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ENVIRONMENT

Ethical Partnership LLP
Land off North Road
West Boldon
Sustainable Drainage Statement

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ENVIRONMENT

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West Boldon
Sustainable Drainage Statement

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1. INTRODUCTION

1.1 A Sustainable Drainage Statement (SDS) sets out the principles of drainage design for a development and summarises the reasoning behind the chosen design. This includes consideration of national and local guidance, justification of specific flow rates, volumes of attenuated storage, as well as the appropriate level of treatment to be provided to surface water runoff.

1.2 This SDS has been produced by BWB Consulting on behalf of Ethical Partnership LLP LLP in respect of a site located off North Road, West Boldon. The report is intended to support an outline application for a proposed residential development that will comprise circa 37 houses and 9 apartments with associated parking and landscaping. Proposed plans, current at the time of writing, are included as **Appendix 1**.

1.3 A Flood Risk Assessment (FRA) has been produced for the site (reference NRB-BWB-ZZ-XX-RP-YE-0001_FRA) and this SDS accompanies this overarching document.

1.4 The site is located at Land off North Road, West Boldon. The site is bound to the north and west by the River Don, to the east by North Road and to the south by open land. The location of the site is illustrated within **Figure 1.1**, with contextual information provided within **Table 1.1**.

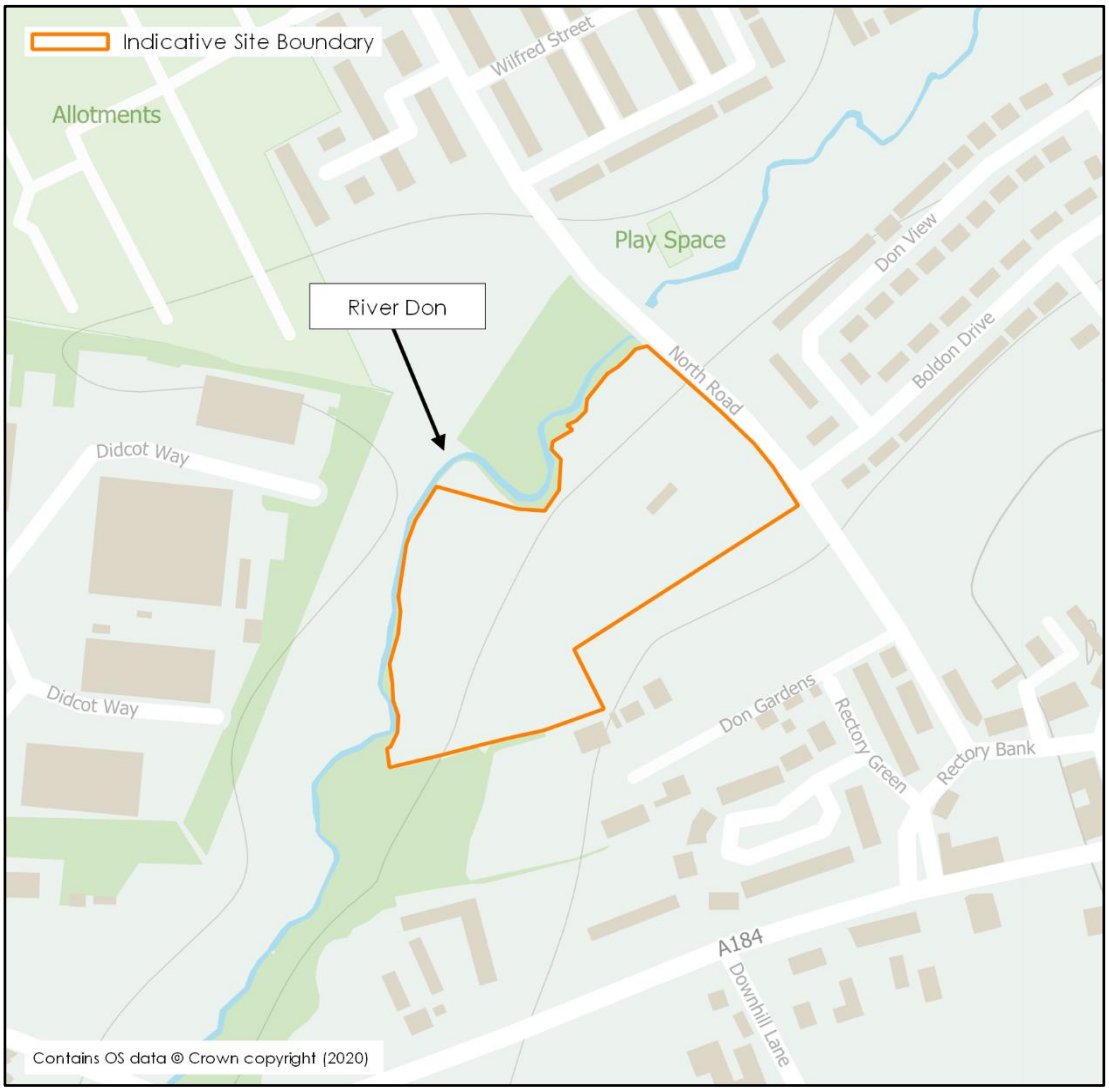


Figure 1.1: Site Location

Table 1.1: Site Details

Site Name	Land off North Road
Location	West Boldon
NGR (approx.)	NZ348612
Application Site Area (ha)	2.4 (approx.)
Development Area (ha)	1.79 (approx.)
Development Type	Residential
Lead Local Flood Authority	South Tyneside Council
Local Planning Authority	South Tyneside Council
Environment Agency Area	North East
Sewerage Undertaker	Northumbrian Water

Sustainable Drainage Guidance

1.5 SuDS aim to mimic a more natural runoff regime, managing rainfall close to where it falls. Surface flows are attenuated and discharged at a controlled rate, in contrast to more traditional drainage systems which convey water to a designated outfall as quickly as possible. SuDS permit water to be temporarily stored which enables a management of flood risk as well as a range of secondary benefits including improvement of water quality, increase in biodiversity, provision of green space and maintenance of groundwater recharge.

1.6 South Tyneside, in their role as Lead Local Flood Authority (LLFA), do not have any specific SuDS guidance to inform planning applications and in the absence of further information, the Non-Statutory Technical Standards for Sustainable Drainage Systems[1] as published by DEFRA and the CIRIA SuDS Manual[2] have been utilised to inform the strategy.

[1] 2015, DEFRA. Non-statutory technical standards for sustainable drainage systems
[2] The SuDS Manual (C753). CIRIA 2015.

2. EXISTING CONDITIONS

2.1 The existing site is considered to be greenfield, comprising of open agricultural fields with a building located within the east of the site.

2.2 A topographical survey of the existing site has been undertaken and is included as **Appendix 2**. The existing site is shown to generally fall in a north westerly direction, towards the River Don. Existing site levels are shown to range from approximately 26.5m Above Ordnance Datum (AOD) in the north west to 39.2m AOD in the south.

2.3 British Geological Survey (BGS) mapping shows the site to be underlain by Pennine Upper Coal Measures Formation (Mudstone, Siltstone and Sandstone) to the west of the site and Pennine Upper Coal Measures Formation (Sandstone) to the east of the site, which are both designated by the Environment Agency (EA) 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.

2.4 Superficial deposits of Pelaw Clay Member, Alluvium (Clay, Silt, Sand and Gravel) and Till (Devensian - Diamicton) are expected to be present throughout the site. Alluvium is designated by the EA as a Secondary A Aquifer, Till is designated as a Secondary (undifferentiated) Aquifer and Pelaw Clay Member is designated as Unproductive Strata.

- Secondary (undifferentiated) Aquifers have been assigned in cases where it has not been possible to attribute either category A or B to a rock type.
- Unproductive Strata are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

2.5 The topographic survey shows no evidence that the site is positively drained and therefore, the existing drainage regime is considered to be generally characteristic of an undeveloped site, with infiltration into the ground, followed by rapid overland flow when the infiltration potential is exceeded. Overland flow routes in the site follow the natural fall of the site and generally flow in a north westerly direction towards the River Don.

Existing Runoff Rates

2.6 An assessment of the equivalent surface water runoff rates from the approximate developable area (1.79ha) has been undertaken. The results are summarised within **Table 2.1**. Calculations are included within **Appendix 3**.

2.7 The runoff rates have been estimated using the IH124 method, with appropriate prorated adjustments for a site of less than 50ha, as recommended in Interim Code of Practice for Sustainable Drainage[3]. This was undertaken within Micro Drainage, which makes the necessary adjustments for small sites automatically.

[3] The National SUDS Working Group (2004), Interim Code of Practice for Sustainable Drainage

Table 2.1: Existing Runoff Rate from the Site

Return Period (Yrs.)	Runoff Rate (l/s)
1	6.5
Mean Annual Flow Rate (QBAR)	7.6
30	13.4
100	15.8

Existing Runoff Volume

2.8 An assessment of the existing surface water runoff rates from the developable area (1.79ha) has been made for a 1 in 100-year, 6 hour storm.

2.9 As the existing site is permeable, the runoff volume has been calculated using the Source Control module within Micro Drainage to be 346.1m^3, results are included within **Appendix 3**.

3. SURFACE WATER DRAINAGE STRATEGY

3.1 The site has an approximate total area of 2.4ha. The proposed developable area of 1.79ha has been measured based on the redline boundary of the proposed plans, included as **Appendix 1**. A total impermeable area of 1.06ha has been measured from the proposed plans.

Drainage Hierarchy

3.2 The Planning Policy Guidance[4] and the SuDS Manual[5] identify that surface water runoff from a development should be disposed of as high up the following hierarchy as reasonably practicable:

i. into the ground (infiltration);
ii. to a surface water body;
iii. to a surface water sewer, highway drain, or another drainage system;
iv. to a combined sewer.

3.3 The aim of this is approach is to manage surface water runoff close to where it falls and mimic natural drainage as closely as possible.

3.4 The Phase 1 Geo-Environment Assessment (ref: NRB-BWB-ZZ-XX-RP-YE-0001-Ph1) undertaken by BWB Consulting in February 2020 notes that a soakaway drainage solution may be possible within the Alluvium and Till deposits present on site. However, they are not consistent across the entire site. Soakaways may also be a viable option within the bedrock depending on the extent of the weathering of the underlying mudstone, siltstone and sandstone. Site specific infiltration testing in accordance with BRE 365 guidance should be undertaken to confirm this assumption. For the purpose of this assessment, a worst-case scenario is presented that demonstrates that an alternative outfall is available if infiltration is proven to not be viable.

3.5 In line with the second tier of the drainage hierarchy and assuming infiltration is not viable, the River Don which forms the western and northern site boundary is the preferable surface water outfall for the development. Given the existing topography, a gravity connection from the entire site to the River Don should be possible.

3.6 For the purpose of outlining proposed attenuation requirements, the site has been split into two catchments with the catchment details included within **Table 3.1**.

Table 3.1: Impermeable Areas

Catchment	Developable Area (ha)	Impermeable Area (ha)
1	0.31	0.21
2	1.48	0.85

[4] Planning Practice Guidance. http://planningguidance.planningportal.gov.uk/.
[5] The SuDS Manual (C753). CIRIA 2015.

Peak Flow Control

3.7 In order to comply with the Non-Statutory Technical Standards for Sustainable Drainage Systems S2-S3[6], runoff from greenfield developments should not exceed the equivalent greenfield rates for the 1 in 1-year and 100-year return period events.

3.8 It is therefore proposed to restrict the 1 in 1-year discharge rate from the development to the receiving watercourse at the equivalent greenfield 1 in 1-year rate. All other rainfall events will be restricted to the equivalent greenfield QBAR rate up to the 1 in 100-year plus climate change event. This is summarised within **Table 3.2**.

Table 3.2: Existing & Proposed Runoff Rates

Return Period (Yr.)	Existing Runoff Rate (l/s)	Proposed Discharge Rate (l/s)
1	6.5	6.5
QBAR	7.6	7.6
30	13.4	
100	15.8	
100 + 40%	-	

Attenuated Storage

3.9 As the development proposals require a restricted runoff rate, it will be necessary to provide attenuated storage to balance the excess volume in a safe manner within the site.

3.10 The surface water storage should be located within the site in a position where it can receive runoff from the development and discharge from the site by gravity, and also is a position where it is hydraulically isolated from any fluvial floodplain or external surface water floodplain/overland flow route that may be present in the site.

3.11 Sufficient storage for events up to the 1 in 100-year storm with an allowance for climate change should be provided, and an allowance should be applied to the current proposed development area to allow for urban creep over the lifetime of the development.

3.12 As South Tyneside Council does not have any specific guidance on urban creep, an increase of 10% will be used as recommended within the SuDS Manual if there is no specified value stipulated, to allow for future urban expansion within the development.

3.13 A 40% allowance for climate change has been used, in line with the latest national guidance regarding climate change[7].

[6] 2015, DEFRA. Non-statutory technical standards for sustainable drainage systems
[7] Environment Agency, Flood risk assessments: climate change allowances: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#history

3.14 After considering the site constraints and development aspirations it is suggested that the necessary surface water storage volume is found within underground cellular storage tanks, located beneath the proposed roads.

3.15 For the purpose of this outline assessment, it has been assumed that the attenuation tanks will accommodate all of the necessary storage, but it may be possible to redistribute a portion of the storage within other drainage components during the detailed design of the development (e.g.: in the pipe network, swales, filter drains, permeable paving etc).

3.16 A simulation has been run using Micro Drainage 'Source Control-Cascade' function, to identify the necessary storage provision. Using a total site restriction of 7.6l/s and applying a 10% urban creep allowance to the proposed impermeable areas, the volume of attenuated storage required for each catchment has been calculated for storm events up to the 100 year + 40% climate change storm. The results are summarised in **Table 3.3** and calculations are included as **Appendix 4**.

Table 3.3: Outline Attenuated Storage Requirements

Catchment	Rainfall Method	Impermeable Area + 10% Urban Creep (ha)	Critical Storm	Maximum Volume (m^3)
1	FSR	0.23	360 min Winter	120
	FEH		480 min Winter	126
2	FSR	0.94	960 min Winter	645
	FEH		1440 min Winter	714

3.17 At this outline design stage it is expected that a minimum of 126m^3 of attenuated storage will be provided for Catchment 1 and a minimum of 714m^3 of attenuated storage will be provided for Catchment 2 to cater for the maximum anticipated runoff volume for all storm durations up to the 1 in 100-year return period storm, including a 40% climate change allowance and future urban creep.

3.18 It is envisaged that the final required attenuated storage volume will be determined during the detailed design stage, once the development layout and drainage areas are fixed.

Runoff Volume Control

3.19 The Non-Statutory Technical Standards for Sustainable Drainage Systems S4-S6[8] states that where reasonable practical the runoff volume from a development for the 1 in 100-year 6 hour rainfall event should not exceed the runoff volume prior to development or redevelopment.

[8] 2015, DEFRA. Non-statutory technical standards for sustainable drainage systems

3.20 Where it is not reasonably practicable to constrain the volume of runoff from a development at or below the existing volume, then the runoff must be discharged in a manner that does not adversely affect flood risk, i.e.:

i. The additional runoff volume resulting from the development (the 'long term storage volume') should be discharged separately from the site at a rate of 2l/s/ha or less. Or,

ii. All the runoff volume from the development should be discharged at a rate equivalent to the mean annual flow rate (QBAR) rate under greenfield conditions or less. Or,

iii. All the runoff volume from the development should be discharged at a rate of 2l/s/ha or less.

3.21 An estimate of the post-development runoff volume for the whole site from the 1 in 100-year 6 hour storm can be derived from the Micro Drainage calculations. The existing and post-development runoff volumes are compared within **Table 3.4**.

Table 3.4: Runoff Volume Comparison

Existing Volume (m^3)	Proposed Volume (m^3)	Difference (m^3)
346	512	+166

3.22 The 1 in 100-year 6 hour storm runoff volume from the site has been shown to increase as a result of the proposed development. However, as the runoff volume from the development will be discharged at a rate equivalent to the mean annual flow rate (QBAR) rate under greenfield conditions, the volume control criteria will be met.

3.23 It is proposed to discharge the runoff from the development at a rate equivalent to the mean annual flow rate (QBAR) rate under greenfield conditions or less. Therefore, provision for long term storage is not required.

Sustainable Drainage Systems

3.24 SuDS mimic natural drainage processes to reduce the effect on the quality and quantity of runoff from developments and provide amenity and biodiversity benefits.

3.25 After considering the site constraints and development aspirations it is suggested that the necessary surface water storage volume is found within two underground cellular storage tanks, located beneath the proposed roads within each catchment with an allowance of 1m cover above.

3.26 It has been assumed that the site levels will be altered so that the highways will be lower than the developments plateaus either side, in order to allow for surface water to drain to the below ground attenuation prior to discharging to the watercourse. An earthwork (cut and fill) exercise should be undertaken in order to confirm the areas of cut and fill.

3.27 It is proposed that the tank located within Catchment 1 outfalls to the tank within Catchment 2 at a restriction of 3.0l/s. The attenuation tank located in Catchment 2 will outfall to the River Don at a restriction of the QBAR rate of 7.6l/s, thus ensuring a single restriction rate and point of discharge for the site.

3.28 An Illustrative Surface Water Drainage Strategy is presented within Appendix 5 (Drawing Reference NRB-BWB-ZZ-XX-DR-CD-0001). The drawing demonstrates that the required storage volume from the development parcels can be achieved within the site boundary.

3.29 Below is a list of potential SuDS features that could be utilised within the development:

- Sump outfall units/gullies
- Permeable paving
- Proprietary vortex separators
- Filter drains
- Tree pits

3.30 The precise details of the drainage network including levels, volumes and the exact form of attenuation/SuDS features will be determined during the detailed design stage, when the development layout is formalised.

Residual Risk and Designing for Exceedance

3.31 It is recommended that the final layout uses the proposed road infrastructure to provide drainage exceedance (overland flood flow) routes through the development and towards positively drained areas.

3.32 In the event that the capacity of the attenuated storage is exceeded, flood water will be directed away from buildings and pool within any car parking areas and highways.

3.33 In addition to the volume of storage provided within the main attenuation, there will be capacity within upstream pipes and manholes which has not been accounted for at this stage and a further level of redundancy to the network will therefore be provided.

4. FOUL WATER DRAINAGE

4.1 It is proposed to drain used water from the development separately to surface water.

4.2 An estimation of the proposed foul water outflow from the development has been made using the guidance in Design and Construction Guidance[9]. For residential developments this is 4000l/dwelling/day (0.05 litres per second per dwelling) and the proposed peak flow rate is therefore approximately 2.3l/s, based on 46 dwellings.

4.3 It is recommended that a pre-development enquiry is submitted to Northumbrian Water at the earliest possible convenience in order to determine the capacity of the local network and any improvements that may need to be undertaken in order to accommodate the expected flows from the development.

4.4 It is expected that a connection could be made to the existing 450mm diameter combined sewer located within North Road. However, it should be noted that a pumped solution may be required, this can be confirmed following clarity on development levels.

4.5 In the event that a gravity connection from the whole development cannot be made, foul pumping station(s) will be required. Any foul pumping stations should be located in the lowest developable area of the catchment that they serve, so a gravity connection to the pumping station can be achieved. The pumping stations should be constructed in accordance with adoptable standards including vehicular access and a 15m cordon sanitaire from to habitable dwellings.

[9] Design and Construction Guidance for foul and surface water sewers, Water UK (March 2020)

5. MAINTENANCE

5.1 Unless adopted, a management company should be appointed to maintain the SuDS features, including vegetation maintenance, trash screen clearing and regular outfall inspections.

5.2 Requirements for ongoing maintenance of the drainage network should form part of the Operation and Maintenance manual for the site and should be undertaken by the site management. Any specialist or proprietary products that are specified at detailed design should have a manufacturer specific maintenance regime which should be included within the document.

5.3 It is envisaged that the Operation and Maintenance manual will be developed at the detailed design stage, but some examples are included below.

i. All drainage features should be located in open areas which are readily accessible.
ii. Gullies should be inspected and de-silted at least once a year, where necessary.
iii. Pipes, manholes and silt traps should be inspected and de-silted at least once a year, where necessary.
iv. If permeable paving is incorporated within the layout, it should be swept a minimum of every 6 months to maintain flow capacity of the joints between blocks.
v. Hydro-brakes should be inspected every 6 months, litter/debris and silt build up should be removed as necessary.

6. SUMMARY

6.1 This statement and supporting appendices demonstrate that the drainage design for the development will comply with the relevant local and national standards, specifically the hierarchy of discharge, runoff rate and volume criterion.

6.2 This SDS is intended to support an outline planning application and as such the level of detail included is commensurate and subject to the nature of the proposals.

Table 6.1: Sustainable Drainage Statement Summary

		Existing Site	Proposed Development
Site Area (Ha)		2.4 (approx.)	
Development Area (ha)		1.79 (approx.)	
Impermeable Area (Ha)		-	1.06
Outfall Location		Watercourse/Infiltration	Watercourse
Peak Runoff Rate (l/s)	**QBAR**	7.6	7.6
	1 in 30-Year	13.4	
	1 in 100-Year	15.8	
	1 in 100-Year + CC	-	
Infiltration Rate		N/A	N/A
Runoff Volume (100yr RP 6 hour Storm)		346m^3	512m^3
Volume Control		-	Discharge rate limited to QBAR
Proposed Storage Volume		-	840m^3
Interception Volume		-	90m^3
Flow Control Type		-	Vortex
SuDS Features		-	Geo-cellular Storage Petrol Interceptor (Potential additional SuDS, Filters Drains & Tree Pits TBC)
Maintenance Responsibility		-	Management Company

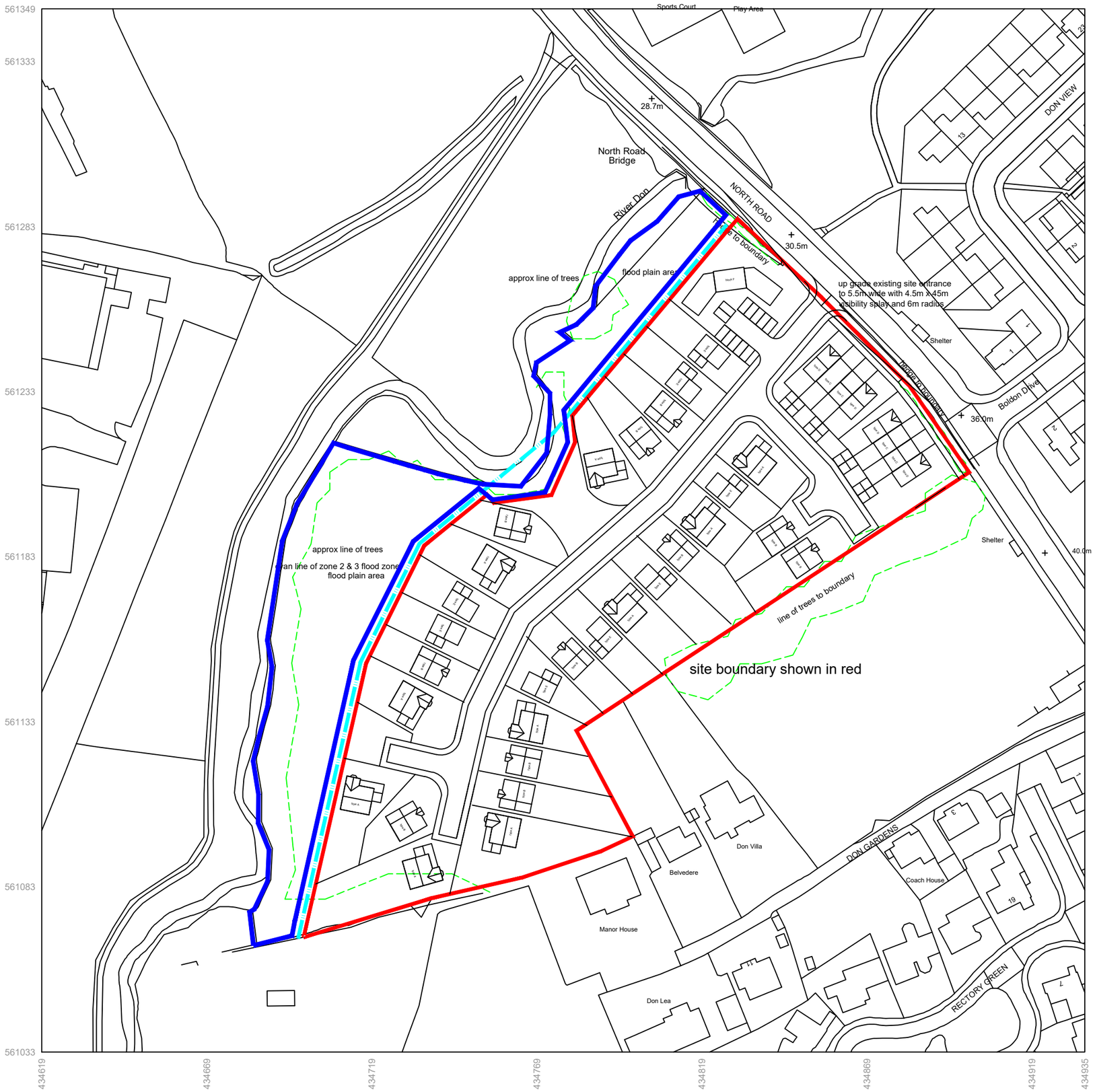
6.3 It is proposed that runoff from the site is restricted to QBAR with discharge being to the River Don to the north of the site.

6.4 Attenuation is proposed to be provided within two below ground cellular storage tanks in which one tank outfalls to the other. The storage is sized to accommodate up to and including the 1 in 100-year + 40% climate change storm.

6.5 It is envisaged that the final drainage strategy will be determined during the detailed design stage, as the development layout is finalised.

APPENDICES

Appendix 1: Proposed Plans



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PROJECT
Land North Road, West Boldon

DRAWING TITLE
proposed plan

DATE	SCALE	JOB NO.	DRAWING NO.	REV.
04.12.19	1250@ A3	19085	02	*

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Dimensions to be confirmed on site before work commences & ordering of materials. Any discrepancies must be reported to Architect before any work is undertaken. This drawing is to be read in conjunction with relevant consultants information and specifications.

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Appendix 2: Topographical Survey

Station Coordinates			
Station Name	Eastings (m)	Northings (m)	Height (m)
BWB01	434863.347	561268.637	31.977
BWB02	434909.354	561215.659	37.188
BWB03	434834.031	561296.559	29.807



Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the os coordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Legend

- OS Buildings
- Surveyed Buildings
- Building
- Wall
- Kerb Channel Line
- Top of Kerb
- Edge of Surface
- Top of Bank
- Bottom of Bank
- Canopy / Overhang
- Line Marking
- Centre Line
- Watercourse Centre Line
- Barrier
- Fence
- Gate
- Overhead Powerline
- Overhead Utilities
- Contour Lines
- Inspection Chamber
- 0.25 Flow direction and pipe diameter
- 1 Station and Name
- BH 1 Monitoring Borehole
- Tree / Bush / Sapling
- Area of Vegetation/ Extent of Tree Canopy
- Hedge
- Body of Water
- Body of Water from OS
- +50.00 Spot Level
- Assumed Surface Water Drainage Line
- Surface Water Drainage Line

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BG	Back Gully	FCB	Fence Closed Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mkr	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PB	Post Box
C	Crest	FMR	Fence Metal Railing	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker Post	FPW	Fence Post & Wire	SP	Sign Post
		FSP	Fence Steel Palisade	ST	Stop Tap
CCTV	Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve
CTV	Cable TV	FFL	Finished Floor Level	TCB	Telephone Call Box
DC	Drainage Channel	FP	Flagpole		
		Gas	Gas	THL	Threshold Level
DK	Drop Kerb	GV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Elec	Electric	Ht	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Rod	IFL	Internal Floor Level	WL	Water Level
FH	Fire Hydrant	IL	Invert Level (as a reduced level)	WM	Water Meter
FL	Floodlight			WO	Wash Out

Rev	Date	Details of issue / revision	Drw	Rev
P2	17.09.20	Trees added	SDS	DS
P1	07.08.20	First Issue	SDS	DS

Issues & Revisions

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Client
Ethical Planning (North East) Ltd

Project Title
Land off North Road, West Boldon

Drawing Title
Existing Site 2D Plan

Drawn:	S D Shreeves	Reviewed:	D. Smith
BWB Ref: MCW2139	Date: 07.08.20	Scale@A1:	1:500

Drawing Status
INFORMATION

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NRB-BWB-00-ZZ-DR-G-001	S2	P2

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C:\Users\Daniel.smith\Desktop\Ongoing Work Dan\MCW2139 - West Boldon\NRB-BWB-00-ZZ-M2-G-001-Existing-Site-2D-Model.dwg

Appendix 3: Greenfield Runoff Rate and Runoff Volume

ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	Soil	0.450
Area (ha)	1.790	Urban	0.000
SAAR (mm)	680	Region Number	Region 3

Results l/s

QBAR Rural	7.6
QBAR Urban	7.6
Q1 year	6.5
Q1 year	6.5
Q30 years	13.4
Q100 years	15.8

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Greenfield Runoff Volume

FEH Data

Return Period (years)	100
Storm Duration (mins)	360
FEH Rainfall Version	1999
Site Location	GB 434850 561350 NZ 34850 61350
C (1km)	-0.022
D1 (1km)	0.396
D2 (1km)	0.381
D3 (1km)	0.284
E (1km)	0.276
F (1km)	2.343
Areal Reduction Factor	1.00
Area (ha)	1.790
SAAR (mm)	648
CWI	95.640
SPR Host	31.170
URBEXT (1990)	0.1123

Results

Percentage Runoff (%)	30.76
Greenfield Runoff Volume (m^3)	346.127

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Appendix 4: Micro Drainage Attenuation Calculations

Cascade Summary of Results for Catchment 1 FSR.srcx

Upstream Structures	Outflow To	Overflow To
(None)	Catchment 2 FSR.srcx	Catchment 2 FSR.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	29.603	0.303	2.9	48.4	O K
30 min Summer	29.703	0.403	2.9	64.4	O K
60 min Summer	29.803	0.503	2.9	80.5	O K
120 min Summer	29.891	0.591	2.9	94.6	O K
180 min Summer	29.928	0.628	2.9	100.5	O K
240 min Summer	29.941	0.641	2.9	102.6	O K
360 min Summer	29.936	0.636	2.9	101.8	O K
480 min Summer	29.925	0.625	2.9	100.0	O K
600 min Summer	29.910	0.610	2.9	97.7	O K
720 min Summer	29.894	0.594	2.9	95.0	O K
960 min Summer	29.859	0.559	2.9	89.4	O K
1440 min Summer	29.788	0.488	2.9	78.0	O K
2160 min Summer	29.691	0.391	2.9	62.6	O K
2880 min Summer	29.612	0.312	2.9	49.9	O K
4320 min Summer	29.505	0.205	2.8	32.7	O K
5760 min Summer	29.443	0.143	2.6	22.9	O K
7200 min Summer	29.409	0.109	2.4	17.5	O K
8640 min Summer	29.394	0.094	2.2	15.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.882	0.0	50.6	25
30 min Summer	79.966	0.0	68.2	39
60 min Summer	51.407	0.0	88.3	68
120 min Summer	31.968	0.0	109.9	126
180 min Summer	23.880	0.0	123.2	184
240 min Summer	19.289	0.0	132.7	242
360 min Summer	14.172	0.0	146.3	320
480 min Summer	11.393	0.0	156.8	380
600 min Summer	9.611	0.0	165.3	442
720 min Summer	8.359	0.0	172.6	506
960 min Summer	6.701	0.0	184.4	642
1440 min Summer	4.898	0.0	202.2	908
2160 min Summer	3.572	0.0	221.6	1288
2880 min Summer	2.852	0.0	235.9	1652
4320 min Summer	2.073	0.0	256.9	2340
5760 min Summer	1.651	0.0	273.2	3048
7200 min Summer	1.382	0.0	286.0	3688
8640 min Summer	1.195	0.0	296.7	4416

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Cascade Summary of Results for Catchment 1 FSR.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	29.384	0.084	1.9	13.4	O K
15 min Winter	29.641	0.341	2.9	54.5	O K
30 min Winter	29.754	0.454	2.9	72.6	O K
60 min Winter	29.869	0.569	2.9	91.0	O K
120 min Winter	29.975	0.675	2.9	108.1	O K
180 min Winter	30.024	0.724	2.9	115.9	O K
240 min Winter	30.046	0.746	2.9	119.3	O K
360 min Winter	30.050	0.750	2.9	120.0	O K
480 min Winter	30.036	0.736	2.9	117.7	O K
600 min Winter	30.012	0.712	2.9	113.9	O K
720 min Winter	29.987	0.687	2.9	109.9	O K
960 min Winter	29.931	0.631	2.9	101.0	O K
1440 min Winter	29.817	0.517	2.9	82.8	O K
2160 min Winter	29.670	0.370	2.9	59.1	O K
2880 min Winter	29.560	0.260	2.9	41.6	O K
4320 min Winter	29.439	0.139	2.6	22.3	O K
5760 min Winter	29.396	0.096	2.2	15.3	O K
7200 min Winter	29.380	0.080	1.9	12.8	O K
8640 min Winter	29.370	0.070	1.6	11.2	O K
10080 min Winter	29.364	0.064	1.4	10.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.058	0.0	306.1	5144
15 min Winter	118.882	0.0	56.7	25
30 min Winter	79.966	0.0	76.5	39
60 min Winter	51.407	0.0	99.0	68
120 min Winter	31.968	0.0	123.1	124
180 min Winter	23.880	0.0	138.0	182
240 min Winter	19.289	0.0	148.7	238
360 min Winter	14.172	0.0	163.8	350
480 min Winter	11.393	0.0	175.6	454
600 min Winter	9.611	0.0	185.2	498
720 min Winter	8.359	0.0	193.3	562
960 min Winter	6.701	0.0	206.6	706
1440 min Winter	4.898	0.0	226.5	984
2160 min Winter	3.572	0.0	248.3	1368
2880 min Winter	2.852	0.0	264.2	1712
4320 min Winter	2.073	0.0	287.8	2380
5760 min Winter	1.651	0.0	306.0	3000
7200 min Winter	1.382	0.0	320.3	3688
8640 min Winter	1.195	0.0	332.3	4408
10080 min Winter	1.058	0.0	343.0	5144

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Cascade Rainfall Details for Catchment 1 FSR.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.200	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.230

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.077	4	8	0.077	8	12	0.077

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Cascade Model Details for Catchment 1 FSR.srcx

Storage is Online Cover Level (m) 31.500

Tank or Pond Structure

Invert Level (m) 29.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	160.0	1.200	160.0	1.201	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0079-3000-1200-3000
Design Head (m)	1.200
Design Flow (l/s)	3.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	79
Invert Level (m)	29.300
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.0
Flush-Flo™	0.348	2.9
Kick-Flo®	0.707	2.4
Mean Flow over Head Range	-	2.6

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	2.3	1.200	3.0	3.000	4.6	7.000	6.8
0.200	2.8	1.400	3.2	3.500	4.9	7.500	7.0
0.300	2.9	1.600	3.4	4.000	5.2	8.000	7.3
0.400	2.9	1.800	3.6	4.500	5.5	8.500	7.5
0.500	2.8	2.000	3.8	5.000	5.8	9.000	7.7
0.600	2.7	2.200	4.0	5.500	6.1	9.500	7.9
0.800	2.5	2.400	4.1	6.000	6.3		
1.000	2.8	2.600	4.3	6.500	6.6		

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Cascade Summary of Results for Catchment 1.srcx

Upstream Structures	Outflow To	Overflow To
(None)	Catchment 2.srcx	Catchment 2.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	29.653	0.353	2.9	56.5	O K
30 min Summer	29.727	0.427	2.9	68.3	O K
60 min Summer	29.808	0.508	2.9	81.3	O K
120 min Summer	29.888	0.588	2.9	94.1	O K
180 min Summer	29.929	0.629	2.9	100.6	O K
240 min Summer	29.952	0.652	2.9	104.2	O K
360 min Summer	29.968	0.668	2.9	106.9	O K
480 min Summer	29.972	0.672	2.9	107.5	O K
600 min Summer	29.969	0.669	2.9	107.0	O K
720 min Summer	29.962	0.662	2.9	106.0	O K
960 min Summer	29.939	0.639	2.9	102.2	O K
1440 min Summer	29.884	0.584	2.9	93.4	O K
2160 min Summer	29.800	0.500	2.9	80.0	O K
2880 min Summer	29.723	0.423	2.9	67.7	O K
4320 min Summer	29.575	0.275	2.9	44.0	O K
5760 min Summer	29.488	0.188	2.7	30.1	O K
7200 min Summer	29.438	0.138	2.5	22.0	O K
8640 min Summer	29.408	0.108	2.4	17.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.928	0.0	58.8	25
30 min Summer	84.599	0.0	72.2	39
60 min Summer	51.889	0.0	89.2	68
120 min Summer	31.827	0.0	109.4	126
180 min Summer	23.912	0.0	123.4	184
240 min Summer	19.521	0.0	134.3	242
360 min Summer	14.666	0.0	151.4	338
480 min Summer	11.973	0.0	164.8	400
600 min Summer	10.230	0.0	176.0	462
720 min Summer	8.996	0.0	185.7	526
960 min Summer	7.312	0.0	201.3	660
1440 min Summer	5.461	0.0	225.4	928
2160 min Summer	4.078	0.0	253.0	1324
2880 min Summer	3.315	0.0	274.2	1704
4320 min Summer	2.380	0.0	295.0	2388
5760 min Summer	1.881	0.0	311.4	3064
7200 min Summer	1.568	0.0	324.3	3752
8640 min Summer	1.351	0.0	335.2	4416

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Cascade Summary of Results for Catchment 1.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	29.395	0.095	2.2	15.1	O K
15 min Winter	29.698	0.398	2.9	63.6	O K
30 min Winter	29.782	0.482	2.9	77.0	O K
60 min Winter	29.875	0.575	2.9	92.0	O K
120 min Winter	29.972	0.672	2.9	107.5	O K
180 min Winter	30.026	0.726	2.9	116.1	O K
240 min Winter	30.057	0.757	2.9	121.1	O K
360 min Winter	30.084	0.784	2.9	125.4	O K
480 min Winter	30.087	0.787	2.9	125.9	O K
600 min Winter	30.078	0.778	2.9	124.6	O K
720 min Winter	30.070	0.770	2.9	123.2	O K
960 min Winter	30.037	0.737	2.9	118.0	O K
1440 min Winter	29.942	0.642	2.9	102.7	O K
2160 min Winter	29.799	0.499	2.9	79.8	O K
2880 min Winter	29.679	0.379	2.9	60.6	O K
4320 min Winter	29.496	0.196	2.8	31.3	O K
5760 min Winter	29.417	0.117	2.4	18.7	O K
7200 min Winter	29.391	0.091	2.1	14.6	O K
8640 min Winter	29.378	0.078	1.8	12.5	O K
10080 min Winter	29.370	0.070	1.6	11.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.191	0.0	344.6	5144
15 min Winter	137.928	0.0	65.9	25
30 min Winter	84.599	0.0	80.9	39
60 min Winter	51.889	0.0	99.9	68
120 min Winter	31.827	0.0	122.6	124
180 min Winter	23.912	0.0	138.2	182
240 min Winter	19.521	0.0	150.4	238
360 min Winter	14.666	0.0	169.6	350
480 min Winter	11.973	0.0	184.6	456
600 min Winter	10.230	0.0	197.1	508
720 min Winter	8.996	0.0	208.0	572
960 min Winter	7.312	0.0	225.4	730
1440 min Winter	5.461	0.0	252.4	1020
2160 min Winter	4.078	0.0	283.4	1416
2880 min Winter	3.315	0.0	307.1	1792
4320 min Winter	2.380	0.0	330.5	2432
5760 min Winter	1.881	0.0	348.8	3064
7200 min Winter	1.568	0.0	363.3	3688
8640 min Winter	1.351	0.0	375.5	4416
10080 min Winter	1.191	0.0	386.0	5136

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Cascade Rainfall Details for Catchment 1.srcx

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 434850 561350 NZ 34850 61350
C (1km)	-0.022
D1 (1km)	0.396
D2 (1km)	0.381
D3 (1km)	0.284
E (1km)	0.276
F (1km)	2.343
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) 0.230

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.077	4	8	0.077	8	12	0.077

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Cascade Model Details for Catchment 1.srcx

Storage is Online Cover Level (m) 31.500

Tank or Pond Structure

Invert Level (m) 29.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	160.0	1.200	160.0	1.201	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0079-3000-1200-3000
Design Head (m)	1.200
Design Flow (l/s)	3.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	79
Invert Level (m)	29.300
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	3.0
Flush-Flo™	0.348	2.9
Kick-Flo®	0.707	2.4
Mean Flow over Head Range	-	2.6

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	2.3	1.200	3.0	3.000	4.6	7.000	6.8
0.200	2.8	1.400	3.2	3.500	4.9	7.500	7.0
0.300	2.9	1.600	3.4	4.000	5.2	8.000	7.3
0.400	2.9	1.800	3.6	4.500	5.5	8.500	7.5
0.500	2.8	2.000	3.8	5.000	5.8	9.000	7.7
0.600	2.7	2.200	4.0	5.500	6.1	9.500	7.9
0.800	2.5	2.400	4.1	6.000	6.3		
1.000	2.8	2.600	4.3	6.500	6.6		

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Cascade Summary of Results for Catchment 2 FSR.srcx

	Upstream Structures	Outflow To	Overflow To
Catchment 1 FSR.srcx	(None)	(None)	

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	29.642	0.342	7.6	205.0	O K
30 min Summer	29.758	0.458	7.6	274.7	O K
60 min Summer	29.883	0.583	7.6	349.7	O K
120 min Summer	30.012	0.712	7.6	427.1	O K
180 min Summer	30.085	0.785	7.6	471.1	O K
240 min Summer	30.131	0.831	7.6	498.7	O K
360 min Summer	30.184	0.884	7.6	530.2	O K
480 min Summer	30.215	0.915	7.6	548.7	O K
600 min Summer	30.232	0.932	7.6	559.1	O K
720 min Summer	30.240	0.940	7.6	564.2	O K
960 min Summer	30.241	0.941	7.6	564.7	O K
1440 min Summer	30.215	0.915	7.6	548.8	O K
2160 min Summer	30.166	0.866	7.6	519.8	O K
2880 min Summer	30.112	0.812	7.6	487.3	O K
4320 min Summer	29.968	0.668	7.6	400.7	O K
5760 min Summer	29.835	0.535	7.6	320.9	O K
7200 min Summer	29.723	0.423	7.6	253.8	O K
8640 min Summer	29.635	0.335	7.6	200.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	118.882	0.0	250.7	26
30 min Summer	79.966	0.0	338.7	41
60 min Summer	51.407	0.0	446.0	70
120 min Summer	31.968	0.0	555.2	130
180 min Summer	23.880	0.0	622.1	190
240 min Summer	19.289	0.0	669.9	248
360 min Summer	14.172	0.0	737.9	366
480 min Summer	11.393	0.0	790.5	486
600 min Summer	9.611	0.0	832.8	604
720 min Summer	8.359	0.0	868.4	724
960 min Summer	6.701	0.0	925.7	960
1440 min Summer	4.898	0.0	1002.8	1246
2160 min Summer	3.572	0.0	1124.8	1628
2880 min Summer	2.852	0.0	1197.0	2020
4320 min Summer	2.073	0.0	1302.8	2728
5760 min Summer	1.651	0.0	1388.7	3416
7200 min Summer	1.382	0.0	1453.2	4112
8640 min Summer	1.195	0.0	1507.0	4768

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Cascade Summary of Results for Catchment 2 FSR.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	29.570	0.270	7.5	162.3	O K
15 min Winter	29.683	0.383	7.6	230.1	O K
30 min Winter	29.814	0.514	7.6	308.4	O K
60 min Winter	29.955	0.655	7.6	393.1	O K
120 min Winter	30.103	0.803	7.6	481.5	O K
180 min Winter	30.184	0.884	7.6	530.2	O K
240 min Winter	30.235	0.935	7.6	561.1	O K
360 min Winter	30.296	0.996	7.6	597.4	O K
480 min Winter	30.332	1.032	7.6	619.1	O K
600 min Winter	30.352	1.052	7.6	631.4	O K
720 min Winter	30.365	1.065	7.6	639.1	O K
960 min Winter	30.374	1.074	7.6	644.5	O K
1440 min Winter	30.352	1.052	7.6	631.1	O K
2160 min Winter	30.289	0.989	7.6	593.3	O K
2880 min Winter	30.212	0.912	7.6	547.0	O K
4320 min Winter	29.977	0.677	7.6	406.2	O K
5760 min Winter	29.762	0.462	7.6	277.5	O K
7200 min Winter	29.613	0.313	7.6	187.7	O K
8640 min Winter	29.519	0.219	7.3	131.5	O K
10080 min Winter	29.464	0.164	6.9	98.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.058	0.0	1553.7	5448
15 min Winter	118.882	0.0	281.4	26
30 min Winter	79.966	0.0	379.5	40
60 min Winter	51.407	0.0	499.8	70
120 min Winter	31.968	0.0	621.9	128
180 min Winter	23.880	0.0	696.7	186
240 min Winter	19.289	0.0	750.1	244
360 min Winter	14.172	0.0	825.9	360
480 min Winter	11.393	0.0	884.3	476
600 min Winter	9.611	0.0	931.2	590
720 min Winter	8.359	0.0	970.2	702
960 min Winter	6.701	0.0	1031.5	926
1440 min Winter	4.898	0.0	1092.7	1352
2160 min Winter	3.572	0.0	1260.0	1692
2880 min Winter	2.852	0.0	1340.7	2136
4320 min Winter	2.073	0.0	1459.8	2900
5760 min Winter	1.651	0.0	1555.5	3576
7200 min Winter	1.382	0.0	1628.0	4192
8640 min Winter	1.195	0.0	1688.3	4840
10080 min Winter	1.058	0.0	1741.3	5416

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Cascade Rainfall Details for Catchment 2 FSR.srcx

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.200	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 0.940

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.313	4	8	0.313	8	12	0.313

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Cascade Model Details for Catchment 2 FSR.srcx

Storage is Online Cover Level (m) 31.500

Tank or Pond Structure

Invert Level (m) 29.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	600.0	1.200	600.0	1.201	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0125-7600-1200-7600
Design Head (m)	1.200
Design Flow (l/s)	7.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	125
Invert Level (m)	29.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	7.6
Flush-Flo™	0.352	7.6
Kick-Flo®	0.761	6.1
Mean Flow over Head Range	-	6.6

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	4.5	1.200	7.6	3.000	11.7	7.000	17.5
0.200	7.2	1.400	8.2	3.500	12.6	7.500	18.1
0.300	7.6	1.600	8.7	4.000	13.4	8.000	18.7
0.400	7.6	1.800	9.2	4.500	14.2	8.500	19.2
0.500	7.4	2.000	9.7	5.000	14.9	9.000	19.8
0.600	7.2	2.200	10.1	5.500	15.6	9.500	20.3
0.800	6.3	2.400	10.5	6.000	16.3		
1.000	7.0	2.600	10.9	6.500	16.9		

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Cascade Summary of Results for Catchment 2.srcx

Upstream Structures	Outflow To	Overflow To
Catchment 1.srcx	(None)	(None)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	29.697	0.397	7.6	238.4	O K
30 min Summer	29.785	0.485	7.6	291.0	O K
60 min Summer	29.889	0.589	7.6	353.1	O K
120 min Summer	30.008	0.708	7.6	425.1	O K
180 min Summer	30.086	0.786	7.6	471.7	O K
240 min Summer	30.142	0.842	7.6	505.0	O K
360 min Summer	30.216	0.916	7.6	549.3	O K
480 min Summer	30.263	0.963	7.6	577.5	O K
600 min Summer	30.294	0.994	7.6	596.4	O K
720 min Summer	30.315	1.015	7.6	609.1	O K
960 min Summer	30.334	1.034	7.6	620.2	O K
1440 min Summer	30.336	1.036	7.6	621.4	O K
2160 min Summer	30.321	1.021	7.6	612.5	O K
2880 min Summer	30.298	0.998	7.6	598.8	O K
4320 min Summer	30.179	0.879	7.6	527.4	O K
5760 min Summer	30.024	0.724	7.6	434.7	O K
7200 min Summer	29.873	0.573	7.6	344.1	O K
8640 min Summer	29.756	0.456	7.6	273.3	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	137.928	0.0	291.7	26
30 min Summer	84.599	0.0	358.4	41
60 min Summer	51.889	0.0	450.2	70
120 min Summer	31.827	0.0	552.7	130
180 min Summer	23.912	0.0	622.9	190
240 min Summer	19.521	0.0	677.9	248
360 min Summer	14.666	0.0	763.5	366
480 min Summer	11.973	0.0	830.3	486
600 min Summer	10.230	0.0	885.7	604
720 min Summer	8.996	0.0	933.1	722
960 min Summer	7.312	0.0	1006.4	960
1440 min Summer	5.461	0.0	1086.3	1248
2160 min Summer	4.078	0.0	1284.0	1648
2880 min Summer	3.315	0.0	1391.0	2048
4320 min Summer	2.380	0.0	1495.2	2852
5760 min Summer	1.881	0.0	1582.9	3576
7200 min Summer	1.568	0.0	1648.3	4248
8640 min Summer	1.351	0.0	1703.2	4928

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Cascade Summary of Results for Catchment 2.srcx

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
10080 min Summer	29.664	0.364	7.6	218.3	O K
15 min Winter	29.746	0.446	7.6	267.5	O K
30 min Winter	29.844	0.544	7.6	326.6	O K
60 min Winter	29.962	0.662	7.6	396.9	O K
120 min Winter	30.099	0.799	7.6	479.3	O K
180 min Winter	30.185	0.885	7.6	530.9	O K
240 min Winter	30.247	0.947	7.6	568.2	O K
360 min Winter	30.333	1.033	7.6	619.8	O K
480 min Winter	30.389	1.089	7.6	653.5	O K
600 min Winter	30.427	1.127	7.6	676.5	O K
720 min Winter	30.454	1.154	7.6	692.2	O K
960 min Winter	30.477	1.177	7.6	706.0	O K
1440 min Winter	30.490	1.190	7.6	713.8	O K
2160 min Winter	30.470	1.170	7.6	702.0	O K
2880 min Winter	30.434	1.134	7.6	680.4	O K
4320 min Winter	30.243	0.943	7.6	566.1	O K
5760 min Winter	29.984	0.684	7.6	410.5	O K
7200 min Winter	29.765	0.465	7.6	279.1	O K
8640 min Winter	29.618	0.318	7.6	191.0	O K
10080 min Winter	29.526	0.226	7.3	135.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
10080 min Summer	1.191	0.0	1749.2	5552
15 min Winter	137.928	0.0	327.1	26
30 min Winter	84.599	0.0	401.4	41
60 min Winter	51.889	0.0	504.5	70
120 min Winter	31.827	0.0	619.1	128
180 min Winter	23.912	0.0	697.6	186
240 min Winter	19.521	0.0	759.0	244
360 min Winter	14.666	0.0	854.4	360
480 min Winter	11.973	0.0	928.6	476
600 min Winter	10.230	0.0	989.4	590
720 min Winter	8.996	0.0	1040.6	702
960 min Winter	7.312	0.0	1113.7	924
1440 min Winter	5.461	0.0	1125.8	1352
2160 min Winter	4.078	0.0	1438.2	1696
2880 min Winter	3.315	0.0	1557.9	2168
4320 min Winter	2.380	0.0	1673.8	3000
5760 min Winter	1.881	0.0	1773.1	3784
7200 min Winter	1.568	0.0	1846.4	4400
8640 min Winter	1.351	0.0	1908.1	5016
10080 min Winter	1.191	0.0	1960.3	5560

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Cascade Rainfall Details for Catchment 2.srcx

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
Site Location	GB 434850 561350 NZ 34850 61350
C (1km)	-0.022
D1 (1km)	0.396
D2 (1km)	0.381
D3 (1km)	0.284
E (1km)	0.276
F (1km)	2.343
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) 0.940

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.313	4	8	0.313	8	12	0.313

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Cascade Model Details for Catchment 2.srcx

Storage is Online Cover Level (m) 31.500

Tank or Pond Structure

Invert Level (m) 29.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	600.0	1.200	600.0	1.201	0.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0125-7600-1200-7600
Design Head (m)	1.200
Design Flow (l/s)	7.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	125
Invert Level (m)	29.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	7.6
Flush-Flo™	0.352	7.6
Kick-Flo®	0.761	6.1
Mean Flow over Head Range	-	6.6

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	4.5	1.200	7.6	3.000	11.7	7.000	17.5
0.200	7.2	1.400	8.2	3.500	12.6	7.500	18.1
0.300	7.6	1.600	8.7	4.000	13.4	8.000	18.7
0.400	7.6	1.800	9.2	4.500	14.2	8.500	19.2
0.500	7.4	2.000	9.7	5.000	14.9	9.000	19.8
0.600	7.2	2.200	10.1	5.500	15.6	9.500	20.3
0.800	6.3	2.400	10.5	6.000	16.3		
1.000	7.0	2.600	10.9	6.500	16.9		

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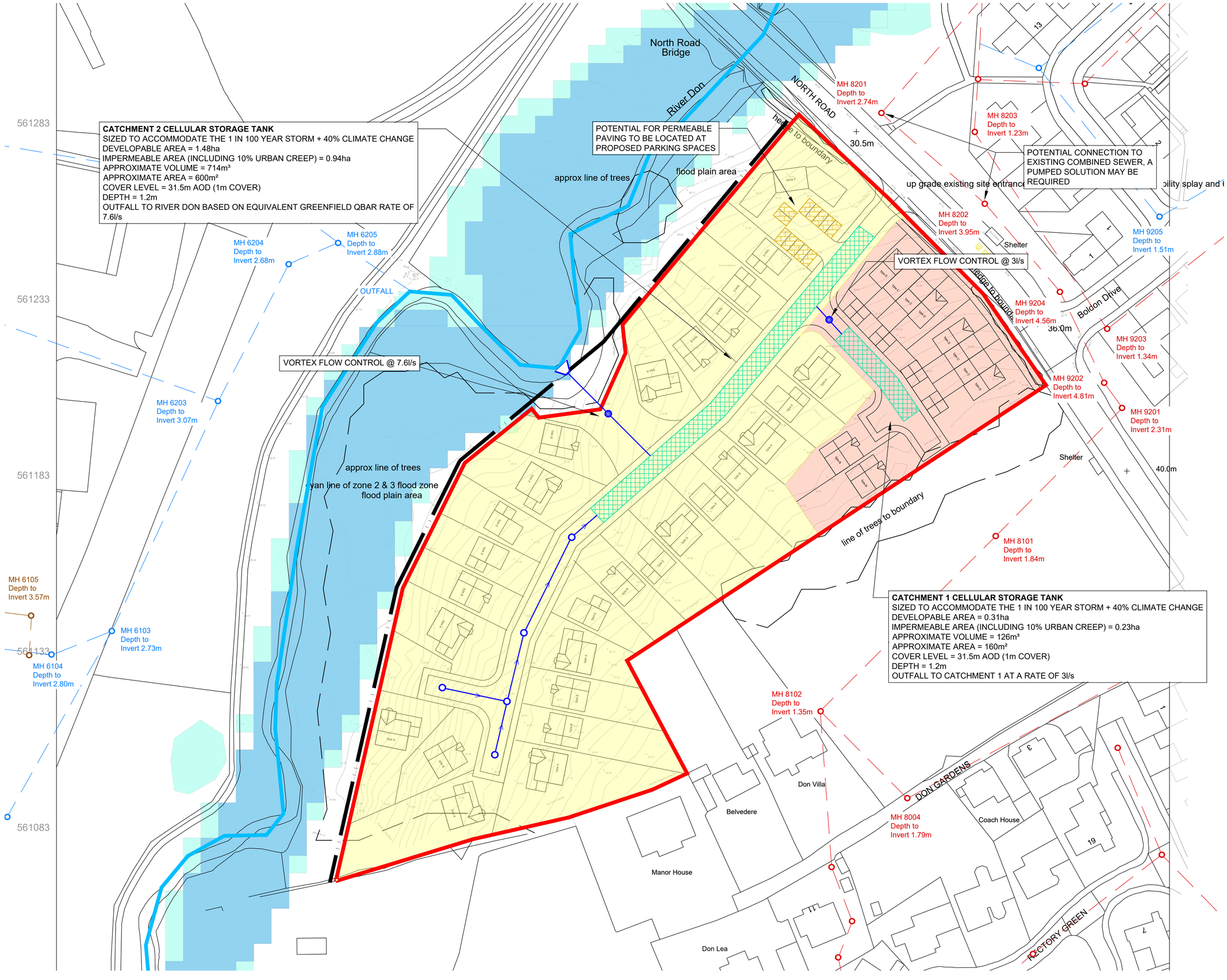
Appendix 5: Illustrative Surface Water Drainage Strategy



Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. Do not construct based on this drawing.
6. Flood Zone Extents are extracted from the Environment Agency's Flood Map for Planning.
7. Existing sewer locations and depth to invert measurements are approximate and are taken from Northumbrian Water Sewer Records.
8. A cut and fill earthworks exercise should be undertaken in order to ensure that necessary levels can be achieved for drainage.
9. Cellular Storage is based on a total impermeable area of 1.17ha, including a 10% allowance for urban creep and a 40% allowance for climate change.
10. It is assumed that site ownership extends to the watercourse centreline and therefore the outfall is located within the clients wider landownership.
11. All levels, position and exact form of drainage is to be confirmed as part of the detailed design.

Legend

- Indicative Red Line Boundary
- EA Main River
- **Environment Agency Flood Zones**
  - Flood Zone 3
  - Flood Zone 2
- Existing Surface Water Sewer
- Existing Combined Sewer
- Existing Foul Water Sewer
- Catchment 1
- Catchment 2
- Below Ground Cellular Storage Tank
- Proposed Surface Water Sewer
- Headwall
- Proposed Surface Water Manhole
- Vortex Flow Control
- Permeable Paving

Rev	Date	Details of issue / revision	Drw	Rev
P01	23.09.20	Preliminary Issue	LR	NJ

Issues & Revisions

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Client

Ethical Partnership

Project Title

Land off North Road, West Boldon

Drawing Title

Illustrative Surface Water Drainage Strategy

Drawn:	L. Reeves	Reviewed:	N. James
BWB Ref:	MCW2139	Date:	23.09.20
Scale@A1:	1:500		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
NRB-BWB-ZZ-XX-DR-CD-0001	S2	P01

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