ARUP

WEPCo | Cardiff and Vale Colleges

Barry Waterfront Campus (BWC)

Surface Water Modelling Report

Reference:

P02 | 27 March 2024

Job number 287279-00

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Document Verification

Project title	Barry Waterfront Campus (BWC)
Document title	Surface Water Modelling Report
Job number	287279-00
Document ref	
File reference	

Revision	Date	Filename			
P01	08/03/2024	**Description**	First Issue		
			Prepared by	**Checked by**	**Approved by**
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		Signature			
P02	27/03/2024	**Filename**	Second Issue		
		Description	Minor amendments to proposed ground levels. Model Results updated		
			Prepared by	**Checked by**	**Approved by**
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		Filename			
		Description			
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		Name			
		Signature			

Issue Document Verification with Document ✓

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1. Introduction

Ove Arup and Partners Limited ('Arup') have been commissioned by *WEPCo | Cardiff and Vale Colleges* (the Client) to provide multidisciplinary engineering services for Barry Waterfront Campus (BWC), a proposed development of a new college facilities located approximately 0.30 km southeast of Barry town centre in South Wales.

This report details the work undertaken to develop a direct rainfall model to understand the surface water flood risk to and from the proposed development.

1.1 Study area

The proposed development is located in Barry, South Wales, as shown in Figure 1.

The proposed development comprises both brownfield land formally used for industrial purposes associated with the disused railway at Hood Road Station and greenfield scrubland. The site contains an existing access road which bisects its eastern and western parcels. Topography for the site is generally flat in the west, centre and northeast; however, within the greenfield scrubland area an elevation of approximately 1.5m exists due to a spoil mound. The site area equates to approximately 1.1ha.

The site is bound to the north by a mixed-use urban development consisting of residential, retail and commercial development. The railway line terminating at Hood Road Station is situated at the northern boundary of the site. Greenfield land exists to the immediate south of the site boundary, beyond which residential development off Ffordd Y Mileniwm Road is located. To the west of the site exists land adjacent to the railway line and a car dealership. To the east of the site boundary and severed by Ffordd Y Mileniwm Road exists an Asda superstore and industrial yard. Surrounding land to the east is in use as the Barry Waterfront and dockland.

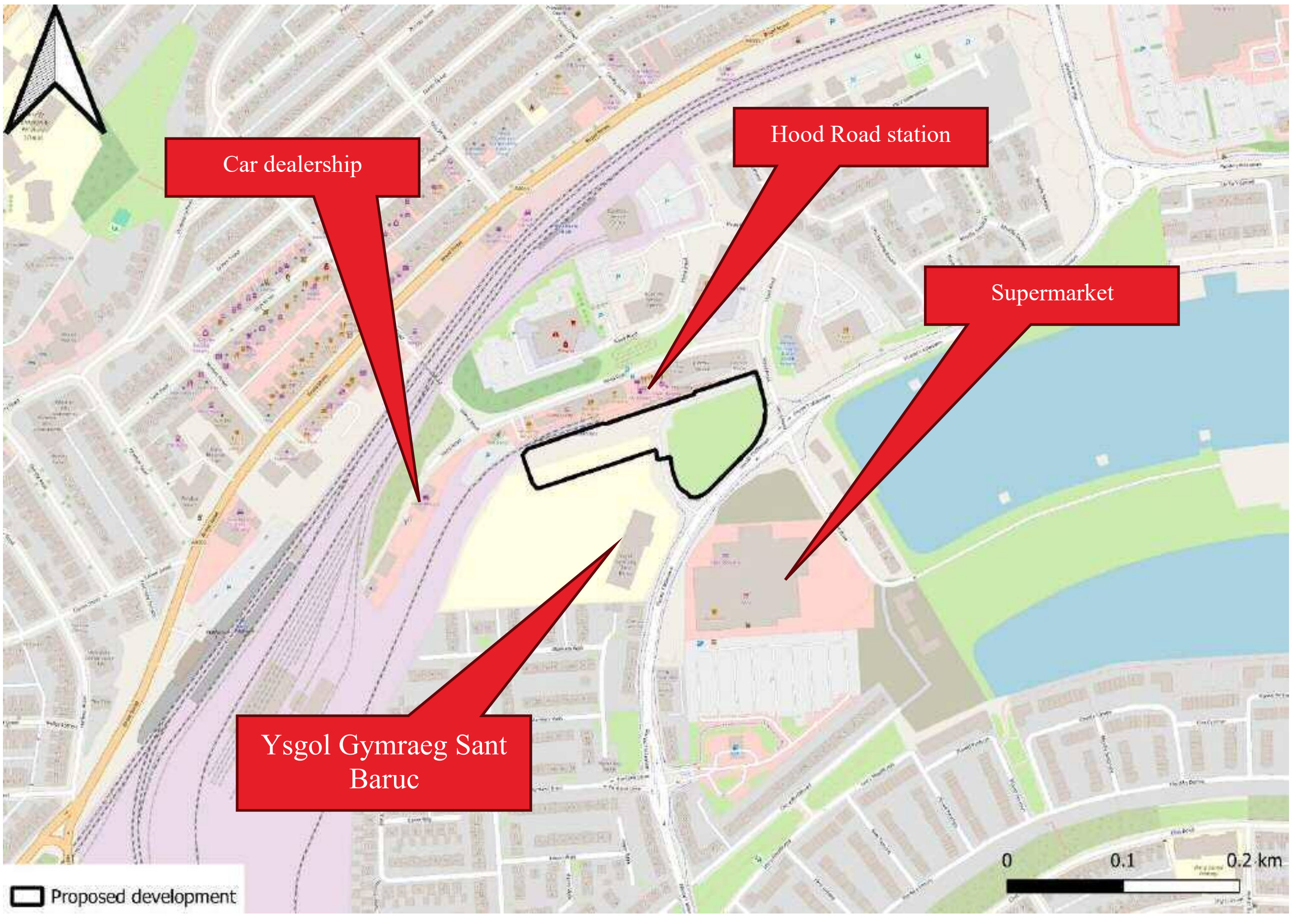

Figure 1: Location of proposed development

2. Incoming Data

2.1 LIDAR

1m resolution Light Detection and Ranging (LIDAR) data has been downloaded from the DataMapWales.

2.2 Topographic survey

Topographic survey was made available as part of this study. It was collected in July 2020 by HSP Consulting Ltd.

A Digital Elevation Model (DEM) was developed from the survey and compared against the LIDAR. It was found that the LIDAR offered a better representation of the development area, as its resolution was finer. As such the topographic survey was not used in the model.

2.3 Proposed development layout

The proposed development is for a new college building, and associated infrastructure, such as a car park and bike storage as shown in Figure 2. A larger version of this drawing can be found in Appendix A.

Figure 2: Proposed development layout

3. Hydrology

3.1 Checking catchment descriptors

The catchment descriptors, incorporating any changes, used for the subject site are shown in Table 1.

Table 1: Catchment descriptors at subject site (incorporating any changes made shown in red text)

Site code	AREA (km^2)	SPRHOST	BFIHOST19	DPLBAR	DPSBAR	FARL	FPEXT	PROPWET	SAAR (mm)	URBEXT 2000 [updated to 2024]
Barry SW	**1.255**	37.3	0.484	**1.133**	54.4	1	0.1581	0.47	933	**0.599**

Visual inspection using Ordnance Survey (OS) contour mapping, aerial imagery and LiDAR data (a 2m resolution DEM) were undertaken to check the catchment boundaries for the subject site. As shown in Figure 3, the catchment boundary as taken from the FEH Web Service was not deemed appropriate as it included wide portions of catchment which were deemed to discharge further downstream of the site or in other directions, following topography.

As a result, the original catchment boundary for the Barry surface water (SW) catchment was adjusted to match the results of the catchment delineation determined using 2m resolution LiDAR data. Following this catchment area adjustment, the catchment area for the Barry SW catchment decreased from $3.29km^2$ to $1.26km^2$. DPLBAR was recalculated using equation 7.1 in FEH Volume 5 following the adjustment in catchment area.

The original URBEXT2000 value of 0.573 was updated to the current year to obtain an URBEXT2024 value of 0.599 which is categorised as 'extremely heavily urbanised' according to FEH Section 6.5 Volume 5.

The BFIHOST19 and SPRHOST values for the catchment were checked using Soilscapes maps and geology maps and deemed appropriate, therefore the original FEH Web Service values were retained. No other descriptors were adjusted.

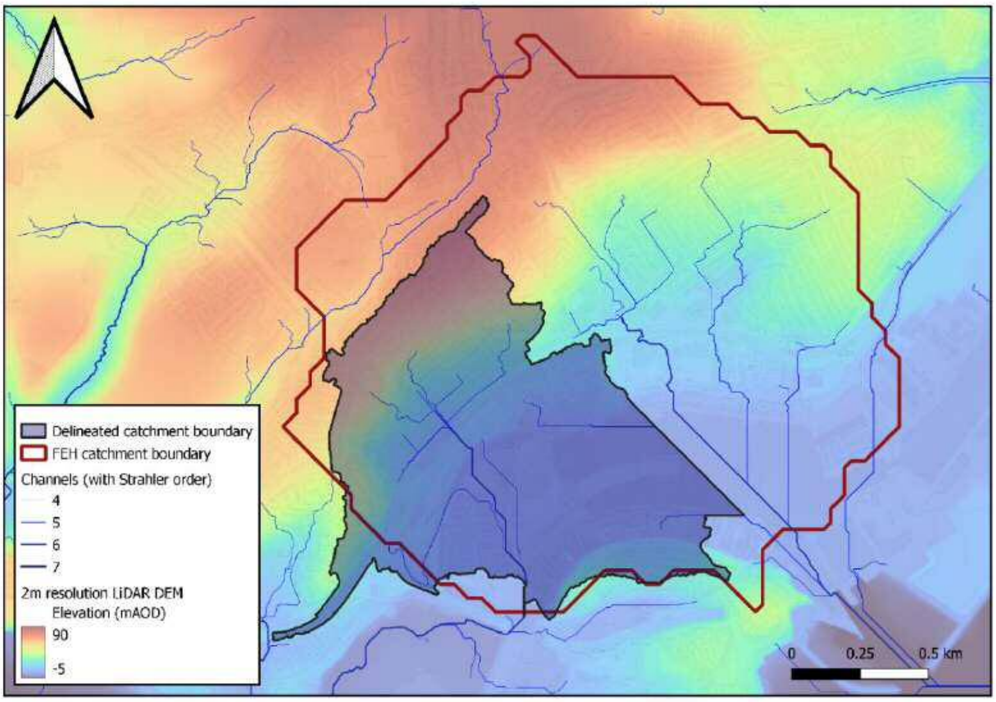

Figure 3: Catchment delineation of study area

3.2 Choice of method

The Revitalised Flood Hydrograph 2 (ReFH2) is the standard method for estimating design DDF rainfall hyetographs. The rainfall inputs are derived using a FEH depth-duration-frequency (DDF) rainfall model. The FEH22 rainfall model is the FEH's latest UK-wide statistical model for rainfall DDF estimation[1]. The catchment is also small (area < $25km^2$) and "extremely heavily urbanised" and ReFH2 is the preferred method for such catchments.

Hydraulic modelling will be conducted based on a direct rainfall (DRF) approach and the rainfall hyetographs for a range of Annual Exceedance Probability (AEP) events will be extracted and used as input data to the rainfall-runoff model. The "net rainfall" output from the ReFH2 module (as opposed to the "raw rainfall" output) will be used as the rainfall input to the 1D-2D hydraulic model as it accounts for ground infiltration.

3.3 Revitalised flood hydrograph (ReFH2) method

The parameters used in the ReFH2 model are shown in Table 2 and Table 3. Testing was conducted in order to find the critical storm duration which generates the peak runoff flow for the 1% AEP event. and it resulted to be the same as the storm duration initially recommended by ReFH2, i.e. 2 hours and 45 minutes. The season of the design event was set to "Summer" as summer storms maximise peak runoff flow for urbanised catchments such as the subject site.

For each AEP, the rainfall hyetograph generating the critical storm was then extracted based on the FEH22 rainfall model which is the latest available rainfall dataset for the UK (released in 2023).

Table 2: Parameters used for ReFH2 model

Site code	Details of method*	Tp (hours) Time to peak	Cmax (mm) maximum storage capacity	BL (hours) baseflow lag	BR baseflow recharge
Barry SW	CD	1.369	365.987	29.009	2.906
Brief description of any flood event analysis carried out			None carried out due to lack of gauged data.		

* CD = Catchment descriptors, DT = Tp data transfer, OPT = Optimisation (Calibration Utility)

Table 3: Design parameters for ReFH2 model

Site code	Season of design event (summer or winter)	Recommended Storm duration (hours)	Storm area for ARF (if not catchment area)	Record any adjustment to default parameters – only to find the critical duration
Barry SW	Summer	2.75	Catchment Area	2.75
Source of design rainfall statistic (FEH13 or FEH22)				FEH22

3.4 Rainfall hyetographs

The net rainfall design hyetographs for a range of AEP events are shown in Figure 4. Those are the 50% (1 in 2-yr), 20% (1 in 5-yr), 10% (1 in 10-yr), 3.33% (1 in 30-yr), 2% (1 in 50-yr), 1.33% (1 in 75-yr), 1% (1 in 100-yr) and 0.1% (1 in 1,000-year) AEP events.

[1] ReFH Technical Guide, Estimation of Design DDF Rainfall Hyetographs (Overview - ReFH Technical Guide (hydrosolutions.co.uk))

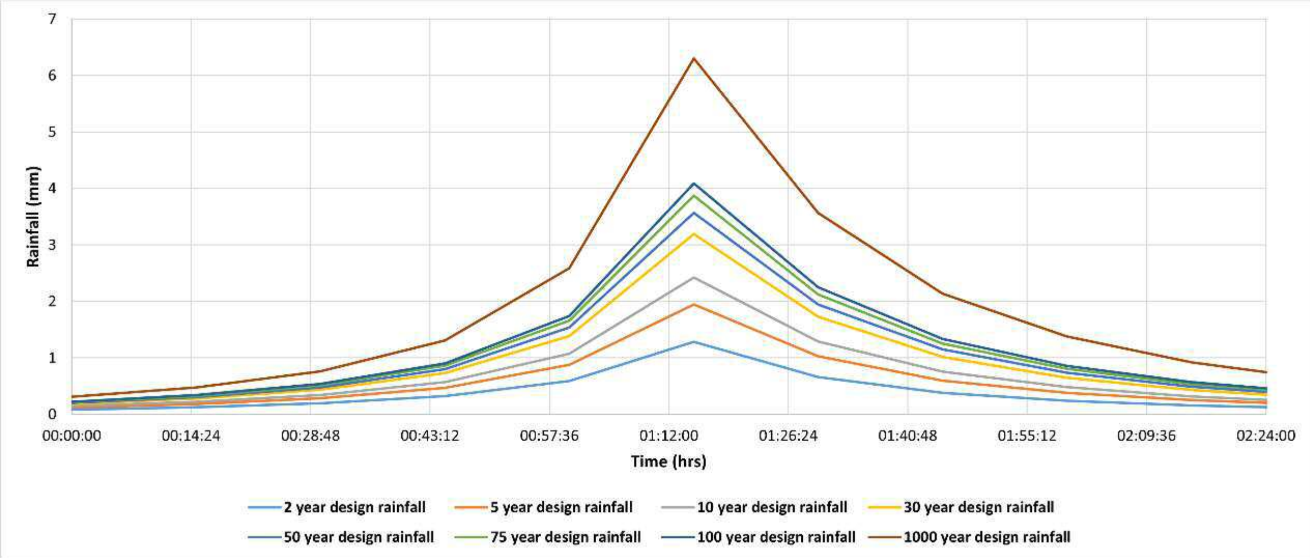

Figure 4: Net rainfall design hyetographs

4. Hydraulic Modelling

A 2D only, direct rainfall model has been developed as part of this study to model the surface water flood risk to and from the proposed development site. A direct rainfall approach means that rainfall hyetographs are applied directly to the 2D domain.

4.1 Model extent

The extent of the model is shown in Figure 5. The extent has been derived to ensure that all surface water flow paths towards the proposed development site are captured.

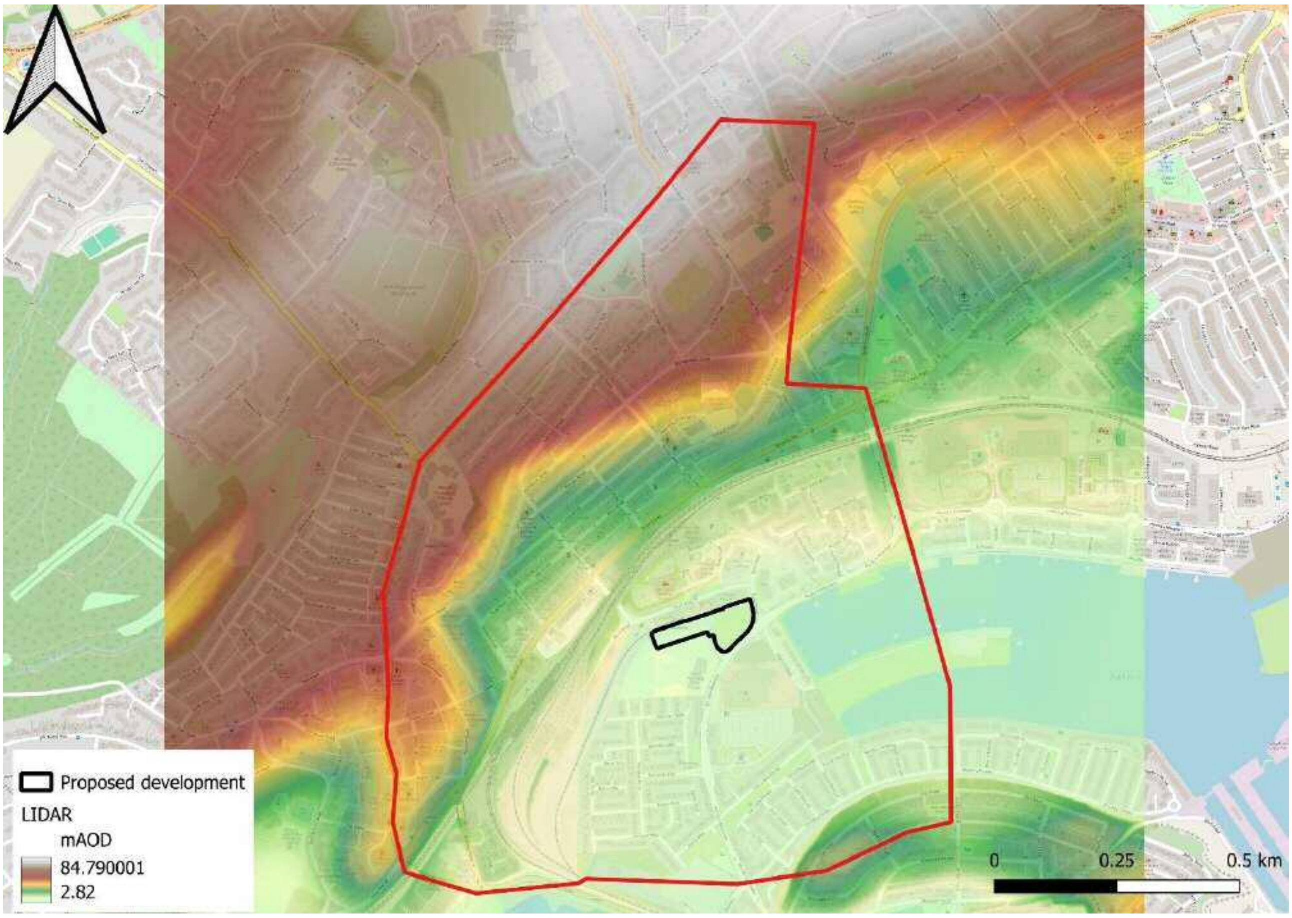

Figure 5: Model extent shown by the red boundary

4.2 Application of hydrology

The rainfall hyetographs, produced as part of the hydrological assessment, are detailed in Section 3, have been applied directly to the model using a 2d_rf boundary polygon.

4.2.1 Loss approach

Losses into the ground (either via infiltration or into the drainage network), can either be calculated in the hydrology, by applying NET rainfall, instead of the RAW rainfall profiles or calculated using the hydraulic model. Both approaches have been tested as part of this study.

When the model was used to calculate losses, the follows approach was used:

1. Rain falling on urban areas (including gardens) was assumed to drain into the drainage network at a rate of 12mm/hr based on previous NRW studies.
2. For rain falling on greenspaces, the Green-Ampt approach was used, which is calculated directly in TUFLOW. The Green-Ampt approach varies the rate of infiltration over time based on the soil's

hydraulic conductivity, suction, porosity and initial moisture content. For the study area the soil type was defined as ‘Clay Loam’, based on referencing the LandIS Soilscapes viewer.

The results from both these approaches showed that when losses were calculated in the model, flooding was overestimated, and as such the NET rainfall approach was taken forward.

4.2.2 Application of climate change

Climate change has been applied based on the latest Welsh Government guidance. Based on this guidance, an uplift of 20%, which is the central estimate, has been applied to the rainfall hyetographs (Welsh Government, 2021).

4.3 Software

The model has been run using the TUFLOW High Performance Computing (HPC) solver. TUFLOW version 2023-03-AB has been used.

4.4 2D Roughness

2D roughness values have been defined using OS Zoomstack polygons. Table 4 provides details of the 2D Mannings values used in the model.

Table 4: 2D Mannings values

Code	Manning’s value	Description
10111	0.1	Woodland from OS Zoomstack
10099	0.04	Greenspace from OS Zoomstack
10021	0.1	Buildings from OS Zoomstack
1	0.05	Urban areas (default roughness value)

4.5 Buildings representation

Buildings have been represented in the hydraulic model as ‘stubby’ buildings. This has been undertaken by using a TUFLOW 2D Z-shape to raise the building polygons from OS Zoomstack by 0.15m from the underlying DTM.

4.6 DTM edits

Table 5 details the DTM edits applied to the 2D domain in the model.

Table 5: 2D domain edits

Layer	Description
2d_zsh_004_R.shp | 2d_zsh_004_P.shp	This TUFLOW Z-Shape represents Island Road underpass, under the railway line which had not been filtered from the DTM.
2d_zsh_School_Site_006_R.shp 2d_zsh_School_Site_006_P.shp	This TUFLOW Z-Shape sets the base ground levels for the Ysgol Gymraeg Sant Baruc, as well as the three storage areas. Elevations have been sourced from planning portal documents.
2d_zsh_school_006_R.shp | 2d_zsh_school_006_P.shp	This TUFLOW layer sets the levels for the sports pitches, car-park and school building of Ysgol Gymraeg Sant Baruc. Elevations have been sourced from planning portal documents.
2d_zsh_drain_006_L.shp | 2d_zsh_drain_006_P.shp	This TUFLOW Z-Shape represents the drain into the storage area with the Ysgol Gymraeg Sant Baruc. Elevations have been sourced from planning portal documents.

Layer	Description
2d_zsh_003_R.shp	This TUFLOW Z-Shape raises building footprints 0.15m above the DTM.

4.7 Representation of proposed development

The proposed development has been represented in the hydraulic model as a geo-tif created in Civils 3D – 'FME_Raster_BWCv2.tif'

4.8 Modelled events

For both the baseline and the proposed, the following Annual Exceedance Probability (AEP) events have been modelled; 20%, 10%, 3.33%, 1.33%, 1%, 1% with an allowance for climate change, 0.1%, 0.1% with an allowance for climate change.

4.9 Initialisation messages

TUFLOW reports a small number of messages whilst in initialisation stage to prompt the modeller on points for further review. These messages are detailed in Table 6.

Table 6: Initialisation messages

Simulations	Message	Commentary
All	WARNING 2073 - Null Shape object ignored. Only Regions, Lines, Polylines & Multiple Polylines used.	No hydraulic impact – informs that there are blank GIS records in TUFLOW input files.
All	CHECK 2370 - Ignoring coincident point found in Z Shape layer.	Occurs 16 times. A check of each instance has been made and the model is using the correct elevations.
All	WARNING 2550 - 1 instability timestep corrections recorded at cell [XXX;XXX].	Occurs 98 times. Details that there are minor instabilities in the 2D result. Instances have been checked and found to not impact water levels at the proposed development.

4.10 Negative depths

There are no negative depths in any modelled scenario.

4.11 Model stability

The TUFLOW HPC dt.csv file has been reviewed to ensure that the model was stable. Two key features have been checked for: erratic bouncing of the dt values and/or extremely low dt values. The dt plot for the Existing scenario 0.1%+CC AEP event is shown in Figure 6. The plot shows:

1. For the majority of the model simulation, there are no erratic values – with the exception of near the start of the model and is considered acceptable as it does not occur at or near the peak of the flood event.
2. dt values for all the model simulation are above 1/10 of a healthy TUFLOW Classic timestep (1s = 0.01).

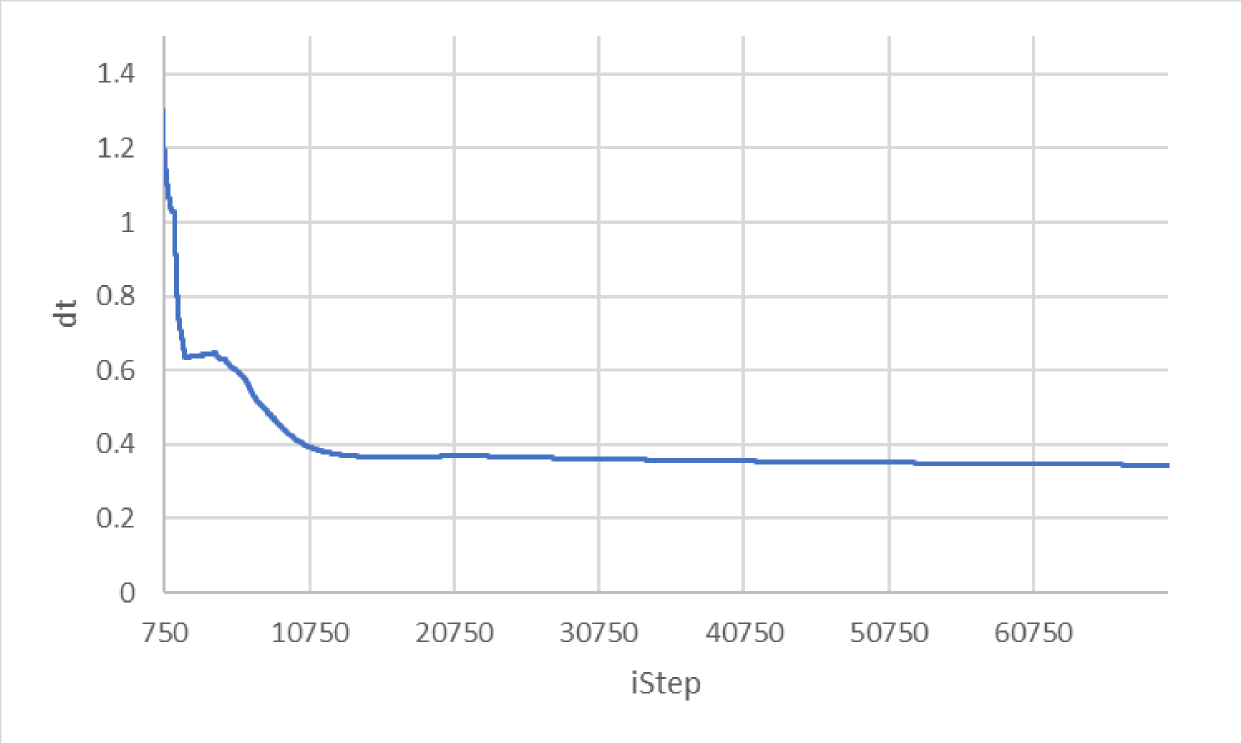

Figure 6: dt plot for 0.1% AEP+CC event

Further to checks on dt, the following parameters were reviewed: Nu, Nc and Nd. The review found the following as shown in Figure 7:

1. Nu values are all at or less than 1 – a Nu value of 1 or greater may indicate velocity is unusually high.
2. Nc values are all at or less than 1– an Nc value of 1 or greater may be caused by erroneously low cell elevation resulting in an artificially large water depth.
3. Nd values are at or less than 0.3 – an Nd value of 0.3 or higher may suggest that there is a poor boundary set-up.

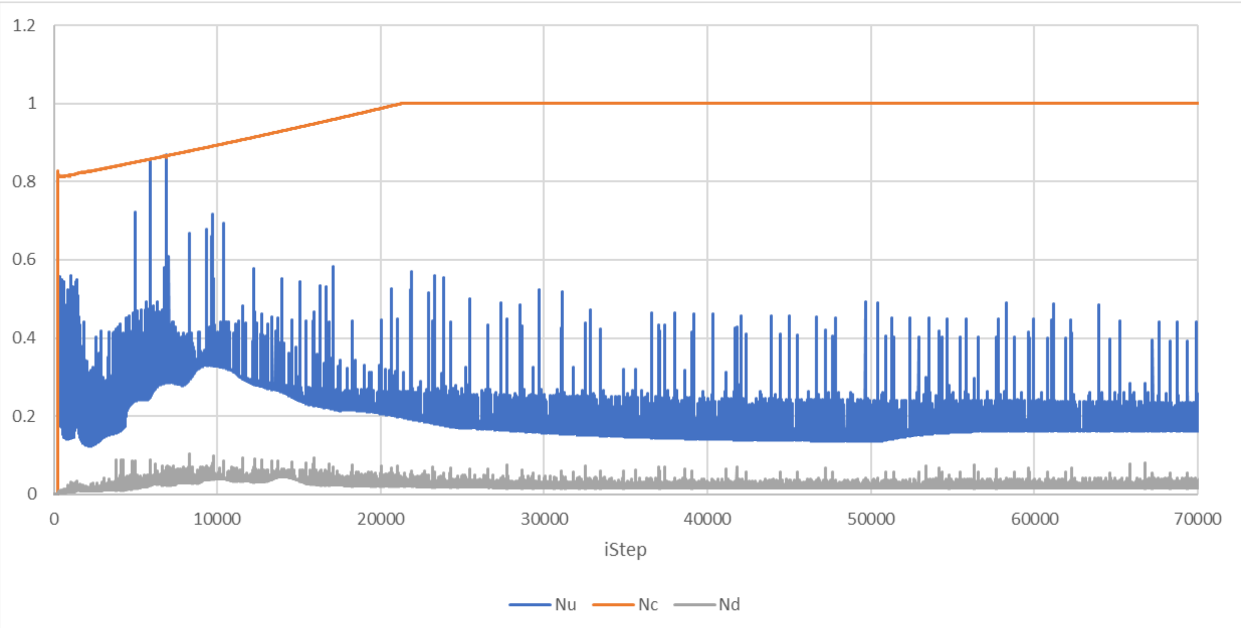

Figure 7: Nu, Nc and Nd values

Model efficiency has also been reviewed. TUFLOW guidance suggests that a healthy model should achieve >90% model efficiency early in the simulation. As shown in Figure 8, the model achieves this early in the simulation.

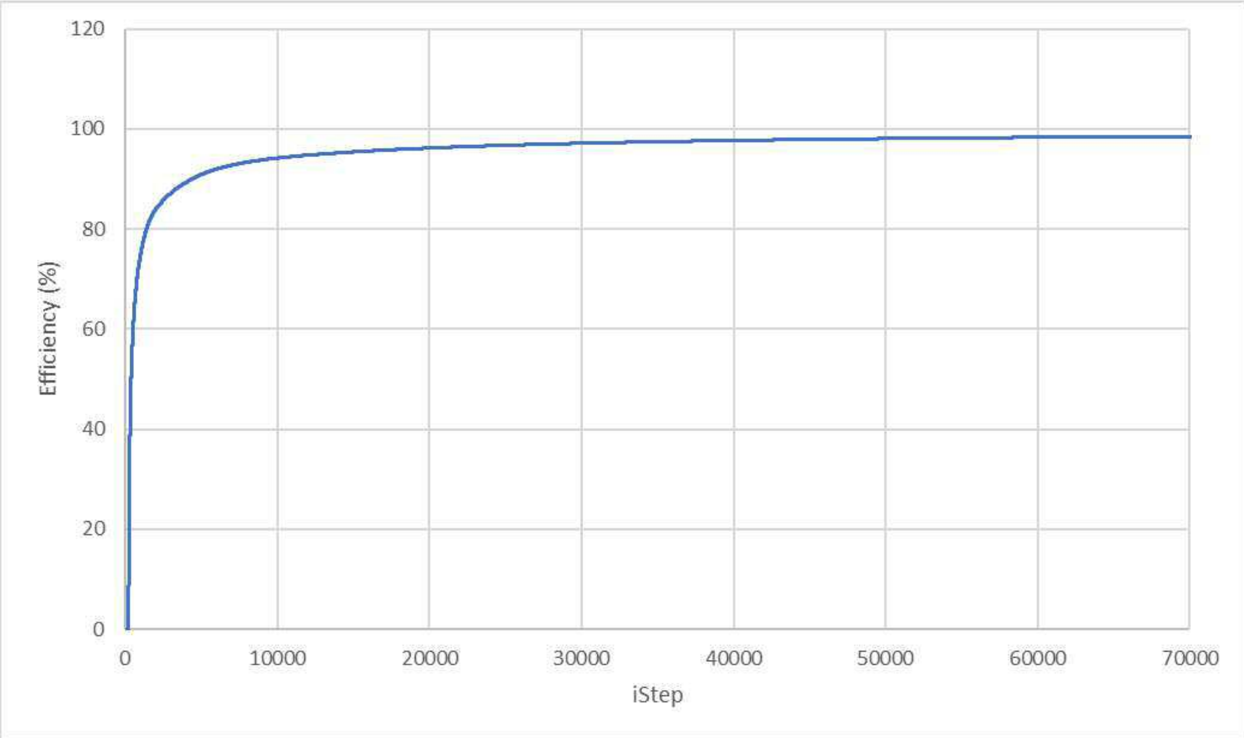

Figure 8: Model efficiency

5. Sensitivity Testing

To understand the sensitivity in modelled results to changes in key model input parameters, a number of sensitivity tests have been undertaken. These are:

- Loss approach;
- 2D roughness values; and
- Building representation.

All sensitivity tests have been undertaken on the 1% with an allowance for climate change AEP event.

5.1 Loss approach

The Green-Ampt loss approach was tested. The Green-Ampt approach varies the rate of infiltration over time based on the soil's hydraulic conductivity, suction, porosity and initial moisture content. For the study area the soil type was defined as 'Clay Loam', based on referencing the LandIS Soilscapes viewer. The raw rainfall profiles were used as part of this sensitivity test.

Results from the sensitivity test show that at the proposed development, there is an increase in both maximum flood depths and modelled flood extent – as shown in Figure 9.

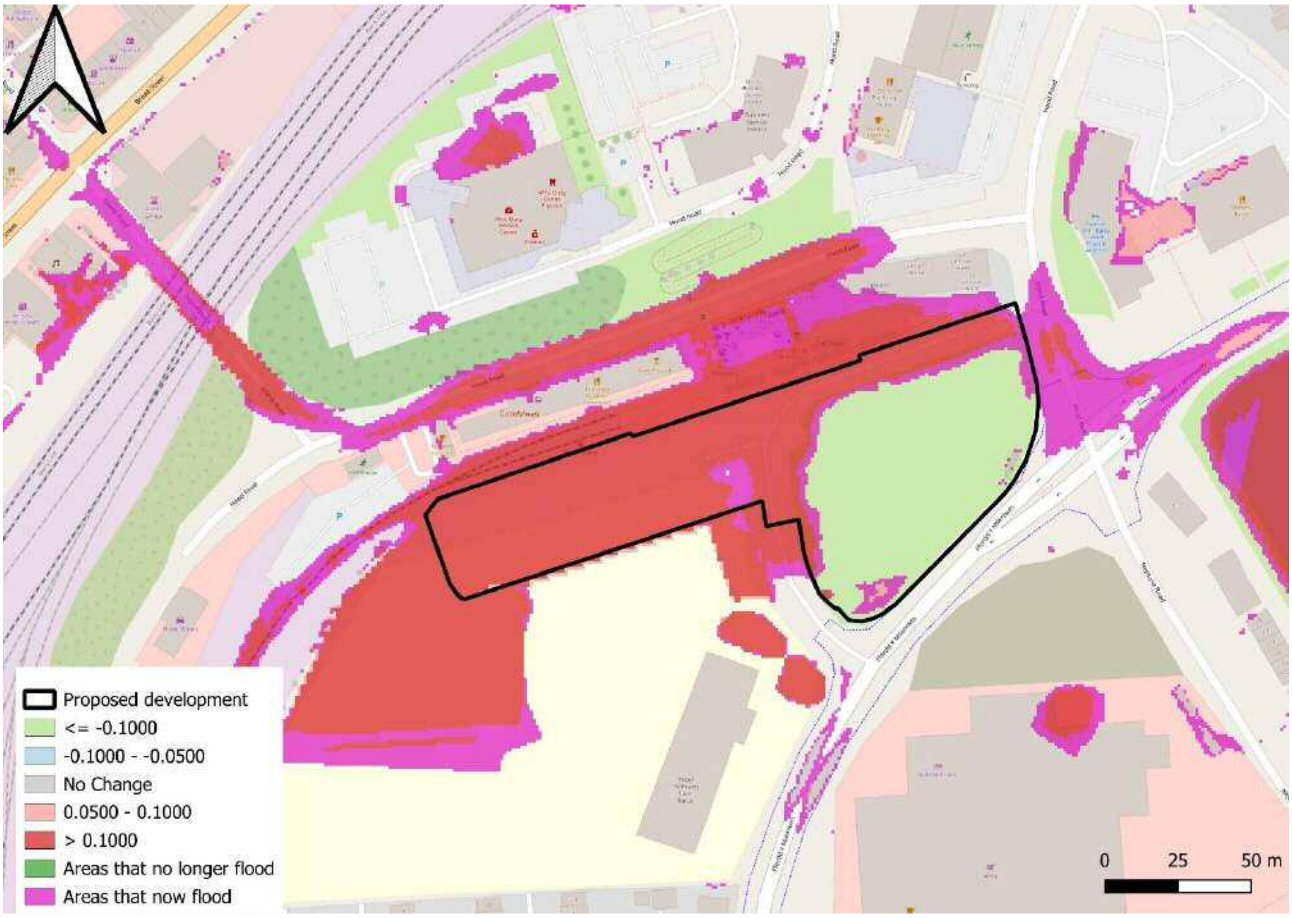

Figure 9: Loss approach sensitivity test

5.2 2D roughness

Variance to 2D roughness values was tested by increasing and decreasing 2D Mannings n values by +/-20%.

When 2D roughness values are increased by 20%, there is no significant change in water levels at the proposed development, as shown in Figure 10.

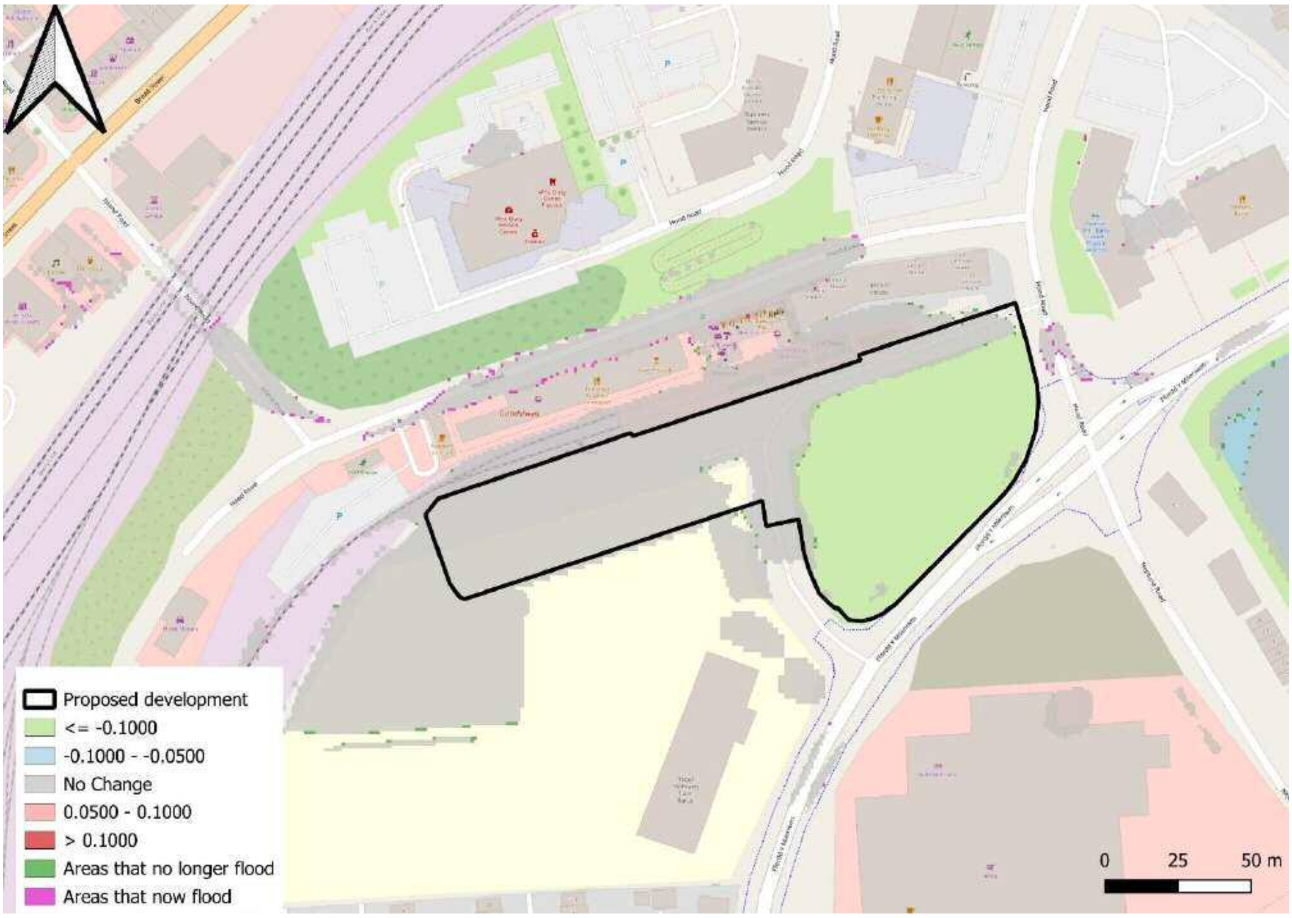

Figure 10: 20% increase in Mannings n roughness sensitivity test

When 2D roughness values are decreased by 20%, there is no significant change in water levels at the proposed development, as shown in Figure 11.

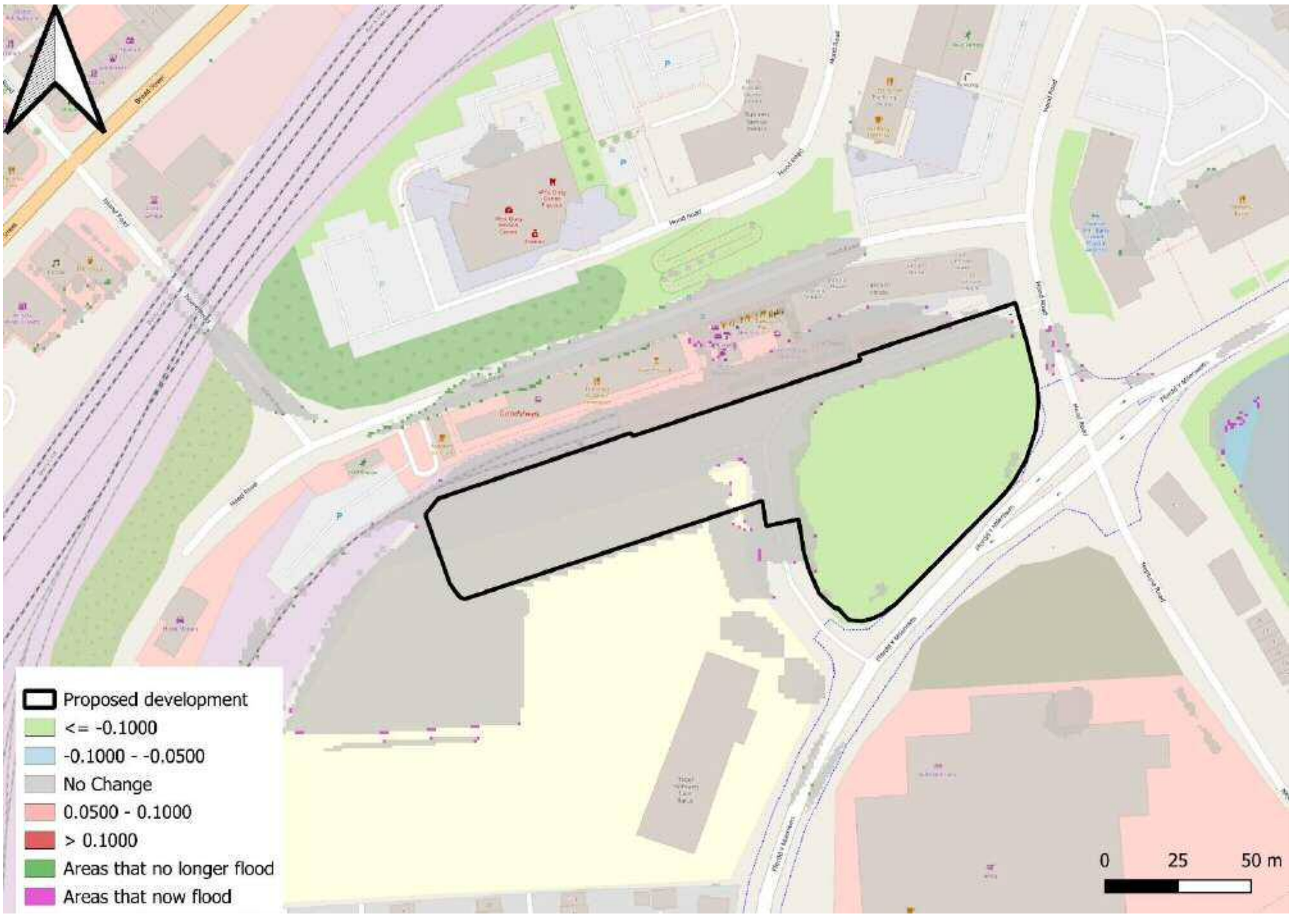

Figure 11: 20% decrease in Mannings n roughness sensitivity test

5.3 Building representation

The sensitivity of the model to building representation was tested by removing the Z-Shape polygon that raises building footprints by 0.15m.

Results from the sensitivity test show at the proposed development site there are no changes in flood depths or modelled flood extent, as shown in Figure 12.

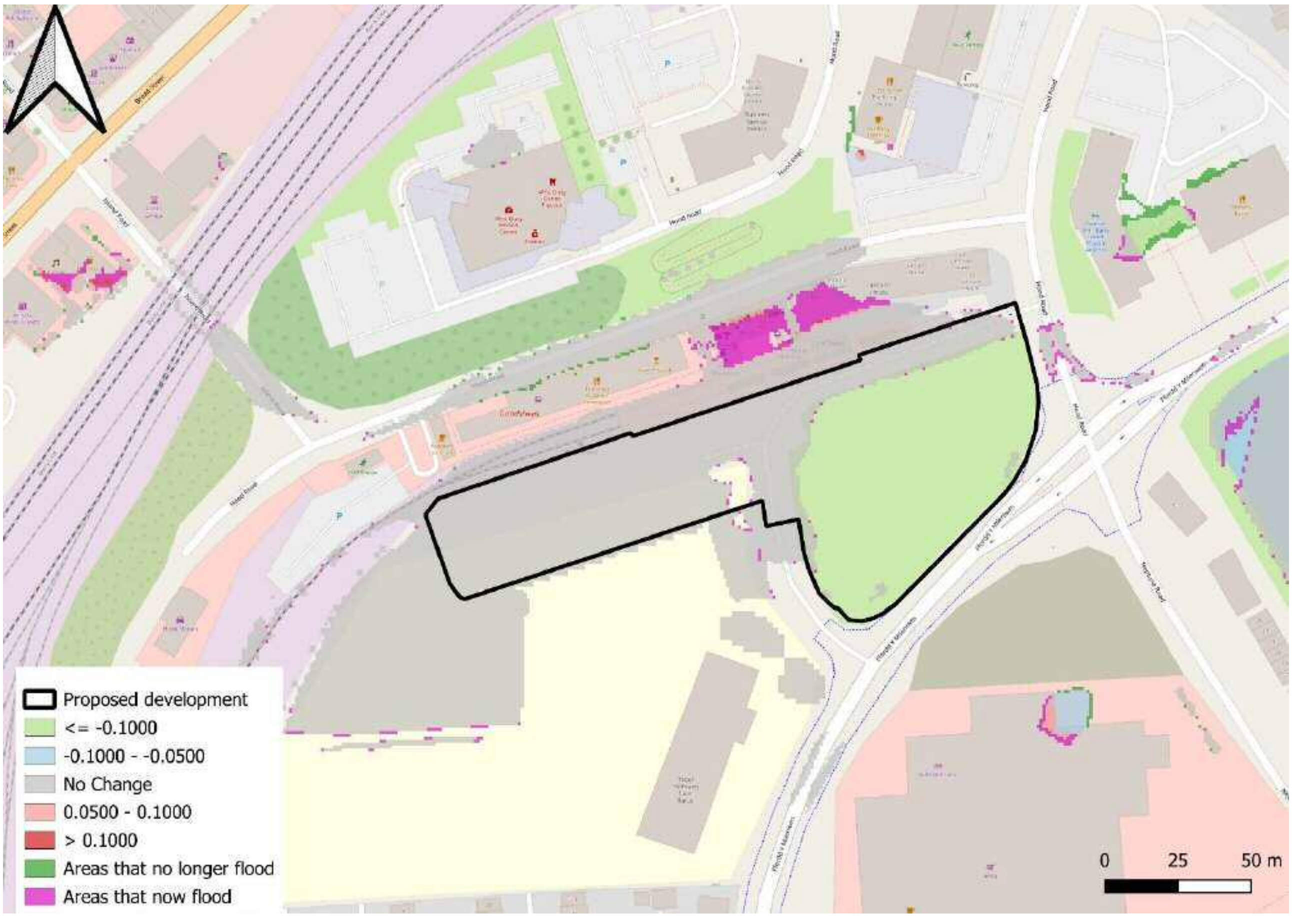

Figure 12: Buildings representation sensitivity test

5.4 Discussion

Results from the sensitivity testing show that the model is insensitive to changes in:

- 2D roughness values; and
- Representation of buildings.

The model appears to be highly sensitive to loss approach. When the Green-Ampt method is used (instead of the NET rainfall profile), there are significant increases in depth on the proposed development site. Both approaches could be considered valid, however the use of NET rainfall has been maintained in the model as a review of the flood depths on the proposed development appear to excessive when the Green-Ampt method is used.

6. Model Results

6.1 Baseline results

The proposed development site is located in a low-lying area, where the majority of the upper catchment drains into. The main surface water flow path into the proposed development is to the west, underneath the railway line onto Hood Road, before flowing south onto the proposed development at two locations – as shown in Figure 13. In the 3.33% AEP event, $0.5m^3s^{-1}$ flows onto Hood Road at this location before flowing onto the proposed development site.

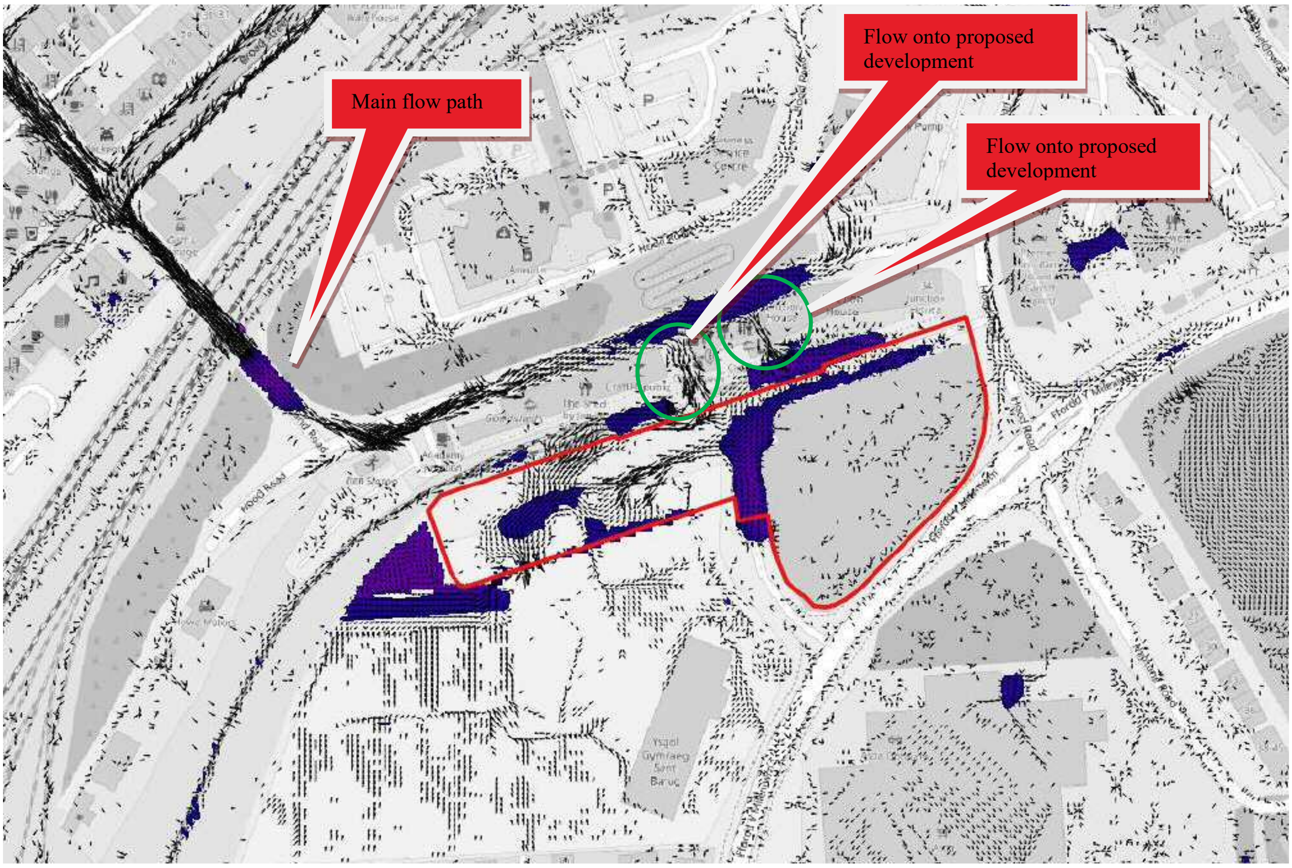

Figure 13: Surface water flow paths onto proposed development

6.1.1 3.33% AEP event

Maximum flood depths on the proposed development site for the 3.33% AEP event are shown in Figure 14. The maximum flood depth for this event is approximately **0.59m**.

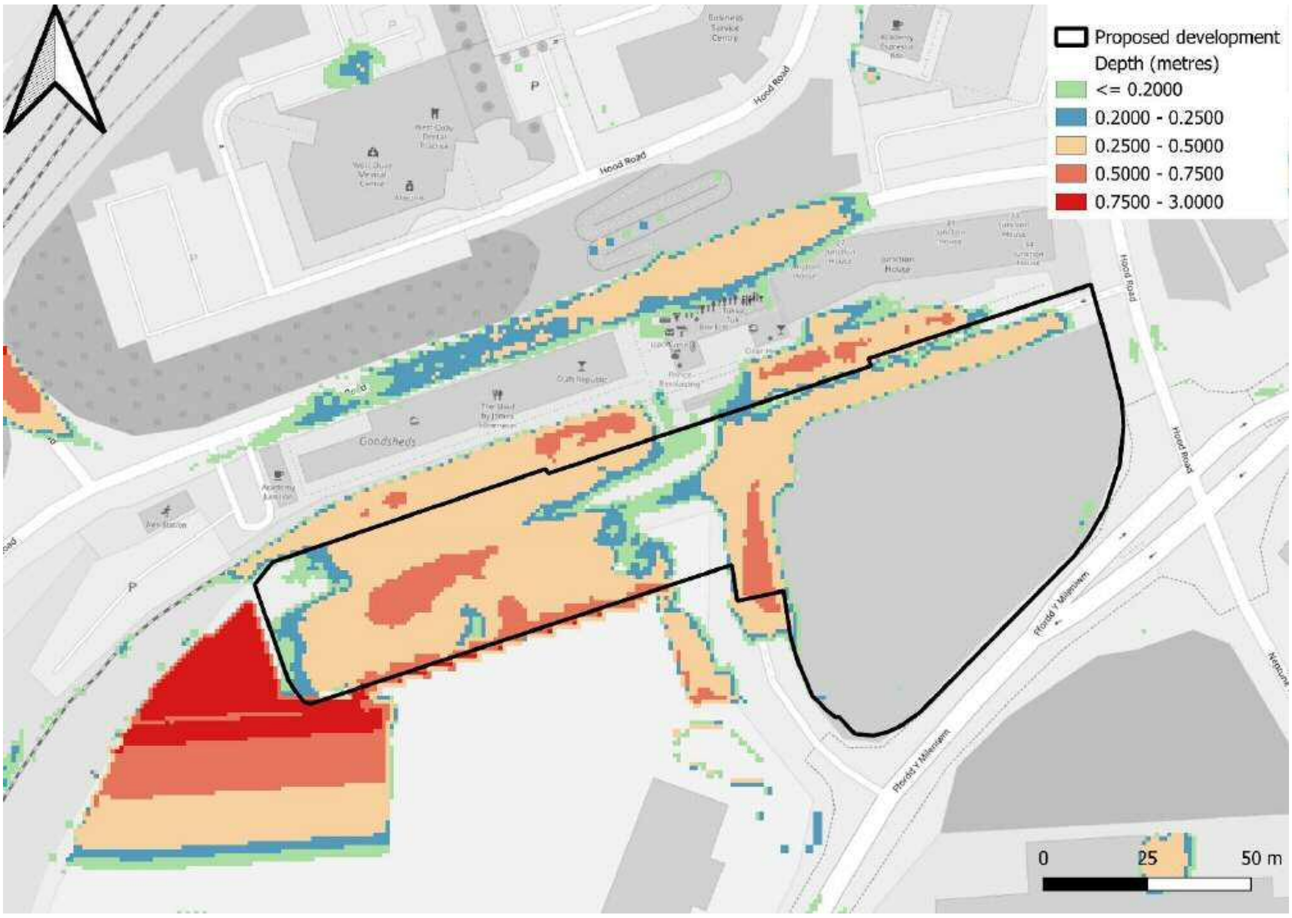

Figure 14: Baseline 3.33% AEP maximum flood depths

6.1.2 1% AEP event

Maximum flood depths on the proposed development site for the 1% AEP event are shown in Figure 15. The maximum flood depth for this event is approximately **0.73m**.

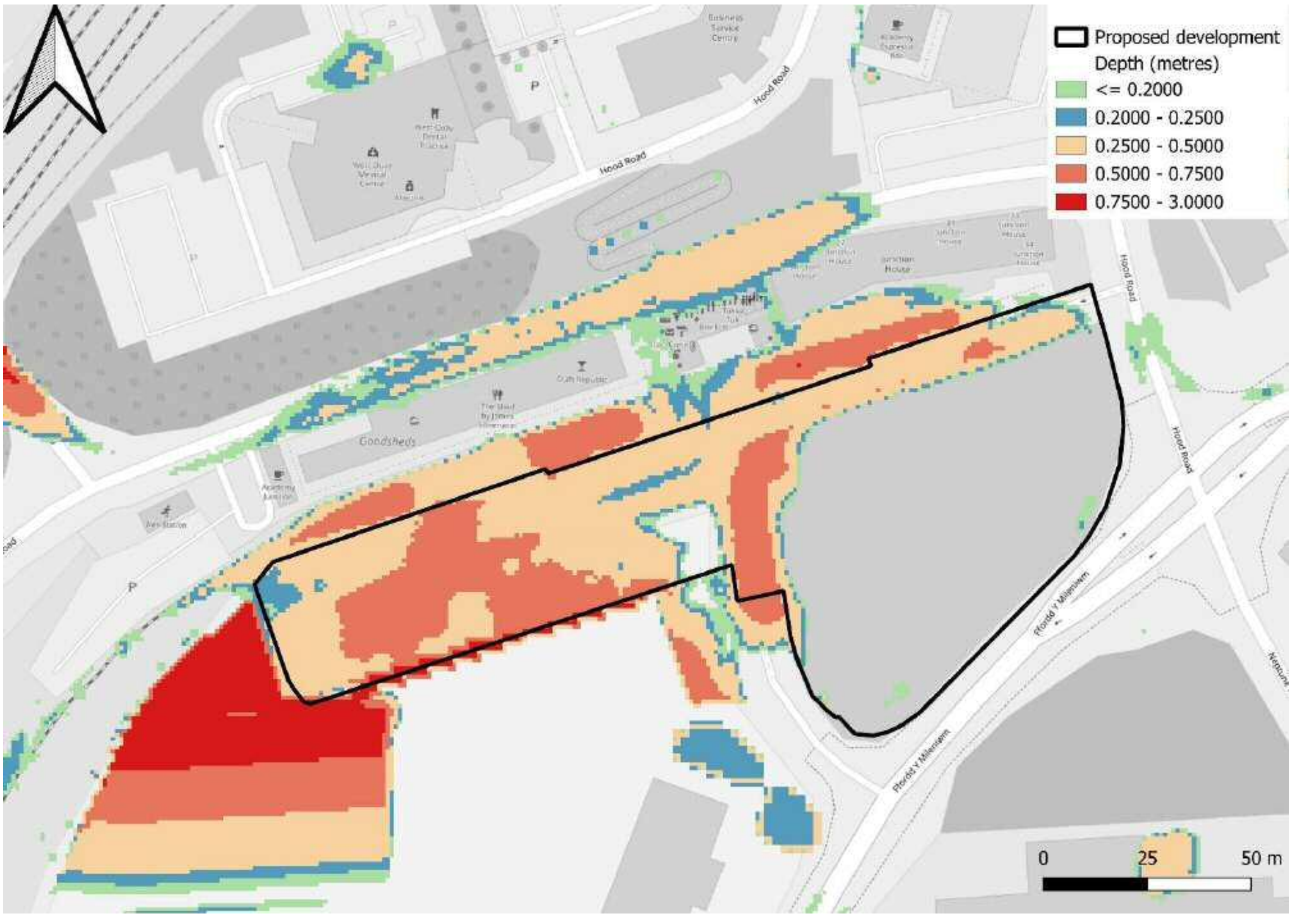

Figure 15: Baseline 1% AEP maximum flood depths

6.1.3 1%+CC AEP event

Maximum flood depths on the proposed development site for the 1% AEP with an allowance for climate change event are shown in Figure 16. The maximum flood depth for this event is approximately **0.78m**.

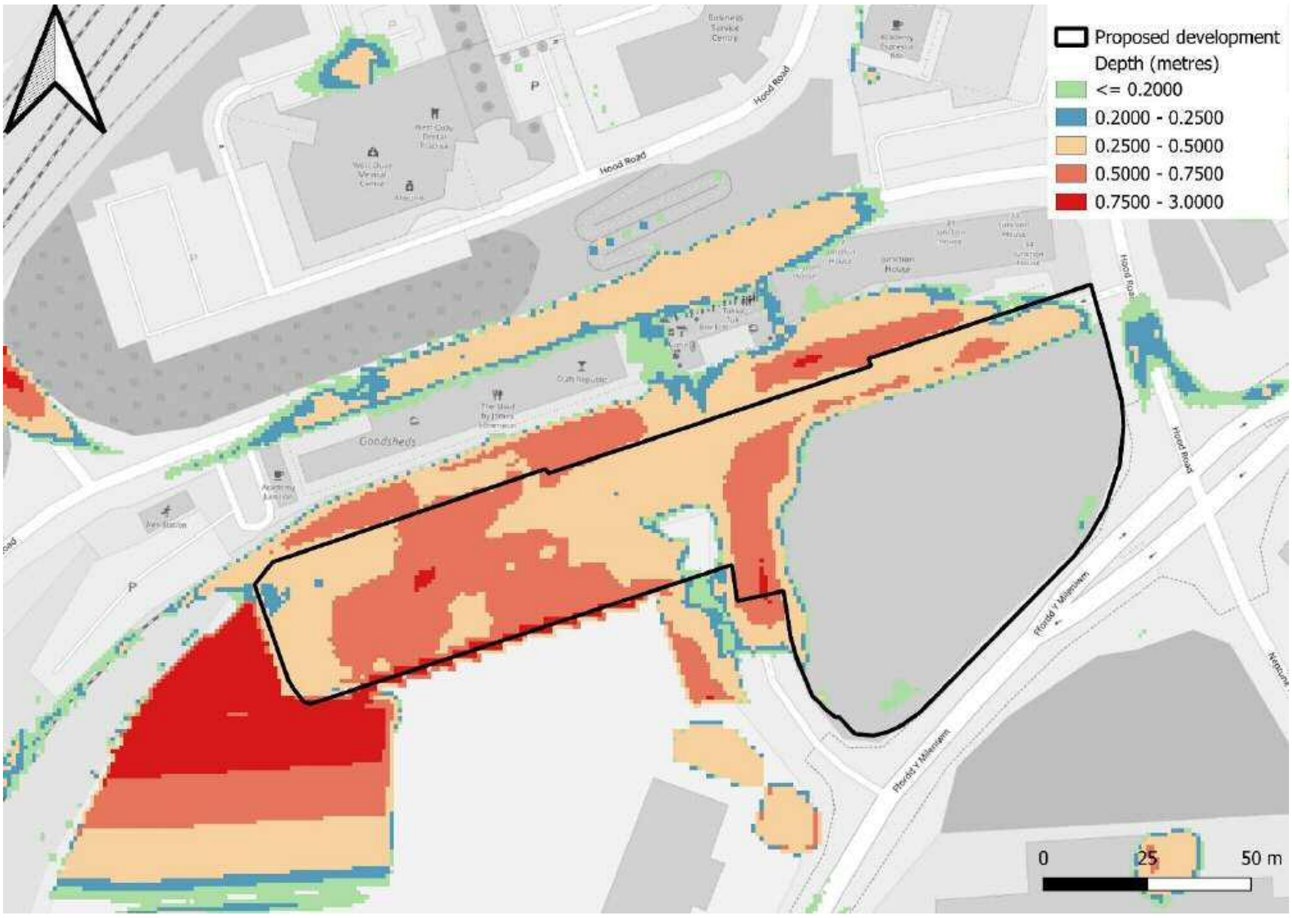

Figure 16: Baseline 1%+CC AEP maximum flood depths

6.1.4 0.1%+CC AEP event

Maximum flood depths on the proposed development site for the 0.1% AEP with an allowance for climate change event are shown in Figure 17. The maximum flood depth for this event is approximately **0.82m**.

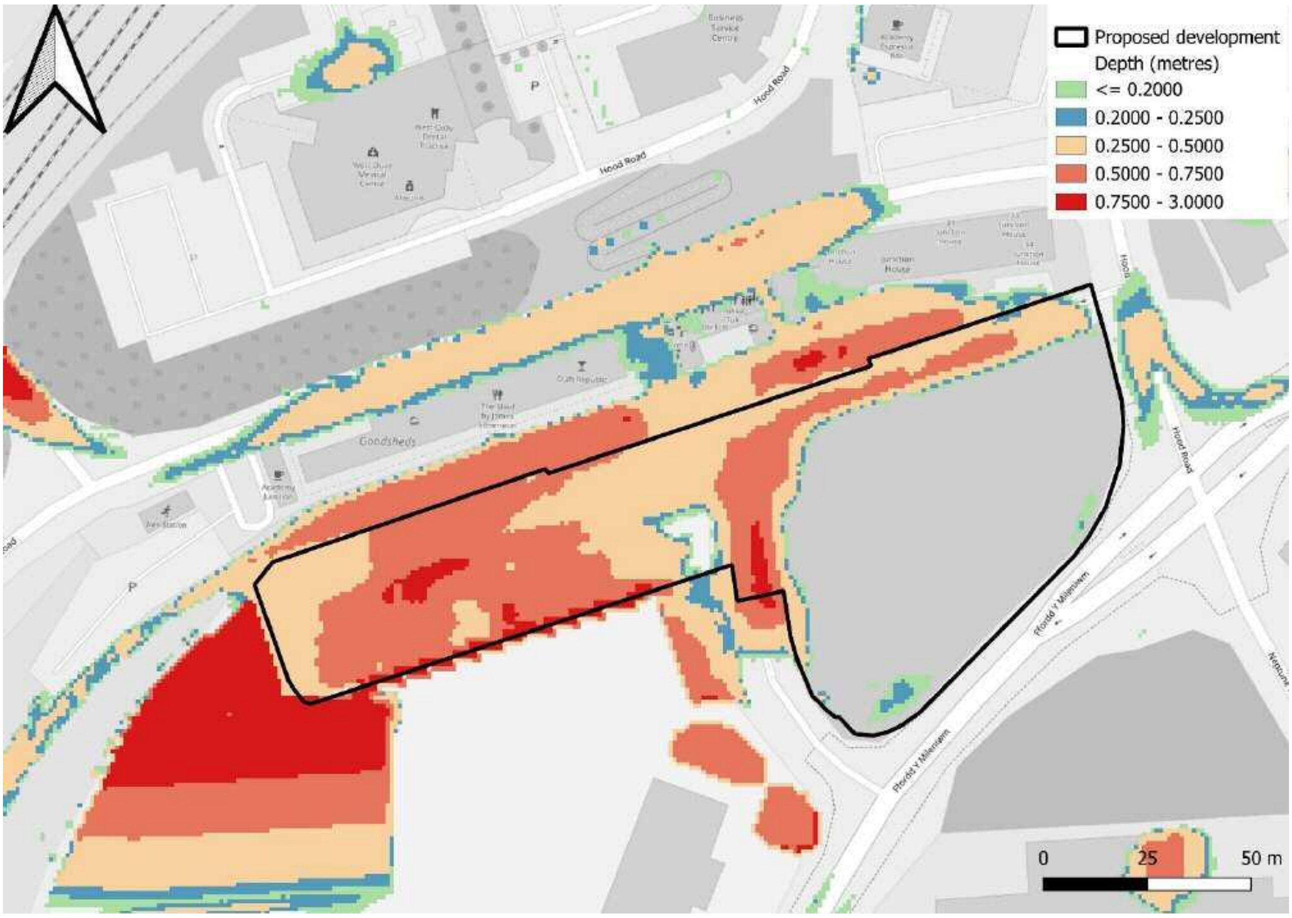

Figure 17: Baseline 0.1%+CC AEP maximum flood depths

6.2 Discussion

As has been discussed, the model used NET rainfall profiles, which include a high-level estimation of interception into the ground from all sources. The existing surface water drainage network is not explicitly represented in the hydraulic model.

Discussions with Vale of Glamorgan (VoG) Council revealed that the surface water drainage network is oversized on Hood Road. Details of the drainage network at this location have been provided, as shown in Appendix B.

On Hood Road, there are 13 gullies connected into a 675mm/750mm pipe, as shown in Figure 18 – a larger version of which is included in Appendix B.

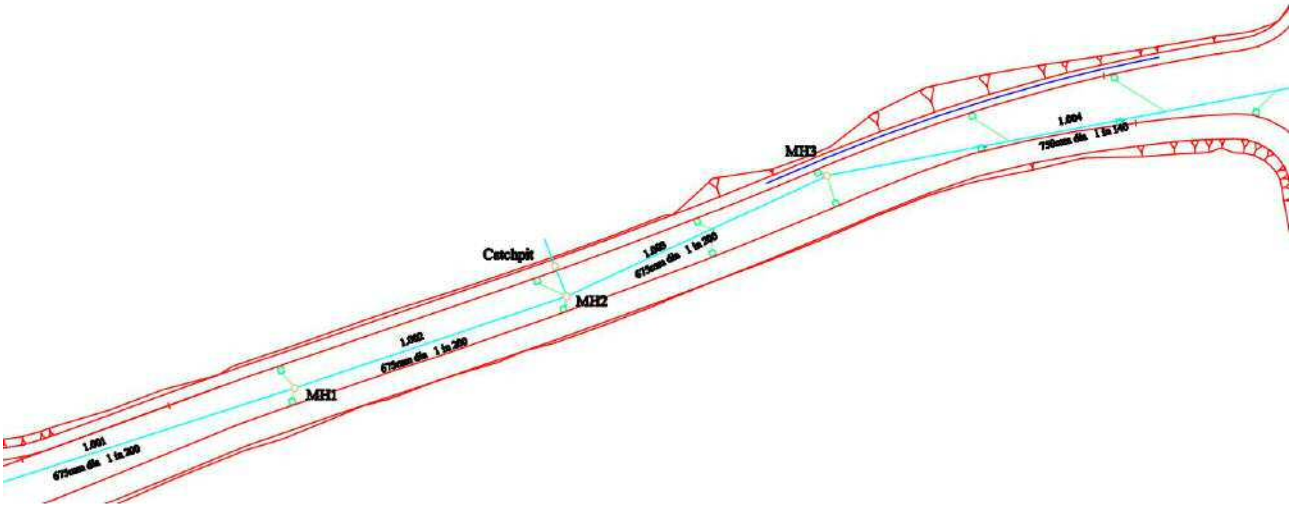

Figure 18: Hood Road surface drainage

6.3 Post-development results

6.3.1 3.33% AEP event

When the proposed development is represented in the hydraulic model, there are no increases in flood depths to 3rd parties during the 3.33% AEP event, as shown in Figure 19. The maximum flood depth on the proposed development is **0.83m**.

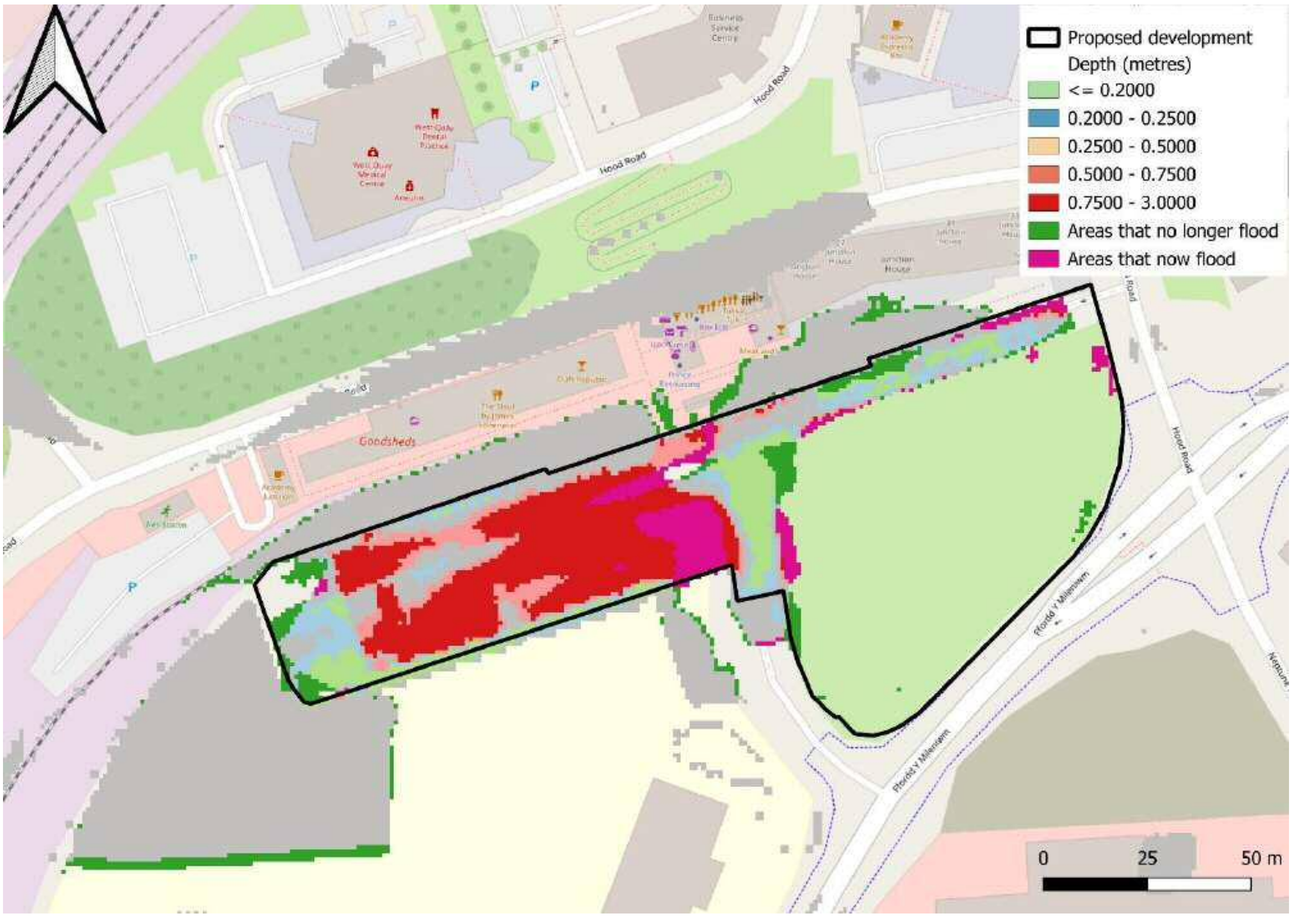

Figure 19: 3.33% AEP change in flood depth in comparison to baseline

6.3.2 1% AEP event

When the proposed development is represented in the hydraulic model, there are no increases in flood depths to 3rd parties for the 1% AEP event, as shown in Figure 20. The maximum flood depth on the proposed development is **1.0m**.

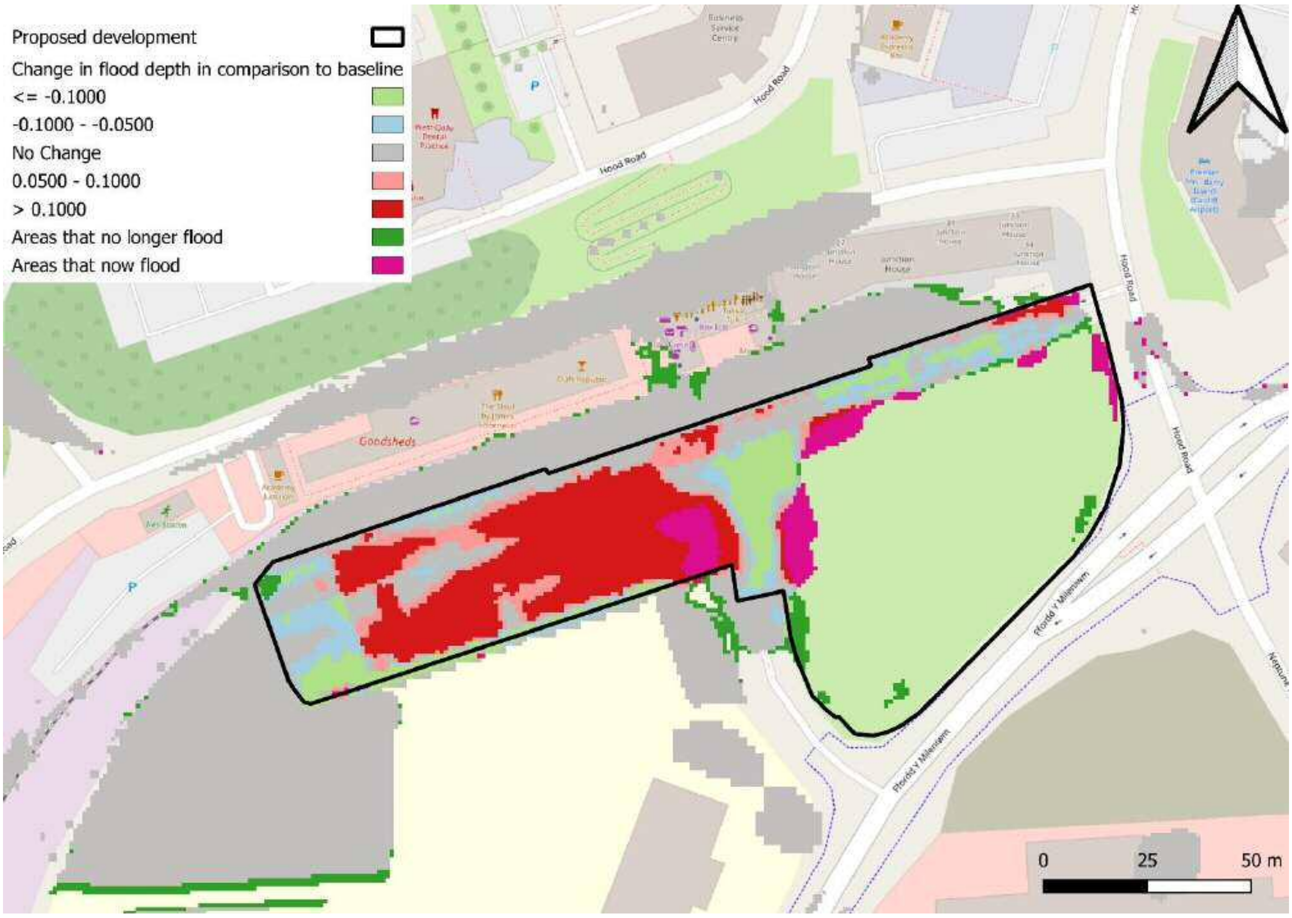

Figure 20: 1% AEP change in flood depth in comparison to baseline

6.3.3 1%+CC AEP event

When the proposed development is represented in the hydraulic model, there are no increases in flood depths to 3rd parties for the 1% AEP with an allowance for climate change event, as shown in Figure 21. The maximum flood depth on the proposed development is **1.01m**.

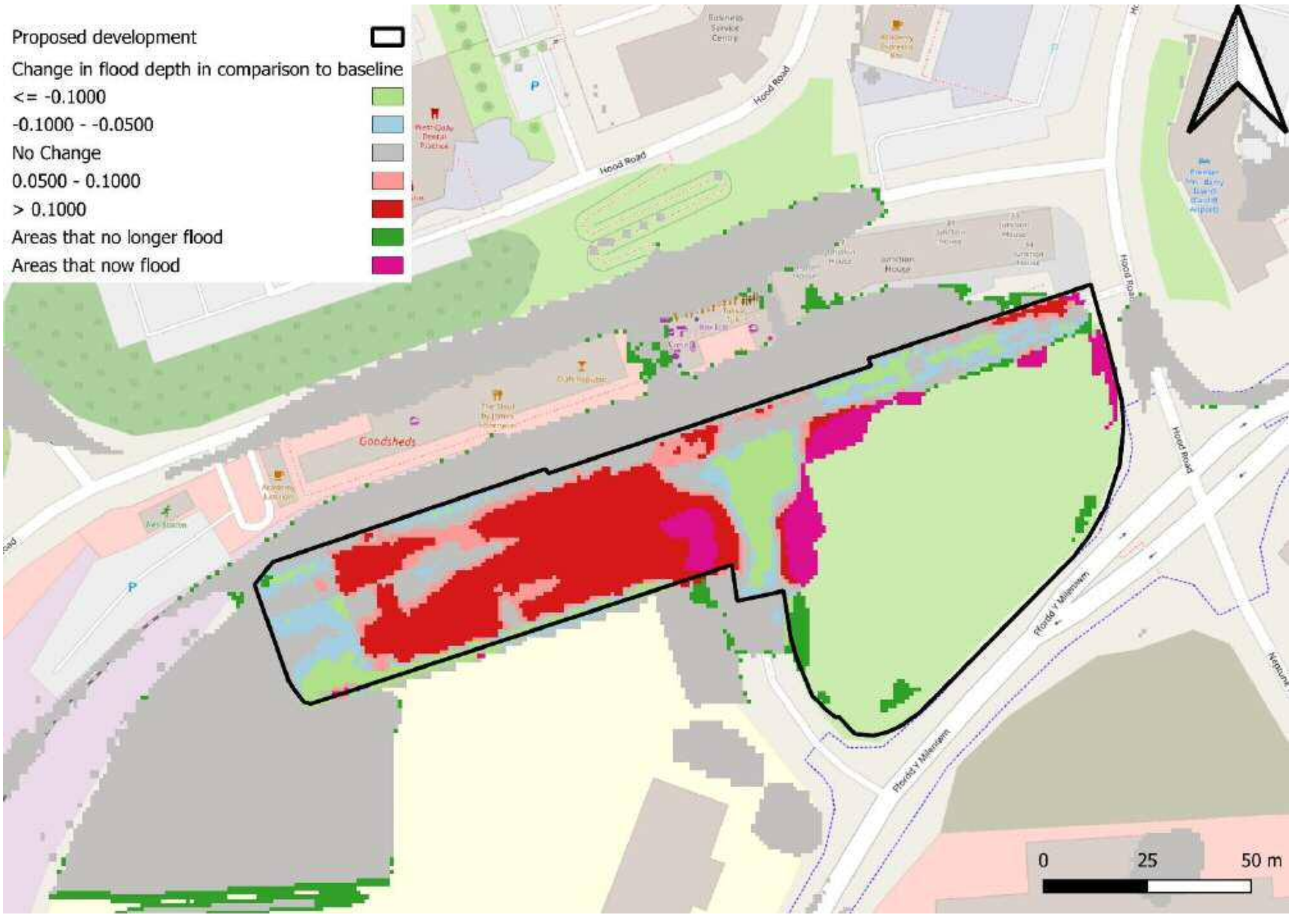

Figure 21: 1%+CC AEP change in flood depth in comparison to baseline

6.3.4 0.1%+CC AEP event

When the proposed development is represented in the hydraulic model, there are no increases in flood depths to 3rd parties for the 0.1% AEP with an allowance for climate change event, as shown in Figure 22. The maximum flood depth on the proposed development is **1.07m**.

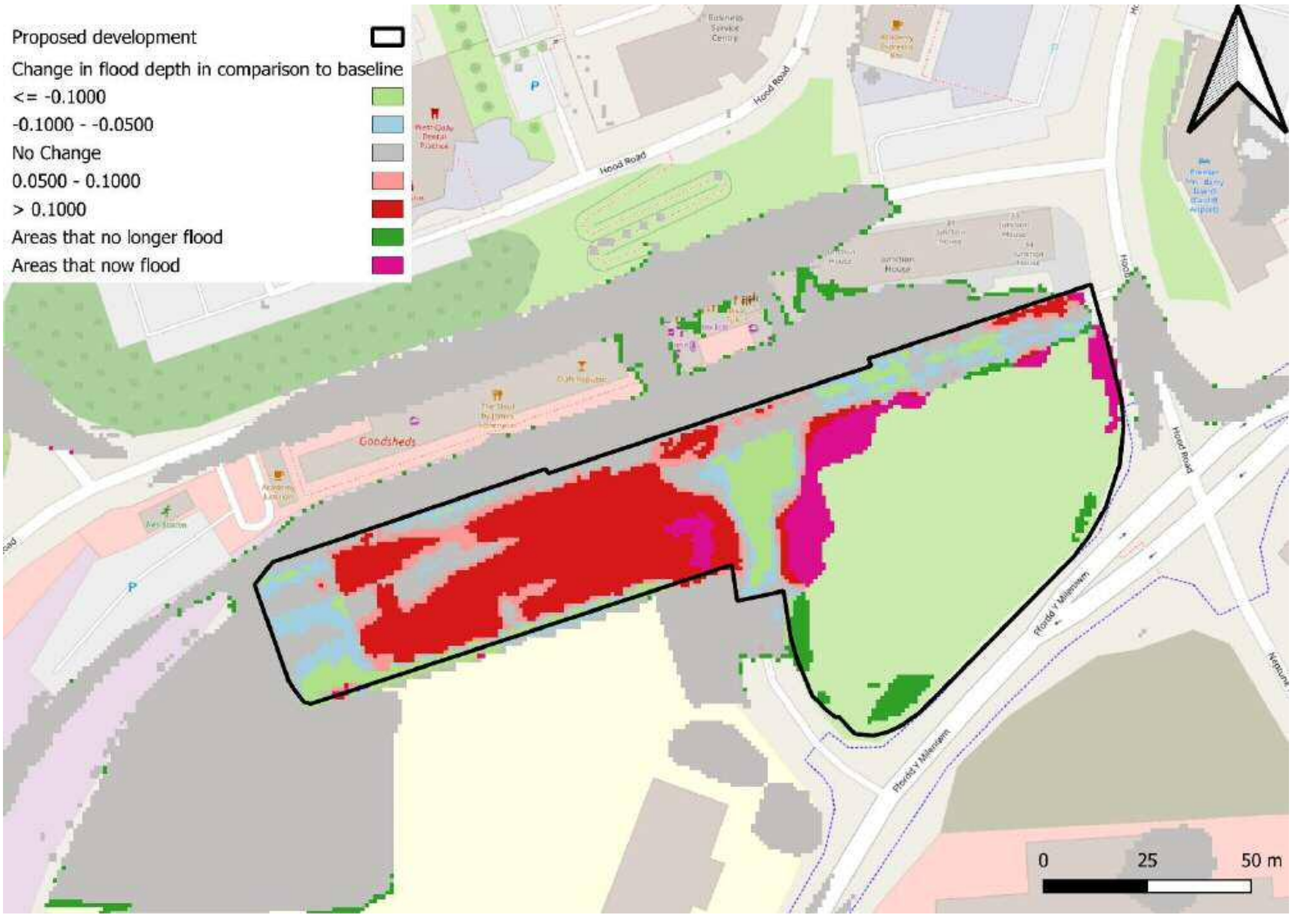

Figure 22: 0.1%+CC AEP change in flood depth in comparison to baseline

6.4 Discussion

The modelling, detailed in the preceding sections has shown the following:

- The proposed development does not result in an increase in flood levels for 3rd parties for any modelled events.
- The building footprint of the proposed development remains flood free for all modelled events.

In comparison to the baseline event, flood depths are increased on the car park. The maximum increase in flood depths in comparison to the baseline model is approximately 0.6m. This is as a results in ground lowering of existing levels in this area.

A surface water drainage network has been designed to serve the proposed site, accommodating runoff generated by impermeable areas on BWC in storm events up to and including the 1 in 100 year return period, plus 40% climate change. Runoff generated by the site is attenuated to a rate agreed with Dŵr Cymru Welsh Water (DCWW) prior to communicating to a DCWW surface water sewer in Ffordd y Mileniwm and ultimately out falling to Barry Dock.

To attenuate surface water runoff generated in storm events up to and including the 1 in 100 year +40% climate change return period, circa. 400m3 of attenuation storage is proposed on the site. Attenuation storage is provided within a geocellular storage tank to the north of the building, in addition to permeable paving and rain gardens with extended subbase depths. In smaller return period storms than the design return period, there will be capacity in the storage structures to accommodate some of the runoff entering the site from the wider catchment.

6.4.1 Access and egress

Safe pedestrian access and egress to the proposed development will be maintained at all times, via the main entrance. As shown in Figure 23, the flood hazard rating at the entrance is 'Caution'.

Figure 23: Flood hazard rating for the 0.1%+CC AEP event overlaid on proposed development layout

7. Conclusions

To understand the baseline and post development flood risk from, and by, the proposed development of a new college building at Barry Waterfront, a 2D only direct rainfall model has been developed, along with new rainfall estimates.

Results from the modelling show that:

- Due to the low-lying nature of the location of the proposed development, baseline flood depths on the proposed development site reach a maximum of **0.82m** for the 0.1% AEP event with an allowance for climate change.
- Given the oversized surface water drainage network that is in place on Hood Road, it is likely that the baseline surface water risk to the proposed development site is over-estimated.
- When the proposed development is represented in the hydraulic model, there is **no increase in flood risk to 3rd parties up to and including the 0.1% AEP event with an allowance for climate change**.
- When the proposed development is represented in the hydraulic model, maximum flood depths on the proposed development reach a maximum of **1.07m**.
- The main building of proposed development **remains flood free** up to and including the 0.1% AEP event with an allowance for climate change.
- Safe access and egress for pedestrians is maintained up to and including the 0.1% AEP event with an allowance for climate change.

8. Bibliography

Welsh Government, 2021. *Flood Consequences Assessments: Climate change,* s.l.: s.n.

Appendix A

Proposed Development Layout

KEY

- (A) ENTRANCE PLAZA
- (B) BIN STORE
- (C) DOUBLE STACKED CYCLE STORAGE
  Number of spaces: 160 long stay, 10 short stay
- (D) CAR PARK ACCESS
  Automatic barrier with intercom to reception and double gate to enable site to be secured when needed
- (E) OUTDOOR DINING
- (F) FEATURE TREES & RAIN GARDEN
- (G) GRASS LAWN
  For socialising and outdoor learning
- (H) DROP OFF ZONE
- (I) AIR SOURCE HEAT PUMP
- (J) CARPARK
  93 spaces (inc. 10no. EVCPs and 4 Accessible Bays)
  2 x Minibus Parking
- (K) SPINKLER & PUMP HOUSE
- (L) ACCESS ROUTE
  For refuse, maintenace and kitchen deliveries only
- (M) L01 ILS TERRACE
  Including shed, greenhouse, Horticulture planting, canopy and external seating
- (N) PV CANOPY
- (O) SITE EGRESS
  For refuse, maintenace and kitchen deliveries only
- (P) HEDGE
- (Q) MOTORCYCLE PARKING
  3no. spaces
- (R) GAS KIOSK
- (S) EDIBLE GARDEN
- (T) BATTERY
- (U) STORAGE SHED
- (V) GENERATOR

Note

1. Do not scale from this drawing
2. To be read in conjunction with Project Risk Register REF: VG0201-ALA-00-XX-RG-L-00001
3. To be read in conjunction with all other Landscape Architect's drawings

ID	RISK	MITIGATION	DATE MITIGATED

RESIDUAL PROJECT RISKS

DATE	REV	DESCRIPTION OF REVISION	DRAWN BY	APPROVED BY
20/03/2024	P05	Issued for Planning	MDS	MH

REVISIONS

STATUS
A2 - ***Authorized and Accepted as Planning Application Submission***

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CLIENT :
Cardiff and Vale College

PROJECT TITLE :
Barry Waterfront Campus

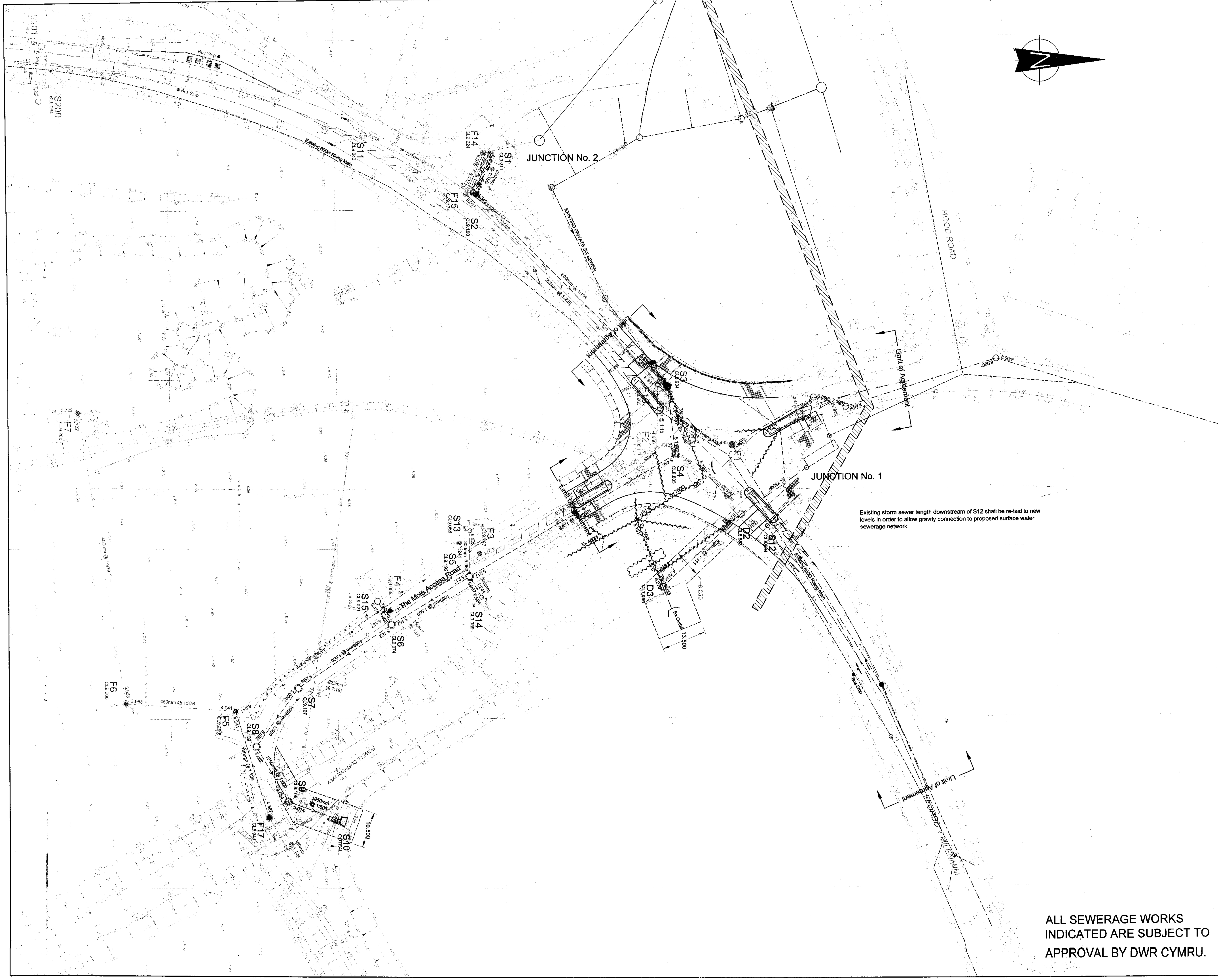
DRAWING TITLE :
Landscape Illustrative Masterplan

DRAWING SCALE :	DRAWN BY :	DRAWN DATE :
1:250	HS	15/06/2022
PAPER SIZE :	APPROVED BY :	ALA PROJECT CODE:
A1	HT	ALA724

DRAWING NUMBER :	STATUS :	REVISION :
VG0201-ALA-00-XX-DR-L-00001	**A2**	**P05**

Appendix B

Hood Road Drainage Plans



ALL SEWERAGE WORKS INDICATED ARE SUBJECT TO APPROVAL BY DWR CYMRU.

NOTES

GENERAL NOTES:-

The Contractor is to check and verify all building and site dimensions, levels and sewer invert levels at connection points before work starts. Any discrepancy is to be reported to Healer Associates before work commences.

The Contractor is to comply in all respects with current building legislation - Building Standard Specifications, Building Regulations etc., whether or not specifically stated on this drawing.
The drawing must be read with and checked against any structural, geotechnical or other specialist documentation provided.

This drawing is not intended to show details of foundations, ground conditions or ground contaminants. Each area of ground relied upon to support any structure depicted (including drainage) must be investigated by the Contractor. A suitable method of foundation should be provided allowing for all existing ground conditions. Any suspect or fluid ground, contaminants on or within the ground, should be further investigated by a suitable expert. Any earthwork construction shown indicates typical slopes for guidance only and should be further investigated by a suitable expert.

Where existing trees are shown to be retained they should be subject to a full Arboricultural inspection for safety.

All trees are to be planted so as to ensure they are a minimum of 5 metres from buildings and 6 metres from drainage and services. A suitable method of foundation is to be provided to accommodate the proposed tree planting.

All sewers which are to be the subject of a Section 104 Agreement are to be constructed in accordance with the National Water Council's Sewers for Adoption document Sixth Edition, and to the satisfaction of the adopting sewerage undertaker.

All the sewer trenches sited within proposed roads are to be back-filled with stone, unless specific written approval is sought and received from the Local Authority's Engineer to return excavated material. Where road levels dictate, the material employed as fill is to be approved by the Local Authority's Engineer.

All adoptable pipes of 225mm diameter or less are to be E.S.V.C. Larger pipes are to be Class H concrete.
U.P.V.C. pipes may be used subject to manufacturers recommendations and specific approval of the adopting sewerage undertaker.

All lateral connections to main foul and storm sewers shall be 150Ø minimum.

All sewers are to be constructed using Class S granular bed and surround.

All sewers with less than 1.2m of cover beneath roads or 0.9m elsewhere area to have 150mm thick Class Z concrete bed and surround..

All outfall levels and existing sewer levels are to be confirmed by the Contractor before works commence.

The existing ground levels along the route of the proposed road are to be confirmed by the Contractor before works commence.

All roads which are to be the subject of a Section 38 Agreement are to be constructed in accordance with the Local Highway Authority's current specification and to the satisfaction of the Local Highway Authority's Engineer.

All construction methods and materials employed are to be in accordance with the current road and bridgeworks specification. All construction thicknesses are to be confirmed by C.B.R. test.

No responsibility will be taken for any construction work undertaken prior to receipt of technical approvals for the intended construction, or when work is not executed strictly in accordance with the drawings.

KEY

- Proposed Combined Sewer Overflow Diversion
- Proposed Foul Water Sewer
- Proposed Surface Water Sewer
- Existing foul water sewer to be abandoned
- Proposed highway gully and connection
- Consortium Title Boundary

REV:	BY:	CHK:	DESCRIPTION:	DATE:
D	EP		Easement to Dock outfall added	March 13
C	EP		BILR and Mole Access in grey lines	March 13
B	EP	EP	Drainage layout corrected.	Feb '13
A	EP	EP	Pipe run between S3 and S4 revised, coloured surfacing removed	Feb '13

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CLIENT:
BARRY WATERFRONT CONSORTIUM

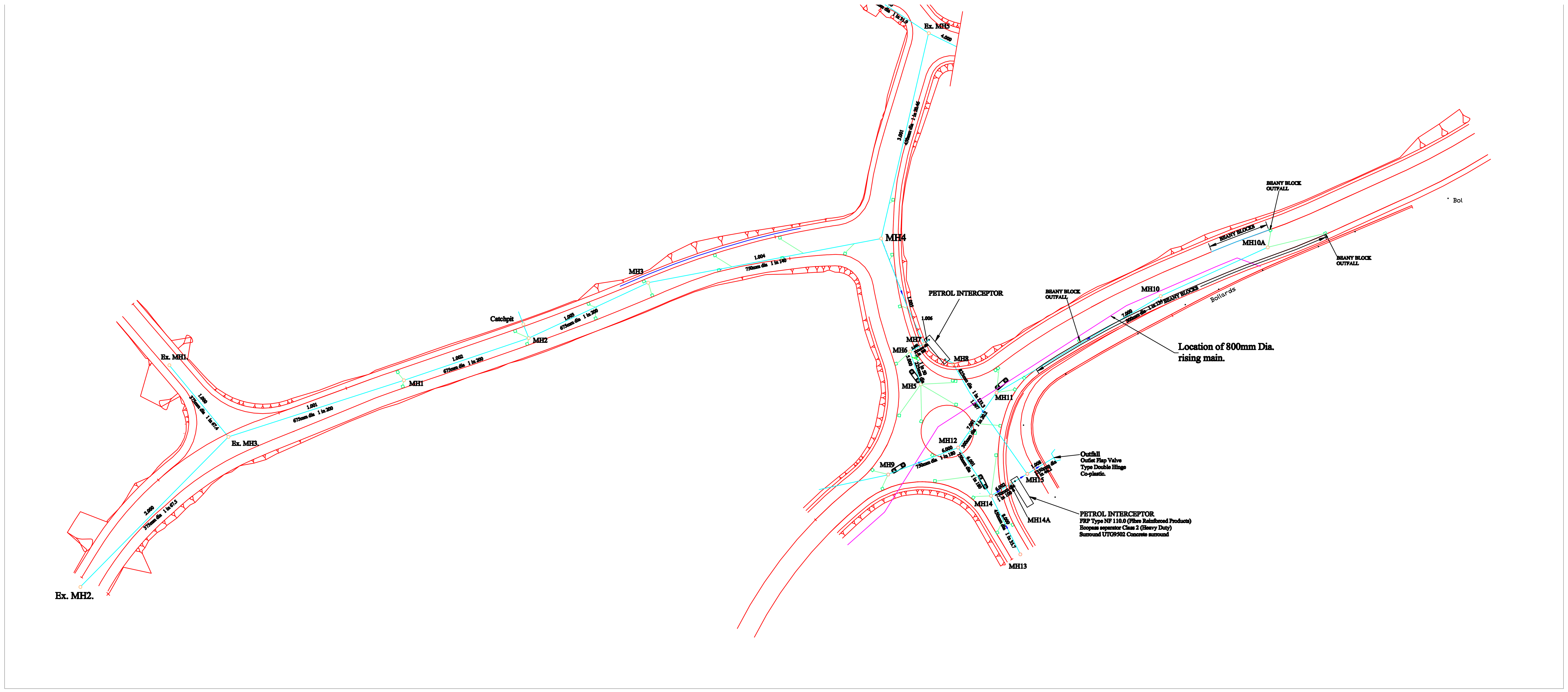
DEVELOPMENT:
BARRY WATERFRONT DEVELOPMENT
MAIN INFRASTRUCTURE PHASE 1

TITLE:
JUNCTION 1
DRAINAGE LAYOUT

SCALE (S): 1:500

DATE:	DRAWN:	CHKD BY:	SIZE:
MAY 2012	EP		A1

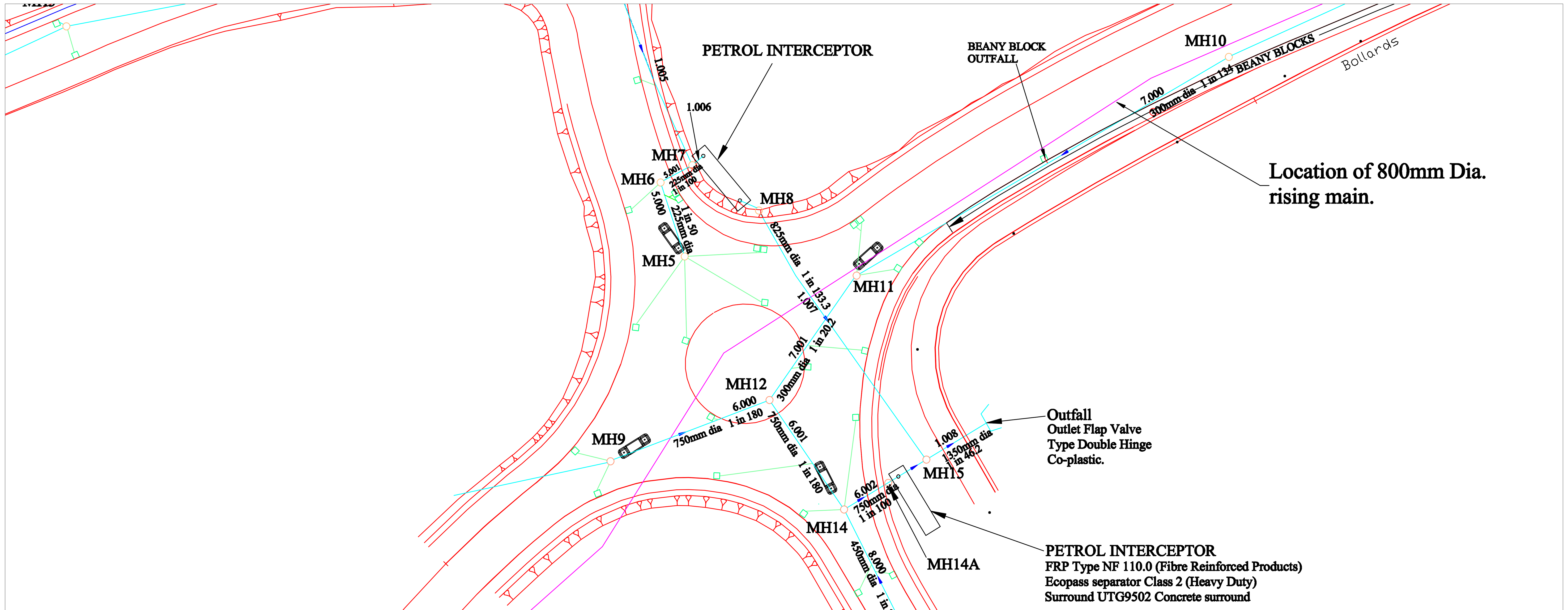
DRAWING NUMBER	REVISION:
3572_S278-J1-102	D



Manhole Schedule

Manhole Number	Cover Level	Manhole Depth (mm)	Manhole Diam.(mm)	Pipes Out			Pipes In		
				PN	IL (m)	Dia (mm)	PN	IL (m)	Dia (mm)
1	8.663	0.932	Type C*	1.002	7.371	675	1.001	7.371	675
2	8.563	1.415	Type C*	1.003	7.121	675	1.002	7.121	675
3	8.399	1.604	Type C*	1.004	6.796	750	1.003	6.871	675
4	9.101	2.951	1800	1.005	6.150	750	1.004	6.150	750
							3.001	6.613	450
5	8.596	1.536	1050	5.000	7.060	225			
6	8.560	1.810	1050	5.001	6.750	225	5.000	6.800	225
7	8.594	2.865	1800	1.006	5.735	750	1.005	5.735	750
							5.001	6.690	225
8	8.600	2.963	1800	1.007	5.637	750	1.006	5.637	750
9	8.571	3.110	1800	6.000	5.440	750			
10	8.650	1.150	Type C*	7.000	7.500	300			
11	8.500	1.537	1050	7.001	6.963	300	7.000	6.963	300
12	8.500	3.225	1800	6.001	5.275	750	6.000	5.285	750
13	8.675	1.595	1350	8.000	7.080	450			
14	8.500	3.349	1800	6.002	5.151	750	6.001	5.151	750
							8.000	6.380	450
15	7.809	3.428	2400	1.008	4.381	1350	1.007	5.233	750
							6.002	4.981	750

* Type C Brick built Manhole (Reference Sewers for Adoption)



ENLARGED DETAIL OF INTERCEPTOR POSITIONS 1:500

Rev	By	Description of Amendment	Chk by
B	SJG	AS CONSTRUCTED	
A		Manhole 10 A added	Gat
		Contract issue	Gat
		TENDER ISSUE	

Revisions

the VALE of GLAMORGAN BRO MORGANNWG

ECONOMIC DEVELOPMENT, PLANNI[NG,]
TRANSPORTATION & HIGHWAYS

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ENGINEERING SERVICES

Client: The Vale of Glamorgan Counci[l]

Project: **HOOD ROAD IMPROVEMENTS PHASE 2**

Drawing Title: **DRAINAGE DETAILS (AS CONSTRUCTED)**

Drawn LTG	Scale 1:1000	Project No. 893	Drawing No. 02/501
Date 05/99			
Checked CWJ	File 893/ph2ascon	Rev A B	
Date 05/99	Window drg893-02-501b		