1.000_1	SW02-PUMP	SW03	47.496	0.600	1.000	2.300	-1.300	-36.5	75	5.79	50.0

Name	Vel (m/s)	Cap (l/s)	Flow (l/s)	US Depth (m)	DS Depth (m)	Σ Area (ha)	Σ Add Inflow (l/s)	Pro Depth (mm)	Pro Velocity (m/s)
1.000	1.015	71.8	22.5	0.700	0.745	0.166	0.0	115	0.901
1.001	0.987	109.0	45.7	0.670	0.685	0.338	0.0	170	0.945
1.002	1.005	111.0	45.7	0.735	0.840	0.338	0.0	167	0.957
2.000	0.985	108.8	0.0	0.865	0.895	0.000	0.0	0	0.000
2.001	0.850	15.0	0.0	1.120	1.165	0.000	0.0	0	0.000
1.000_1	1.000	4.4	23.2	0.715	0.625	0.171	0.0	75	0.000

Pipeline Schedule

Link	Length (m)	Slope (1:X)	Dia (mm)	Link Type	US CL (m)	US IL (m)	US Depth (m)	DS CL (m)	DS IL (m)	DS Depth (m)
1.000	34.454	237.6	300	Circular	3.100	2.100	0.700	3.000	1.955	0.745
1.001	5.000	333.3	375	Circular	3.000	1.955	0.670	3.000	1.940	0.685
1.002	33.750	321.4	375	Circular	3.000	1.890	0.735	3.000	1.785	0.840
2.000	10.028	334.3	375	Circular	3.000	1.760	0.865	3.000	1.730	0.895
2.001	6.256	139.0	150	Circular	3.000	1.730	1.120	3.000	1.685	1.165
1.000_1	47.496	-36.5	75	Circular	1.790	1.000	0.715	3.000	2.300	0.625

Link	US Node	Dia (mm)	Node Type	MH Type	DS Node	Dia (mm)	Node Type	MH Type
1.000	SW01	1200	Manhole	Adoptable	SW03	1350	Manhole	Adoptable
1.001	SW03	1350	Manhole	Adoptable	SEPERATOR	1350	Manhole	Adoptable
1.002	SEPERATOR	1350	Manhole	Adoptable	HW01		Junction	
2.000	HW02		Junction		SW04-FCC	1350	Manhole	Adoptable
2.001	SW04-FCC	1350	Manhole	Adoptable	HW03		Junction	
1.000_1	SW02-PUMP	1200	Manhole	Adoptable	SW03	1350	Manhole	Adoptable

Manhole Schedule

Node	Easting (m)	Northing (m)	CL (m)	Depth (m)	Dia (mm)	Connections	Link	IL (m)	Dia (mm)	
SW01	538529.125	325414.174	3.100	1.000	1200		0	1.000	2.100	300
SW03	538498.209	325429.382	3.000	1.045	1350		1	1.000	1.955	300
						2	1.000_1	2.300	75	
						0	1.001	1.955	375	
SEPERATOR	538492.328	325432.166	3.000	1.110	1350		1	1.001	1.940	375
						0	1.002	1.890	375	
HW01	538460.510	325447.793	3.000	1.215			1	1.002	1.785	375
HW02	538451.128	325431.507	3.000	1.240			0	2.000	1.760	375
SW04-FCC	538454.066	325421.919	3.000	1.270	1350		1	2.000	1.730	375
						0	2.001	1.730	150	
HW03	538455.519	325415.834	3.000	1.315			1	2.001	1.685	150
SW02-PUMP	538535.466	325458.841	1.790	0.790	1200		0	1.000_1	1.000	75

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	0.0
Summer CV	0.750	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.840	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)	Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0	100	0	0	0
10	0	0	0	100	20	0	0
30	0	0	0				

Node SW04-FCC Online Hydro-Brake® Control

Flap Valve	x	Objective	(HE) Minimise upstream storage
Replaces Downstream Link	✓	Sump Available	✓
Invert Level (m)	1.730	Product Number	CTL-SHE-0102-5000-1270-5000
Design Depth (m)	1.270	Min Outlet Diameter (m)	0.150
Design Flow (l/s)	5.0	Min Node Diameter (mm)	1200

Node SW02-PUMP Online Pump Control

Flap Valve	x	Invert Level (m)	1.000	Design Flow (l/s)	40.0	Switch off depth (m)	0.100
Replaces Downstream Link	✓	Design Depth (m)	0.790	Switch on depth (m)	0.300		

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.250	40.000	0.790	40.000

Node HW02 Flow through Pond Storage Structure

Base Inf Coefficient (m/hr)	0.00000	Porosity	1.00	Main Channel Length (m)	18.800
Side Inf Coefficient (m/hr)	0.00000	Invert Level (m)	1.760	Main Channel Slope (1:X)	750.0
Safety Factor	2.0	Time to half empty (mins)		Main Channel n	0.030

Inlets

HW01

Depth (m)	Area (m ²)	Inf Area (m ²)	Depth (m)	Area (m ²)	Inf Area (m ²)
0.000	150.0	0.0	1.240	400.0	0.0

Results for 2 year Critical Storm Duration. Lowest mass balance: 98.16%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.215	0.115	23.2	0.1299	0.0000	OK
15 minute winter	SW03	10	2.135	0.180	54.8	0.2575	0.0000	OK
15 minute winter	SEPERATOR	10	2.051	0.161	45.6	0.2311	0.0000	OK
180 minute winter	HW01	132	1.937	0.152	14.3	0.0000	0.0000	OK
180 minute winter	HW02	132	1.937	0.177	13.2	0.0000	0.0000	OK
120 minute winter	SW04-FCC	90	1.940	0.210	6.7	0.3008	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	4.3	0.0000	0.0000	OK
30 minute winter	SW02-PUMP	12	1.311	0.311	18.0	0.3515	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	22.8	0.663	0.318	1.1869	
15 minute winter	SW03	1.001	SEPERATOR	45.6	0.964	0.419	0.2373	
15 minute winter	SEPERATOR	1.002	HW01	46.3	1.919	0.417	0.9189	
180 minute winter	HW01	Flow through pond	HW02	13.2	0.042	0.001	27.5235	
180 minute winter	HW02	2.000	SW04-FCC	6.7	0.240	0.061	0.5702	
120 minute winter	SW04-FCC	Hydro-Brake®	HW03	4.7				48.3
30 minute winter	SW02-PUMP	Pump	SW03	20.3				

Results for 10 year Critical Storm Duration. Lowest mass balance: 98.16%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.301	0.201	51.5	0.2277	0.0000	OK
15 minute winter	SW03	10	2.220	0.265	90.5	0.3788	0.0000	OK
180 minute winter	SEPERATOR	144	2.149	0.259	29.4	0.3712	0.0000	OK
180 minute winter	HW01	152	2.126	0.341	26.3	0.0000	0.0000	OK
180 minute winter	HW02	148	2.126	0.366	24.6	0.0000	0.0000	OK
180 minute winter	SW04-FCC	148	2.127	0.397	6.5	0.5680	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	4.9	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	10	1.790	0.790	53.0	0.8935	1.4517	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	50.5	0.860	0.704	1.9996	
15 minute winter	SW03	1.001	SEPERATOR	90.1	1.196	0.827	0.3760	
180 minute winter	SEPERATOR	1.002	HW01	26.3	1.054	0.237	3.1435	
180 minute winter	HW01	Flow through pond	HW02	24.6	0.046	0.002	65.6193	
180 minute winter	HW02	2.000	SW04-FCC	6.5	0.274	0.060	1.1026	
180 minute winter	SW04-FCC	Hydro-Brake®	HW03	5.0				105.5
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 30 year Critical Storm Duration. Lowest mass balance: 98.16%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.389	0.289	70.6	0.3269	0.0000	OK
120 minute winter	SW03	102	2.336	0.381	47.8	0.5451	0.0000	SURCHARGED
240 minute winter	SEPERATOR	216	2.335	0.445	35.0	0.6363	0.0000	SURCHARGED
240 minute winter	HW01	232	2.289	0.504	29.3	0.0000	0.0000	OK
240 minute winter	HW02	224	2.289	0.529	27.5	0.0000	0.0000	SURCHARGED
240 minute winter	SW04-FCC	224	2.289	0.559	6.3	0.8004	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	5.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	9	1.790	0.790	72.7	0.8935	6.4694	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	68.6	0.980	0.956	2.4104	
120 minute winter	SW03	1.001	SEPERATOR	47.1	0.973	0.432	0.5514	
240 minute winter	SEPERATOR	1.002	HW01	29.3	1.001	0.264	3.7225	
240 minute winter	HW01	Flow through pond	HW02	27.5	0.046	0.002	104.4015	
240 minute winter	HW02	2.000	SW04-FCC	6.3	0.280	0.058	1.1061	
240 minute winter	SW04-FCC	Hydro-Brake*	HW03	5.0				127.7
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 100 year Critical Storm Duration. Lowest mass balance: 98.16%

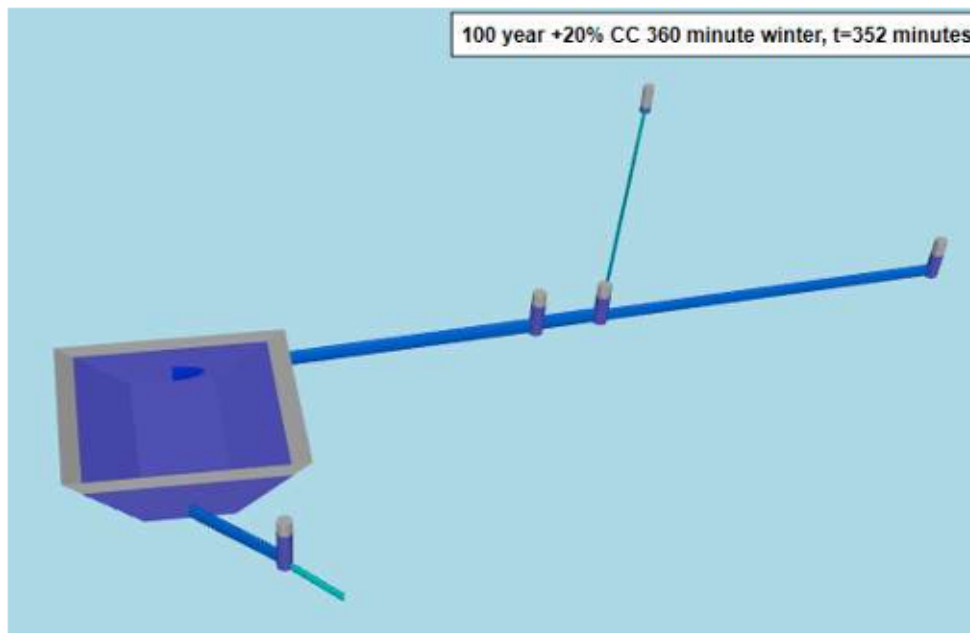
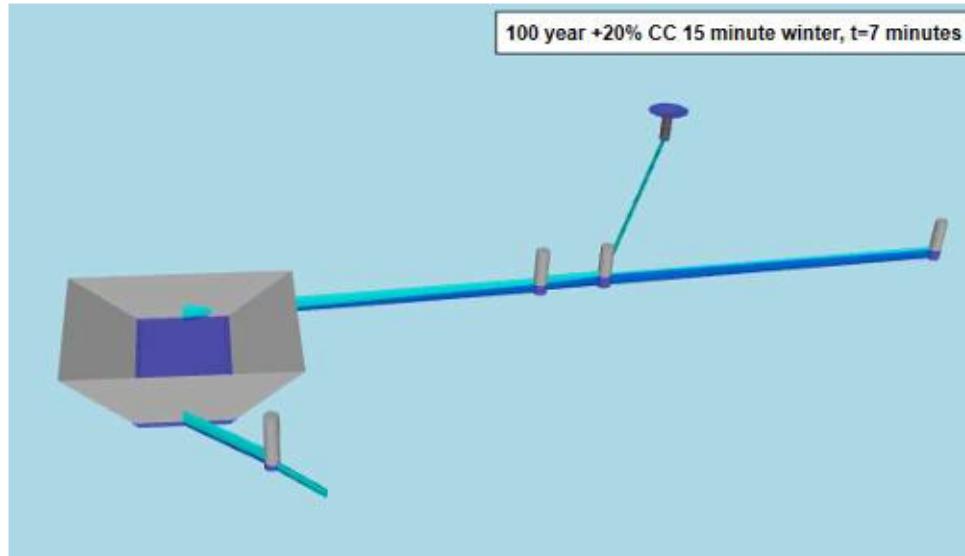
Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
360 minute winter	SW01	264	2.620	0.520	15.5	0.5876	0.0000	SURCHARGED
240 minute winter	SW03	192	2.610	0.655	51.5	0.9374	0.0000	SURCHARGED
240 minute winter	SEPERATOR	192	2.587	0.697	40.3	0.9975	0.0000	SURCHARGED
360 minute winter	HW01	352	2.535	0.750	34.6	0.0000	0.0000	OK
360 minute winter	HW02	352	2.535	0.775	32.1	0.0000	0.0000	SURCHARGED
360 minute winter	SW04-FCC	352	2.535	0.805	9.8	1.1526	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	5.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	8	1.790	0.790	96.6	0.8935	14.6786	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
360 minute winter	SW01	1.000	SW03	27.0	0.579	0.376	2.4262	
240 minute winter	SW03	1.001	SEPERATOR	40.3	0.875	0.370	0.5515	
240 minute winter	SEPERATOR	1.002	HW01	39.6	1.107	0.356	3.7225	
360 minute winter	HW01	Flow through pond	HW02	32.1	0.040	0.003	173.0733	
360 minute winter	HW02	2.000	SW04-FCC	9.8	0.244	0.090	1.1061	
360 minute winter	SW04-FCC	Hydro-Brake*	HW03	5.0				146.3
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 100 year +20% CC Critical Storm Duration. Lowest mass balance: 98.16%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
240 minute winter	SW01	220	2.765	0.665	24.8	0.7524	0.0000	SURCHARGED
240 minute winter	SW03	220	2.773	0.818	49.5	1.1701	0.0000	FLOOD RISK
240 minute winter	SEPERATOR	216	2.751	0.861	49.7	1.2325	0.0000	FLOOD RISK
360 minute winter	HW01	352	2.691	0.906	36.4	0.0000	0.0000	OK
360 minute winter	HW02	352	2.691	0.931	42.3	0.0000	0.0000	SURCHARGED
360 minute winter	SW04-FCC	352	2.691	0.961	7.1	1.3755	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	5.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	7	1.790	0.790	115.9	0.8935	22.4201	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
240 minute winter	SW01	1.000	SW03	24.0	0.632	0.335	2.4262	
240 minute winter	SW03	1.001	SEPERATOR	49.7	0.880	0.456	0.5515	
240 minute winter	SEPERATOR	1.002	HW01	48.8	1.128	0.439	3.7225	
360 minute winter	HW01	Flow through pond	HW02	42.3	0.039	0.003	222.8862	
360 minute winter	HW02	2.000	SW04-FCC	7.1	0.250	0.066	1.1061	
360 minute winter	SW04-FCC	Hydro-Brake*	HW03	5.0				145.8
15 minute winter	SW02-PUMP	Pump	SW03	40.0				



FEH Data 1:100 Year Maximum Water Level Graphic

FSR Rainfall Data Hydraulic Model Output

Simulation Settings

Rainfall Methodology	FSR	Summer CV	0.750	Drain Down Time (mins)	240
FSR Region	England and Wales	Winter CV	0.840	Additional Storage (m³/ha)	0.0
M5-60 (mm)	20.000	Analysis Speed	Normal	Check Discharge Rate(s)	x
Ratio-R	0.400	Skip Steady State	x	Check Discharge Volume	x

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)	Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
2	0	0	0	100	0	0	0
10	0	0	0	100	20	0	0
30	0	0	0				

Results for 2 year Critical Storm Duration. Lowest mass balance: 98.26%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.233	0.133	30.3	0.1505	0.0000	OK
15 minute winter	SW03	10	2.164	0.209	60.8	0.2992	0.0000	OK
15 minute winter	SEPERATOR	10	2.074	0.184	59.7	0.2631	0.0000	OK
120 minute winter	HW01	94	1.962	0.177	20.1	0.0000	0.0000	OK
120 minute winter	HW02	92	1.962	0.202	20.5	0.0000	0.0000	OK
120 minute winter	SW04-FCC	96	1.963	0.233	6.4	0.3340	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	4.5	0.0000	0.0000	OK
60 minute summer	SW02-PUMP	30	1.322	0.322	19.6	0.3646	0.0000	SURCHARGED

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	29.8	0.719	0.415	1.4226	
15 minute winter	SW03	1.001	SEPERATOR	59.7	1.044	0.548	0.2862	
15 minute winter	SEPERATOR	1.002	HW01	60.2	2.009	0.543	1.1651	
120 minute winter	HW01	Flow through pond	HW02	20.5	0.049	0.002	32.0469	
120 minute winter	HW02	2.000	SW04-FCC	6.4	0.271	0.059	0.6644	
120 minute winter	SW04-FCC	Hydro-Brake®	HW03	4.8				55.1
60 minute summer	SW02-PUMP	Pump	SW03	34.7				

Results for 10 year Critical Storm Duration. Lowest mass balance: 98.26%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.280	0.180	45.4	0.2040	0.0000	OK
15 minute winter	SW03	11	2.209	0.254	84.5	0.3638	0.0000	OK
15 minute winter	SEPERATOR	11	2.109	0.219	84.2	0.3138	0.0000	OK
120 minute winter	HW01	114	2.061	0.276	29.3	0.0000	0.0000	OK
120 minute winter	HW02	110	2.060	0.300	16.5	0.0000	0.0000	OK
120 minute winter	SW04-FCC	104	2.061	0.331	7.7	0.4732	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	4.8	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	11	1.790	0.790	46.7	0.8935	0.2314	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	44.5	0.815	0.620	1.8578	
15 minute winter	SW03	1.001	SEPERATOR	84.2	1.168	0.773	0.3600	
15 minute winter	SEPERATOR	1.002	HW01	84.5	2.182	0.761	1.7551	
120 minute winter	HW01	Flow through pond	HW02	16.5	0.057	0.001	51.6501	
120 minute winter	HW02	2.000	SW04-FCC	7.7	0.293	0.071	0.9906	
120 minute winter	SW04-FCC	Hydro-Brake®	HW03	5.0				80.4
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 30 year Critical Storm Duration. Lowest mass balance: 98.26%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.323	0.223	57.6	0.2526	0.0000	OK
15 minute winter	SW03	10	2.230	0.275	96.4	0.3936	0.0000	OK
180 minute winter	SEPERATOR	148	2.169	0.279	32.3	0.3992	0.0000	OK
120 minute winter	HW01	116	2.149	0.364	36.4	0.0000	0.0000	OK
120 minute winter	HW02	114	2.150	0.390	23.5	0.0000	0.0000	SURCHARGED
120 minute winter	SW04-FCC	114	2.150	0.420	6.2	0.6006	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	4.9	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	9	1.790	0.790	59.2	0.8935	3.4051	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	56.4	0.902	0.786	2.1345	
15 minute winter	SW03	1.001	SEPERATOR	95.9	1.223	0.880	0.3913	
180 minute winter	SEPERATOR	1.002	HW01	27.7	1.075	0.249	3.3059	
120 minute winter	HW01	Flow through pond	HW02	23.5	0.065	0.002	70.9009	
120 minute winter	HW02	2.000	SW04-FCC	6.2	0.280	0.057	1.1061	
120 minute winter	SW04-FCC	Hydro-Brake®	HW03	5.0				94.9
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 100 year Critical Storm Duration. Lowest mass balance: 98.26%

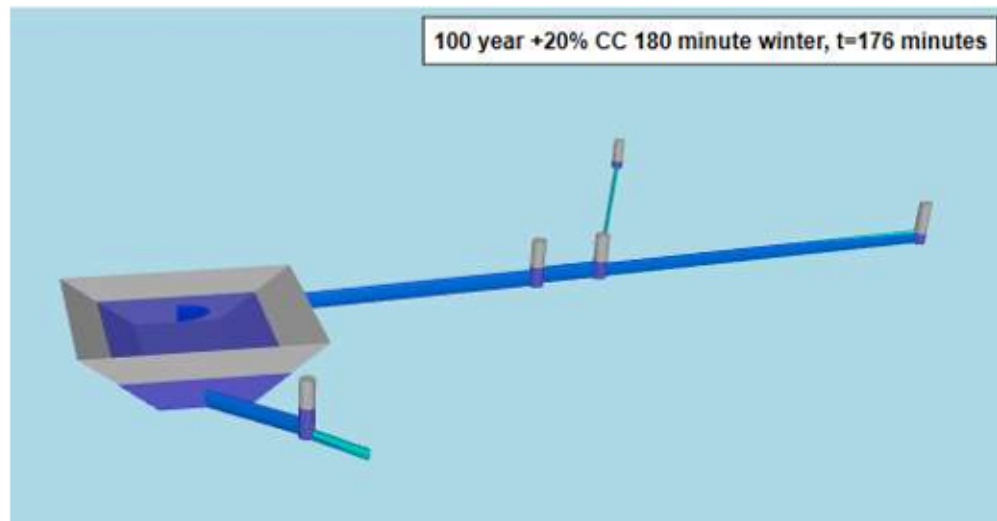
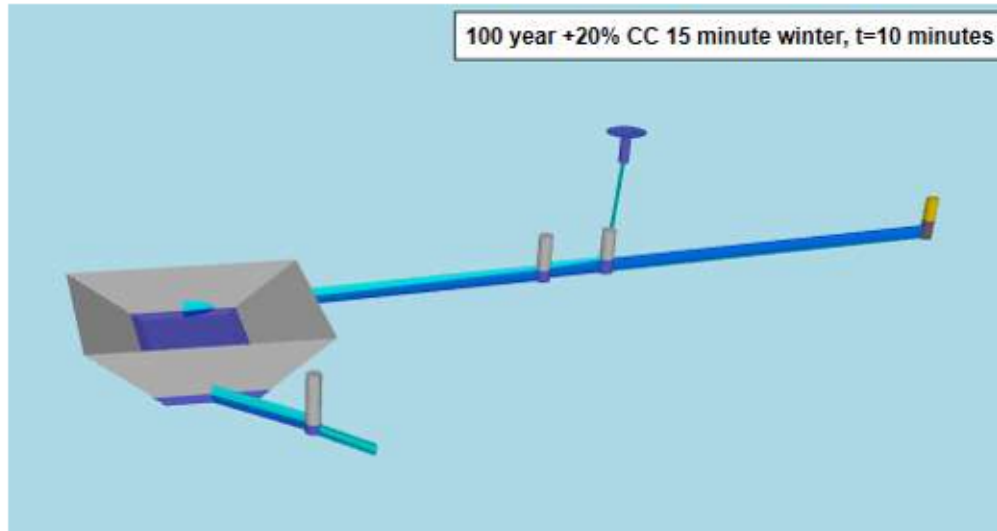
Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.451	0.351	74.7	0.3970	0.0000	SURCHARGED
120 minute winter	SW03	106	2.347	0.392	53.2	0.5611	0.0000	SURCHARGED
120 minute winter	SEPERATOR	106	2.332	0.442	49.0	0.6322	0.0000	SURCHARGED
180 minute winter	HW01	176	2.276	0.491	34.2	0.0000	0.0000	OK
180 minute winter	HW02	176	2.277	0.517	29.0	0.0000	0.0000	SURCHARGED
180 minute winter	SW04-FCC	176	2.277	0.547	7.4	0.7823	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	5.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	8	1.790	0.790	76.9	0.8935	8.7014	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	74.4	1.057	1.037	2.4262	
120 minute winter	SW03	1.001	SEPERATOR	49.0	0.978	0.450	0.5515	
120 minute winter	SEPERATOR	1.002	HW01	46.9	1.178	0.423	3.7225	
180 minute winter	HW01	Flow through pond	HW02	29.0	0.059	0.002	101.2165	
180 minute winter	HW02	2.000	SW04-FCC	7.4	0.262	0.068	1.1061	
180 minute winter	SW04-FCC	Hydro-Brake*	HW03	5.0				113.2
15 minute winter	SW02-PUMP	Pump	SW03	40.0				

Results for 100 year +20% CC Critical Storm Duration. Lowest mass balance: 98.26%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
15 minute winter	SW01	10	2.562	0.462	89.6	0.5228	0.0000	SURCHARGED
240 minute winter	SW03	220	2.421	0.466	46.6	0.6673	0.0000	SURCHARGED
240 minute winter	SEPERATOR	220	2.419	0.529	52.2	0.7564	0.0000	SURCHARGED
180 minute winter	HW01	176	2.386	0.601	40.3	0.0000	0.0000	OK
180 minute winter	HW02	176	2.386	0.626	28.3	0.0000	0.0000	SURCHARGED
180 minute winter	SW04-FCC	176	2.386	0.656	6.1	0.9385	0.0000	SURCHARGED
15 minute summer	HW03	1	1.685	0.000	5.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	8	1.790	0.790	92.2	0.8935	13.3608	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
15 minute winter	SW01	1.000	SW03	88.8	1.261	1.237	2.4262	
240 minute winter	SW03	1.001	SEPERATOR	52.2	0.885	0.479	0.5515	
240 minute winter	SEPERATOR	1.002	HW01	32.4	1.051	0.292	3.7225	
180 minute winter	HW01	Flow through pond	HW02	28.3	0.066	0.002	129.9553	
180 minute winter	HW02	2.000	SW04-FCC	6.1	0.287	0.056	1.1061	
180 minute winter	SW04-FCC	Hydro-Brake*	HW03	5.0				112.2
15 minute winter	SW02-PUMP	Pump	SW03	40.0				



FSR Data 1:100 Year Maximum Water Level Graphic

FEH Rainfall Data Surcharged Outfall Hydraulic Model Output

Design Settings

Rainfall Methodology	FEH-13	Minimum Velocity (m/s)	1.00
Return Period (years)	2	Connection Type	Level Soffits
Additional Flow (%)	0	Minimum Backdrop Height (m)	0.200
CV	0.750	Preferred Cover Depth (m)	1.200
Time of Entry (mins)	5.00	Include Intermediate Ground	✓
Maximum Time of Concentration (mins)	30.00	Enforce best practice design rules	x
Maximum Rainfall (mm/hr)	50.0		

Simulation Settings

Rainfall Methodology	FEH-13	Analysis Speed	Normal	Additional Storage (m³/ha)	0.0
Summer CV	0.750	Skip Steady State	x	Check Discharge Rate(s)	x
Winter CV	0.840	Drain Down Time (mins)	240	Check Discharge Volume	x

Storm Durations

15 | 30 | 60 | 120 | 180 | 240 | 360 | 480 | 600 | 720 | 960 | 1440

Return Period (years)	Climate Change (CC %)	Additional Area (A %)	Additional Flow (Q %)
100	20	0	0

Node HW03 Surcharged Outfall

Overrides Design Area	x	Depression Storage Area (m²)	0	Evapo-transpiration (mm/day)	0
Overrides Design Additional Inflow	x	Depression Storage Depth (mm)	0		

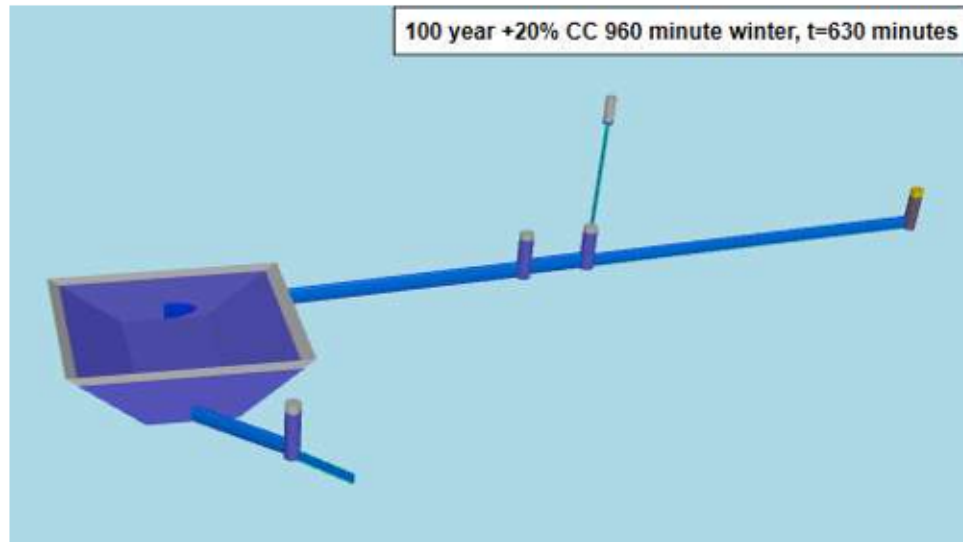
Applies to All storms

Time (mins)	Depth (m)	Time (mins)	Depth (m)
0	0.885	1440	0.885

Results for 100 year +20% CC Critical Storm Duration. Lowest mass balance: 99.08%

Node Event	US Node	Peak (mins)	Level (m)	Depth (m)	Inflow (l/s)	Node Vol (m³)	Flood (m³)	Status
960 minute winter	SW01	630	2.938	0.838	18.9	0.9475	0.0000	FLOOD RISK
960 minute winter	SW03	645	2.908	0.953	36.0	1.3631	0.0000	FLOOD RISK
960 minute winter	SEPERATOR	645	2.891	1.001	31.7	1.4322	0.0000	FLOOD RISK
720 minute winter	HW01	555	2.838	1.053	29.2	0.0000	0.0000	OK
720 minute winter	HW02	555	2.838	1.078	22.5	0.0000	0.0000	FLOOD RISK
720 minute winter	SW04-FCC	555	2.838	1.108	5.0	1.5857	0.0000	FLOOD RISK
15 minute summer	HW03	1	2.570	0.885	0.0	0.0000	0.0000	OK
15 minute winter	SW02-PUMP	7	1.790	0.790	115.9	0.8935	22.4253	FLOOD

Link Event (Upstream Depth)	US Node	Link	DS Node	Outflow (l/s)	Velocity (m/s)	Flow/Cap	Link Vol (m³)	Discharge Vol (m³)
960 minute winter	SW01	1.000	SW03	19.2	0.397	0.267	2.4262	
960 minute winter	SW03	1.001	SEPERATOR	31.7	0.608	0.291	0.5515	
960 minute winter	SEPERATOR	1.002	HW01	37.1	0.860	0.334	3.7225	
720 minute winter	HW01	Flow through pond	HW02	22.5	0.034	0.002	274.2448	
720 minute winter	HW02	2.000	SW04-FCC	5.0	0.046	0.046	1.1061	
720 minute winter	SW04-FCC	Hydro-Brake*	HW03	4.9				149.7
15 minute winter	SW02-PUMP	Pump	SW03	40.0				



FEH Data Surcharged 1:100 Year Maximum Water Level Graphic