BAM

Victoria North Infrastructure and Enabling Works

Flood Risk Assessment

VNIF-ARP-ZZ-YYY-RP-CD-0002

P04 | 28 April 2022

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 282022

Ove Arup & Partners Ltd
6th Floor 3 Piccadilly Place
Manchester M1 3BN
United Kingdom
www.arup.com

ARUP

Document verification

ARUP

Job title		Victoria North Infrastructure and Enabling Works			**Job number** 282022
Document title		Flood Risk Assessment			**File reference**
Document ref		VNIF-ARP-ZZ-YYY-RP-CD-0002			
Revision	**Date**	**Filename**			
P01	30 Nov 2021	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Emily Stoddart	Drew Hunter/ Ryan Griffiths	Melanie Edwards
		Signature			
P02	28 Jan 2022	Filename	Flood Risk Assessment – Planning Application 2		
		Description	Revised after updated flood modelling received		
			Prepared by	Checked by	Approved by
		Name	Emily Stoddart	Drew Hunter/ Ryan Griffiths	Melanie Edwards
		Signature			
P03.01	11 Feb 22	Filename			
		Description	Updated to clarify the proposed mitigation proposals		
			Prepared by	Checked by	Approved by
		Name	Ryan Griffiths	Lanzhu Shao	Michael Wilton
		Signature			
P03.02	16 Mar 22	Filename			
		Description	Updated to reflected updated hydraulic modelling		
			Prepared by	Checked by	Approved by
		Name	Ryan Griffiths	Lanzhu Shao	Michael Wilton
		Signature			
			Issue Document verification with document		✓

Document Verification

Job title		Victoria North Infrastructure and Enabling Works			**Job number** 282022
Document title		Flood Risk Assessment			**File reference**
Document ref		VNIF-ARP-ZZ-YYY-RP-CD-0002			
Revision	**Date**	**Filename**	Main Works FRA V5.docx		
P03	19 Apr 2022	**Description**	Updated to reflect approved hydraulic modelling		
			Prepared by	Checked by	Approved by
		Name	Ryan Griffiths	Ryan Griffiths	Michael Wilton
		Signature			
P04	26 Apr 2022	**Filename**	Main Works FRA V5.1.docx		
		Description	Updated with AY and PF comments		
			Prepared by	Checked by	Approved by
		Name	Ryan Griffiths	Ryan Griffiths	Michael Wilton
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document Verification with Document	✓

Contents

Page

1 Introduction 1

2 Site location 4

3 Development proposals 5

3.1 Plateau Area 6
3.2 St Catherine's wood 6
3.3 Dantzic Street 8
3.4 Red Bank terrace 8
3.5 Union Plaza and RB06, 07 and 08 9

4 Site specific flood risk 10

4.1 Fluvial flood risk 10
4.2 Surface water flood risk 12
4.3 Ground water flood risk 13
4.4 Flooding from public sewers 13
4.5 Reservoir flood risk 13
4.6 Sequential Test 13
4.7 Existing flood risk conclusions 14

5 Impact of proposed scheme 15

5.1 Fluvial 15
5.2 Surface water 18

6 Flood risk management measures 18

6.1 Fluvial 18
6.2 Surface water 24

7 Conclusion 25

Figures

Figure 1 Victoria North HIF Works Boundary 1
Figure 2 Victoria North HIF Infrastructure Works Site Location 4
Figure 3 Proposed development arrangement5
Figure 4 Proposed HIF works areas for reference 6
Figure 5 St Catherine's Wood river wall removal indicative section 7
Figure 6 St Catherine's Wood bank reprofile indicative section 8
Figure 7 Red Bank Terrace indicative section 8
Figure 8 Typical indicative section through the Union Plaza terracing 9
Figure 9 Flood Zones 2 and 3 from the EA Flood Map for Planning10

Figure 10 Flood Zone Extents identified in the Manchester, Salford and Trafford SFRA (note: flood zones 2 and 3a will be taken from EA flood maps and updated modelling) 11

Figure 11 Surface Water Flood Extents extracted from EA Flood Map for Planning (High Risk ≥3.3%, 1< Medium Risk <3.3%, 0.1%< Low Risk <1%, Very Low Risk ≤0.1%) 12

Figure 12 Impacts of scheme on flood depth and extent from interim 2021 modelling for 100 year plus climate change event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology. 16

Figure 13 Impacts of scheme on flood depth and extent from interim 2021 modelling for 1000 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology. 17

Figure 14 interim 2021 modelled out of bank flow (1000 year) under exiting condition (left) and proposed removal of river wall (right). 17

Figure 15 Proposed bund 19

Figure 16 Bund section A-A 20

Figure 17 Impacts of scheme including the bund on flood depth and extent from interim 2021 modelling for 100 year plus climate change event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology. 21

Figure 18 Impacts of scheme including the bund on flood depth and extent from interim 2021 modelling for 1000 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology. 21

Figure 19 Interim model flood extents proposed mitigation bund comparison 1 in 100 year plus climate change event 22

Figure 20 Interim model flood extents proposed mitigation bund comparison 1 in 1000 year event 22

1 Introduction

Arup has been commissioned by BAM to produce a Flood Risk Assessment (FRA) for the Victoria North HIF Infrastructure Works. These works are for the installation and construction of infrastructure elements to allow for the future development of the land included within the red line boundary. Separate planning applications are to be submitted for works proposed downstream of the site within the River Irk and for the development of the plots at later a date.

The proposed development covers an area of approximately 15.74ha, a proportion of this area includes the future development plots and which will be delivered separately to the HIF Infrastructure works. The site currently consists of a combination of greenfield and brownfield industrialised landscape and parkland. The proposed development under the HIF scheme includes land remediation, landscaping of green areas and public realm, a new access road and utilities provisions and diversions including foul and surface water drainage.

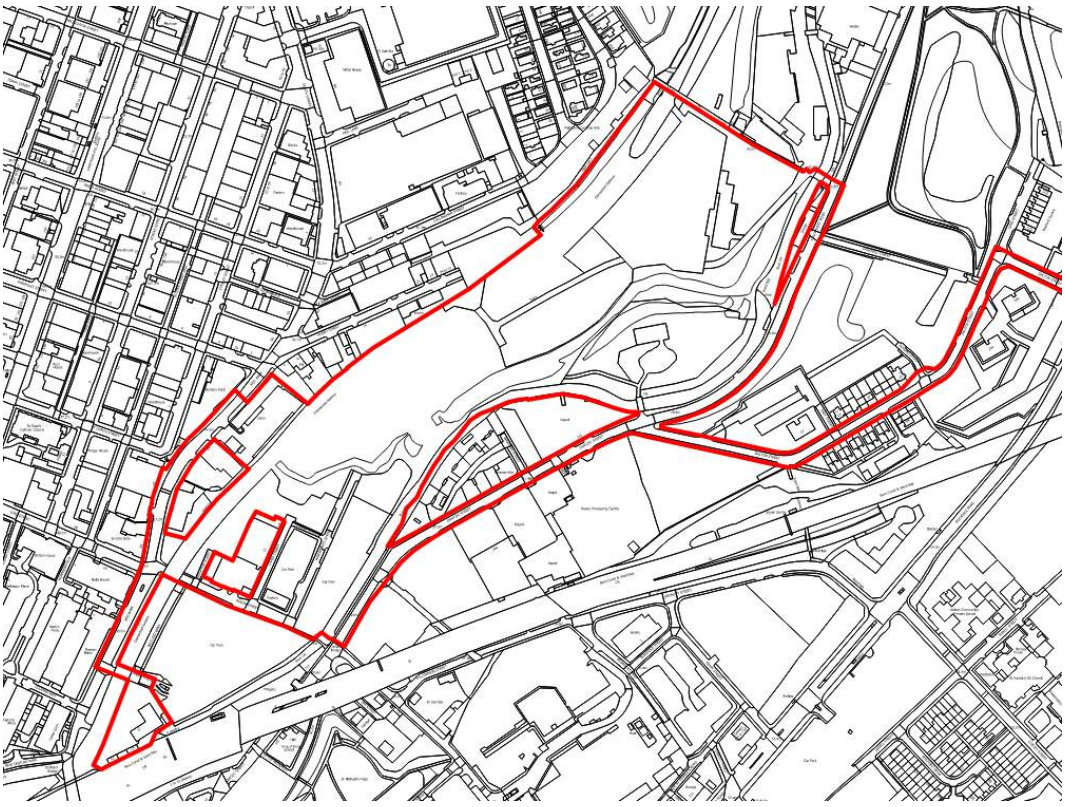


Figure 1 Victoria North HIF Works Boundary

The infrastructure and enabling works, flood alleviation works and the plot development on land controlled and owned by MCC and FEC at Red Bank constitutes the “Development Project”. This FRA is prepared in respect of the HIF Infrastructure Works (the Proposed Development) (Application 2). Four planning applications in total will be made, as follows:

- HIF Advance Enabling Works (referred to hereafter as ‘Application 1’). – for which planning permission has been granted, as explained below.

- City River Park (Phase 1), Future Development Platforms, New Spine Road, and Associated Infrastructure Works (HIF Infrastructure Works - referred to hereafter as 'Application 2'). i.e. this application, submitted by MCC.
- HIF Flood Defence Works (referred to hereafter as 'Application 3').
- Red Bank Neighbourhood (referred to hereafter as 'Application 4').

It is noted that, although the applications are given numbered references, this does not depict the order in which the applications are to be submitted and does not denote a pre-determined sequencing.

Application 1 for the HIF Advance Enabling Works was submitted to MCC on 25th November 2021 (planning ref. 132252/VO/2021) and was approved on 23rd December 2021

The majority of the HIF Infrastructure Works are related to level and layout changes (as discussed in section 3) and the provision of new utilities connections including surface water drainage. The boundary as shown in Figure 1 also includes a section of Red Bank, Roger Street, Dantzic Street and a section South of Dantzic Street. Within these existing roads the proposed works are limited to modifications of existing and installation of proposed utilities within the existing highway corridor. No changes to layout or levels are proposed within these areas and therefore they have been excluded from the FRA as there are no changes to the existing conditions.

The works are in areas of flood zones 1, 2 and 3. The majority of the works to modify levels and install new infrastructure will be within flood zone 1, identified within the project as the Plateau area of works, these areas are at a low risk of flooding. The areas around and within plots RB06-RB08, the area of St Catherine's Wood and the roads including Dantzic Street to the south of the river, are a mix of flood zones 2 and 3, these areas are at a high risk of flooding from fluvial sources.

This FRA has been produced to support the planning application submission for the HIF infrastructure works. The future development of the plots will be covered by a further FRA under a separate flood risk assessment. At present the areas identified as part of the HIF Infrastructure works will also remain at the same level of risk for the plot development. The future application will therefore need to take into account this risk and provide suitable mitigation for the development plots.

There are also proposals for works to be undertaken to the River Irk as part of the wider scheme which will be undertaken under a separate planning application. These works aim to reduce the flood risk within the area by making improvements to the river channel and removing potential flow throttle points. These works are likely to be undertaken within a similar timescale to the HIF Infrastructure Works. However as this scheme has not been finalised the flood risk reduction these works will provide cannot be taken into account for this application.

This report summarises the flood risk due to all potential sources, assesses the impact of the proposed HIF Infrastructure Works development and recommends flood management measures to mitigate the impacts of the works.

The FRA has been developed with reference to the following data and guidance:

- EA flood maps
- Updated fluvial flood extents baseline conducted by Arup for the Victoria North HIF proposals dated December 2021.
- National Planning Policy Framework
- Manchester, Salford and Trafford Strategic Flood Risk Assessment

2 Site location

The Victoria North HIF site lies to the north of Manchester Victoria Train Station to the east of Red Bank and north of Dantzic Street. The site mostly consists of post-industrial land and areas of hardstanding, as well as some buildings with industrial uses, which are mostly disused. Historically the area to the north of the site was used as railway sidings which is now disused and forms a plateau above the River Irk valley to the South East. The works covers an area of approximately 15.74ha and is shown by the red line boundary below in Figure 2.



Figure 2 Victoria North HIF Infrastructure Works Site Location

3 Development proposals

The HIF Infrastructure Works will involve land remediation, modifications to existing levels and slopes, landscaping of green areas and public realm, new access road, and utilities provisions and diversions including foul and surface water. Under the HIF infrastructure works, no infrastructure will be delivered on-plot other than land remediation. All works covered within this FRA are therefore classified as Less Vulnerable within the Flood Risk vulnerability classification. The wider future development of the Victoria North site will include the build of multiple high density residential and commercial buildings and public realm and as discussed above will be covered by future planning applications.



Figure 3 Proposed development arrangement

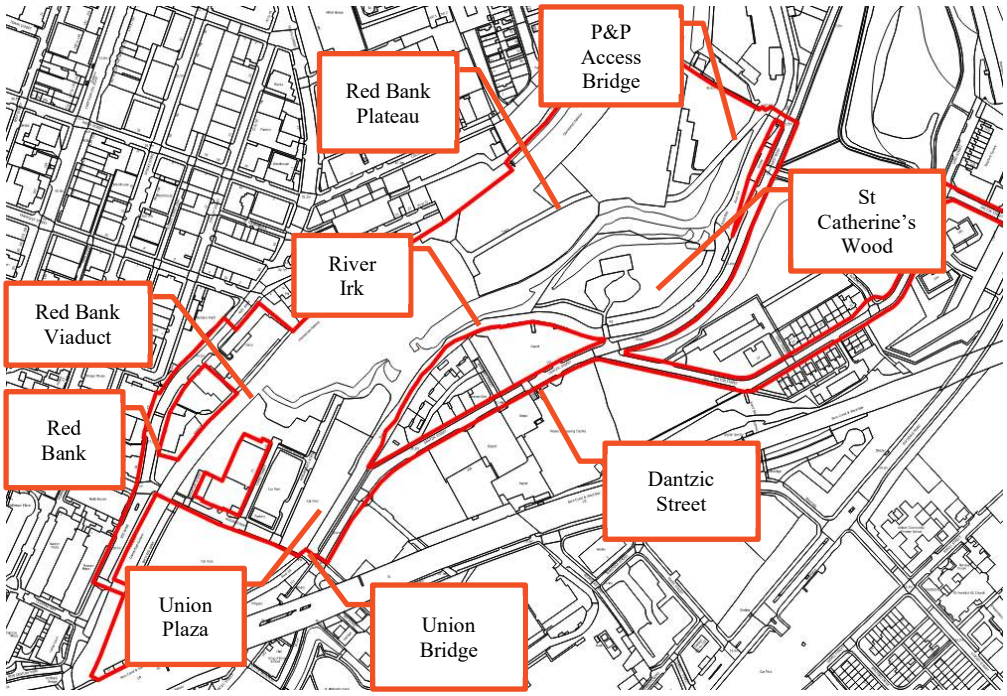


Figure 4 Proposed HIF works areas for reference

3.1 Plateau Area

Works within the Plateau Area of the site involve the construction of an access road, the installation of services including surface water drainage and the remediation and remodelling of the ground in the area to form development platforms RB12b, RB01, RB02, RB03, RB04, RB05a, RB05b and RB05c. This area lies wholly within flood zone 1 due to its relatively elevated position above the river and surround ground.

3.2 St Catherine's wood

Works within the existing St Catherine's wood are proposed to improve the amenity value of the area, including new footways, play equipment and the removal of sections of the existing river walls to improve the amenity and ecological value of the river. The below indicative section Figure 5 shows how the areas where the river wall is to be removed may look. The proposed walkway balustrades will be designed to minimise the chance of debris being caught within them during a flood event. This will be achieved by ensuring the walkways are as high as possible above the normal river level and the balustrades/handrails will be lightweight and have maximum openings to allow debris to pass through them if necessary.

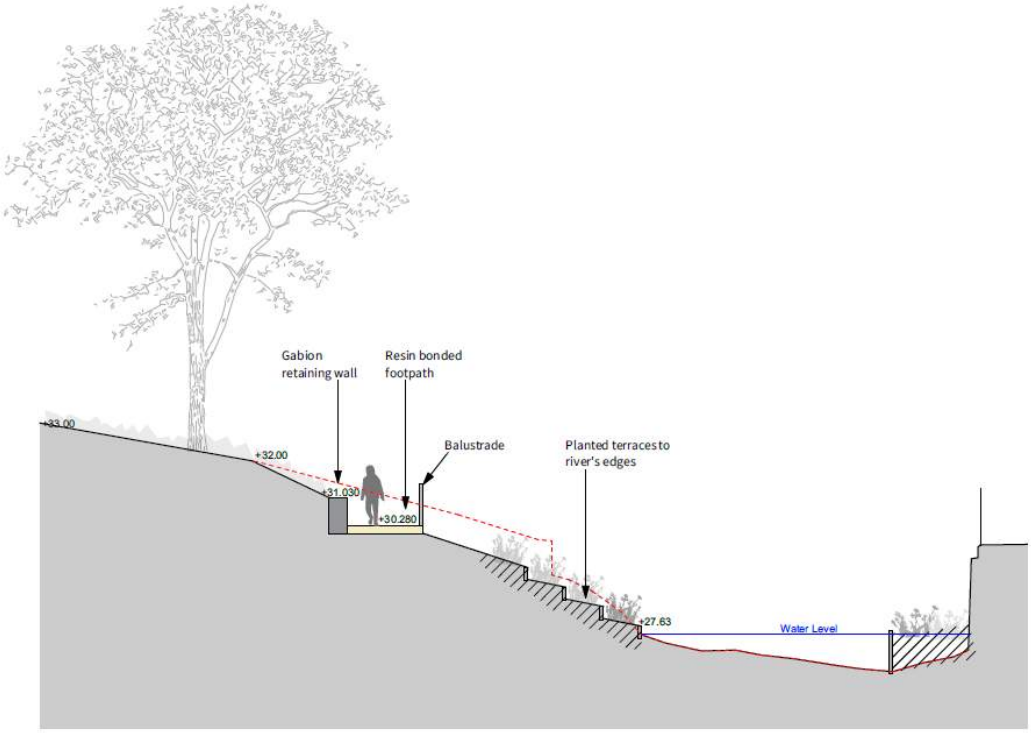


Figure 5 St Catherine's Wood river wall removal indicative section

Further west along the river the existing steep sided bank, which shows some signs of instability will be remodelled to reduce the gradients and ensure that it will be stable in the long term, see Figure 6 below showing proposed modifications. The existing river wall along this section will be maintained at its current height and in its present condition.

It is proposed that a bridge is to be incorporated in a future phase of the works and this has therefore not been included in this FRA. Any flood risk impact of this future bridge will be considered in future as part of a later planning application.

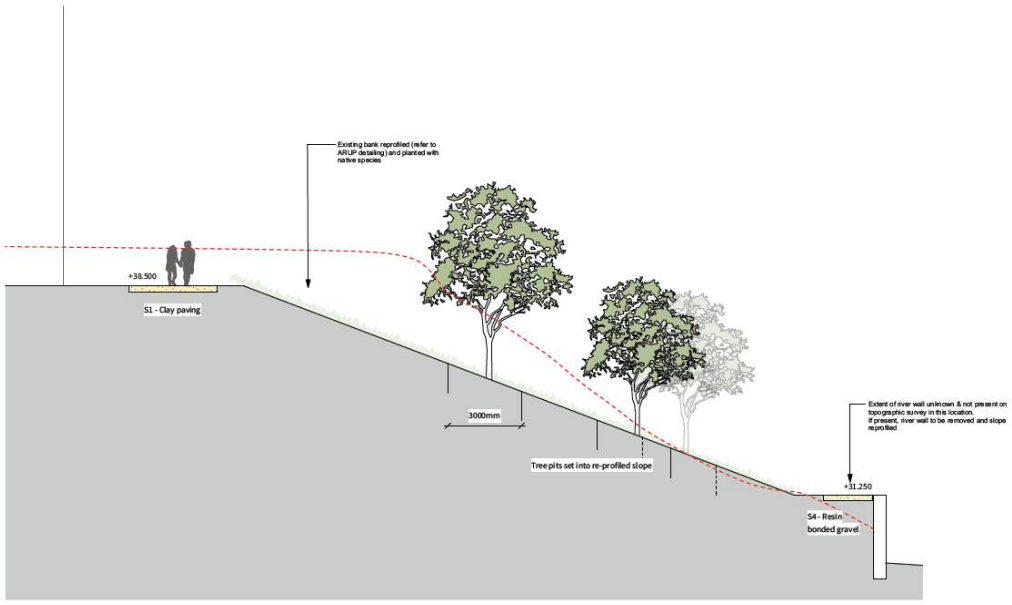


Figure 6 St Catherine's Wood bank reprofile indicative section

3.3 Dantzic Street

Works within Dantzic street will be the diversion of existing services, installation of new services and modifications to the existing sewers to allow for new connections. All works will be undertaken within the existing highway corridor. No modifications to the levels or alignment of the highway will be included in the works.

3.4 Red Bank terrace

Within the area between the Plateau and Rb06, 07 and 08 it is proposed to create a terraced access route, this will include the remodelling of an existing slope to reduce the gradients to allow for accessible footpaths to be formed. An indicative section is shown in Figure 7.

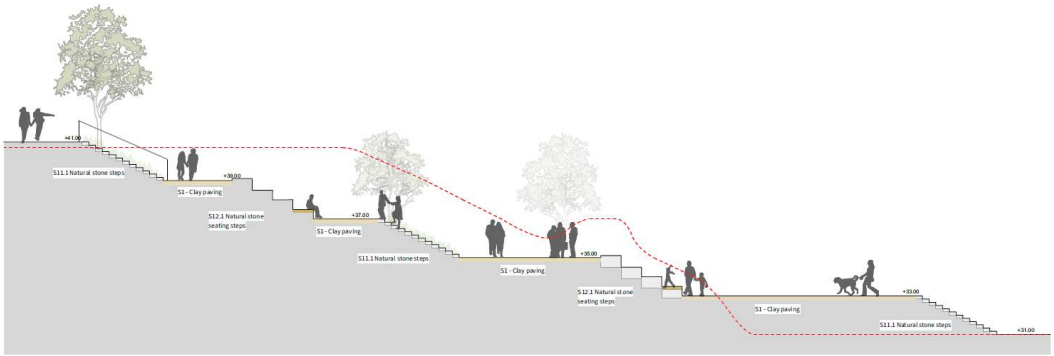


Figure 7 Red Bank Terrace indicative section

The extent of the works to the terrace have been designed to ensure that where levels are to be increased above existing this does not enter into the current EA flood zone 2 extents from the flood maps.

3.5 Union Plaza and RB06, 07 and 08

It is proposed that the existing river wall adjacent to plots RB06 and RB07 are to be removed and a terraced plaza adjacent to the river is created, improving the amenity value of the river. Figure 8 shows a proposed indicative section within the remodelled section.

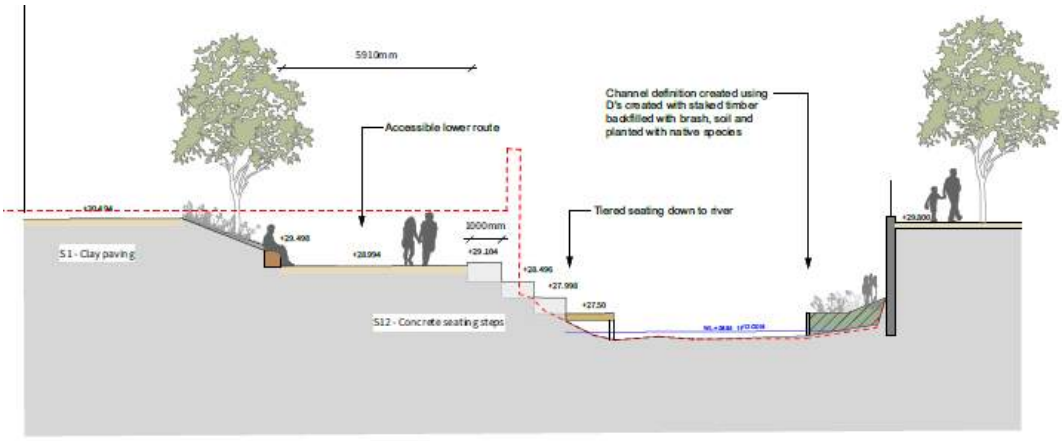


Figure 8 Typical indicative section through the Union Plaza terracing

The proposed stepped terrace area will open up the existing walled bank to provide a more open environment. The ground level immediately adjacent to the river will be reduced. Within this area it is also proposed that a buried 'U-tube' trench service crossing will be installed which will require works within the river channel, it is proposed to reinstate the river bed at the same level as existing, to ensure there is no adverse effect on the current flow and flood regime.

Beyond the terracing, the land between the plots RB06 and 07 will be landscaped as part of the works, including the installation of services and surface water drainage.

Plots RB06 and 07 will be remediated as part of the works to create development platforms. RB08 will not be included within the works. The existing highways within the vicinity of the plots will remaining as existing with some minor works.

4 Site specific flood risk

4.1 Fluvial flood risk

4.1.1 Flood zone extents

The EA flood maps show that the site sits in areas of flood zones 1, 2 and 3. Figure 9 is an extract of the existing EA flood map.



Figure 9 Flood Zones 2 and 3 from the EA Flood Map for Planning

The majority of the site sits within flood zone 1, this is due to the relatively elevated nature of the site compared to the river.

Where the site is at risk of fluvial flooding the majority of the site is within flood zone 2 including St Catherine's Wood and Plots RB06 and 08. There is a small area along the River edge and at the south east corner of RB07 which is within flood zone 3.

The Manchester, Salford and Trafford SFRA identifies areas within flood zone 3b which is the functional flood plain for the River Irk in Figure 10. These extents are shown to follow the edges of the river channel within the site, therefore all areas of flood zone 3 are considered as flood zone 3a. It is noted that the extent of flood zone 3a varies between the SFRA and the EA flood maps. The SFRA suggests that plot RB07 and land adjacent to the river are within flood zone 3, and that more land surrounding RB08 is in flood zone 2.

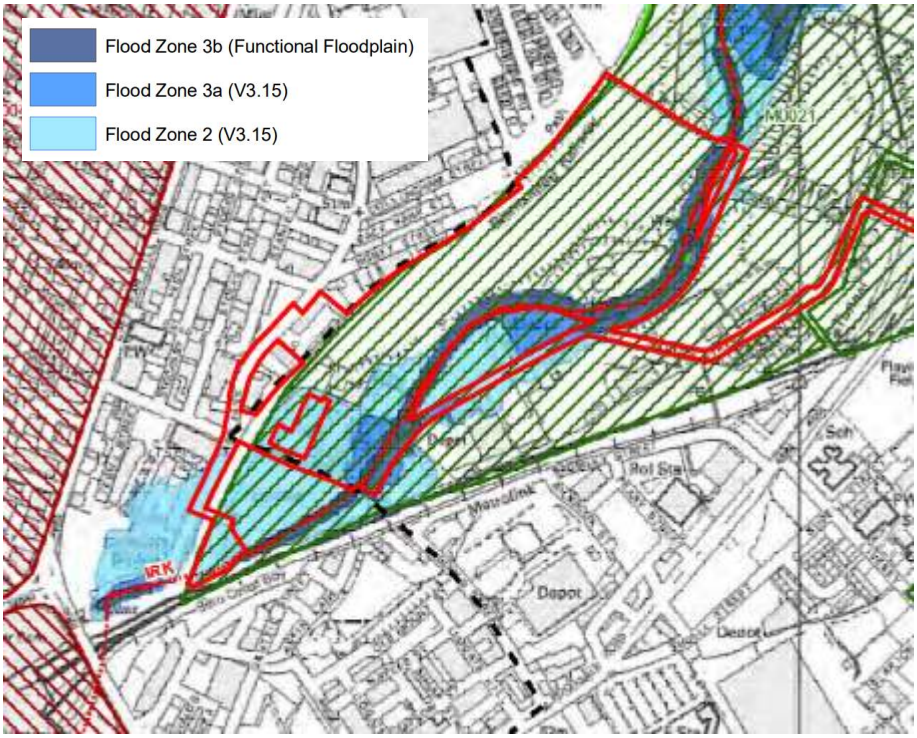


Figure 10 Flood Zone Extents identified in the Manchester, Salford and Trafford SFRA (note: flood zones 2 and 3a will be taken from EA flood maps and updated modelling)

As part of the future downstream improvement works to the River Irk, Arup are currently working with the EA to develop a new hydraulic model, this will then be used to determine which works river downstream of the site will achieve the best reduction in flood risk, within the budget allocated.

Whilst the new model is being agreed the proposals for HIF Infrastructure Works have been modelled using an 'interim 2021 model'. The aim of this interim 2021 model is to undertake a like-for-like comparison between the existing levels and the proposed HIF Infrastructure Works landscaping alterations. The results of this model have been included in Appendix A. This interim model uses a "precautionary approach" to the hydrology as requested by the EA, this has led to an increase in flows within the River for all storm events over that used to create the EA flood maps. This "precautionary approach" means that the extent of areas within flood zone 3 increase within plots RB06 and RB07. The proposed removal of a river wall upstream of Union Bridge is shown by this model to increase flood risk locally and off-site. Further discussion on the impact of the scheme and proposed mitigation measures are outlined in section 5.

4.1.2 Victoria North river works

As discussed above there is a separate project within the Victoria North development, which is also to be funded by HIF to improve the river channel downstream of the site. The objective of these works is to reduce the flood risk within and downstream of the site. At present this work has not been completed and therefore any future improvements this scheme will bring cannot be included in this FRA.

The future river works are anticipated to have an end date similar to that of the HIF Infrastructure Works and therefore the risk identified by the interim modelling works in Appendix A are likely to be temporary or to not occur at all depending upon the timing of the two projects. The future river works scheme will include a planning application and FRA to support them, however the timescales for these are unlikely to align with the planning submission for the HIF Infrastructure Works and therefore mitigation measures to take account of the increased flood risk identified in the model will be required.

4.2 Surface water flood risk

Figure 11 shows the flood risk from surface water for the site according to the EA Flood Map for Planning. This shows there are localised areas of low, medium and high risk for surface water flooding.

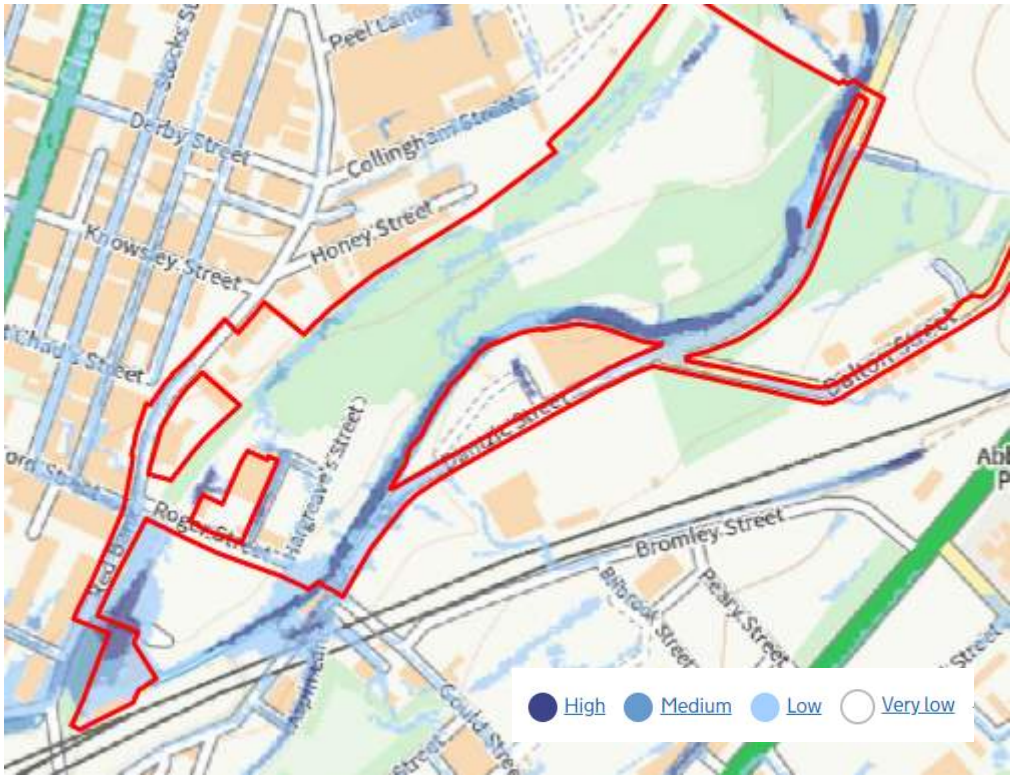


Figure 11 Surface Water Flood Extents extracted from EA Flood Map for Planning (High Risk ≥3.3%, 1< Medium Risk <3.3%, 0.1%< Low Risk <1%, Very Low Risk ≤0.1%)

The areas of high risk from surface water flooding are predominantly evident within the existing river channel and so represent the permanent water within the channel. Onsite other areas of concentrated surface water flood risk (low to medium) are shown along Dantzic Street, Hargreave's Street and Chase Street.

The areas of surface water flooding are a result of localised low points in the existing topography of the site. Although a large proportion of the site is not positively drained, initial geotechnical investigation indicates that infiltration varies due to large areas of made ground beneath the site. Therefore, overland flow is likely across the site which may contribute to surface water flooding. The proposed development will include resurfacing of many areas with identified

localised surface water flood risk, proposed levels will be designed to mitigate the risk of flooding.

Immediately downstream from site there is an area with high risk of surface water flooding. Any mitigations or proposals for the site within the red line boundary shall not worsen the surface water flood risk further downstream. The southern area within the red works boundary will not be developed by HIF.

4.3 Ground water flood risk

The Manchester, Salford and Trafford Strategic Flood Risk Assessment doesn't identify the site as an area at risk of groundwater flooding. The groundwater level is anticipated to be below most proposed works. However, measures to control groundwater inflow will be implemented if required.

4.4 Flooding from public sewers

The site sits within the Conurbation Core Critical Drainage Area (CDA) as identified in the Manchester, Salford and Trafford SFRA. This means that the area is particularly sensitive to an increase in surface water runoff due to new development and is likely associated with historic flooding in the area. This could be a result of the capacity of the existing sewer network or other watercourses including culverts. In 2020 the CSOs within the site boundary spilled a total of 108 times for a total of 660 hours[1], with the most spills occurring at the Dantzic Street/Warford Street CSO. This indicates that there may be reduced capacity in these combined sewers.

Any proposed new connections to existing sewers will consider existing sewer capacity to ensure that flooding is not worsened as a result of the works. Measures set out in section 6. will reduce the impact of the development on the existing sewers and reduce surface water flooding. SuDS will be utilised as far as possible and surface water will be discharged to the River Irk to reduce the surface water discharge to existing sewers, and to prevent worsening CSO spill rates.

4.5 Reservoir flood risk

Reservoir risk is considered to be low. The EA's flood risk from reservoirs map indicates reservoir flood risk along the river channel, therefore this has been considered as fluvial flood risk and is summarised in section 4.1.

4.6 Sequential Test

The proposed development is within the area covered by the Victoria North Strategic Regeneration Framework (SRF) which was endorsed by MCC in 2019. The framework sits alongside the MC adopted development plan and is therefore a material consideration in planning decisions. The SRF sets out the vision to deliver 15,000 homes supported by social and physical infrastructure. As the

[1] The Rivers Trust: https://www.theriverstrust.org/key-issues/sewage-in-rivers

proposed development lies wholly within the SRF area it is considered that the sequential test has already been satisfied for this development.

4.7 Existing flood risk conclusions

The main flood risk mechanisms for the site have been identified as fluvial and surface water. The impact of both of these mechanisms varies across the site as a result of levels changes and differing drainage catchments.

The plateau area sits within flood zone 1 and so has low risk of flooding from the River Irk. Development on the Plateau should be designed to prevent surface water flood risk from worsening in this area or elsewhere. This should be applied to all plots on the Plateau as well as the proposed Plateau Road.

The proposed St Catherine's Wood area sits mostly in flood zone 1. A small area of the park is within flood zone 2 as shown by the EA flood maps. The interim 2021 model shows limited changes between the 'existing' and proposed HIF Infrastructure Works scenario in this area, using the updated "precautionary approach" hydrology. The proposed land use for this area is parkland, this should be designed to ensure that water compatible zones are located in areas of higher flood risk close to the river. Due to its proximity to the river, development here should prevent additional spatial restrictions on the river flow to prevent flood risk worsening downstream.

The area north of the River around plots RB06, 07 and 08 currently sits mostly within flood zone 2, with an area in the south east corner of RB07 in flood zone 3 according to the EA flood maps. The area south of the River including Dantzic Street is also within both flood zone 2 and 3 as shown by both the EA flood maps. The interim 2021 model shows that the extent of flood zone 3 areas for the existing scenario increases to include all of RB06 and 07 with the modified "precautionary approach" hydrology, due to the increased flow within the river channel.

5 Impact of proposed scheme

5.1 Fluvial

The interim 2021 model has been used to assess the impact of the proposed works on the flood levels. This is a like-for-like comparison against the existing scenario – both using the "precautionary approach" hydrology. The results show that the proposed development will change the flood levels in channel and within vicinity of the proposed development. This interim model and modelling report have been accepted and approved by the EA.

Appendix A includes the detailed modelling report, below summarises the results. Appendix B also includes extracted detailed plans for the figures 6, 9 and 10 from the modelling report.

Collyhurst weir

There is a small reduction in the 1 in 100 year plus climate change flood levels by 0.04m, this reduction continues upstream towards HMG paints, after which the difference is negligible.

Upstream of Union Bridge

Localised increases in flood risk are shown to the right bank of Union Bridge due to the proposed removal of a river wall in this location, as shown in Figure 12 and 13. The increases in flood levels impact on the development plots RB06 and 07. Flood depths within the site for the 1 in 100 year events are increased by +0.035m compared to the existing scenario with the wall in place to the north of Union Bridge. For the 1 in 1000 year event the increase is +0.015m over the existing condition.

Levels to the southern bank of the Irk (Dantzic Street) are decreased as the water is allowed to freely re-enter the channel under the proposed scenario. Water levels within the river are also significantly reduced upstream of Union Street Bridge, this is due to the flows being able to propagate over the flood plain, to the north due to the wall being removed. Figure 14 shows the impact of the removal of the wall on the flows during the 1 in 1000 year event. This shows the greater propagation of flows during extreme events with the wall removed.

Downstream of Union Bridge

Flood levels for all events excluding the 1 in 1000 year are shown to be increased to the right bank downstream of Union Street Bridge, this is due to the removal of the wall allowing an increase in overland flow within the site and south onto Roger Street. The increase in flood level is approximately +0.01 to +0.02m, from existing flood levels of 0.63m, this leads to a small increase in the flood extents for the events up to the 1 in 100 year plus climate change event. In the 1 in 1000 year event the flood depths and extents are as existing. It should be noted that there is also a decrease in flood risk to the south bank downstream of Union Street Bridge in the proposed scenario, likely due to increased flows leaving the northern bank and propagating within the RB06, 07 and 08 plot area.

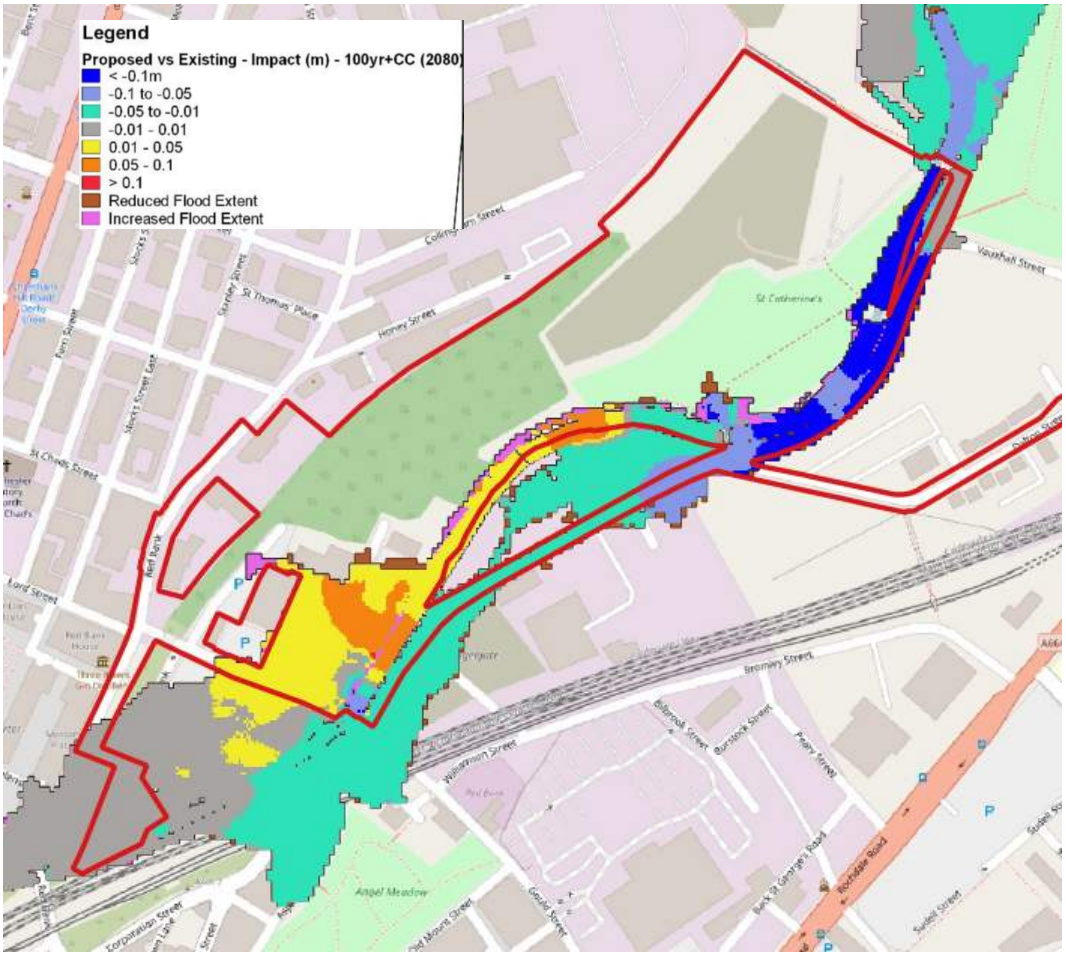


Figure 12 Impacts of scheme on flood depth and extent from interim 2021 modelling for 100 year plus climate change event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

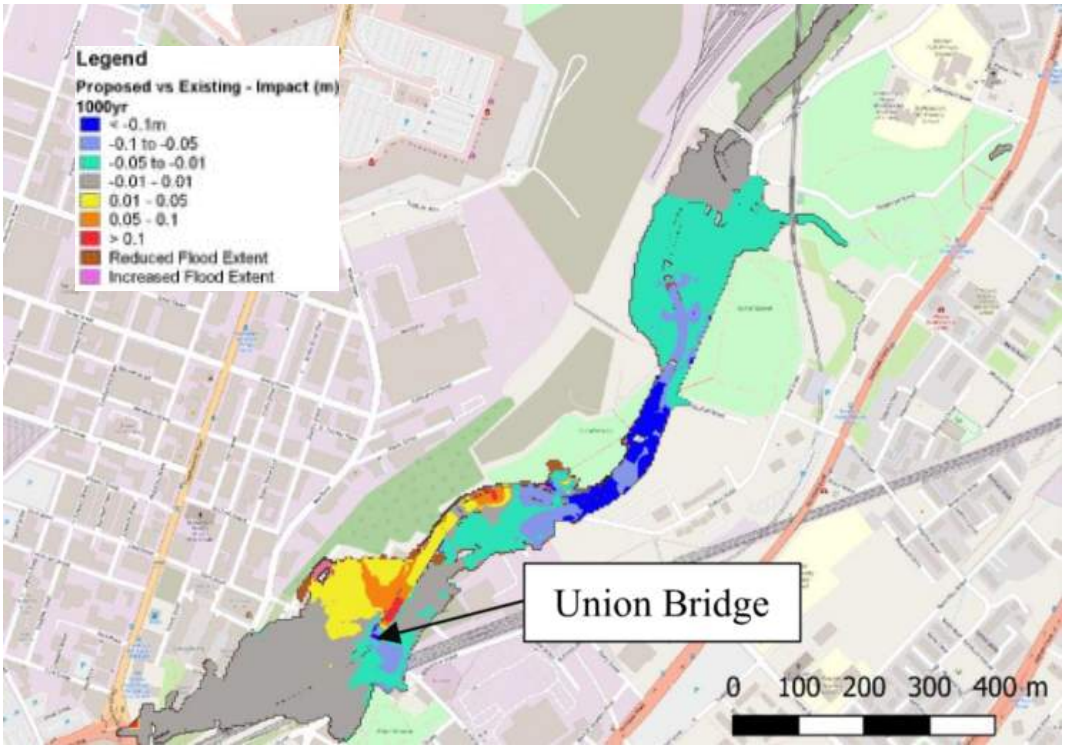


Figure 13 Impacts of scheme on flood depth and extent from interim 2021 modelling for 1000 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

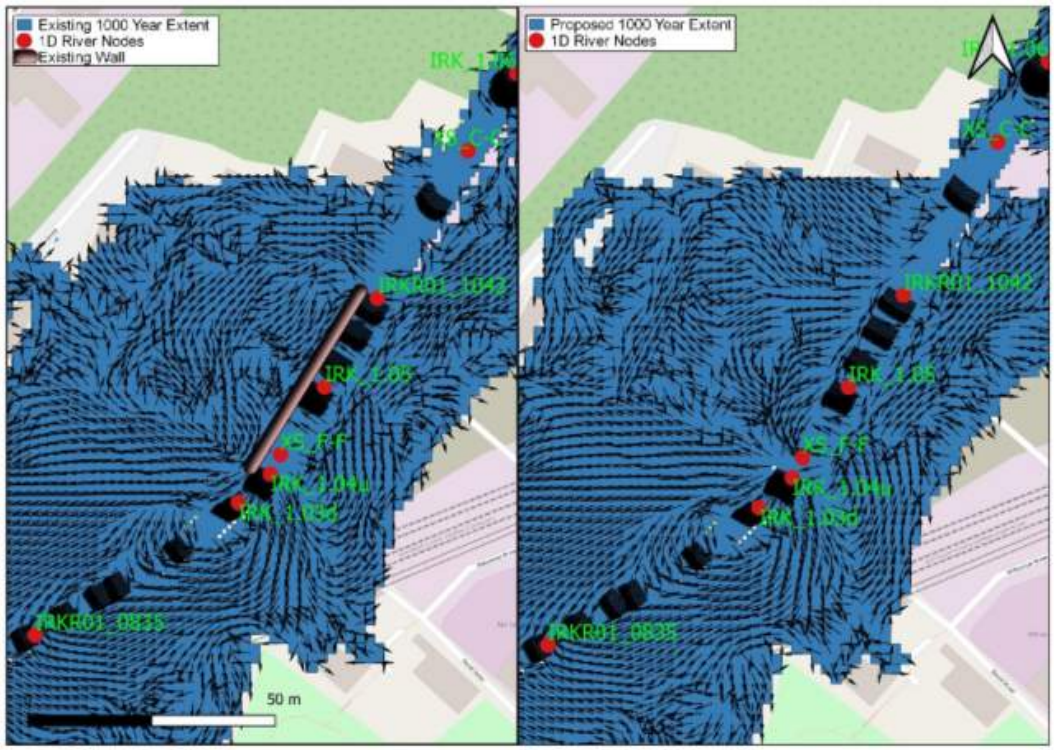


Figure 14 interim 2021 modelled out of bank flow (1000 year) under exiting condition (left) and proposed removal of river wall (right).

5.2 Surface water

The sitewide drainage strategy has been developed in coordination with the HIF river works team and the on-plot developers in order to achieve the best strategy to prevent flooding by all mechanisms. The drainage strategy will restrict discharge to the watercourse to greenfield runoff rates and utilise SuDS, including basins and rain gardens, to attenuate and store surface water runoff to prevent worsening the surface water flood risk as a result of the works. The drainage strategy can be found in appendix D which discusses the proposed approach to surface water drainage.

6 Flood risk management measures

6.1 Fluvial

As the site sits within areas of flood zones 1, 2 and 3, different management approaches will be needed for different areas.

Upper plateau

The plateau lies within Flood Zone 1 where there is a risk of flooding <0.1%. Development in these areas is at low risk from fluvial flooding. Existing flow regimes in these areas will be maintained to ensure flood risk is not worsened and a suitable drainage strategy will be adopted to manage surface water runoff.

St Catherine's Wood

The majority of St Catherine's Wood lies within Flood Zone 1 where there is a risk of flooding <0.1%. The proposed alterations to the rivers walls have been shown to reduce the flood levels adjacent to the banks of the River Irk within the area of the wood and therefore the proposed works reduce the flood risk in this area slightly. The proposed works will be undertaken to ensure that features such as balustrades etc. will not be susceptible to capturing debris which could increase flood risk.

There is a small area of the existing park within the flood zone. To ensure that users remain safe during extreme events safe egress from the park needs to be considered. As part of the park management plan a flood evacuation/management plan should be incorporated. This would provide details of how the public would be informed of the risks posed by extreme events and how the park will be managed during events which may pose a risk.

Dantzic Street

The area to the south of the River Irk along Dantzic Street is shown as being within Flood Zone 2 on the EA flood maps. The modelling work using the precautionary approach suggests that this area would fall within Flood Zone 3 if this model were used to determine the zones for the existing scenario. However, the modelling has shown that the proposed works to the banks of the Irk as part of the works will reduce the flood levels within this area and therefore improve flood

risk. Development in these areas should follow the Environment Agency Standing Advice. A suitable water management strategy should be developed for both plots and public realm south of the river. This should be developed with consideration of flood levels and is likely to require consideration of flood resistant and flood resilient measures to manage the potential impact for the development. A suitable access and egress strategy should also be included in the proposals to ensure occupants of the site have a means of escape during flood events. These elements will be considered when the FRA for the future plot development application is produced.

South of Roger Street (Offsite)

As identified above the proposed works will have the effect of increasing the flood risk off the site to the south of Roger Street by +0.01m and increase the flood extents. As stated in the NPPF the development should not materially increase the risk of flooding elsewhere. It is therefore proposed to construct a bund within Union Plaza to reduce the propagation of flows beyond the site boundary. The proposal seeks to replicate the effect of the existing wall, despite being in an alternative position. Figures 15 and 16 show the proposal for the bund.

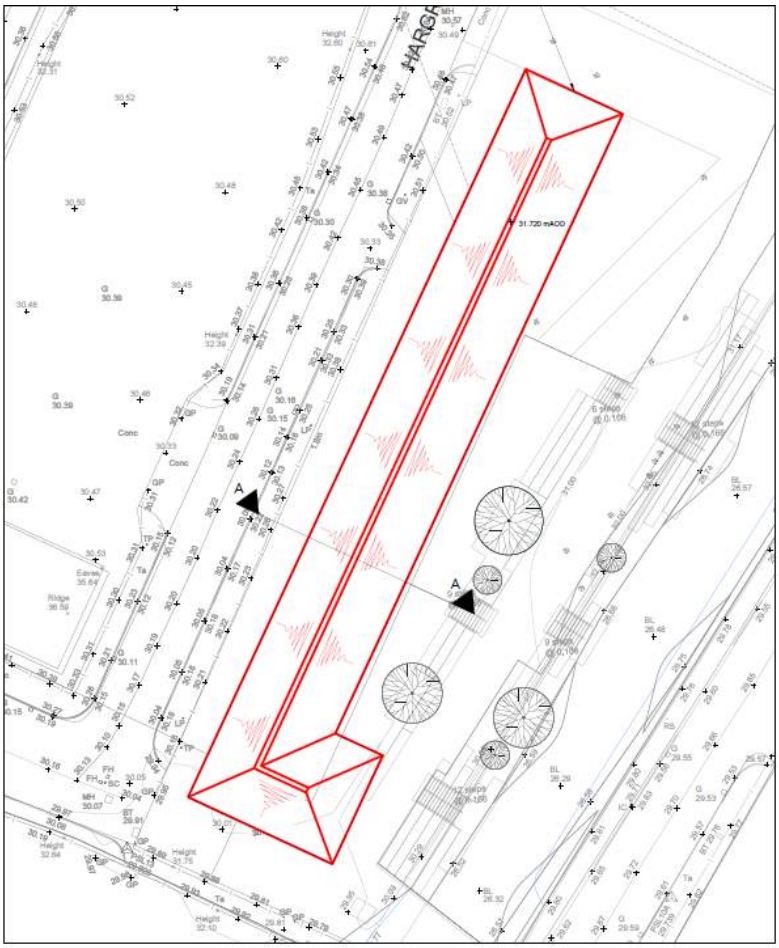


Figure 15 Proposed bund

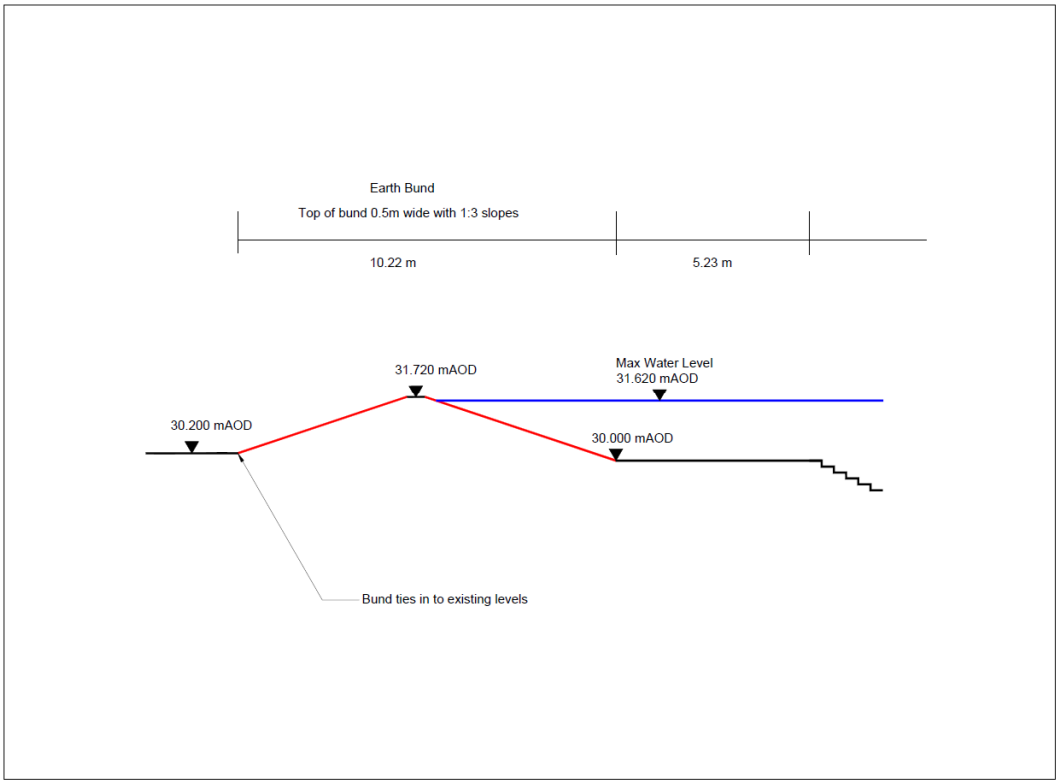


Figure 16 Bund section A-A

The bund has been incorporated into the interim 2021 model to determine the impact of the proposal on the flood risk. Figures 17 and 18 show the flood extents modelled with the proposed bund incorporated.

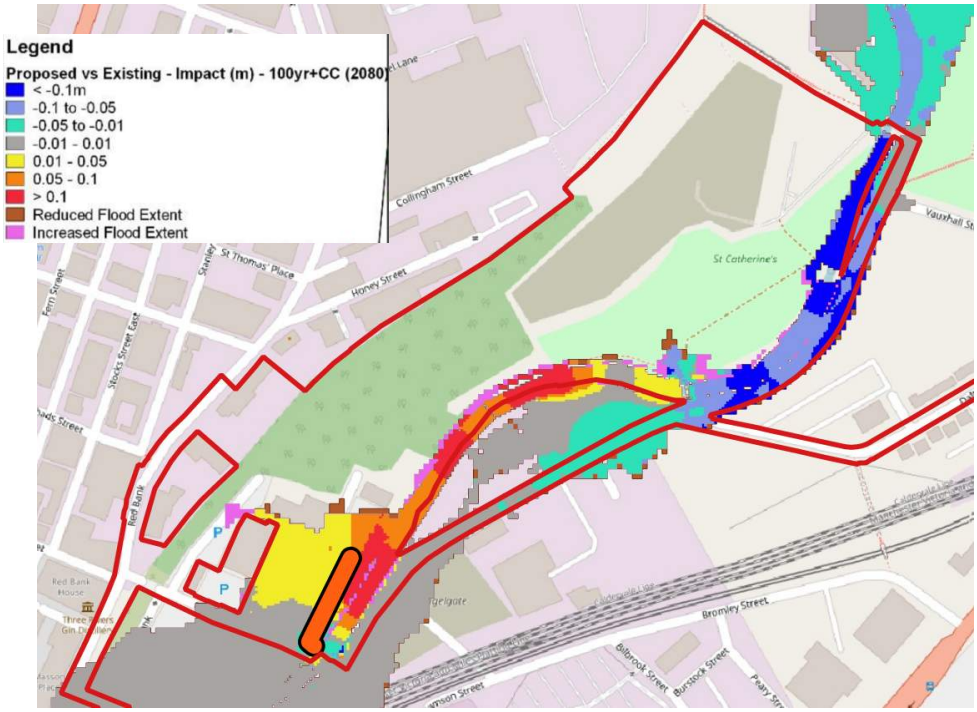


Figure 17 Impacts of scheme including the bund on flood depth and extent from interim 2021 modelling for 100 year plus climate change event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

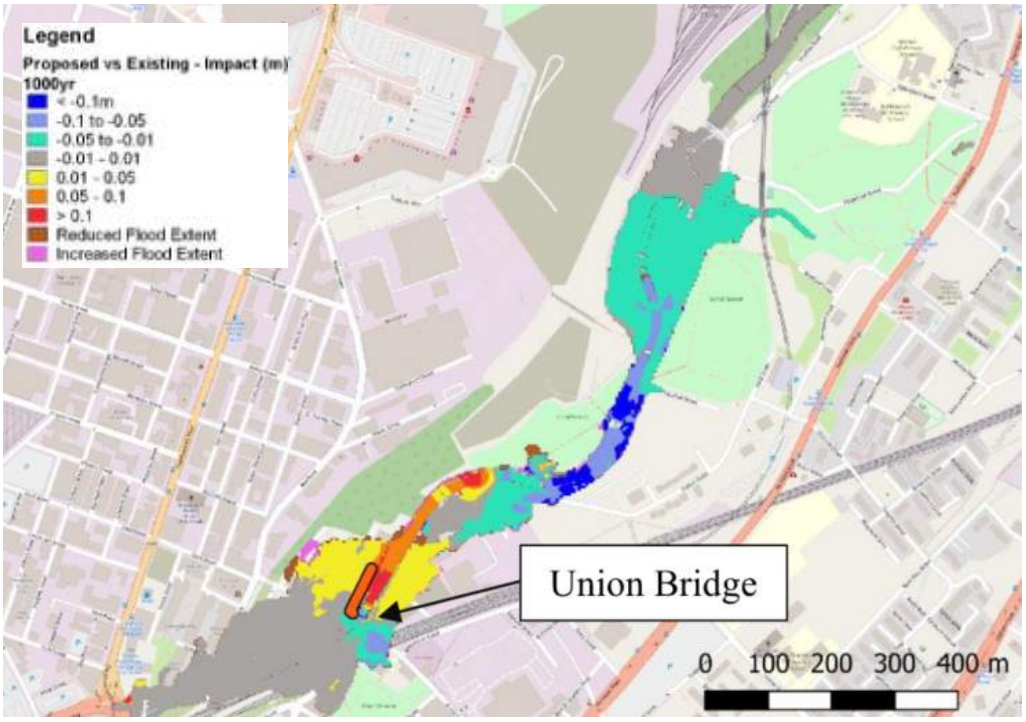


Figure 18 Impacts of scheme including the bund on flood depth and extent from interim 2021 modelling for 1000 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

Figures 19 and 20 show the proposed works modelled flood risk with and without the proposed bund when compared to the existing condition.

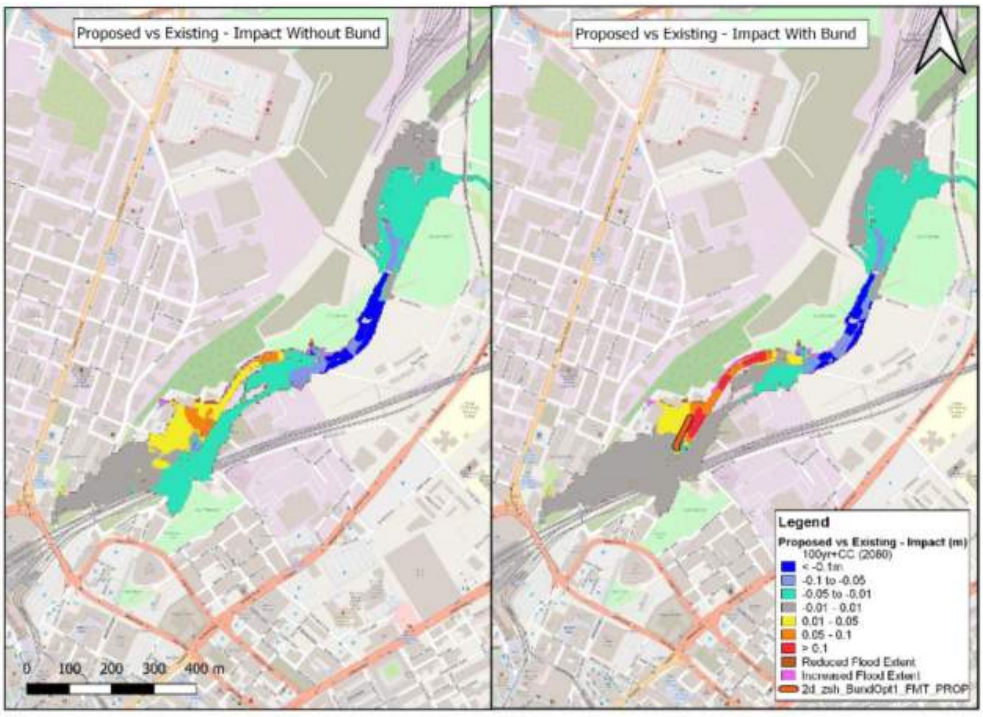


Figure 19 Interim model flood extents proposed mitigation bund comparison 1 in 100 year plus climate change event

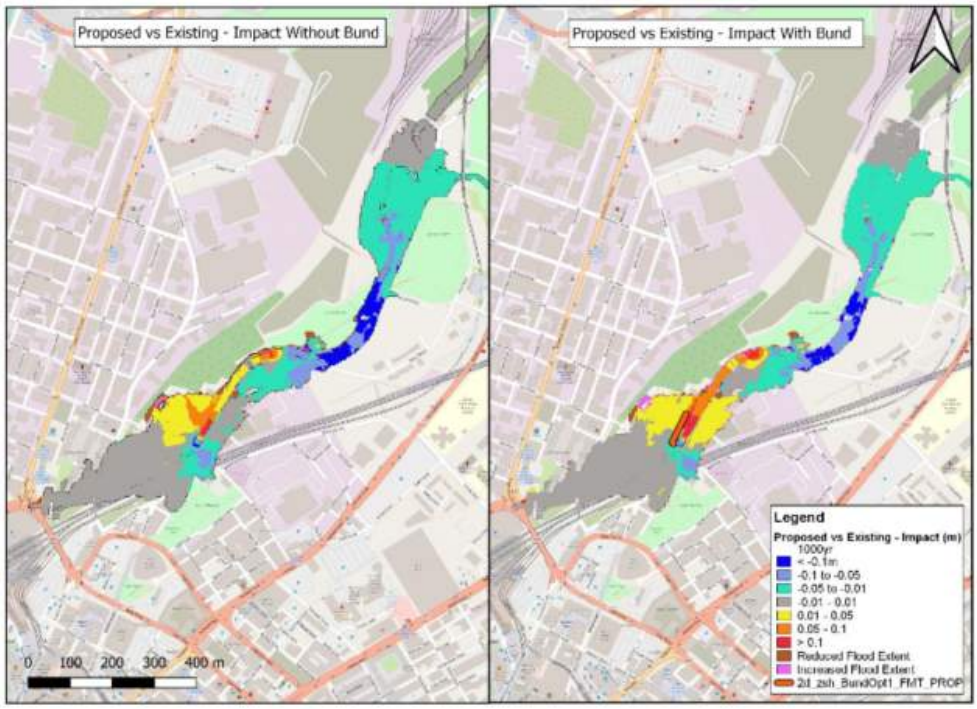


Figure 20 Interim model flood extents proposed mitigation bund comparison 1 in 1000 year event

Figure 17 shows that for the 1 in 100 year plus climate change event that with the bund in place that although flood risk remains increased within the plots over the existing case, there is no increase in flood risk off site. Figure 19 shows that mitigation proposal is effective at reducing the offsite increase in flood risk in comparison to the extents without the bund.

Figure 18 shows that the proposed mitigation has a significant impact on reducing the increase in flood extent for the 1 in 1000 year event. However, there is a small area on Roger Street into Plot RB09 where propagation of flood water remains. The model suggests that the increase in level will be up to +0.012m.

It should also be noted that there is an increase to the flood level within Dantzic Street of +0.02 to +0.04m (compared to the flood depth of 1 metre in the existing) and also an increase within the Travis Island site of approx. +0.015 m (compared to the flood depth of 0.7m in the existing). These increases are considered to not be significantly adverse when compared to the existing flood depths.

Union Plaza and Plots RB06 and RB07

As shown above in section 5.1 the proposed works increase the flows on to the area of the proposed Union Plaza and the plots RB06-08. This is due to the removal of an existing wall which is considered to reduce the flows passing from the river on to this area during flood events.

To mitigate for the loss of the wall, as discussed above a bund is proposed on Union Plaza. As shown in figures 19 and 20 the bund reduces the flood level increases within the plots RB06-08 during all events when compared to the scenario with no mitigation. However it should be noted that using the interim 2021 model these plots are shown to be within flood zone 3 due to the 'precautionary approach' hydrology when the current EA flood maps show them as flood zone 2.

The HIF scheme will not include development of on-plot infrastructure or any groundwork for the proposed plots. The development of these plots will be covered by a separate FRA as discussed above.

During the works for the HIF infrastructure the areas of RB06 and 07 will be at risk of flood. It is therefore proposed that the contractor will sign up to the EA flood warning scheme to ensure that any works within the area can be controlled in the event of a flood event. The contractor will also produce an evacuation plan so that should a flood event occur during the works on site there is a clear strategy for egress and access. Based upon the flood models there are safe routes off site to the north and the south of the site where the topography of the land raises above the flood extents.

As discussed above the proposed river works (aimed at reducing flood risk in this area) are scheduled to be complete within the same horizon as the HIF Infrastructure Works. Although the final modelling and design have not yet been completed for this future river works package it is anticipated that the design will be completed prior to the start of works on site for the HIF Infrastructure Works. It is likely that the proposed mitigation bund will therefore not be required to be built as the scenario that creates the increased flood risk will not occur. However

to ensure that in the unlikely scenario that the works in the river are delayed, a sound and robust solution is available for HIF Infrastructure Works and has therefore been included in this application.

6.2 Surface water

The following measures will be undertaken to reduce the risk of the proposed development to surface water flooding:

- Existing overland flow paths will be maintained to prevent additional flood risk outside the site boundary and to existing buildings.
- On-plot and off-plot levels will be designed to fall away from existing or proposed buildings and thresholds.
- A suitable surface water strategy will be adopted for both on-plot and off-plot development to capture and store surface water. This will incorporate SuDS to attenuate flow where infiltration is limited due to ground conditions. Surface water will be controlled at source wherever possible to reduce the risk of surface water flooding.
- Consideration of the impact of construction activities on the drainage system should be made, an adequate maintenance plan will be developed to prevent the proposed drainage and SuDS from becoming blocked due to construction debris.
- All new development will be drained to a new surface water sewer and discharged directly to the River Irk to reduce the strain on the existing combined sewer network.
- The impact of climate change on surface water risk will be considered as 40% for the 100-year return period in line with NPPF guidance.

7 Conclusion

This FRA has assessed all potential sources of flooding for the Victoria North HIF site. The primary flooding mechanisms are identified as fluvial and surface water. The site is also classified as a Critical Drainage Area which indicates historical cases of surface water flooding, this could be a result of sewers in the area having low capacity and so flooding from public sewers is also identified as a risk.

The fluvial flood risk varies across the site as a result of the topography. The Plateau area sits wholly in flood zone 1, and so does most of the park. The lower zones to the south of the river and North of Union Bridge are in areas of flood zones 2 and 3a. The HIF works will not include any work within plot boundaries in areas of flood zones 2 or 3, these will be progressed by future developers.

The impacts of the proposed development on flood risk have been shown by the interim 2021 “precautionary approach” hydraulic model to generally have a negligible effect, however there are localised issues which will require mitigation. Increased flood depths and extents, originating from the removal of a river wall to the upstream right bank of Union Bridge, are identified both on and off the site. A bund within the proposed Union Plaza area has been proposed to reduce the flow from the River Irk during extreme events and prevent additional flooding beyond the site boundary. Modelling has been undertaken to demonstrate that the proposed bund provides sufficient mitigation of the flood extents.

The HIF works are considered water compatible development. An integrated surface water management strategy will restrict the discharge from the site to greenfield rates and will discharge all surface water to the River Irk. SuDS features will be implemented to achieve the required discharge rate in order to mitigate the risk of worsening fluvial flood risk.

Consultation is ongoing with United Utilities to achieve a foul strategy which considers the capacity of existing sewers to reduce the risk of flooding from combined sewers. This FRA also outlines measures to mitigate surface water flood risk, which will be implemented in the surface water strategy to reduce the risk of localised flooding across the site.

Appendix A – Hydraulic assessment of HIF infrastructure proposals

Technical Note

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
United Kingdom
www.arup.com

t +44 161 228 2331
f +44 161 228 6879

Project title	Victoria North River and Flood Alleviation Works	Job number	281943
cc		File reference	4-05-02
Prepared by	Louise O'Regan / Emma Cecil / Rob Parry	Date	31 March 2022
Subject	Hydraulic Assessment of HIF Infrastructure Proposals – Rev 3		

1 Introduction

The Victoria North HIF Infrastructure Works propose to undertake some changes to riverbank (including ground levels/profiles) and river wall features along the extent of their works. The timing of these works requires approval through Planning Application process and EIA assessment work, but in advance of the precise details of the HIF River & Flood Works downstream being confirmed. Consequently, an assessment of any changes in flood risk or extreme river level is required as part of the Infrastructure Works application, sufficient to demonstrate that there is no adverse impact to flood risk within the site (resulting from HIF Infrastructure Works Proposals in isolation), and more importantly upstream and downstream of the proposed works site since there are several operational businesses in the vicinity of the River Irk.

This note documents the hydraulic impact of this advanced piece of work to assess these proposals in isolation, and compare them back to a baseline (Existing Condition) situation.

This has been assessed for the HIF Infrastructure Works Application using the most developed version of the hydraulic river model of the Irk, as described below.

2 Methodology

2.1 Overview

The Environment Agency flood model used for flood mapping purposes dates back to 2009 and has already undergone significant development, both in 2019 for the HIF application, and more recently with updates to hydrology and model geometry/detail as an early phase of this Victoria North project.

This work has been carried out using the most current version of this model (termed '**Interim 2021**' Model) using a precautionary approach 2021 hydrology (refer to Section 2.3.2), so that recent updates are captured to represent the best understanding of flood risk at this time. However, it is recognised that this model still requires development for use in the river works design in 2022, including the incorporation of new topographical survey and a further update to hydrology.

Consequently, this work will not seek to define final flood levels or flood extents, but will report relative differences as a result of **Proposed** HIF Infrastructure Works relating to flood regime, flows and levels, compared back to the **Existing** situation using the **Interim 2021** model.

2.2 Method

In 2019, Arup utilised three existing EA models as the basis to develop a more detailed 'combined' baseline River Irk hydraulic model to aid our river restoration and optioneering. This process is summarised below and discussed in more detail in Report MNG-ARP-SW-FN-GX-0021:

In May 2021, the EA undertook an initial review of this 2019 baseline model and provided a series of comments to be actioned. Many of these have been incorporated (where possible) in this Interim 2021 model, where new information has been available to do so. A summary of the responses to the EA actions can be found in **Appendix B**, with detailed comments recorded in the EA standard reporting log ref '*EANon-real time Hydraulic Model Review - Victoria North Baseline _Arupreply03feb22.xlsm*.'

2.2.1 Interim 2021 Model Updates

1D in-channel roughness in the Interim 2021 model was reviewed against satellite imagery and online images, and compared against Manning's n Chow tables[1]. A review of spill weir coefficients in the model was also carried out, with coefficients for spills representing structures changed to 1.2, spills representing weirs changed to 1.5, and spills representing confluences changed to 1.5.

Sections on Moston Brook were removed for stability and the 1D sections extended. These exist in an isolated valley section so would have negligible impact elsewhere on levels or flood extent. Sections on the River Irk that relate to the left bank wall of the rail bridge overpass immediately upstream of Victoria Station that do not overtop, even in extreme events, were omitted from the existing EA model and left out for this study too.

2D floodplain roughness in the Interim 2021 model is defined using Manning's n values attributed to mapping polygons, using a TMF (TUFLOW Materials File); the polygons used were updated for the Interim 2021 model, based on OS OpenMap – Local, and satellite imagery.

Following the updates made to create the Interim 2021 Model, the warnings below remain, however are not considered to impact model results:

- Warning W2010: Poor interpolation
- Warning W2044: Different values (+/- 20 %) for Manning's n encountered within one panel
- Warning W2238: Panel at offset

[1] http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

J:\280000\281943-00\4 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\VNIF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRAPROPOSALS_ISSUE3.DOCX

Arup | F0.15

Page 2 of 56

- Warning W2229: Value of trash screen height is set to 0
- Warning: Backflow encountered at CULVERT OUTLET unit.
- Warning: Bridge downstream of IRK_1.04bu is surcharged
- Poor model convergence

Remaining EA actions will be concluded for the 2022 HIF Rivers Planning Application, to test the future engineering river works, including anticipated weir removal.

Consequently, the proposed HIF Infrastructure soft landscaping modifications have been modelled using the Interim 2021 model, and 'precautionary approach' 2021 hydrology. Although this model does not have formal EA sign off, it is deemed that proposed modifications to the watercourse are limited to local enhancements around the centre of the Victoria North project (St Catherine's Wood and Union Bridge area) and so a like-for-like comparison has been undertaken to assess overall impacts as a result of the HIF Infrastructure proposals.

The proposed HIF Infra Model has been developed by modifying the cross section and 2D levels to represent the HIF Infrastructure proposals set out in **Appendix A**.

There are limitations with this approach, including the model instability seen in the 1000-year results.

2.3 Sources of data

2.3.1 EA Hydraulic Models

Several models have been combined and used to create the latest model, as shown in **Figure 1**.

- 2009 EA Irk model (by JBA) which extended from the A6010 Queens Road Bridge to the Irwell confluence, immediately downstream of Victoria Station culvert (blue).
- 2004 EA Irk model (by Atkins) for approx. 1.5km extent upstream of Queens Road Bridge (red).
- 2007 1D EA model of Moston Brook (purple).
- 2015 EA model of River Irwell.

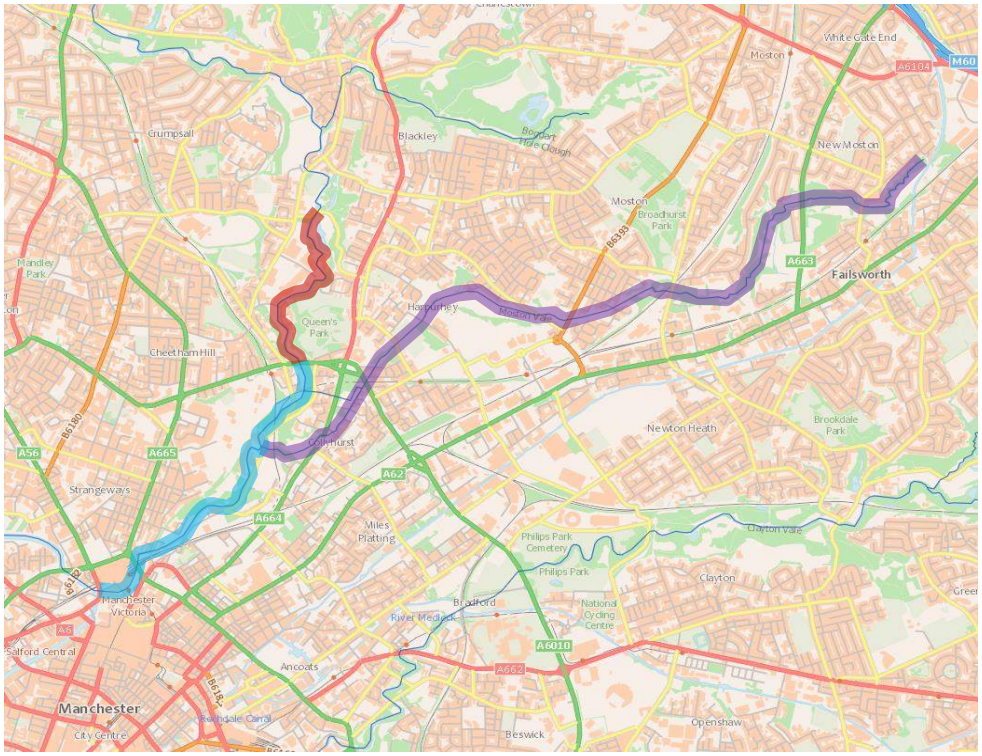


Figure 1 - Extents of existing EA models used

2.3.2 Hydrology

In Nov 2021, Arup carried out an update to the hydrology to be used in the Irk model. This has been developed in discussions with the Environment Agency, with the output Report **VNR-ARP-00-YYY-RP-CH-0001** reviewed by the EA. This work drew on gauged data from the Collyhurst Weir and concluded that there is some uncertainty in which rating curve best fits the data, since there are very few historical measurements taken around QMED flows, which are then used to extrapolate flood flow estimates for the higher return periods.

Consequently, it was agreed with the Environment Agency that the Proposed Infrastructure works are assessed using the higher flow estimates, termed 'precautionary approach', since these would allow any change in flood risk to be assessed against the worst-case scenario.

A summary of the range of estimated flows is given below in **Table 1**. A second round of comments have been also been incorporated in Issue 2 of this note and are documented in *'EA Hydrology Review Victoria North - 28.01.22_Arup_responses31.01.22.xls'*

The impact of on flood extents resulting from using this hydrology is considerable since flows are generally 15 to 20% higher than those previously adopted by earlier studies (but effects are not discussed further in this report).

On agreement with the Environment Agency, the downstream boundary for the Interim 2021 model was scaled in both peak and shape to the existing Manchester Ship Canal Model boundary, for each return period, so that the 20-year downstream boundary is scaled to the 20-year Manchester Ship Canal Model results.

		Peak Flow Estimate in Irk Flow at Collyhurst Weir (Irk_003) m^3/s		
Return Period (Years)	Comment	2004 Hydrology	2021 Hydrology (NFRA Rating)	2021 Hydrology Used in Interim Model (Precautionary Approach Rating)
5		38	37.8	43.5
10		45	44.2	50.8
20			50.9	58.6
50		62	60.6	69.7
75		63	65.2	75.0
100	Flood Zone 3	66	68.7	79.0
100+CC (2080 Epoch)				106.6
1000	Flood Zone 2		112.5	131.8

Table 1 - Hydrology Summary of Peak Flow Estimates

2.3.3 Survey Information

- A watercourse survey was commissioned and undertaken (January 2019), including a number of river cross sections.
- BAM have undertaken a wider topographical survey of the HIF site on behalf of HIF Infrastructure Works. This has been used to confirm bank levels and generate a 2D surface of the existing condition floodplain.
- Volker Stevin have recently completed a topographical survey of the river channel in December 2021 but the finding have not been incorporated into this work (planned for 2022 update).

3 Summary of Works Assessed

A set of design proposals have been received from the HIF Infrastructure team, showing proposed river wall alterations, changes in cross section and river extents - these include any riverbed modifications and proposed changes to ground level/channel wall top levels. These are shown on drawings **VNIF-PLA-ZZ-YYY-SK-L-0001** & **VNIF-PLA-ZZ-YYY-DR-L-1000**) received 22nd November 2021.

A high level summary of these proposals include:-

- Within two discrete areas of St Catherine's Wood, the existing northern channel wall (river right) has been removed and the bank reprofiled.

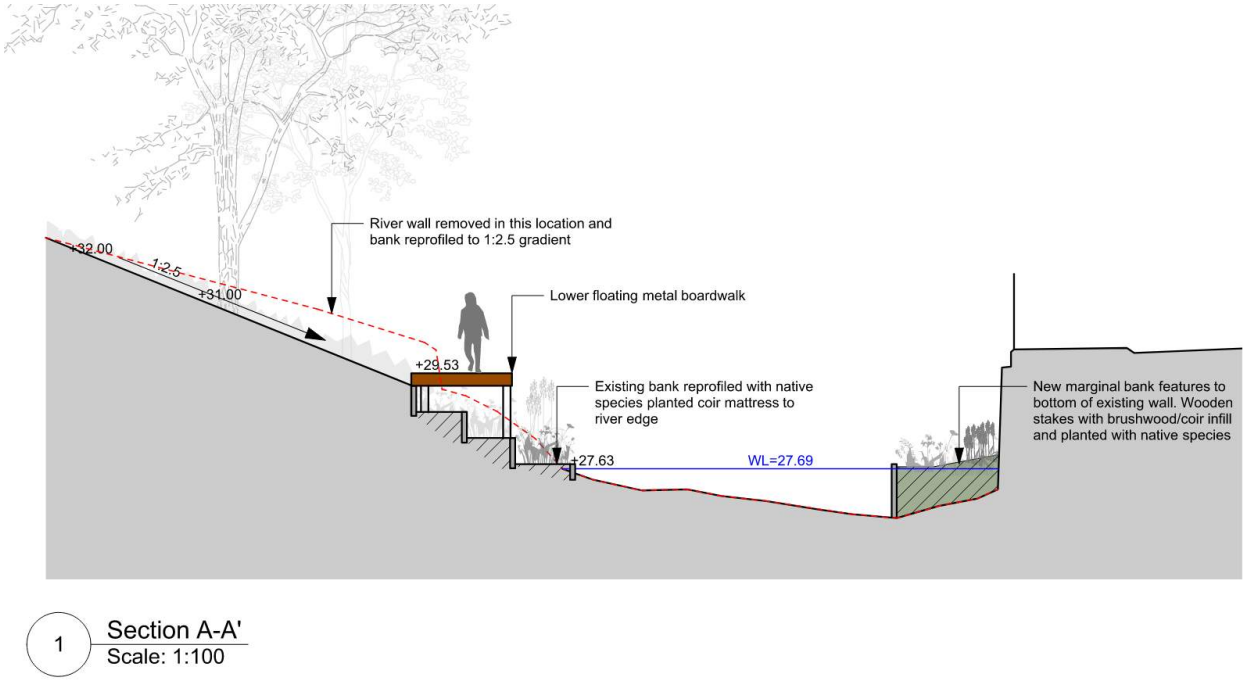


Figure 2 - St Catherine's Wood Typical X-Section

- Flow deflectors created from staked logs and gravel bars with boulders within the channel, located near St Catherine's Wood.
- Marginal bank features introduced along bottom of existing river walls along Dantzic Street/Collyhurst Road.
- Union Walk (northern/right bank) stepped back as hard landscaped public realm, with the existing channel wall removed.

A 2D surface of the proposed ground levels has been used in the model to represent the out of bank areas / floodplain.

Table 6 in **Appendix A** documents how the changes proposed by the HIF Infrastructure Works have been incorporated within the Hydraulic Model.

4 Model Results

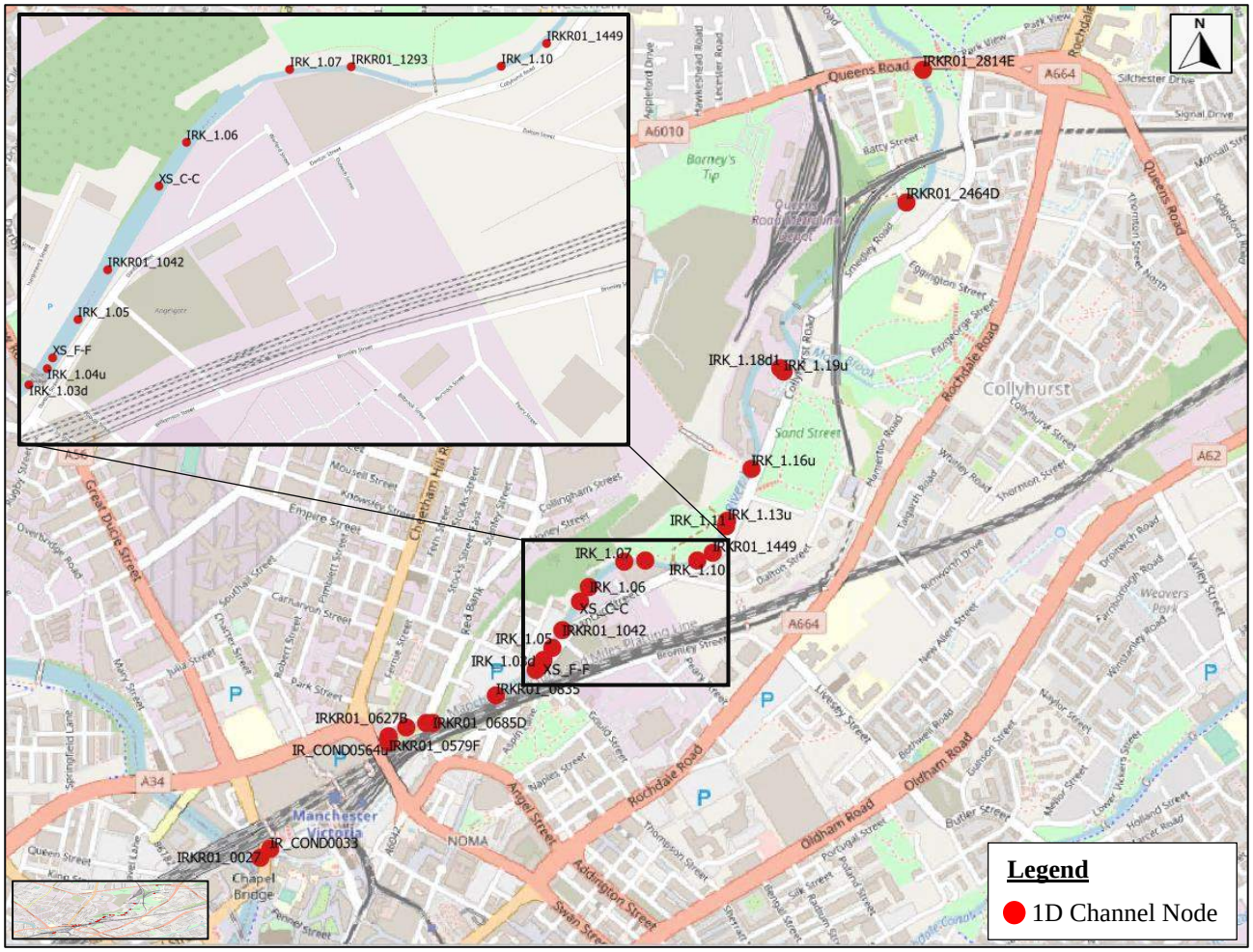


Figure 3 - Model Node Location Plan

Figure 3 shows the location of 1D modelling nodes assessed in **Table 2** and **Table 3**. While these are not all the 1D sections in the model, these nodes have been selected at key locations for review purposes here and give a good representation of the mechanisms within the model.

4.1 Existing Condition vs HIF Infrastructure Proposals

The tables below show the flow and stage for each of the 1D channel nodes shown, with **Table 2** showing the difference in flood level resulting from the proposed works, and **Table 3** showing the difference in flow.

Table 2: Results table (stage) for Existing Condition (EXIST) vs with HIF Infrastructure Proposals (PROP).

Location	Label	20 Year Stage (mAOD)			100 Year Stage (mAOD)			100 Year + CC (2020) Stage (mAOD)			100 Year + CC (2050) Stage (mAOD)			100 Year + CC (2080) Stage (mAOD)			1000 Year Stage (mAOD)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Queens Road U/S	IRKR01_2814E	36.63	36.63	0.00	37.07	37.07	0.00	37.67	37.67	0.00	37.84	37.84	0.00	38.29	38.29	0.00	39.02	39.02	0.00
Smedley Rd D/S	IRKR01_2464E	35.09	35.09	0.00	35.87	35.87	0.00	36.25	36.25	0.00	36.41	36.41	0.00	36.84	36.83	0.00	37.72	37.71	-0.01
HMG Paints Weir U/S	IRK_1.19u	32.93	32.93	0.00	33.64	33.64	0.00	33.85	33.84	-0.01	33.95	33.94	-0.01	34.18	34.16	-0.01	34.51	34.51	0.00
HMG Paints Weir D/S	IRK_1.18d1	32.77	32.77	0.00	33.51	33.50	-0.01	33.75	33.74	-0.01	33.85	33.84	-0.01	34.08	34.07	-0.01	34.44	34.44	0.00
P&P Bridge U/S	IRK_1.16u	31.44	31.43	-0.01	32.46	32.43	-0.03	32.83	32.80	-0.03	32.96	32.92	-0.04	33.28	33.22	-0.06	34.01	33.95	-0.06
Collyhurst Weir U/S	IRK_1.13u	31.13	31.11	-0.02	31.61	31.54	-0.07	31.82	31.74	-0.08	31.90	31.82	-0.08	32.14	31.99	-0.15	32.41	32.32	-0.09
Collyhurst Weir D/S	IRK_1.11	31.10	31.08	-0.02	31.57	31.51	-0.07	31.78	31.70	-0.08	31.86	31.78	-0.08	32.10	31.94	-0.16	32.36	32.26	-0.10
Location of Planit Cross-section A-A	IRKR01_1449	31.04	31.05	0.00	31.54	31.49	-0.05	31.74	31.68	-0.06	31.83	31.77	-0.06	32.01	31.94	-0.07	32.32	32.23	-0.09
	IRK_1.10	31.01	31.00	-0.01	31.50	31.42	-0.08	31.69	31.55	-0.14	31.75	31.61	-0.13	31.86	31.71	-0.15	32.12	31.96	-0.16
Location of Planit Cross-section B-B	IRKR01_1293	30.65	30.67	0.02	31.13	31.12	0.00	31.33	31.31	-0.03	31.43	31.40	-0.03	31.60	31.56	-0.05	31.98	31.90	-0.08
	IRK_1.07	30.49	30.53	0.04	30.91	30.97	0.06	31.07	31.14	0.06	31.16	31.23	0.07	31.28	31.38	0.10	31.59	31.71	0.12
	IRK_1.06	30.41	30.45	0.04	30.82	30.87	0.04	30.97	31.01	0.04	31.04	31.08	0.04	31.14	31.19	0.05	31.41	31.47	0.05
Location of Planit Cross-section C-C	XS_C-C		30.44			30.86			31.00			31.07			31.17			31.43	
	IRKR01_1042	30.38	30.43	0.05	30.80	30.86	0.06	30.95	31.00	0.05	31.03	31.07	0.04	31.12	31.17	0.05	31.37	31.44	0.06

Location of Planit Cross-section D-D	**IRK_1.05**	30.34	30.36	0.01	30.74	30.80	0.05	30.88	30.95	0.07	30.96	31.03	0.06	31.04	31.13	0.09	31.19	31.40	0.21
Location of Planit Cross-section F-F	**XS_F-F**		30.33			30.63			30.75			30.87			30.92			31.12	
Union Bridge U/S	**IRK_1.04u**	30.37	30.37	0.00	30.92	30.89	-0.03	31.12	31.07	-0.04	31.21	31.17	-0.04	31.35	31.30	-0.05	31.68	31.60	-0.07
Union Bridge D/S	**IRK_1.03d**	29.57	29.57	0.00	30.54	30.53	-0.01	30.82	30.80	-0.01	30.87	30.85	-0.02	31.03	31.01	-0.01	31.33	31.32	-0.01
	IRKR01_0835	29.07	29.07	0.00	29.94	29.94	0.00	30.21	30.20	-0.01	30.28	30.27	-0.01	30.45	30.45	0.00	31.07	31.08	0.01
Aspin Lane U/S	**IRKR01_0685D**	28.66	28.66	0.00	29.65	29.65	-0.01	30.02	30.00	-0.01	30.12	30.10	-0.02	30.40	30.39	-0.01	31.04	31.04	0.00
Aspin Lane D/S	**IRKR01_0685E**	28.49	28.49	0.00	28.93	28.93	0.00	29.26	29.25	0.00	29.38	29.37	-0.01	29.72	29.72	0.00	30.62	30.62	0.00
	IRKR01_0627B	28.19	28.19	0.00	28.63	28.63	0.00	28.90	28.89	-0.01	29.00	28.99	-0.01	29.29	29.28	0.00	30.27	30.27	0.01
Scotland Weir U/S	**IRKR01_0579F**	28.06	28.06	0.00	28.46	28.46	0.00	28.70	28.69	-0.01	28.78	28.78	-0.01	29.02	29.02	0.00	29.93	29.94	0.00
Scotland Weir D/S	**IRKR01_0579G**	25.54	25.54	0.00	26.39	26.39	0.00	26.71	26.70	0.00	26.87	26.86	0.00	27.26	27.26	0.00	29.42	29.42	0.00
Irk Culvert U/S Face	**IR_COND0564u**	25.46	25.46	0.00	26.35	26.35	0.00	26.67	26.67	0.00	26.83	26.83	0.00	27.23	27.23	0.00	29.40	29.41	0.00
Irk Culvert D/S Face	**IR_COND0033**	25.22	25.22	0.00	26.08	26.08	0.00	26.36	26.36	0.00	26.51	26.51	0.00	26.87	26.87	0.00	28.92	28.92	0.00
Irk/Irwell Confluence	**IRKR01_0027**	25.17	25.17	0.00	26.03	26.03	0.00	26.29	26.29	0.00	26.45	26.45	0.00	26.80	26.80	0.00	28.87	28.87	0.00

Red = increase in peak water level compared with existing (worsening) of >100mm.
Yellow = nominal increase in peak water level compared with existing (worsening) of less than 100mm.
Green = reduction in peak water level compared with existing (betterment)

[Note: Nodes XS_C-C and XS_F-F were created for the proposed run only and hence, no corresponding level exists in the existing run]

Table 3: Results table (flow) for Existing Condition (EXIST) vs with HIF Infrastructure Proposals (PROP).

Location	Label	20 Year Flow (m3/s)			100 Year Flow (m3/s)			100 Year + CC (2020) Flow (m3/s)			100 Year + CC (2050) Flow (m3/s)			100 Year + CC (2080) Flow (m3/s)			1000 Year Flow (m3/s)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Queens Road U/S	IRKR01_2814E	37.9	37.9	0.0	51.4	51.4	0.0	60.6	60.6	0.0	64.9	65.0	0.0	77.8	77.7	-0.1	99.6	99.8	0.2
Smedley Rd D/S	IRKR01_2464E	44.9	44.9	0.0	64.8	64.8	0.0	76.5	76.5	0.0	81.3	81.3	0.0	95.6	95.6	-0.1	118.2	118.1	-0.2
HMG Paints Weir U/S	IRK_1.19u	44.8	44.8	0.0	57.5	57.7	0.3	57.9	58.4	0.5	58.1	58.8	0.7	59.2	60.0	0.7	60.2	60.4	0.2
HMG Paints Weir D/S	IRK_1.18d1	44.8	44.8	0.0	57.5	57.7	0.3	57.9	58.4	0.5	58.1	58.8	0.7	59.2	60.0	0.7	60.2	60.4	0.2
P&P Bridge U/S	IRK_1.16u	58.7	58.7	0.0	76.1	76.3	0.2	86.4	86.6	0.3	89.4	89.9	0.4	98.2	96.9	-1.3	120.4	119.0	-1.5
Collyhurst Weir U/S	IRK_1.13u	58.7	58.7	0.0	77.3	77.7	0.4	90.0	89.5	-0.5	95.3	94.4	-0.9	110.7	107.8	-2.9	145.8	145.7	-0.1
Collyhurst Weir D/S	IRK_1.11	58.7	58.7	0.0	77.3	77.7	0.4	90.0	89.5	-0.5	95.3	94.4	-0.9	110.7	107.8	-2.9	145.8	145.7	-0.1
Location of Planit Cross-section A-A	IRKR01_1449	51.8	53.4	1.6	66.3	69.8	3.6	76.5	80.5	4.0	80.8	84.8	4.1	94.8	97.2	2.4	126.6	131.0	4.4
	IRK_1.10	51.5	50.8	-0.7	65.4	67.4	2.0	76.4	81.7	5.3	83.3	87.8	4.5	101.9	103.7	1.8	131.0	136.2	5.2
Location of Planit Cross-section B-B	IRKR01_1293	59.5	59.4	-0.1	78.5	78.8	0.2	89.2	89.9	0.7	92.7	93.7	1.0	103.8	104.4	0.6	120.9	123.5	2.6
	IRK_1.07	59.5	59.0	-0.5	78.9	76.8	-2.1	90.0	87.1	-2.8	93.8	90.5	-3.3	105.3	100.3	-5.0	124.3	117.7	-6.6
	IRK_1.06	59.4	59.4	0.0	79.0	78.0	-1.0	91.2	89.4	-1.8	95.8	93.9	-1.9	108.0	106.2	-1.8	129.1	126.1	-3.0
Location of Planit Cross-section C-C	XS_C-C		59.1			78.0			89.6			94.2			106.8			127.9	
	IRKR01_1042	59.4	59.4	0.0	78.7	78.0	-0.8	90.0	89.9	0.0	93.7	94.6	1.0	106.7	107.6	0.9	129.8	129.5	-0.4
Location of Planit Cross-section D-D	IRK_1.05	59.4	59.4	0.0	78.8	73.0	-5.7	90.0	80.4	-9.6	93.7	83.7	-9.9	106.0	93.3	-12.7	136.2	109.0	-27.2

Location of Planit Cross-section F-F	**XS_F-F**		59.6			90.6			100.5			103.4			113.6			134.3	
Union Bridge U/S	**IRK_1.04u**	52.2	52.2	0.0	52.5	52.5	0.0	52.6	52.6	0.0	52.6	52.6	0.0	53.0	53.0	0.0	47.0	47.0	0.0
Union Bridge D/S	**IRK_1.03d**	52.2	52.2	0.0	52.5	52.5	0.0	52.6	52.6	0.0	52.6	52.6	0.0	53.0	53.0	0.0	47.0	47.0	0.0
	IRKR01_0835	59.3	59.2	-0.1	78.0	77.5	-0.6	84.7	83.9	-0.8	85.8	85.0	-0.9	88.8	87.5	-1.3	85.1	83.8	-1.4
Aspin Lane U/S	**IRKR01_0685D**	59.3	59.2	-0.1	76.6	76.1	-0.5	78.4	77.7	-0.8	78.9	78.2	-0.8	80.1	79.3	-0.8	72.0	71.5	-0.5
Aspin Lane D/S	**IRKR01_0685E**	59.3	59.2	-0.1	76.6	76.1	-0.5	78.4	77.7	-0.8	78.9	78.2	-0.8	80.1	79.3	-0.8	72.0	71.5	-0.5
	IRKR01_0627B	59.3	59.2	-0.1	78.3	78.2	0.0	89.8	89.6	-0.3	93.7	93.3	-0.4	104.0	103.9	-0.1	115.4	115.4	0.0
Scotland Weir U/S	**IRKR01_0579F**	59.3	59.2	-0.1	78.3	78.2	0.0	90.3	90.1	-0.3	94.7	94.3	-0.4	107.6	107.5	-0.1	133.1	133.5	0.5
Scotland Weir D/S	**IRKR01_0579G**	59.3	59.2	-0.1	78.3	78.2	0.0	90.3	90.1	-0.3	94.7	94.3	-0.4	107.6	107.5	-0.1	133.1	133.5	0.5
Irk Culvert U/S Face	**IR_COND0564u**	59.3	59.2	-0.1	78.3	78.2	0.0	90.3	90.1	-0.3	94.7	94.3	-0.4	107.6	107.5	-0.1	133.1	133.6	0.4
Irk Culvert D/S Face	**IR_COND0033**	59.2	59.2	-0.1	78.2	78.2	-0.1	90.3	90.0	-0.3	94.6	94.3	-0.4	107.5	107.4	-0.1	133.2	133.5	0.3
Irk/Irwell Confluence	**IRKR01_0027**	59.2	59.2	-0.1	78.2	78.2	0.0	90.3	90.0	-0.3	94.6	94.3	-0.4	107.5	107.4	-0.1	133.2	133.5	0.3

Red = increase in peak flow compared with existing (worsening) of >0.1m^3/s.
Yellow = nominal increase in peak flow compared with existing (worsening) of less than 0.1m^3/s.
Green = reduction in peak flow compared with existing (betterment)

[Note: Nodes XS_C-C and XS_F-F were created for the proposed run only and hence, no corresponding level exists in the existing run]

4.2 Flood extents

Figure 4 shows the flooding extents for the 20 year, 100 year and 1000 year events for the updated 2021 Existing model

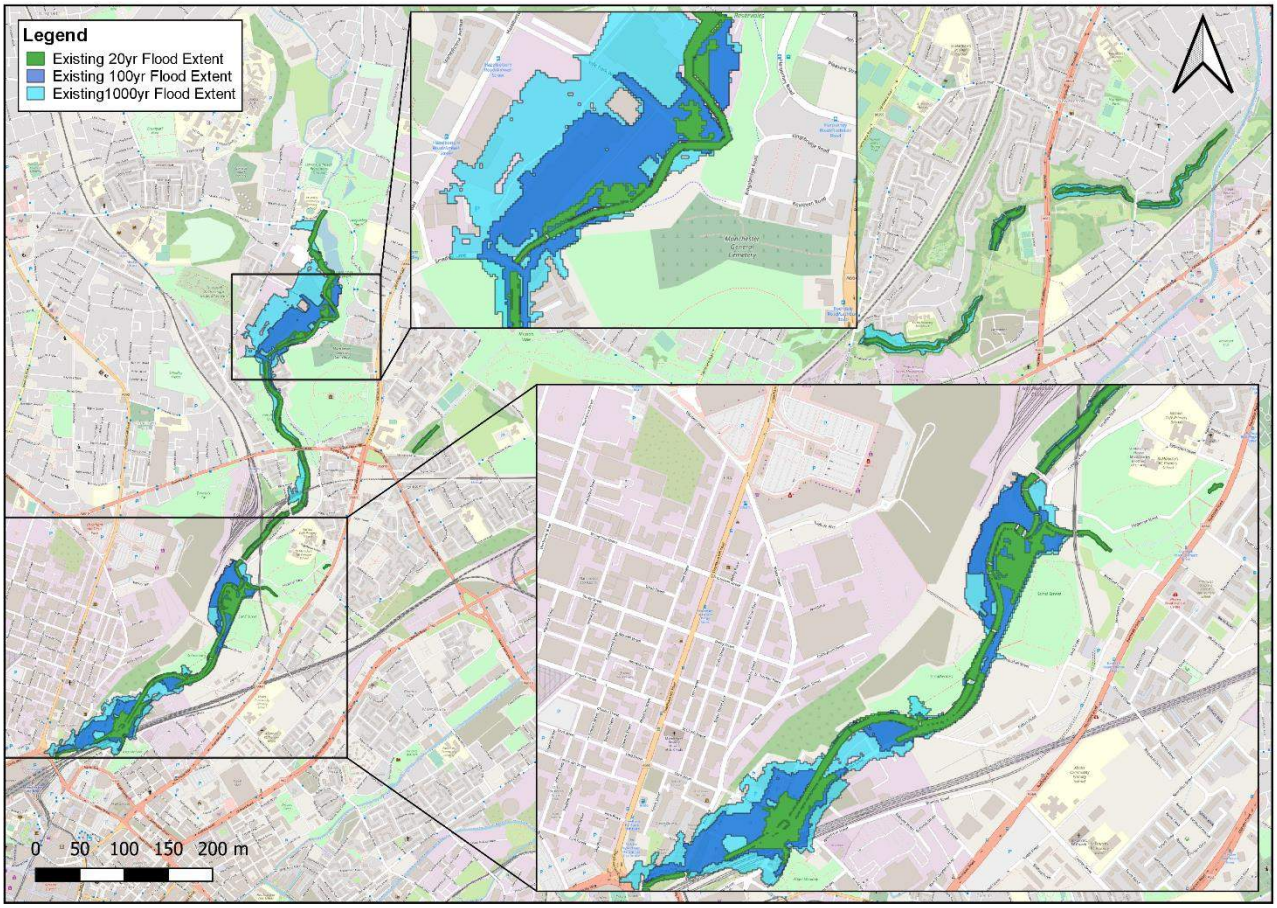


Figure 4: 20 year, 100 year and 1000 year events for the Existing Condition Interim 2021 model.

Figure 5 shows the change in levels for the 100 year event when comparing the Proposed HIF Infrastructure Works to the Existing using the Interim 2021 model.

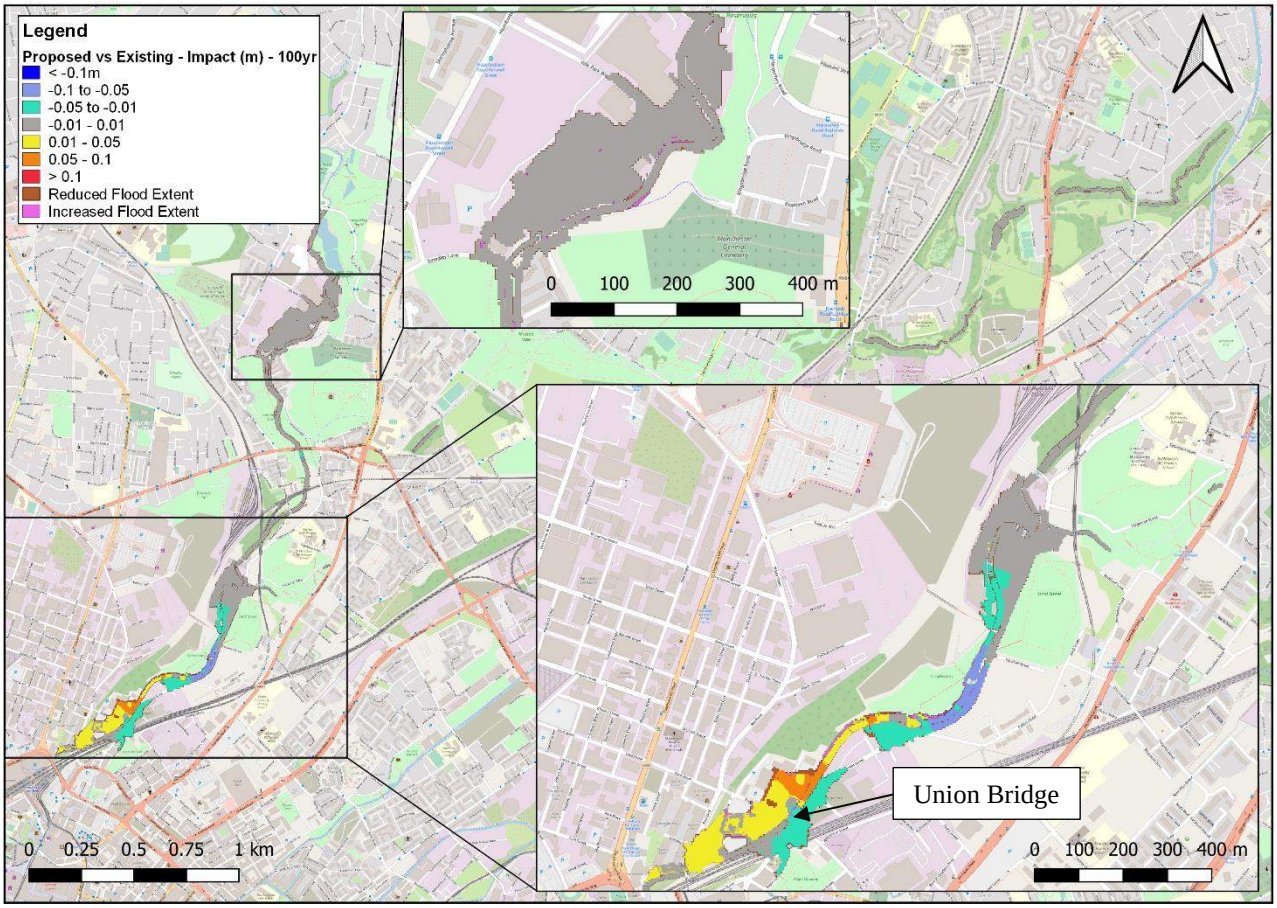


Figure 5: 100 year event Proposed vs Existing

Figure 6 shows the change in levels for the 100 year event plus climate change (2080) when comparing the Proposed HIF Infrastructure Works to the Existing using the Interim 2021 model.

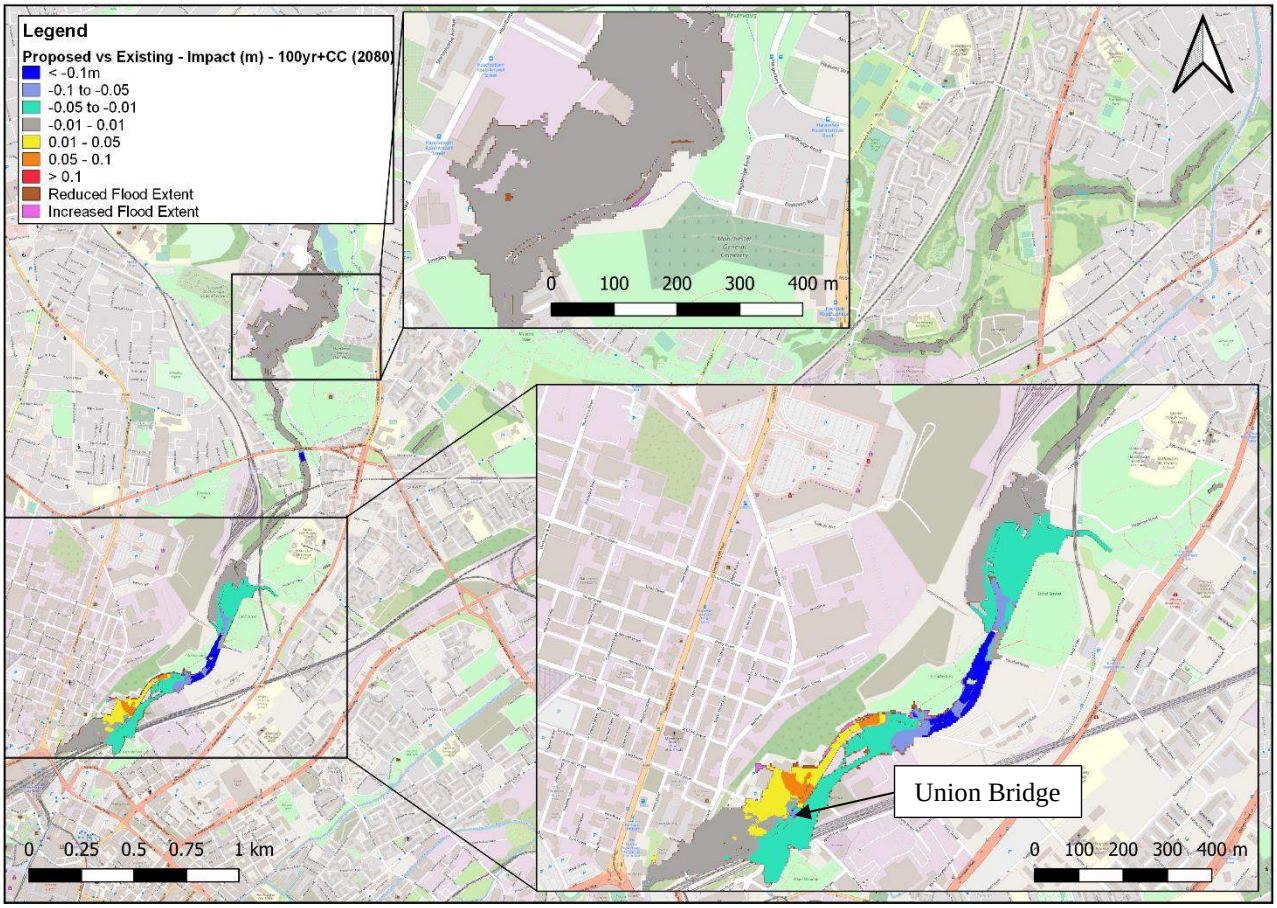


Figure 6: 100 year plus climate change (2080) event Proposed vs Existing

Figure 7 shows the change in levels for the 1000 year event comparing the Proposed HIF Infrastructure Works to the Existing using the Interim 2021 model.

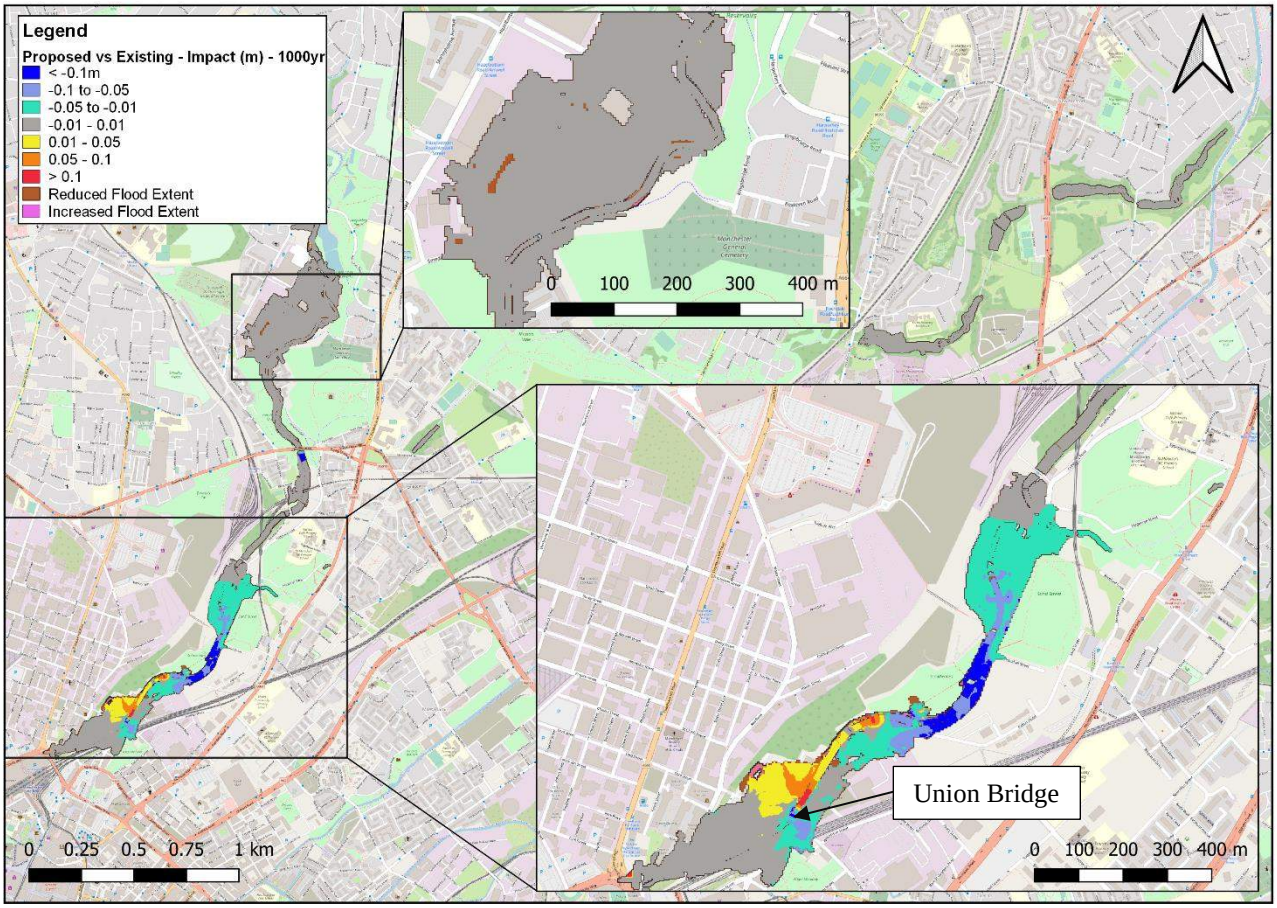


Figure 7: 1000 year Proposed vs Existing

4.3 Existing Condition vs HIF Works with Flood Mitigation Bund Inclusion

Due to the impact seen in **Figure 5**, **Figure 6** and **Figure 7** immediately west and south of Roger Street (Plot RB09), mitigation was modelled in the form of a flood bund immediately behind the proposed terracing upstream of Union Bridge. The bund was modelled as to not overtop and to mitigate changes in flood risk which resulted from the removal of the existing wall on the north bank. More information on the flood bund can be found in the HIF Infrastructure FRA (Document VNIF-ARP-ZZ-YYY-RP-CD-0002) and its location and orientation are shown in **Figure 8**.

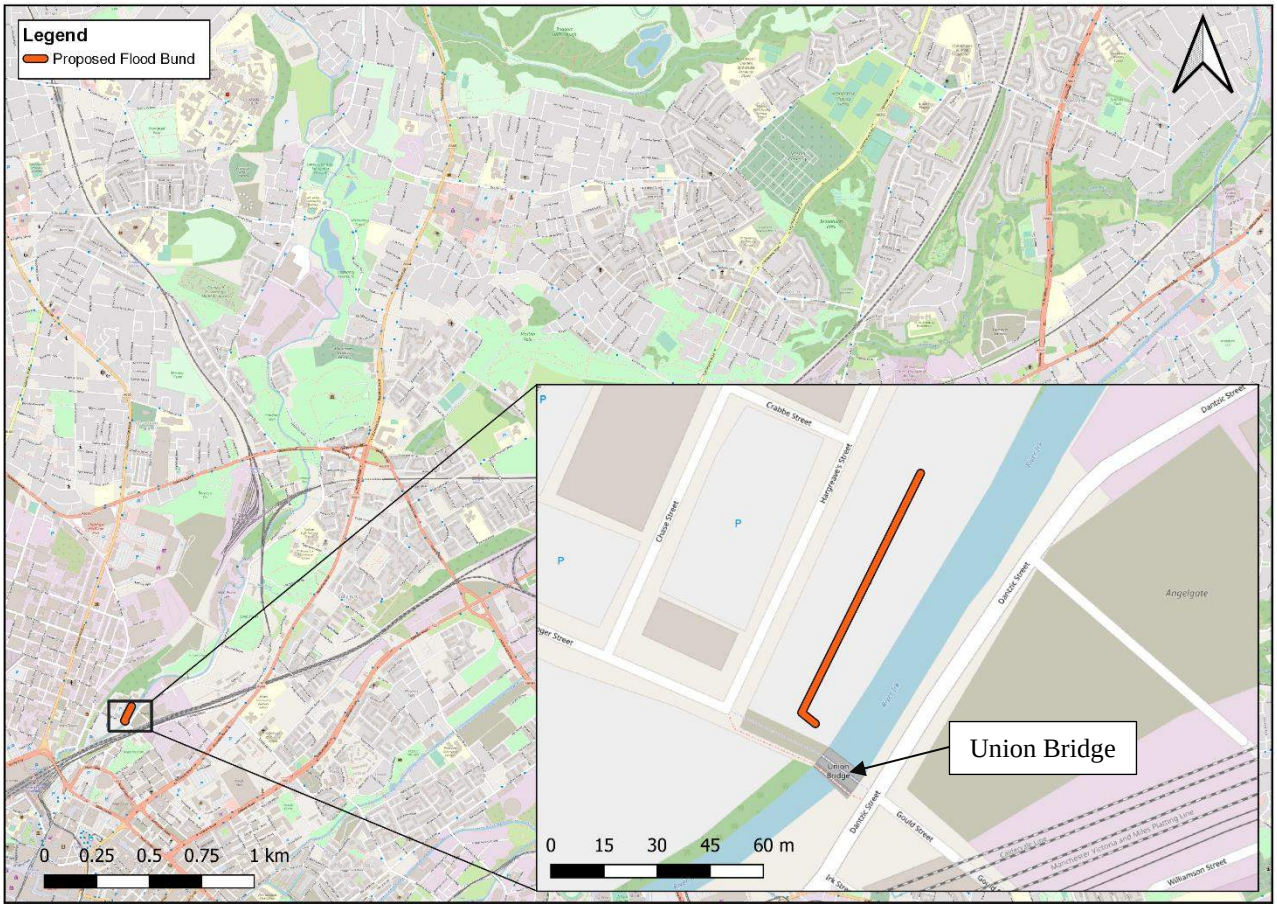


Figure 8: Location of proposed flood bund

The tables below show the stage and flow for each of the 1D channel nodes shown in **Figure 3**, with **Table 4** showing the difference in flood level resulting from the proposed works, and **Table 5** showing the difference in flow.

Table 4: Results table (stage) for Existing Condition (EXIST) vs with HIF Infrastructure Proposals (PROPM) with flood mitigation bund.

Location	Label	20 Year Stage (mAOD)			100 Year Stage (mAOD)			100 Year + CC (2020) Stage (mAOD)			100 Year + CC (2050) Stage (mAOD)			100 Year + CC (2080) Stage (mAOD)			1000 Year Stage (mAOD)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Queens Road U/S	IRKR01_2814E	36.63	36.63	0.00	37.07	37.07	0.00	37.67	37.68	0.00	37.84	37.84	0.00	38.29	38.29	0.00	39.02	39.02	0.00
Smedley Rd D/S	IRKR01_2464E	35.09	35.09	0.00	35.87	35.87	0.00	36.25	36.25	0.00	36.41	36.41	0.00	36.84	36.83	0.00	37.72	37.72	0.00
HMG Paints Weir U/S	IRK_1.19u	32.93	32.93	0.00	33.64	33.64	0.00	33.85	33.85	-0.01	33.95	33.94	-0.01	34.18	34.16	-0.01	34.51	34.52	0.01
HMG Paints Weir D/S	IRK_1.18d1	32.77	32.77	0.00	33.51	33.50	0.00	33.75	33.74	-0.01	33.85	33.84	-0.01	34.08	34.07	-0.01	34.44	34.44	0.01
P&P Bridge U/S	IRK_1.16u	31.44	31.43	-0.01	32.46	32.43	-0.03	32.83	32.81	-0.02	32.96	32.93	-0.03	33.28	33.23	-0.05	34.01	33.98	-0.03
Collyhurst Weir U/S	IRK_1.13u	31.13	31.11	-0.02	31.61	31.55	-0.06	31.82	31.78	-0.04	31.90	31.84	-0.06	32.14	32.01	-0.13	32.41	32.34	-0.07
Collyhurst Weir D/S	IRK_1.11	31.10	31.08	-0.02	31.57	31.52	-0.06	31.78	31.74	-0.04	31.86	31.80	-0.06	32.10	31.97	-0.14	32.36	32.28	-0.07
Location of Planit Cross-section A-A	IRKR01_1449	31.04	31.05	0.00	31.54	31.50	-0.04	31.74	31.73	-0.02	31.83	31.79	-0.04	32.01	31.96	-0.05	32.32	32.25	-0.07
	IRK_1.10	31.01	31.00	-0.01	31.50	31.43	-0.07	31.69	31.59	-0.10	31.75	31.64	-0.11	31.86	31.73	-0.13	32.12	31.98	-0.14
Location of Planit Cross-section B-B	IRKR01_1293	30.65	30.67	0.02	31.13	31.14	0.02	31.33	31.38	0.05	31.43	31.44	0.01	31.60	31.61	0.00	31.98	31.93	-0.05
	IRK_1.07	30.49	30.53	0.04	30.91	30.99	0.08	31.07	31.23	0.16	31.16	31.28	0.13	31.28	31.44	0.16	31.59	31.74	0.15
	IRK_1.06	30.41	30.45	0.04	30.82	30.89	0.07	30.97	31.12	0.15	31.04	31.14	0.10	31.14	31.25	0.11	31.41	31.51	0.10
Location of Planit Cross-section C-C	XS_C-C		30.44			30.88			31.09			31.13			31.22			31.46	
	IRKR01_1042	30.38	30.43	0.05	30.80	30.88	0.08	30.95	31.09	0.15	31.03	31.13	0.10	31.12	31.23	0.11	31.37	31.48	0.10

Location of Planit Cross-section D-D	**IRK_1.05**	30.34	30.36	0.01	30.74	30.81	0.07	30.88	31.05	0.17	30.96	31.09	0.13	31.04	31.18	0.15	31.19	31.44	0.25
Location of Planit Cross-section F-F	**XS_F-F**		30.33			30.70			30.92			30.93			30.97			31.14	
Union Bridge U/S	**IRK_1.04u**	30.37	30.37	0.00	30.92	30.92	0.00	31.12	31.17	0.05	31.21	31.22	0.01	31.35	31.35	0.00	31.68	31.64	-0.04
Union Bridge D/S	**IRK_1.03d**	29.57	29.57	0.00	30.54	30.54	0.00	30.82	30.82	0.00	30.87	30.87	0.00	31.03	31.03	0.00	31.33	31.33	0.00
	IRKR01_0835	29.07	29.07	0.00	29.94	29.95	0.00	30.21	30.21	0.00	30.28	30.28	0.00	30.45	30.46	0.01	31.07	31.08	0.02
Aspin Lane U/S	**IRKR01_0685D**	28.66	28.66	0.00	29.65	29.65	0.00	30.02	30.01	0.00	30.12	30.12	0.00	30.40	30.40	0.00	31.04	31.05	0.00
Aspin Lane D/S	**IRKR01_0685E**	28.49	28.49	0.00	28.93	28.93	0.00	29.26	29.26	0.00	29.38	29.38	0.00	29.72	29.73	0.01	30.62	30.62	0.01
	IRKR01_0627B	28.19	28.19	0.00	28.63	28.63	0.00	28.90	28.90	0.00	29.00	29.00	0.00	29.29	29.29	0.01	30.27	30.28	0.01
Scotland Weir U/S	**IRKR01_0579F**	28.06	28.06	0.00	28.46	28.46	0.00	28.70	28.70	0.00	28.78	28.78	0.00	29.02	29.03	0.01	29.93	29.94	0.00
Scotland Weir D/S	**IRKR01_0579G**	25.54	25.54	0.00	26.39	26.39	0.00	26.71	26.71	0.00	26.87	26.87	0.00	27.26	27.26	0.00	29.42	29.42	0.00
Irk Culvert U/S Face	**IR_COND0564u**	25.46	25.46	0.00	26.35	26.35	0.00	26.67	26.67	0.00	26.83	26.83	0.00	27.23	27.23	0.00	29.40	29.41	0.00
Irk Culvert D/S Face	**IR_COND0033**	25.22	25.22	0.00	26.08	26.08	0.00	26.36	26.36	0.00	26.51	26.51	0.00	26.87	26.87	0.00	28.92	28.92	0.00
Irk/Irwell Confluence	**IRKR01_0027**	25.17	25.17	0.00	26.03	26.03	0.00	26.29	26.29	0.00	26.45	26.45	0.00	26.80	26.80	0.00	28.87	28.87	0.00

Red = increase in peak water level compared with existing (worsening) of >100mm.
Yellow = nominal increase in peak water level compared with existing (worsening) of less than 100mm.
Green = reduction in peak water level compared with existing (betterment)

[Note: Nodes XS_C-C and XS_F-F were created for the proposed run only and hence, no corresponding level exists in the existing run]

Table 5: Results table (flow) for Existing Condition (EXIST) vs with HIF Infrastructure Proposals (PROP) with applied flood bund.

Location	Label	20 Year Flow (m3/s)			100 Year Flow (m3/s)			100 Year + CC (2020) Flow (m3/s)			100 Year + CC (2050) Flow (m3/s)			100 Year + CC (2080) Flow (m3/s)			1000 Year Flow (m3/s)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Queens Road U/S	IRKR01_2814E	37.9	37.9	0.0	51.4	51.4	0.0	60.6	60.8	0.2	64.9	65.0	0.1	77.8	77.7	-0.1	99.6	100.1	0.4
Smedley Rd D/S	IRKR01_2464E	44.9	44.9	0.0	64.8	64.8	0.0	76.5	76.5	0.0	81.3	81.3	0.0	95.6	95.6	-0.1	118.2	118.3	0.0
HMG Paints Weir U/S	IRK_1.19u	44.8	44.8	0.0	57.5	58.1	0.6	57.9	58.7	0.8	58.1	59.1	1.0	59.2	60.2	0.9	60.2	60.9	0.7
HMG Paints Weir D/S	IRK_1.18d1	44.8	44.8	0.0	57.5	58.1	0.6	57.9	58.7	0.8	58.1	59.1	1.0	59.2	60.2	0.9	60.2	60.9	0.7
P&P Bridge U/S	IRK_1.16u	58.7	58.7	0.0	76.1	76.3	0.2	86.4	86.7	0.3	89.4	89.8	0.3	98.2	96.8	-1.4	120.4	120.0	-0.5
Collyhurst Weir U/S	IRK_1.13u	58.7	58.7	0.0	77.3	77.7	0.4	90.0	89.9	0.0	95.3	94.7	-0.6	110.7	108.2	-2.5	145.8	147.7	2.0
Collyhurst Weir D/S	IRK_1.11	58.7	58.7	0.0	77.3	77.7	0.4	90.0	89.9	0.0	95.3	94.7	-0.6	110.7	108.2	-2.5	145.8	147.7	2.0
Location of Planit Cross-section A-A	IRKR01_1449	51.8	53.4	1.6	66.3	69.9	3.6	76.5	80.9	4.4	80.8	85.1	4.4	94.8	97.6	2.8	126.6	132.7	6.1
	IRK_1.10	51.5	50.8	-0.7	65.4	67.3	1.9	76.4	82.5	6.1	83.3	87.9	4.6	101.9	105.1	3.2	131.0	138.6	7.6
Location of Planit Cross-section B-B	IRKR01_1293	59.5	59.4	-0.1	78.5	78.8	0.3	89.2	90.5	1.3	92.7	93.5	0.7	103.8	104.1	0.3	120.9	123.4	2.5
	IRK_1.07	59.5	59.0	-0.5	78.9	76.8	-2.1	90.0	87.5	-2.4	93.8	90.0	-3.8	105.3	99.7	-5.6	124.3	117.6	-6.7
	IRK_1.06	59.4	59.4	0.0	79.0	78.0	-1.0	91.2	90.1	-1.1	95.8	93.7	-2.0	108.0	107.0	-1.0	129.1	125.9	-3.2
Location of Planit Cross-section C-C	XS_C-C		59.1		0.0	78.5			91.0			94.3			108.5			128.3	
	IRKR01_1042	59.4	59.4	0.0	78.7	78.0	-0.8	90.0	90.7	0.7	93.7	94.5	0.9	106.7	108.0	1.3	129.8	130.0	0.2
Location of Planit Cross-section D-D	IRK_1.05	59.4	59.4	0.0	78.8	73.8	-4.9	90.0	83.0	-7.0	93.7	84.2	-9.4	106.0	94.0	-12.0	136.2	107.7	-28.5

Location of Planit Cross-section F-F	**XS_F-F**	0.0	59.5			86.5			98.8			101.4			115.4			137.1	
Union Bridge U/S	**IRK_1.04u**	52.2	52.2	0.0	52.5	52.6	0.1	52.6	52.8	0.2	52.6	52.9	0.2	53.0	53.0	0.1	47.0	47.0	0.0
Union Bridge D/S	**IRK_1.03d**	52.2	52.2	0.0	52.5	52.6	0.1	52.6	52.8	0.2	52.6	52.9	0.2	53.0	53.0	0.1	47.0	47.0	0.0
	IRKR01_0835	59.3	59.2	0.0	78.0	78.1	0.0	84.7	84.9	0.2	85.8	86.1	0.3	88.8	88.7	-0.1	85.1	84.9	-0.2
Aspin Lane U/S	**IRKR01_0685D**	59.3	59.2	0.0	76.6	76.5	0.0	78.4	78.4	0.0	78.9	78.9	0.0	80.1	80.1	0.0	72.0	71.9	-0.1
Aspin Lane D/S	**IRKR01_0685E**	59.3	59.2	0.0	76.6	76.5	0.0	78.4	78.4	0.0	78.9	78.9	0.0	80.1	80.1	0.0	72.0	71.9	-0.1
	IRKR01_0627B	59.3	59.2	0.0	78.3	78.3	0.0	89.8	89.8	-0.1	93.7	93.7	0.1	104.0	104.3	0.3	115.4	115.5	0.1
Scotland Weir U/S	**IRKR01_0579F**	59.3	59.2	0.0	78.3	78.3	0.0	90.3	90.3	-0.1	94.7	94.8	0.1	107.6	107.8	0.3	133.1	133.8	0.7
Scotland Weir D/S	**IRKR01_0579G**	59.3	59.2	0.0	78.3	78.3	0.0	90.3	90.3	-0.1	94.7	94.8	0.1	107.6	107.8	0.3	133.1	133.8	0.7
Irk Culvert U/S Face	**IR_COND0564u**	59.3	59.2	0.0	78.3	78.3	0.0	90.3	90.3	-0.1	94.7	94.8	0.1	107.6	107.8	0.2	133.1	133.8	0.6
Irk Culvert D/S Face	**IR_COND0033**	59.2	59.2	0.0	78.2	78.2	0.0	90.3	90.2	-0.1	94.6	94.7	0.1	107.5	107.8	0.3	133.2	133.7	0.5
Irk/Irwell Confluence	**IRKR01_0027**	59.2	59.2	0.0	78.2	78.2	0.0	90.3	90.2	-0.1	94.6	94.7	0.1	107.5	107.8	0.3	133.2	133.7	0.5

Red = increase in peak flow compared with existing (worsening) of >0.1m^3/s.
Yellow = nominal increase in peak flow compared with existing (worsening) of less than 0.1m^3/s.
Green = reduction in peak flow compared with existing (betterment)

[Note: Nodes XS_C-C and XS_F-F were created for the proposed run only and hence, no corresponding level exists in the existing run]

Figure 9 shows the change in levels for the 100 year event when comparing the Proposed HIF Infrastructure Works (with mitigation bund) vs the Existing, using the Interim 2021 model.

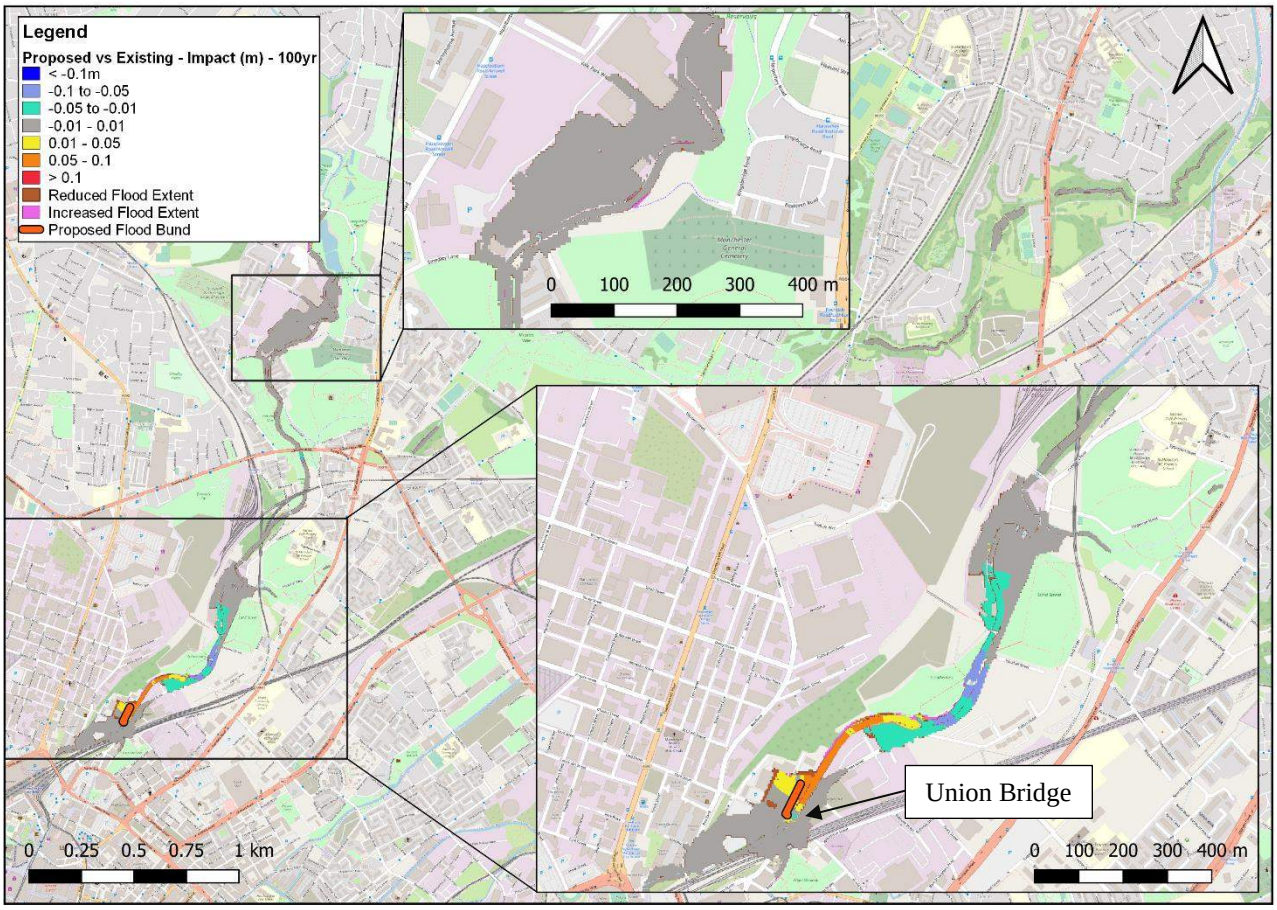


Figure 9: 100 year event HIF with flood bund vs Existing

Figure 11 shows the change in levels for the 100 year plus climate change (2080) event comparing the Proposed HIF Infrastructure Works (with mitigation bund) vs Existing, using the Interim 2021 model.

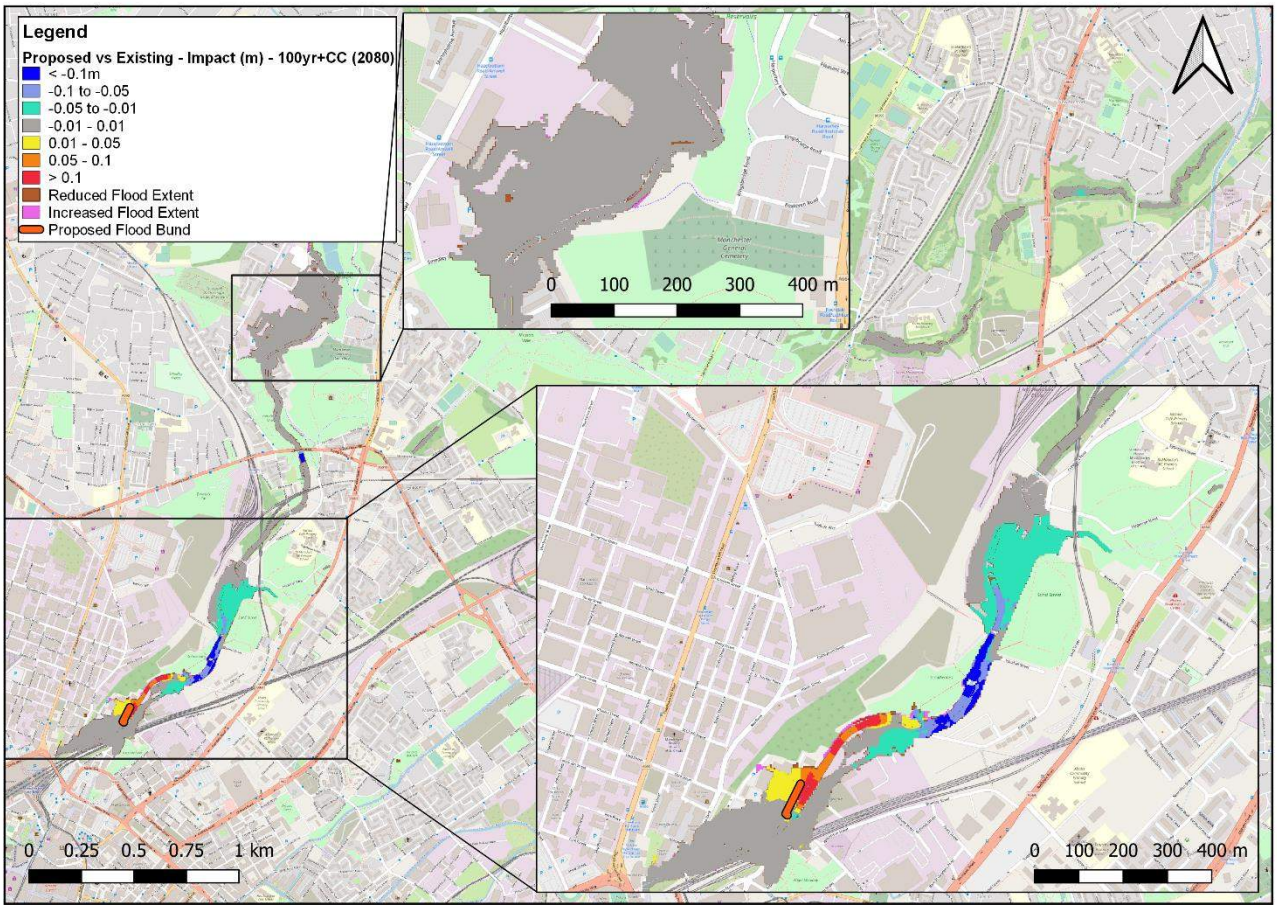


Figure 10: 100 year plus climate change (2080) event HIF with flood bund vs Existing

Figure 11 shows the change in levels for the 1000 year event comparing the Proposed HIF Infrastructure Works (with mitigation bund) vs Existing, using the Interim 2021 model.

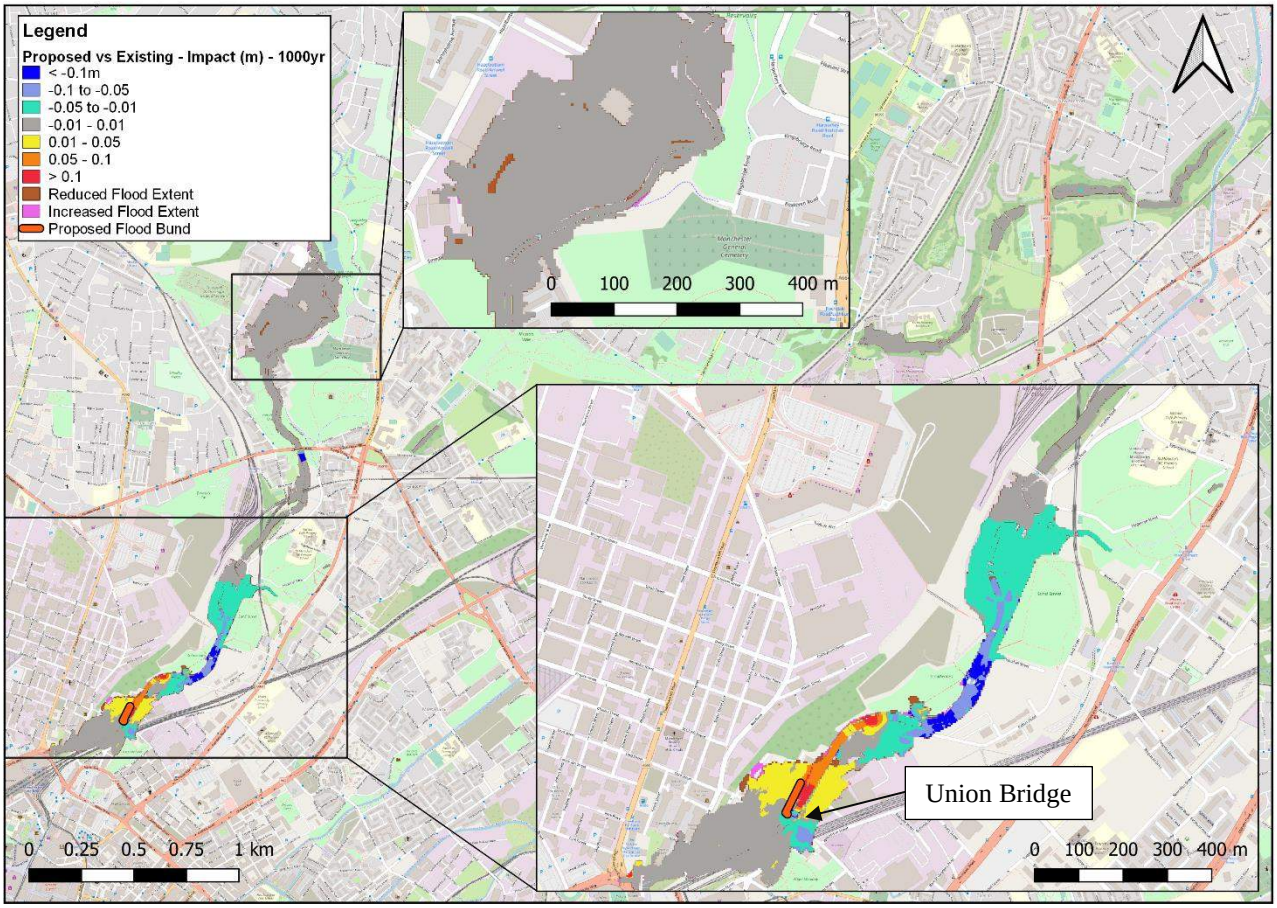


Figure 11: 1000 year event HIF with flood bund vs Existing

5 Discussion and Conclusions

A comparison has been made between Existing Conditions vs HIF Infrastructure Proposals below, using the Interim 2021 hydraulic model.

5.1 Pre Flood Bund (HIF Works)

5.1.1 Overview

Figure 5, **Figure 6**, **Figure 7** and **Table 2** all show that there is a general decrease in peak flood levels upstream of the proposed HIF Infrastructure works as a result of the proposed works.

Downstream of the proposed HIF works, there are generally negligible changes to flood levels in-channel, as shown in **Table 2**.

There are no changes in flood level at the confluence with the River Irwell as the larger river is dominant here.

Table 3 shows small increases in flow of 0.3m^3/s for the 1000 year event (<1% change of the overall flow) passing forward to the River Irwell. However, the 1000 year event model is subject to some in-channel oscillations and instabilities for both existing and proposed model runs, particularly immediately south of HMG Paints due to steepness of Moston Brook Channel and limitation due to high magnitude of flow under this extreme return period. Reasonable attempts were made to reduce the instabilities using one and/or a combination of 'a' flags on bank lines, using viscosity boundary factors and roughness patches. However, these only slightly reduced the oscillations at the expense of producing an unrealistic schematisation. These additions were therefore discarded and as such, the 1000 year results should be not be interrogated in fine detail and considered with caution.

5.1.2 Location specific comments

At Collyhurst Weir, there is a small reduction in flood level by approximately 0.07m in channel and in the floodplain (reducing from a floodplain depth of 0.89m to 0.82m) for a 100 year event. This reduction continues upstream towards HMG Paints, after which the difference is deemed negligible.

As a result of the proposals, there are small instances of both increases in flood extent at St. Catherine's Wood and decreases in extent on the right bank around the northern edge of Red Bank.

Within the boundaries of the HIF Infrastructure proposals, **Figure 5, Figure 6**and **Figure 7** show localised increases in flood levels in the out of bank areas around St Catherine's Wood and to the right bank (north side) of Union Bridge. This is due to the removal of an existing wall and introduction of terracing along the bank as shown in Section D-D, E-E and F-F in **Table 6** in **Appendix A**. The removal of this wall allows more flow to propagate into the floodplain on the right (north) bank as shown in **Figure 17**, due to proposed localised changes in topography. The removal of the wall also explains the large decreases in in-channel flow observed upstream of Union Bridge, as noted in **Table 3**, as more water is able to propagate onto the floodplain rather than stay within the channel.

Table 3 shows a significant reduction in flows up to the 1000 year event around cross-section Irk_1.05 then a swift increase in at the next section, cross-section XS_F-F for the proposed scenario. The reduction in flows at section IRK_1.05 is due to more flow being in the floodplain due to the terracing allowing more out of bank flow. Then, as **Figure 12** shows, depicting the direction of flow, the increase in flows at section XS_F-F is due to overland flow re-entering the channel at section XS_F-F.

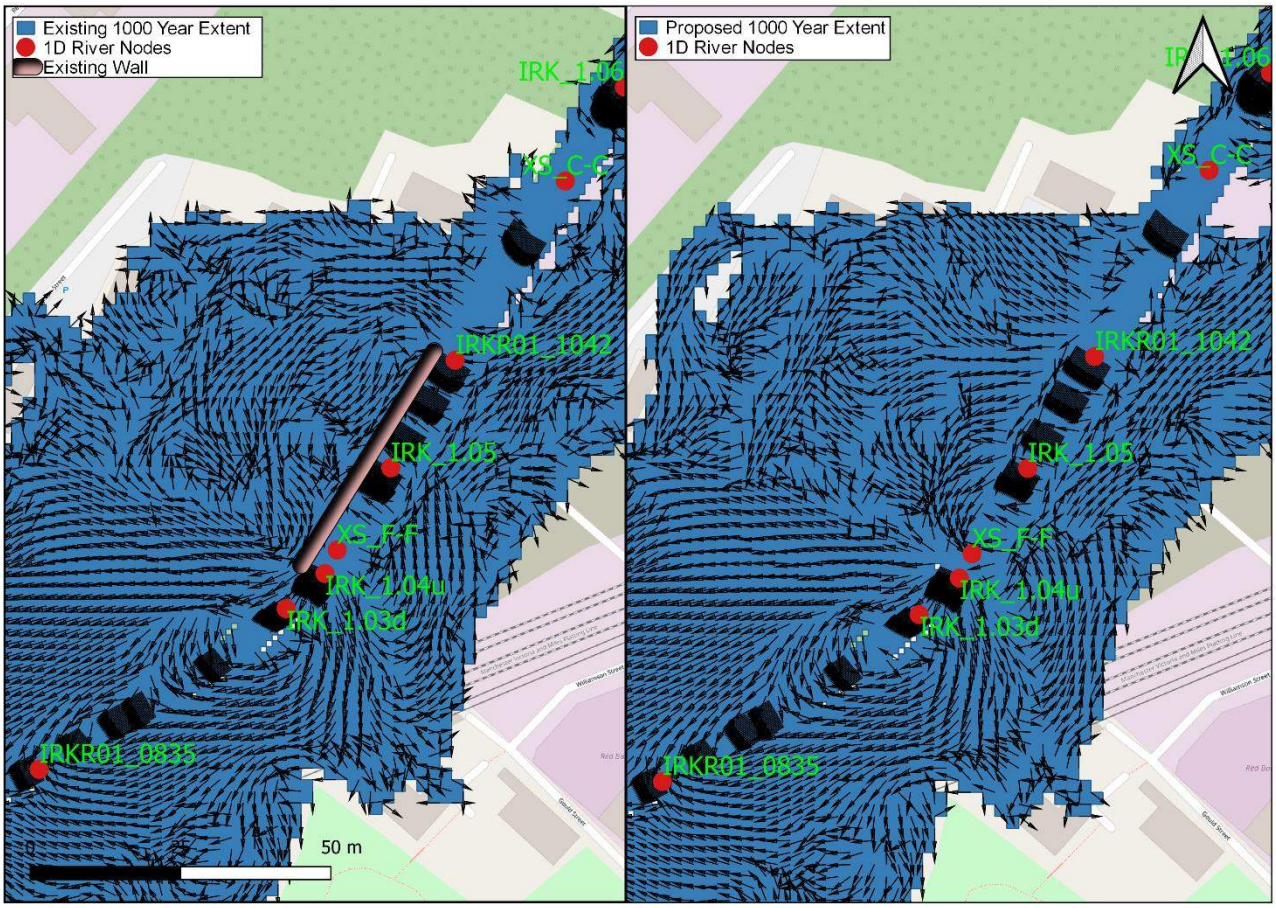


Figure 12: Direction of flow (1000 year event) Existing vs Proposed

Increases in flood heights in the floodplain are seen on the right (north) bank, immediately west of Union Bridge on Roger Street up to a maximum of +0.035m (from existing condition depth of 0.45m) for the 100 year and up to a maximum of +0.015m (from existing condition depth of 1m) for the 1000 year event.

In all return periods except for the 1000 year, levels and extent are increased downstream and to the right bank of Union Bridge. This isn't increased in the 1000 year scenario since flows are comparable and already entering Roger Street and continuing south in the existing situation. In the 100 year event, there is generally an increase in flood levels of approximately 0.01-0.02m, (from existing depths of up to 0.63m) immediately south of Roger Street (Plot RB09) with small increases in extent. Since overland flows are in a SW direction, further south-west of the HIF site (along Scotland Street), there are general increases in depths of approximately 0.01m as a result of overland flow beneath the railway sidings viaduct (which have originated from the drop in wall height and stepped nature of the bank Union Bridge Plot RB07).

It should be noted that although the source of these additional overland flows result from the terracing and proposed removal of the wall upstream of Union Bridge, it is questionable if, in reality, the existing wall could withstand hydraulic loading during extreme events in the existing condition and consequently, may occur anyway.

5.2 HIF Works With Flood Mitigation Bund

5.2.1 Overview

Figure 9, **Figure 11** and **Table 4** all show that there is a general decrease in peak flood levels upstream of the proposed HIF Infrastructure works as a result of the proposed works.

Downstream of the proposed HIF works, there are generally negligible changes to flood levels in-channel, as shown in **Table 4**.

There are no changes in flood level at the confluence with the River Irwell as the larger river is dominant here.

Table 5 shows small increases in flow of 0.5m^3/s for the 1000 year event (0.37% of the overall flow) passing forward to the River Irwell. However, as described in **Section 5.1** the 1000 year event is still subject to some in-channel oscillations and instabilities.

5.2.2 Location specific comments

Figure 13 illustrates a comparison of the 100 year impact without and with the mitigation bund in place, compared to existing.

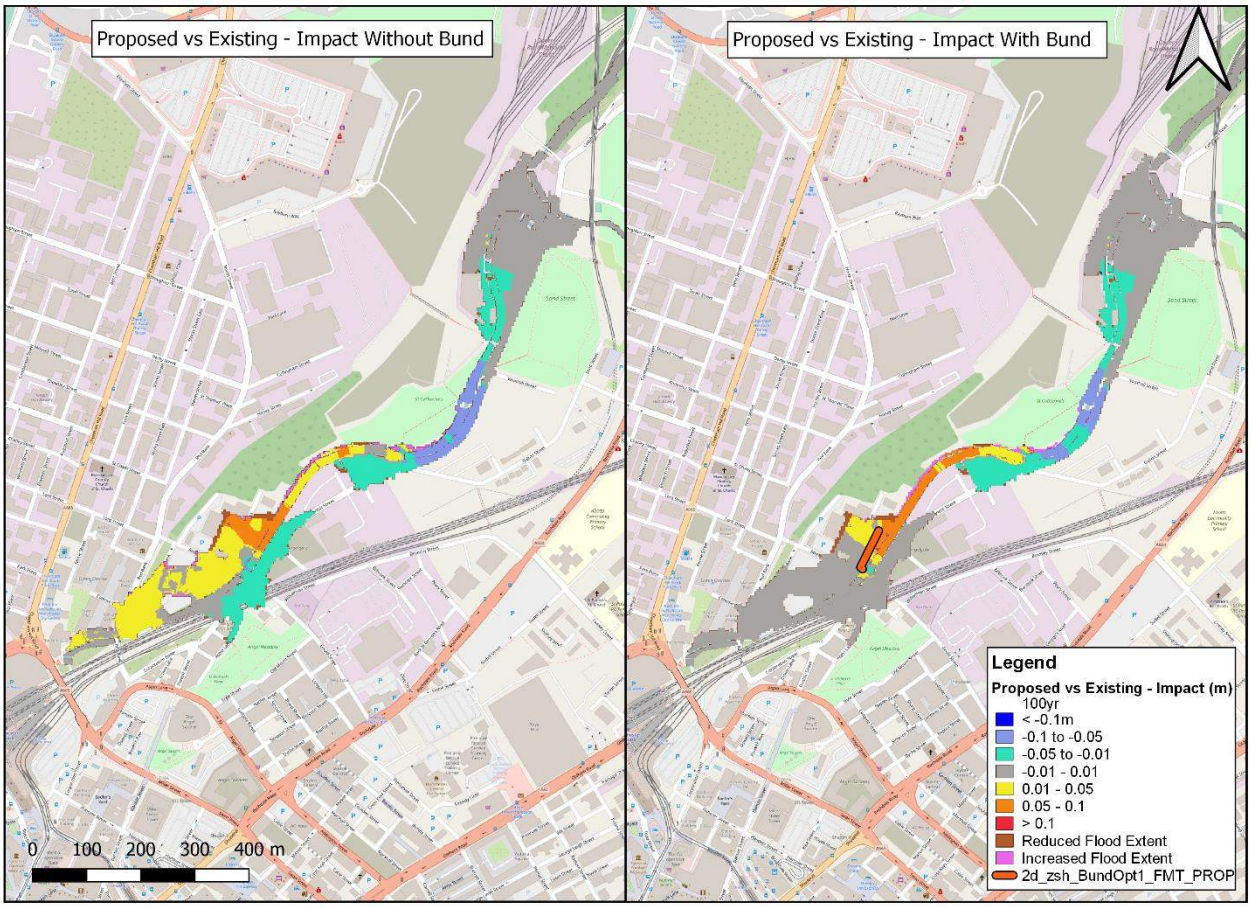


Figure 13: Impact comparison – with and without the flood bund – 100 year

Figure 13 shows that by implementing the flood bund, the increase in flood depth off site (to the south of Roger Street (Plot RB09)), is now mitigated for the 100 year event. The impact on flood depth along Dantzic Street is negligible comparing the bunded solution compared to the existing scenario.

Within the channel, in the area of the proposed works, there is a slight increase in stage. There is an increase in level along the bank, within the floodplain, at Travis Island of up to 0.035m (from an average depth of 0.7m), however the majority of the flood depths at Travis Land remain unchanged by the proposed works. Further upstream, at St Catherine's Wood, Collyhurst Road and HMG Paints, there is a reduction in channel stage of up to approximately 0.03m.

There is also no increase in flood extent here when implementing the flood bund, whereas without the bund modelling showed minimal increases.

Figure 14 shows the increase in flood depth off site (to the south of Roger Street (Plot RB09)), is still mitigated for the 100 year plus climate change (2080) event. Within the channel, in the area of the proposed works, there is a slight increase in stage. There is an increase in level along the bank, within the floodplain, at Travis Island of up to 0.03m (from an average depth of 1m), however the majority of the flood depths at Travis Land remain unchanged or reduced by the proposed works. Further upstream, at St Catherine's Wood, Collyhurst Road and HMG Paints, there is a reduction in channel stage of up to approximately 0.135m.

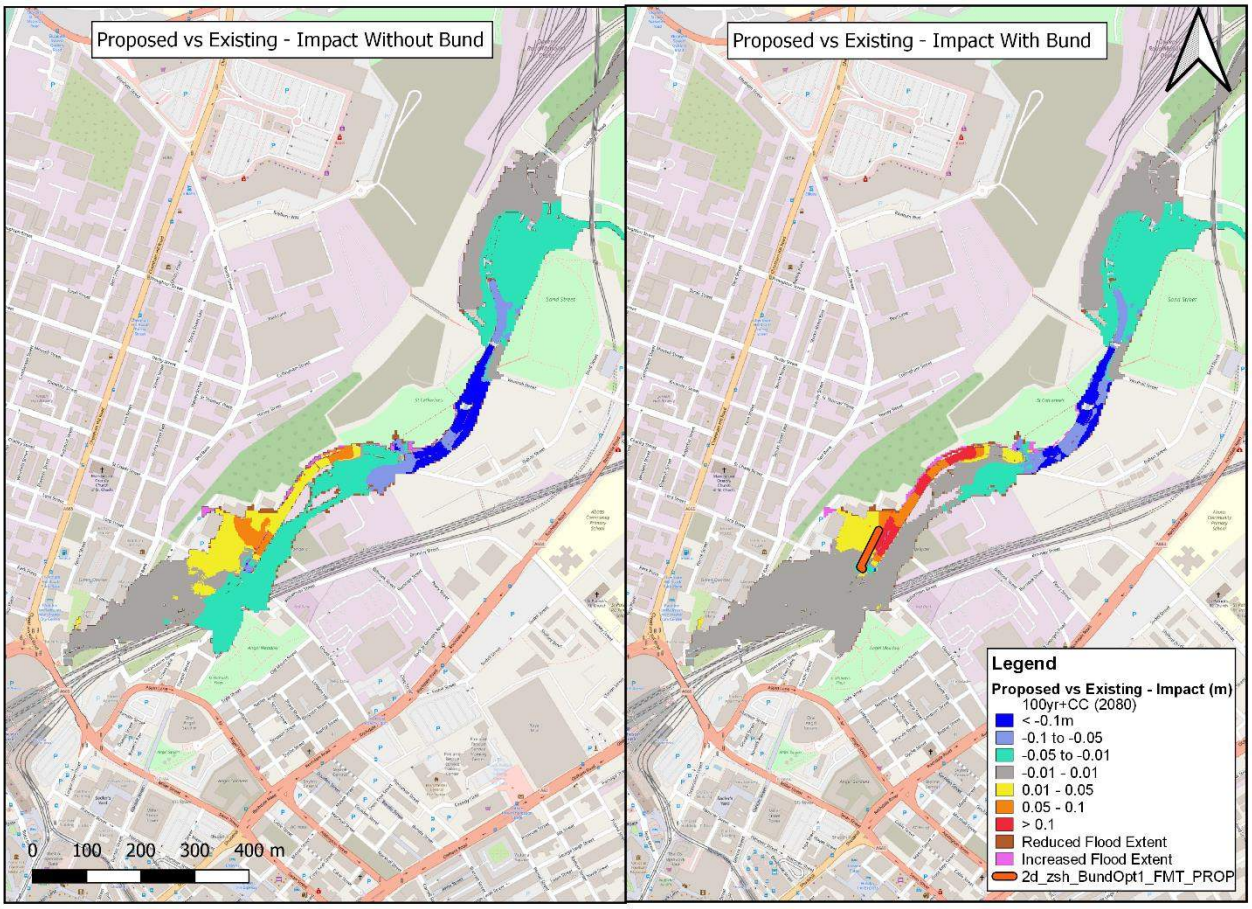


Figure 14: Impact comparison – with and without the flood bund – 100 year plus climate change (2080)

At the confluence with the River Irk downstream, as shown in **Table 5**, there is a Negligible change to pass forward flows for 100 year event and a small increase in pass forward flow of 0.3 to 0.5m^3/s for the 100 year + CC 2080 and 1000 year events (100 +CC 2028 Year flow changes from 107.5 to 107.8 m^3/s), which is less than 0.5% change.

The bund predominately mitigates the changes flood risk predicted for the proposed HIF Infra works, however **Figure 15** shows that the impact for the 1000 year event does still marginally propagate (up to 0.012m increase) south of Roger Street (into Plot RB09) but to a lesser extent than without the bund.

There is also a small increase in flood level on the eastern side of the river on Dantzic Street, with an increase in flood depth in the region of 0.02-0.04m (compared to an average flood depth prediction of approximately 1.0m in existing situation).

There is a marginal increase in predicted flood depths at Travis Island of 0.015m (from an average depth of approximately 0.7m in existing situation) illustrated in yellow, although the majority of this area has negligible impact or a reduction of up to approximately 0.06m.

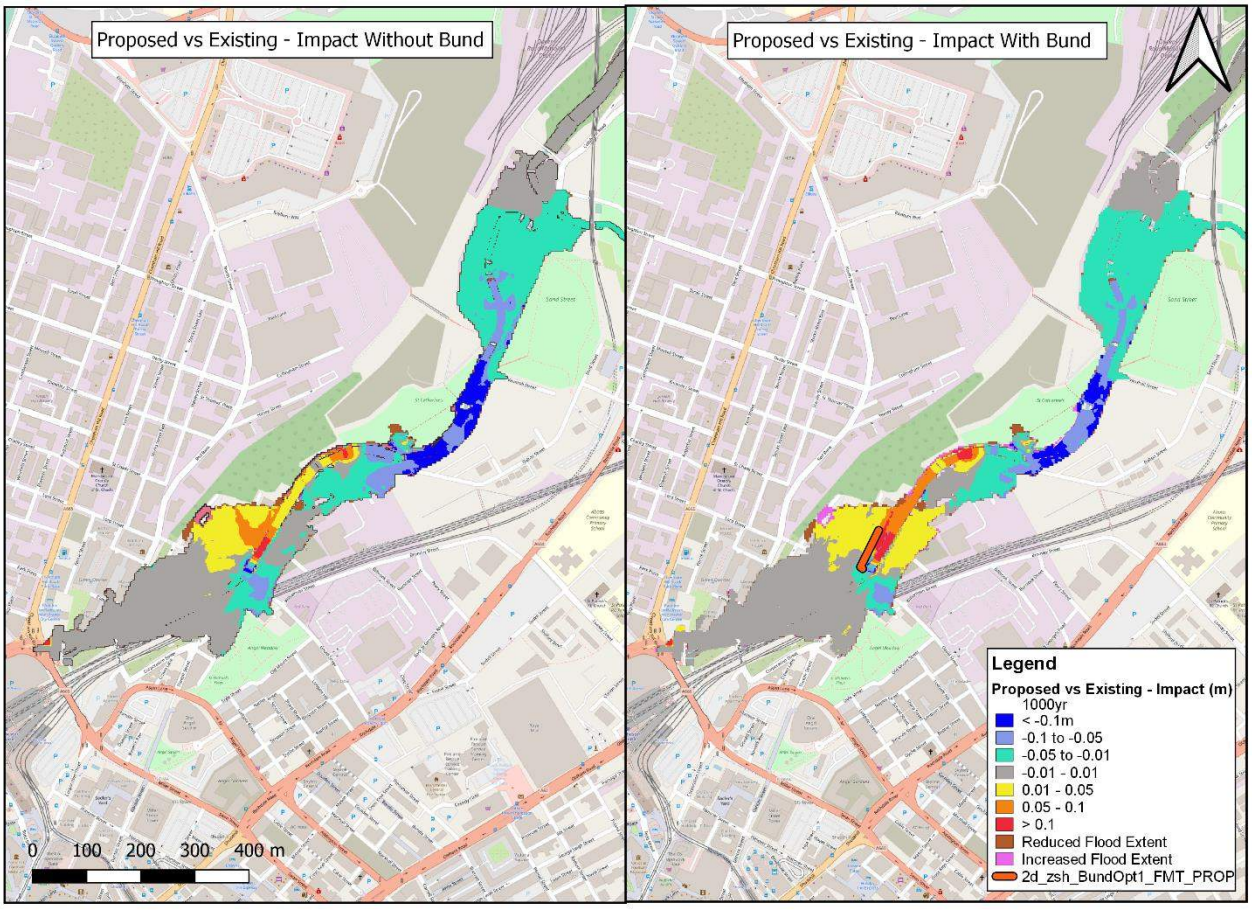


Figure 15: Impact comparison – with and without the flood bund – 1000 year

APPENDICES

A. Proposed HIF Infrastructure Works

Planit Drawings

To undertake the Flood Risk Assessment for the proposed HIF Infra works, including landscaping and river modifications, it is necessary to represent the proposed works in the model. Arup have received cross-sections highlighting the proposed changes to the channel geometry, in addition to a plan drawing of proposed changes to the floodplain (ref. **VNIF-PLA-ZZ-YYY-SK-L-0001** & **VNIF-PLA-ZZ-YYY-DR-L-1000**).



Figure 16: Location of the cross-sections representing the proposed works, in the context of the Victoria North site. Provided to Arup by Planit.

Depending on the landscaping works proposed, the ID cross-sections were updated to represent the updated river channel. Proposed updates to 1D cross-sections are detailed in **Table 6**.

Changes include the addition of sections to provide an upstream and downstream bound to the proposed modifications.

Where out of bank changes were also proposed, or where the channel wall removed and bank stepped back, this was reflected in corresponding changes to the 2D domain. This included updating roughness values, defining the addition of paths and vegetation, and the use of z-shapes to represent changes to the topography.

An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The left hand image of **Figure 17** shows a comparison of the existing and proposed levels within the study area.

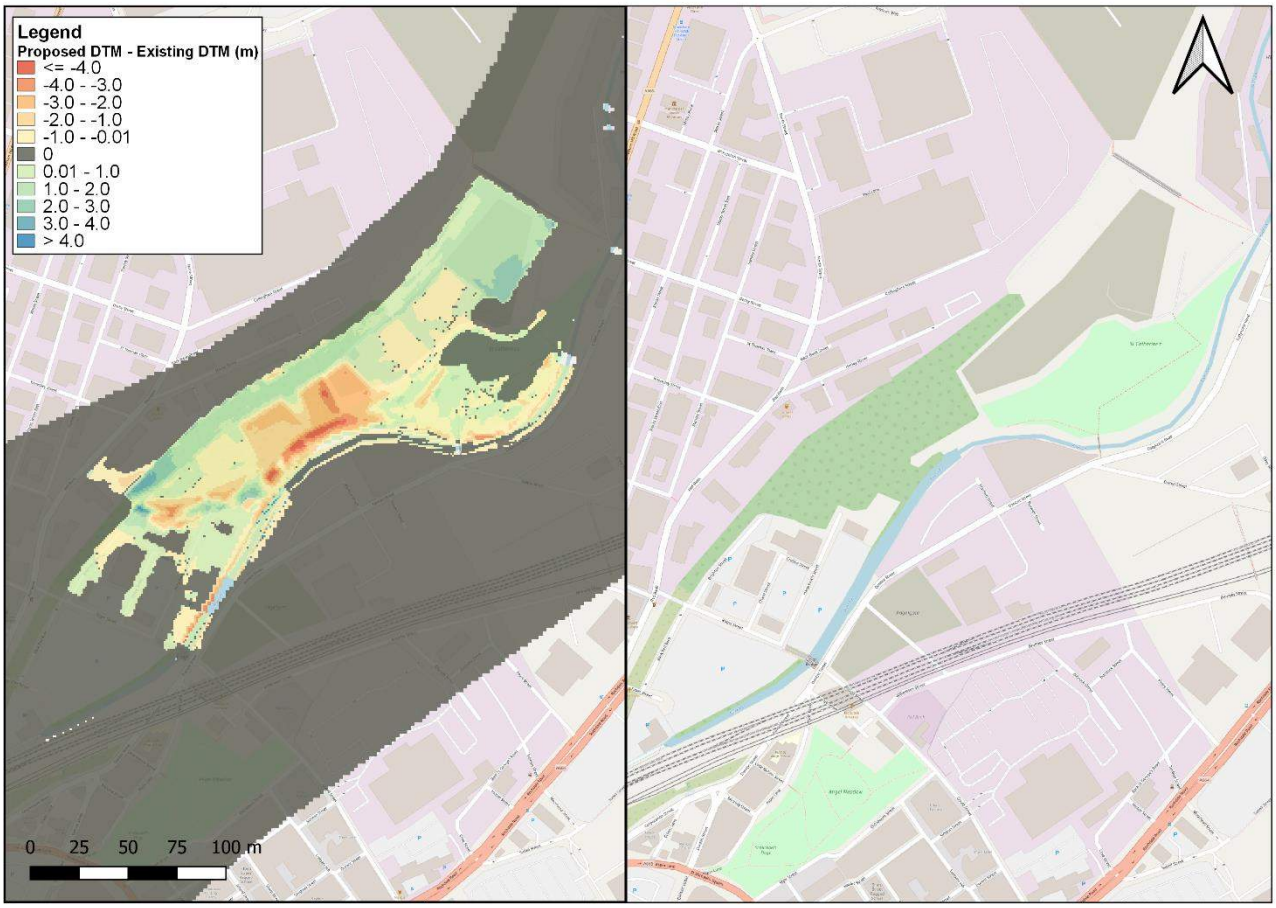
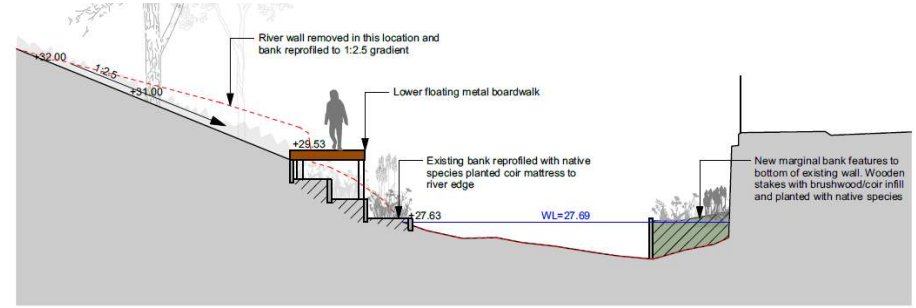


Figure 17: Comparison of the existing and proposed topography within the study area

Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
A – A’  	IRKR01_1449	Channel manually edited to include steps noted in cross-section A-A. Wooden stakes with brushwood/coir infill modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA[2], with roughness also increased to 0.07 as per 1g in Chow tables. Pathway not physically represented, rather with an increase in roughness, to 0.1, as per 1h in Chow tables[3]. Roughness increased where vegetation is shown in the infills. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.

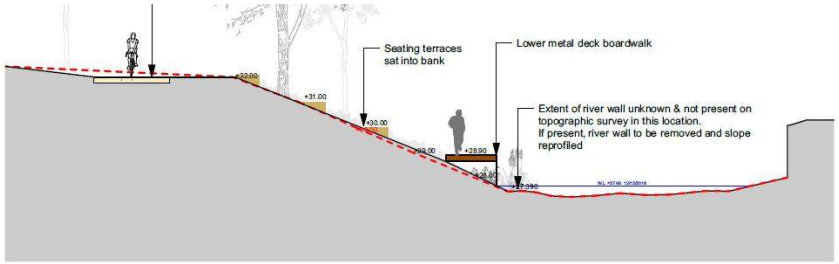
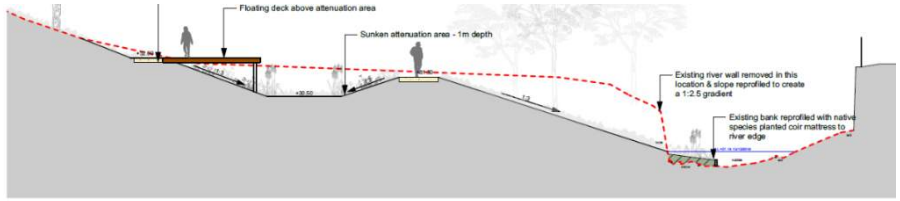
[2] https://nrfa.ceh.ac.uk/data/station/meanflow/69043

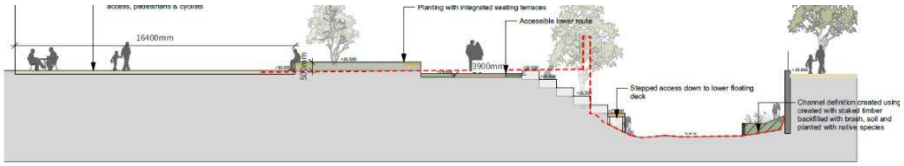
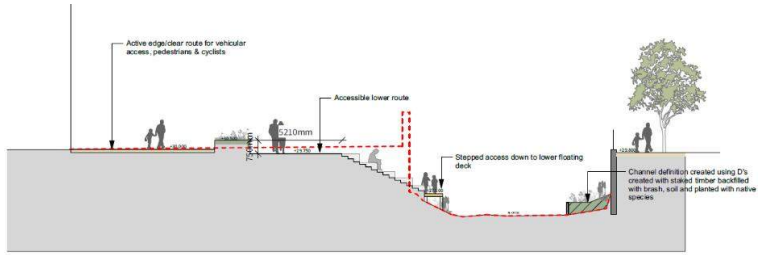
[3] http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

J:\280000\281943-00\4 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\VNIF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRAPROPOSALS_ISSUE3.DOCX

Arup | F0.15

Page 32 of 56

Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
B – B’  2 Section B-B' Scale: 1:150	IRKR01_1293	Right bank slope amended to represent cross-section B-B and tie in with amended 2D DTM levels. Metal boardwalk not physically represented, rather with an increase in roughness to 0.1, as per 1h in Chow tables. Roughness increased where vegetation is shown on the right bank. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.
C – C’  3 Section C-C' Scale: 1:150	Intermediary cross-section, between IRK_1.06 and IRKR01_1042 introduce, named XS_C-C.	New cross-section introduced, a copy of IRK_1.06. Right bank edited to remove the bank and introduce a slope of 1:3. Coir mattress modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA. Roughness increased for the coir mattress. A value of 0.07 used as per 1g in Chow tables. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.

Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
D – D’  4 Section D-D' Scale: 1:150	IRKR01_1042 & IRK_1.05	Channel manually edited to include steps noted in cross-section D-D. Wooden Staked timber backfilled with brash modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA, with roughness increased to 0.07 as per 1g in Chow tables. Floating deck not physically represented, rather with an increase in roughness, to 0.1, as per 1h in Chow tables. Roughness increased where vegetation is shown on both sides of the bank. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.
E – E’  5 Section E-E' Scale: 1:150	IRKR01_1042, IRK_1.05 and XS_F-F	New cross-section introduced, a copy of IRK_1.06. Channel manually edited to include steps noted in cross-section E-E. Wooden Staked timber backfilled with brash modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA, with roughness also increased to 0.07, as per 1g in Chow tables. Floating deck not physically represented, rather with an increase in roughness, to 0.1 (1h in Chow tables). Roughness increased where vegetation is shown on both sides of the bank. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in

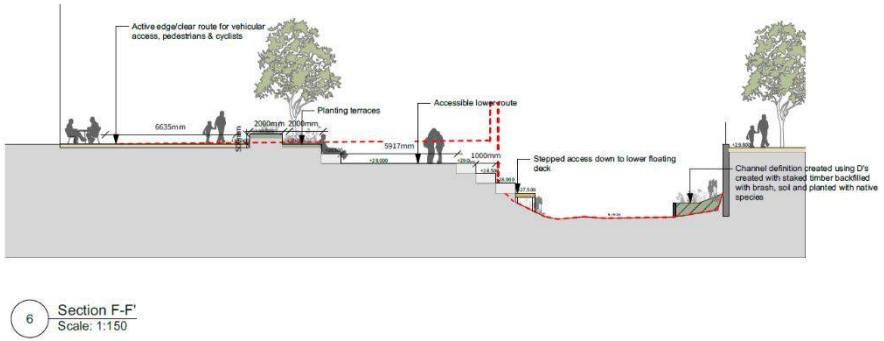
Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
		with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.
F – F’  	IRK_1.05 and XS_F-F	Channel manually edited to include steps noted in cross-section F-F. Wooden Staked timber backfilled with brash modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA, with roughness also increased to 0.07, from 1h in Chow tables. Floating deck not physically represented, rather with an increase in roughness to 0.1, from 1h in Chow tables. Roughness increased where vegetation is shown on both sides of the bank. An ASC layer was generated of the proposed level changes to the 2D floodplain and was read in over the existing DTM in the study area. The levels in the 2D ASC were made to tie in with the 1D node levels. To account for the terrain changes shown in **Figure 16**, a new Mastermap layer was created to assign current roughness values.

Table 6 - Summary of HIF Infrastructure Works modelled



Figure 18 - Plot Boundaries

B. Responses to EA Model Review Actions

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
Flood Modeller and TUFLOW versions: Flood Modeller version 4.3 single precision, TUFLOW 2017-09-AC-iSP-w64	Use most up-to-date software. Currently this is: FMP version - version 5.0 TUFLOW - 2020-10-AA Ideally, double precision version of software will be used.	Completed – model updated to FMP version 5.0, and TUFLOW version 2020-10-AA
Return periods simulated: Q100, Q100+CC and Q1000 and have been run. Bare minimum of runs required, a fuller range of return periods may help to sensitivity check model outputs in the absence of validation/verification information.	Consider simulating a larger range of events. Although the wider suite of events are expected in the next stage, for this FRA we will require a comparison for the 2020 and 2050 climate change epochs to ensure the model is stable and results look sound. The results have not been provided with this submission or discussed in the report.	20 year added. More to be added for the full modelling exercise in 2022 2020 and 2050 climate change epochs added for the 100yr event
Sensitivity runs and uncertainty: Sensitivity runs have been undertaken but no analysis of these in reporting.	Quantify uncertainty of the modelling by analysing the sensitivity test results and include this in the reporting.	A full suite of SEN runs will be completed at next stage
Georeferencing: FMP gxy a bit of a mess. This won't impact model results, but makes working with and reviewing the model more difficult!	Please georeference the FMP nodes.	Minimal georeferencing so difficult to identify exact location of sections, but all have been moved to general location, based on structures. Original source EA model was not georeferenced.
Review cross-section and bed profiles: Model is based on survey from before 2004 (survey date unclear from reporting) and from Jan 2019. On Moston Brook, several cross sections are low resolution with only a few data points. This is likely attributed to the survey information available, but is	Give further detail on the survey used for the hydraulic model in the reporting. Review cross section widths on Moston Brook. Review deactivation markers for IRKR01_1788D, MOST01_5400 and MOST01_5337.	Completed – deactivation markers for IRKR01_1788D, MOST01_5400 and MOST01_5337 set to top of bank

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
considered a limitation. There are also large changes in cross section width - some sections ~10m wide, other >50m. This should be reviewed. Two sections had points on the right bank where it went down in elevation - IRKR01_1788D, MOST01_5400 and MOST01_5337. Was this intentional? The initial approach should be to deactivate at the bank crest.	There still seems to be an issue at MOST01_5400 with the right bank continuing down into the floodplain due to inappopriate bank location. There are also a handful other sections identified using a GIS tool where the bank may not be trimmed to an appropriate location, please see screenshot to the right. Action: ensure banks are trimmed at appropriate locations, especially the sections on Moston Brook. The cross sections highlighted at the d/s limit of the Irk are unlikely to have an impact and are not connected to 2d. ---------- Proposed model. Appendix A describes the amended cross sections as part of the proposed works. One source of confusion notes is that the report states that sections D-D and E-E both influence overlapping baseline units of IRK01_1042 and IRK 1.05, whilst proposed sections E-E and F-F influence IRK_1.05 and XS_F-F. Action: this is confusing, so please clarify if the drawings overlap several cross sections? Additionally, the drawings were compared to amended cross sections with the following issues noted:	Updates made to the 1D sections flagged in the screenshot to the right, ensuring the section is deactivated at the bank level. B-B - one point set to 0.07 on the LB has been removed. D-D - Given the progression of the numbers down the steps (from 30.0 to 27.5 as seen in the screenshot added opposite), the first step in the model is at 28m, not 27.5m. 27.5m would be the deck level, which is not being modelled. No changes made. E-E - represented between IRK_1.05 and F-F. deck level is 27.5m for all sections in the area, so it's not felt an individual section is necessary

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	A-A (IRK01_1449): All OK aside. 2d elevations appear to tie in with design on right bank and are lower than baseline. B-B (IRK01_1293): High roughness used on LB in the model but nothing is indicated there on the drawing - please clarify. C-C (XS_C-C): All OK D-D (IRK01_1042 and IRK_1.05): Expected to see the first step on the right bank at 27.5m (28m in the model) although the arrow in the design drawing does obscure the value - please clarify. Wall successfully removed and 1d-2d boundary elevations have been altered to reflect the change. E-E: Hard to tell what cross section this is reflected in - is it IRK_1.05 i.e. same as D-D? F-F (XS_F-F): Amendments look OK and RB wall removed successfully.	
Chainage: This check was not undertaken.	Limited checks have been possible using the 2019 survey data. New cross sections have been added between existing nodes, and this has caused some discrepancies. E.g. CS 1.25 to 1.24 in the dwg file is 56m, but total chainage between corresponding sections in DAT file is 45m. There is also a difference betwen 1.18 and 1.17 from a spot check. Action: Please check where new survey has been added that 1d chainage matches.	A comparison was made between the chainage measured in the .DAT file, and the 2019 survey and aerial imagery. The difference between sections 1.25 and 1.24 mentioned is due to the Smedley Road Bridge not being accounted for - the section downstream of the bridge was ammended to account for this. Chainage in the model between sections 1.18 and 1.17 was compared to aerial imagery and survey, and values were adjusted accordingly.
Conveyance: Generally smooth. A handful of sections have minor	Review sections and add panel markers as appropriate.	Completed – all addressed

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
"wobbles" in conveyance - IRKR01_3652, IRKR01_3520, IRKR01_1188A, MOST01_5900, MOST01_5892A, MOST01_5270, MOST01_4212A and MOST02_0000H.	MOST02_0000 has a conveyance issue at the higher end of flows but unlikely to impact results significantly. Action: Please investigate - the conveyance issue probably only affects the highest water level for the Q1000 flow but may impact out of bank flow.	Addition of panel markers to cross-section MOST02_0000 to improve conveyance
Review flow gauge: Gauge available within study area - Irk @ Collyhurst Weir (NRFA 69043). Not mentioned in reporting at all.	Make use of gauge data for both hydrology and validation of modelled flows.	Hydrology inflows scaled to match gauge records
Channel roughness: No mention of 1D roughness in the report.	Add detail on how roughness values were calculated, along with example photos of the channel to verify the values used. Thank you for clarifying, please summarise in future reporting for wider stakeholders.	Existing values appraised for appropriateness. Aerial photography and online images reviewed against the values noted in Chow tables. Added to reporting
Manning's n values: For many of the cross sections, we have bank roughness 0.06 and channel roughness 0.04. This is suspiciously close to usual survey values. For several other cross section, possibly from the 2019 survey (as the node label was a different format), several different values are used, very low values are used (0.015-0.020) and the channel roughness is significantly higher than the bank roughness. This need review and justification. Checked against the raw survey values and they are	Review all manning's values, describe and justify values in the reporting along with example photos. As above, please summarise in report e.g. range of values in different reaches. Proposed model Roughness has been increases where channel interventions include vegetation with a value of 0.1	Review of low roughness values was completed; these values appear to correspond to the location of walls lining the channel so Chow values, as documented in the Roughness Values tab in the EA model review spreadsheet document. No changes applied Roughness values of vegetated areas outside of boardwalks in the proposed model have been dropped to 0.07, as per Chow item 1g (normal).

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
the same, so suspicious that this was not checked during the baseline model development.	being selected. As per email discussion this is ok for some areas given the expectation for piers associated with walkways along with wooden stakes where vegetation is being held, and 0.1 would represent the obstruction to flow. However where the FMP cross section panel only includes vegetation, please consider carefully if in reality this vegetation will be dense to justify the high value. If not please undertake a sensitivity test. It would be appreciated if further detail could be provided in the report justifying the high roughness.	
Roughness estimation method: Unclear if any method has been used.	Describe the process for assigning roughness values in the reporting.	Aerial photography and online images reviewed and compared against the values noted in Chow tables
Inflows: Hydrological estimates, dated 2004, not updated for this hydraulic model. 1 flow time boundary at the upstream extent. 3 FEHBDY for lateral inflows on river Irk, 7 FEHBDY used as upstream and lateral inflows on Moston Brook.	As discussed previously, hydrology needs updating as considered very out of date.	Hydrology has been updated – 20 year, 100 year (including climate change allowances) and 1000 year events modelled; subsequent updates to be made in the next modelling exercise.
Downstream boundary: Downstream boundary taken from 2017 Lower Irwell hydraulic model. Applied as a head-time boundary, with peak matching Irk peak flow, although unclear if the peak inflow or water level just upstream of boundary is taken. Sensitivity testing show that the downstream boundary has limited impact upstream of culvert. This is stated in the reporting text, but results from	Confirm whether the peak matches the Irk peak inflow, the Moston Brook peak inflow, or the peak water level near to the downstream of the model. Reviewer would consider the latter option to be most appropriate. Present downstream boundary sensitivity test results in the report - both maps and long sections.	Downstream boundary taken from the Manchester Ship Canal 2018 model. As agreed with Nick Prebble on 15/12/2021: •The shape of the head-time boundary from the previous modelling stage will be retained •The shape will be scaled to match the peak stage from the updated Ship Canal model •The peak is shifted to match the peak on the Irk at the downstream boundary

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
sensitivity test not actually presented within the report. Mention of using the Manchester Ship Canal model for the downstream boundary data is included in the reporting in the Recommendations section, without being mentioned anywhere else in the reporting.	Confirm if the MSC model is required and add detail to the justification within the main report Please also confirm the return period used from 2018 model for the downstream boundary in reporting.	•The shape will be further scaled to cover 16hrs as opposed to the previous 10hrs •This approach will be revised for the full modelling exercise in the new year. Return periods varied for each run (i.e. 20yr used for 20yr), added to report
Missing structures (bridge and viaduct along the Irk): Checked FMP against 10km OS mapping. Two missing structures noted: - possible bridge downstream of IRKR01_3652 shown on OS map, cannot see in survey photos or satellite imagery. - viaduct downstream of IRKR01_2271. survey shows very high soffit and comment in model states no constriction to flow. What about piers?	Any structures not included in the model should be investigated and exclusion should be justified in reporting.	Unsure of first structure. Looks to possibly be pipes over the river given the industrial location. This would not be modelled. Conservative approach to omit so as not to underestimate flow travelling downstream to study area. Flow at 2271 is completely within channel for all AEPs
Invert levels of 1D structures: New survey (2019) checked for all structures. All match surveyed geometries with one exception - weir IRK_1.12wu where breadth of crest in model 19.427, surveyed 16.77. Comment says "Exponent adjusted to parabolic". Not sure what this means. Old survey (2003) checked for all structures. Minor discrepancies at:	Check and address comments for structures highlighted. If not changed, need full justification in reporting. NB - no one issue causes the "red" RAG status, but lots of smaller issues together does.	Completed: Weir in new survey amended Structures in old survey amended Note in existing model states – “RAIL VIADUCT AT IRKR01_2271- NOT MODELLED AS VIADUCT REPRESENTS NO CONSTRICTION TO FLOWS”. In the absence of survey to add in, and the nature of the

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
- IRKR01_2770D - modelled springing 36.94, rather than 36.69 surveyed - IRKR01_1903D - modelled soffit 32.5 rather than 31.69 surveyed - IRKR01_1788D modelled soffit 32.03 rather than 31.67 surveyed Other comments on Irk structures: - piers for viaduct downstream of IRKR01_2271 not represented in model. - bridge and upstream cross section widths should match. This was not the case for the following bridges - Irkr01_3311A, IRKR01_2814. IRK_1.16bu. IRK_1.09bu. IRK_1.04bu. - all weir structures have spills in the same location. No description what these spills are representing. - Culvert IRK_1.01cu very low Manning's (0.015). Did not have survey for Moston Brook so structures not compared to survey here. However, the following issues were noted: - Culvert MOST01_5712J - orifice unit instead of culvert inlet, no culvert outlet. Manning's 0.02 (low) - culverts starting atMOST01_5270J, MOST01_3820, MOST01_1349, MOST01_0605J, MOST01_0177 - manual topslot in culvert, roughness 0.01-0.015 (very low), no culvert outlet. - culvert at MOST01_4980A, MOST01_4268A, represented as orifice unit. Generally conduit units preferred.	2019 survey suggests IRK_1.12wu starts at 0.27m and finishes at 22.6, giving a breadth of 22.33. Comment in survey states section observed along crest (not perpendicular), so does this account for the	surrounding topography, it's believed the flows are well represented here U/S of bridges or bridges amended so they match Spill at weir at IRK 1.23 shortened to represent the RB flow. Spill at IRK_1.18 removed Culvert at IRK_1.01cu Manning's n unchanged as brick closed conduit. 0.015 is appropriate based on roughness tab in this doc Inlet and outlet added to MOST01_5712J - roughness not changed, appropriate Culvert outlets applied to MOST01_0605J and MOST01_0177. Topslots in all added for stability Breadth of weir in section IRK_1.12wu increased to 22.33, from survey. Addition of culvert outlets on all Moston Brook culverts will be run as a sensitivity test at the next stage of modelling.

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
- stability spills used, not necessarily unacceptable, but needs highlighting in report.	curve shape? Please clarify since breadth of 21.3m is used in the model. Irk bridges look OK now - no action. Regarding IRKR01_2271, a photo is evident within Appendix D of the Irk 2004 data which indicates no piers enter the channel. No action. U/S width issues at bridges resolved. No action. Weirs/spills ok .No action. IRK_1.01cu accepted. No action. Acknowledged that some Moston Brook culverts now have outlet units, but others still don't have outlets. Confirm if this was intention and how any outlet losses can be accounted for. General comment requested such details in the report in the original review comment.	
Orifice flow on surcharging bridges: The following bridges surcharge with orifice flow not enabled: IRKR01_2770A, IRKR01_2464A, IRKR01_2123D, IRKR01_2024D, IRKR01_1930D, IRK_1.09bu, IRK_1.04bu, IRKR01_0685D, MOST01_5892D, MOST01_4212D	Enable orifice flow for the sections highlighted. If this is not suitable, justification is required in the reporting.	Completed – orifice flow enabled on all noted
Spill coefficients: Range of different spill coefficients (1.0 to 1.5) used for in line spills and overtopping spills. For example,	Review spill coefficients and ensure consistent across study area. Justification for values used should be included in reporting.	Spill at HMG paints reduced to 1.0

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
spill IRK_1.20su represents overtopping of bridge at HMG Paints site where the spill level is at windows. However, the spill coefficient used is 1.2 (default). A lower spill coefficient should be considered. All spill coefficients require justification.	Reduction at HMG Paints location is appreciated, but the wider point of justifying the coefficients is expected in model report. Values may be inherited from older models but judgement should be used in ongoing appropriateness.	Spill coefficients in the model were reviewed, and updated where necessary. Justification of spill coefficients added to the model report.
Non-default run parameters: Several parameters have been changed from default. These include: Dflood = 15 (default 6), Qtol = 0.001 (default 0.01), Maxitr = 47 (default 11), Dfloodb = 15 (default 10), Matrix dummy coefficient = 1E-6 (default 0),	Investigate the extent to which these parameters can be relaxed to their default values. If not, then justify the non-default values used in the reporting.	DFlood set to 3m for 20yr, 6m for 100yr and 100yrCC and to 8m for 1000yr – required for model to run. Dfloodb required to remain at 15 for all runs. Model doesn't initiate without it. All other parameters set back to default.
Grid size sensitivity: Was a smaller grid cell size considered? Was a sensitivity test with a smaller grid cell size undertaken to ensure that all flow routes in the urban area are represented with 4m grid?	Confirm whether a smaller grid cell size was considered and tested. Ideally, we would ensure that all flow routes are represented by completing a sensitivity test.	Given the industrial nature of the land. 4m would be sufficient for this exercise. SEN tests will be performed on cell size for the main modelling exercise in 2022
DTM rotation: Flood plain flow predominantly NE-SW.	Consider rotated DTM and grid to better represent flow routes.	Not addressed at this stage. A full suite of SEN runs will be completed for the main modelling exercise
Building representation: "Stubby buildings" approach used with 0.3m added to all building footprints. Several building polygons do not match with full building footprint as seen on OS mapping - see figures below with purple showing 2d_zsh_building_threshold_FMT_NorthernGateway	Ensure that all buildings are represented, including their full footprint. The combination of two 2d_mat layers appears to provide acceptable coverage. However for the '2022' model we recommend fully updating the floodplain with Mastermap land use with one single mat layer. (consider this item as GREEN colouration)	Completed – buildings now represented The 2d_mat layers will be combined at the next stage of modelling. Figure 8 shows plots, not buildings; each of these plots will have future modelling for individual planning

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
_007_R.shp. It looks as if the polygons were cropped to the previous domain boundary, but have not been reinstated for a larger 2D domain.	Regarding the proposed buildings, a 2d_mat_Buildings layer has been used but only represents three buildings. Looking at Figure 8 of the report there are several more buildings. Confirm if all the other buildings as part of the design should have been included in the additional shapefile. Also just a general query from Figure 9 is that the proposed buildings appear to give significant (up to 4m) reduction in ground levels, is this correct?	permissions. Only the ones included in the model now are applicable to this application
Defences/embankments/banks: Zlines and points representing bank crests, based on surveyed cross section extremes. TGC also states that additional points were taken from the LiDAR used. It is unclear which are surveyed and which are from LiDAR. Z line read in as THICK as appropriate. In some locations, there are buildings right on the bank. It is unclear how the bank crest elevations tie in with the building polygons. More justification is required here to explain the representation of the buildings in the model.	More careful thought needs to be taken on how buildings on the banks have been represented. Currently it does not appear that the bank crest elevations used tie in with the building thresholds. This will have a significant effect on flow paths through and near to the buildings. A check of 2d Z points against 1d bank limit reveals poor match up in places. Action Amend or explain the 1d-2d bank elevation differences. These have been primarily checked through the proposed VN development site reach but may be apparent elsewhere. Risk of early or late spilling from 1d to 2d.	Completed: Survey shows where buildings are. These levels have been used in the river bank levels. Anything past Queens Road that is not on a cross-section has been taken from LiDAR (generally if it's to 3dp it's from LiDAR). These are to be separated out to a separate file to avoid confusion. While a mismatch between 1d and 2d bank levels will have no implication on model results, 1d sections were trimmed where possible to better match to the 2d bank levels. In some cases, for instance section 1.04u, the difference remains as the surveyed cross-section does not contain a wall, which is represented by surveyed levels along the right bank (and so the wall is included in the 2d rather than 1d domain)

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	E.g. IRK01_0564 right bank 31.13m in 2d, 33.76m in 1d. (it is acknowledged here that extreme events are kept in bank) IRK01_0676 right bank 30.38m in 2d, 30.765m in 1d, Q1000 max water level 30.551m. IRK_1.04u right bank 31.32m in 2d, 30.12m in 1d, Q1000 max water level 31.907m. IRK01_1188B 1d-2d match up correct in baseline with 31.59m on right bank, but in 2d proposed Z point it is 29.8m. IRK_1.07 1d-2d match up in proposed model is correct but in baseline model the 2d elevation on the right bank is 29.67m. IRK_1.10 1d-2d match up in baseline model is correct at 30.05m but in proposed model the 2d elevation on the right bank is 29.27m. IRK_1.11 the left bank 32.39m in 2d, 30.48m in 1d, Q1000 max water level 32.38m.	
Methods to estimate 2D roughness areas: Assumed to be Manning's n roughness values attributed to mapping polygons	Clarify in the reporting how roughness values have been chosen. Outstanding action for improved reporting.	Manning's n values attributed to polygons using .TMF. Will be updated in corresponding reporting. Added to reporting
Representation of different 2D roughness areas: As with 7.8, the previous model's polygons do not match the 2D domain boundary.	Use up to date mapping to create polygons for 2D roughness across all of 2D domain.	Completed – in the absence of OS MasterMap of the area upstream of Queens Road Bridge, roughness polygons

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
Up to date mapping has been used for roughness near to the Victoria North study area. Is there a reason why this wasn't extended over the entire 2D domain?	Just to confirm, is the OS Open Map use due to the lack of availability of MasterMap? If so action for Item 7.8 can be discounted.	were updated based on OS Open Map – Local, and satellite imagery upstream of Queens Road Yes. OS MasterMap will be used at the next stage - OpenMap was used here as it was considered to be proportionate to the interim 2021 work
Defence representation: According to EA AIMS database, there is an EA maintained flood risk management wall near to Vale Park Industrial Estate (asset number 78624). Unclear if this has been represented in the bank crest elevations used.	Ensure that this defence has been represented appropriately. If a flood map update is required, then an undefended model scenario should be developed.	Wall is now explicitly represented in the model, using 2d_zln and 2d_zpt features, with location and levels from received EA AIMS data
1D/2D links: FMP and TUFLOW coupled using 2d BC HX lines along the bank crests as appropriate. Some HX missing between MOST01_0653 to MOST01_0605, MOST01_5087 to MOST01_4789, left bank upstream of IRK_1.01u, and left bank from IRK_1.01cud to IRKR01_0.564. Some 2D spills only have HX line on upstream/downstream, for example IRKR01_3311 doesn't have a spill on the upstream.	Justify missing HX lines, and as far as possible, add HX lines to connect 1D and 2D domains at locations highlighted. Justify representation of 2D overtopping using HX lines.	Completed: Sections on Moston Brook removed for stability and the 1D section extended. These exist in an isolated valley section so would have no meaningful impact elsewhere on levels or extent. Sections on River Irk relate to the left bank wall of the rail bridge overpass, that would never overtop in any event, were omitted from the existing EA model and left out for this study too. IRKR01_3311 already has a spill on u/s and d/s
1D/2D channel widths: A sample of cross section widths were compared to 2D river representation widths: 1d 2d Diff IRKR01_4091 - 28.12 - 28.60 - 0.48	There are some large differences between 1D and 2D widths in the sample of sections checked. These include IRK_1.25, IRKR01_1878, IRKR01_0627, MOST01_4950 and MOST01_0645.	Completed: Amendments made to the following sections to ensure they match between 1d and 2d: IRKR02_0229E, IRKR02_0000H, IRKR02_0000I, IRKR01_3876, IRKR01_3822, IRKR01_3652, IRKR01_3520, IRKR01_2464E, IRK_1.22,

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
IRKR01_2888 - 19.16 - 20.42 - 1.26 IRKR01_2612 - 29.07 - 32.88 - 3.81 IRK_1.25 - 27.31 - 26.21 - 1.1 IRK_1.21 - 24.90 - 34.72 - 9.82 IRKR01_1878 - 10.10 - 14.78 - 4.68 IRKR01_1449 - 22.64 - 20.31 - 2.33 IRKR01_0627 - 17.13 - 08.84 - 8.29 MOST01_6250 - 15.80 - 13.80 - 2.00 MOST01_5850 - 12.26 - 10.95 - 1.31 MOST01_5300 - 09.02 - 10.16 - 1.14 MOST01_4950 - 57.20 - 08.80 - 48.4 MOST01_4500 - 12.02 - 10.48 - 1.54 MOST01_3830 - 21.45 - 22.11 - 0.66 MOST01_1400 - 39.16 - 41.65 - 2.49 MOST01_0645 - 25.00 - 11.25 - 13.75	All cross section widths need to be checked and corrected. The current version of the model is an improvement for 1d-2d widths but some issues still remain - see screenshot to the right. The tolerance for the comparison has been set at the 2d grid size so please address where discrepancies remain, especially where the difference is more significant.	IRKR01_2419, IRKR01_2360, IRK_1.21, IRKR01_2123E, IRK_1.18d1, IRK_1.18d2, IRKR01_1930A, IRKR01_1878, IRKR01_1826, IRKR01_1810B, IRK_1.14, IRK_1.13, IRK_1.13u, IRK_1.11, IRK_1.09u, IRK_1.08d, IRKR01_1293, IRK_1.07, IRKR01_1188A, IRKR01_1188B, IRK_1.06 The 1d-2d widths in the baseline and proposed works models were altered for the nodes identified in the screenshot to the right to provide a better match in channel widths
Water level lines: WLL lines used although missing at some 1D nodes, therefore coverage looks patching - see figure below.	Add WLL lines at all 1D nodes to ensure full coverage. There appear to be a number of cross sections not included in the 1d_x1d_nodes layer e.g. IRKR01_0027, IRKR01_0030I, IRKR01_0030H, IRKR01_0627A, IRKR01_0685E, IRKR01_0685D, IRK01_1188A, IRK01_1778A, IRKR01_2204A, IRKR01_2529A, IRKR01_2603E, IRKR01_2770A, MOST02_0000H, MOST02_0000 (confluence with the Irk).	Completed – added throughout After discussion with Nick (07/02/2022) updates were made to the water level lines in the baseline and proposed models to "fill in" the channel in 2d results. Missing nodes also added.

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	Action: please include or explain absence.	
1D Comments and warnings: zzd checked for Q1000 event. The following warnings and errors: W2054 - urban extent not recommended to exceed 0.5. this is related to hydrology and will likely change with a hydrology update. W2302 - Time to peak is not an integer multiple of the data interval. this is related to hydrology and will likely change with a hydrology update. W2532 - model start time is not t=0. Why is the start time not t=0? W2044 - different values for Manning's n encountered within one panel add panel markers at locations highlighted. W2238 - panel at offset has very small width. Review cross sections highlighted. W2229 - value of trash screen height is set to 0, areas will be calculated using piezometric head. This warning can be ignored.	Review warnings and make updates as appropriate. W2010 - poor interpolation W2044 - mannings +/- 20% W2238 - panel at offset has small width. (This appears to be at locations where the section is small due to a wall bordering the channel). W2229 - trash screen height set to 0 W2262 - backflow encountered at culvert outlet. (This is evident at most of the culvert units undernath Victoria station, where the influence of the Irwell boundary causes negative flow early in the simulation). W2204 - Bridge downstream of IRK_1.04bu is surcharged. (Orifice flow is enabled here). W2058 - convergence issues. These warnings are not judged to be significant enough to impact results, but please include a section in the main report detailing the issues.	Modelling/hydrology updated so original warnings not relevant. Updated model checked and warnings addressed where possible. Added to the reporting - after model has been run with updates

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
W2204 - bridge downstream of XX is surcharged. Afflux calculation may be inaccurate. Review this location. W2205 - extrapolating base curves, base coefficient may not be reliable. Review this warning. W2058 - model convergence criteria were not met for one or more timesteps during the run. Review model stability. W2019 - water level rose beyond the max level of the section data. 1D domain connected to 2D, therefore this warning can be ignored.		
1D convergence: Some non-convergence related to culverts surcharging. See Q1000 bitmap below.	1D stability could be better in terms of convergence. Investigate how much improvements can be made. Include a section in reporting describing model stability and any measures undertaken to reduce instability. There are oscillations in Q1000 flow and stage that begin around the vicinity of IRK_1.17 and continue quite markedly through the upstream reach of the proposed VN development site, with peak flow oscillating in the order of 0.5-1m. Given the proximity to development and the uncertainty this brings around peak flow, the stability needs to be improved or at least demonstrated to not have an impact on results. It is our view that some of the peak stage results in Table 1 of the report may be too	Increase of boundary viscosity factor to 3 in the 1000yr event. Testing around the use of roughness patches carried out to attempt to slow cyclical flow patterns seen in the 1000yr events. Oscillations in flow and stage in the 1000yr event are due to circulation of flow in the floodplain (screenshot to the right shows oscillations in the baseline event).

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	high given oscillating peak stage spikes and are therefore unreliable.	
1D/2D instability: Some visible instability in long section water level animation near to IRK_1.13u and MOST01_0605J.	Look at stability measures near to areas highlighted. Include a section in reporting describing model stability and any measures undertaken to reduce instability. Dvol appears to be more unstable compared to previous submission, see screenshot to the right. Please improve the oscillating nature of the signature. Can you please expand on the review response? dVol signature for several events still appears jumpy and discussion has not been provided in the reporting.	Increase of boundary viscosity factor to 3 in the 1000yr event. Testing around the use of roughness patches carried out to attempt to slow cyclical flow patterns seen in the 1000yr events. Initial conditions have been redefined to reduce the cases of poor model convergence at the start of the model run which were associated with the culvert at the downstream extent of the model. Orifice transitions have been added at IRK_1.04bu and IRKR01_2770D to remove instances of poor model convergence associated with rising and falling water levels reaching the soffit of the structures. Embankment markers have been added/adjusted at structures IRKR01_2770D, IRKR01_2603D and MOST01_5892D to improve model stability. Boundary Viscosity Factor == 3 command has been activated for all modelled events. Previously this was only set for the Q1000 event.. Improvements to the dVol curves for the baseline and proposed scenario during the 100 year 2080 event are shown in XLS file.

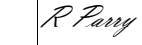
EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
2D Comments and warnings: Warning's from Q1000 tlf. W0305 - Projection of .shp file is different to that specified by the SHP Projection == command. Minor, ideally projections should match for all model files. Warning 2218 - Manning's n value of 1 for Material 2 is unusually low or high. Represented buildings, accepted although ideally would be ~0.3. Warning 2236 - XF file is an old version or wrong format. XF file not read. Warning 2235 - Unknown error reading XF file [Loc C]. XF file not read. Investigate these warnings. Warning1317 - WLL does not cross (2 point WLL only) or snap to 1D channel See comment 12.4.	Review warnings and make updates as appropriate.	Model and hydrology updates changed warnings slightly Water level lines causing Warning 1317 were edited/removed where necessary Building representation using Manning's n value of 1 retained
Calibration: Calibration runs have not been completed. It is unclear whether any previous historic flood event data is available.	Investigate any previous flooding and data there may be available. Clearly state whether calibration or verification was possible in the reporting. Confirm whether any updates have been made to reduce uncertainty in the modelled outputs.	To be investigated for the full modelling exercise in 2022. Flows scaled to gauge records at Collyhurst Weir Updates were made to the schematisation of Collyhurst Weir to produce a better calibration

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
It is unclear if any changes have been made to the model in response to validation or verification of outputs.		
Comparison of hydrograph peaks: There is a gauge in the modelled study reach. No comparison between modelled and recorded peaks has been included.	Compare modelled and gauged data to increase confidence in modelled results.	Flows scaled to match gauge records at Collyhurst Weir
Sensitivity testing: Some sensitivity test model files and outputs have been provided, although it is unclear which tests have been undertaken. The report mentions a downstream boundary sensitivity test, however, the results are not presented in detail. In the absence of any previous flood event information, sensitivity test are more important to understand uncertainty of modelled outputs.	Add a sensitivity test section to the reporting and describe and present the outputs from the sensitivity tests undertaken.	A full suite of model sensitivity tests will be completed for the next stage of modelling, in 2022
Confidence limits: Not provided	Comment on model uncertainty limits in the reporting. Please ensure this is undertaken at any modelling stage.	Confidence limits will be calculated for the next stage of modelling in 2022. Initial findings from sensitivity tests on roughness, downstream boundaries and inflows are shown in the full model comments and review log.

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
Audit trail comments: Not obvious what sensitivity tests were undertaken. Majority of comments in the 1D dat file are out of date (from the previous model). Model history was not detailed in the model log. Report quality is ok, focusses a lot on the outputs, but little detail on model decisions and justification, calibration/verification/sensitivity testing, or model stability.	Update comments. Add model history to log. Add detail on model performance to the reporting. Comment on accuracy of model and its ability to represent reality. Add detail in response to issues raised in this review. Several issues in the review could have been resolved with better reporting. The technical note received was very useful for the specific discussion of application stage 2 proposals but was still limited in the wider modelling detail.	Updates will be made to corresponding reporting Reporting was updated based on the changes made in response to this review

Table 7 - Hydraulic modelling review commentary. Updated to include EA comments received in January and March 22, and the Arup responses in February and Mar 22.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Louise O'Regan / Emma Cecil / Rob Parry	Rob Parry / Tom Saville	Mike Wilton
Signature			

Appendix B – Extracted figures from flood model

13/04/2022 10:56:58

Legend

Proposed vs Existing - Impact (m) 100yr with Bund

- < -0.1m
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- > 0.1
- Reduced Flood Extent
- Increased Flood Extent
- Proposed Flood Bund
- Red Line Boundary

Notes:
1. Flood extents are based on Existing Condition 2021 Interim Hydraulic Modelling using Precautionary Approach Hydrology.
2. To be read in conjunction with Technical Note VNIF-ARP-ZZ-RIV-RP-DF-0002

ARUP

6th Floor, 3 Piccadilly Place,
Manchester M1 3BN
Tel +44 (0) 161 228 2331
www.arup.com

Victoria North River and Flood Alleviation Works

0 100 200 300 400 500

Metres

Proposed vs Existing - Impact (m) 100yr with Bund

Drawing Number

Scale at A3
1:18,000

Arup Job No	Drawing Status
281943-02	**DRAFT**

Rev	Author	Check	Approve
001	**RP**	**TS**	**TS**

Contains Ordnance Survey data © Crown copyright and database right [year]. © Crown copyright and database rights [year of supply] Ordnance Survey [licence number]. You are permitted to use this data solely to enable you to respond to, or interact with, the organisation that provided you with the data. You are not permitted to copy, sub-licence, distribute or sell any of this data to third parties in any form.
Contains Environment Agency information © Environment Agency and/or database right.
© OpenStreetMap contributors

© Arup

13/04/2022 10:55:24

Legend

Proposed vs Existing - Impact (m) 100yr+CC (2080) with Bund

- < -0.1m
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- > 0.1
- Reduced Flood Extent
- Increased Flood Extent
- Proposed Flood Bund
- Red Line Boundary

Notes:
1. Flood extents are based on Existing Condition 2021 Interim Hydraulic Modelling using Precautionary Approach Hydrology.
2. To be read in conjunction with Technical Note VNIF-ARP-ZZ-RIV-RP-DF-0002

ARUP

6th Floor, 3 Piccadilly Place,
Manchester M1 3BN
Tel +44 (0) 161 228 2331
www.arup.com

Victoria North River and Flood Alleviation Works

0 100 200 300 400 500

Metres

Proposed vs Existing - Impact (m) 100yr+CC (2080) with Bund

Drawing Number

Scale at A3
1:18,000

Arup Job No	Drawing Status
281943-02	**DRAFT**

Rev	Author	Check	Approve
001	**RP**	**TS**	**TS**

Contains Ordnance Survey data © Crown copyright and database right [year]. © Crown copyright and database rights [year of supply] Ordnance Survey [licence number]. You are permitted to use this data solely to enable you to respond to, or interact with, the organisation that provided you with the data. You are not permitted to copy, sub-licence, distribute or sell any of this data to third parties in any form.
Contains Environment Agency information © Environment Agency and/or database right.
© OpenStreetMap contributors

© Arup

13/04/2022 16:33:21

Legend

Proposed vs Existing - Impact (m) 100yr+CC (2080)

- < -0.1m
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- > 0.1
- Reduced Flood Extent
- Increased Flood Extent
- Red Line Boundary

Notes:
1. Flood extents are based on Existing Condition 2021 Interim Hydraulic Modelling using Precautionary Approach Hydrology.
2. To be read in conjunction with Technical Note VNIF-ARP-ZZ-RIV-RP-DF-0002

ARUP

6th Floor, 3 Piccadilly Place,
Manchester M1 3BN
Tel +44 (0) 161 228 2331
www.arup.com

Victoria North River and Flood Alleviation Works

0 100 200 300 400 500

Metres

Proposed vs Existing - Impact (m) 100yr+CC (2080)

Drawing Number

Scale at A3
1:18,000

Arup Job No	Drawing Status
281943-02	**DRAFT**

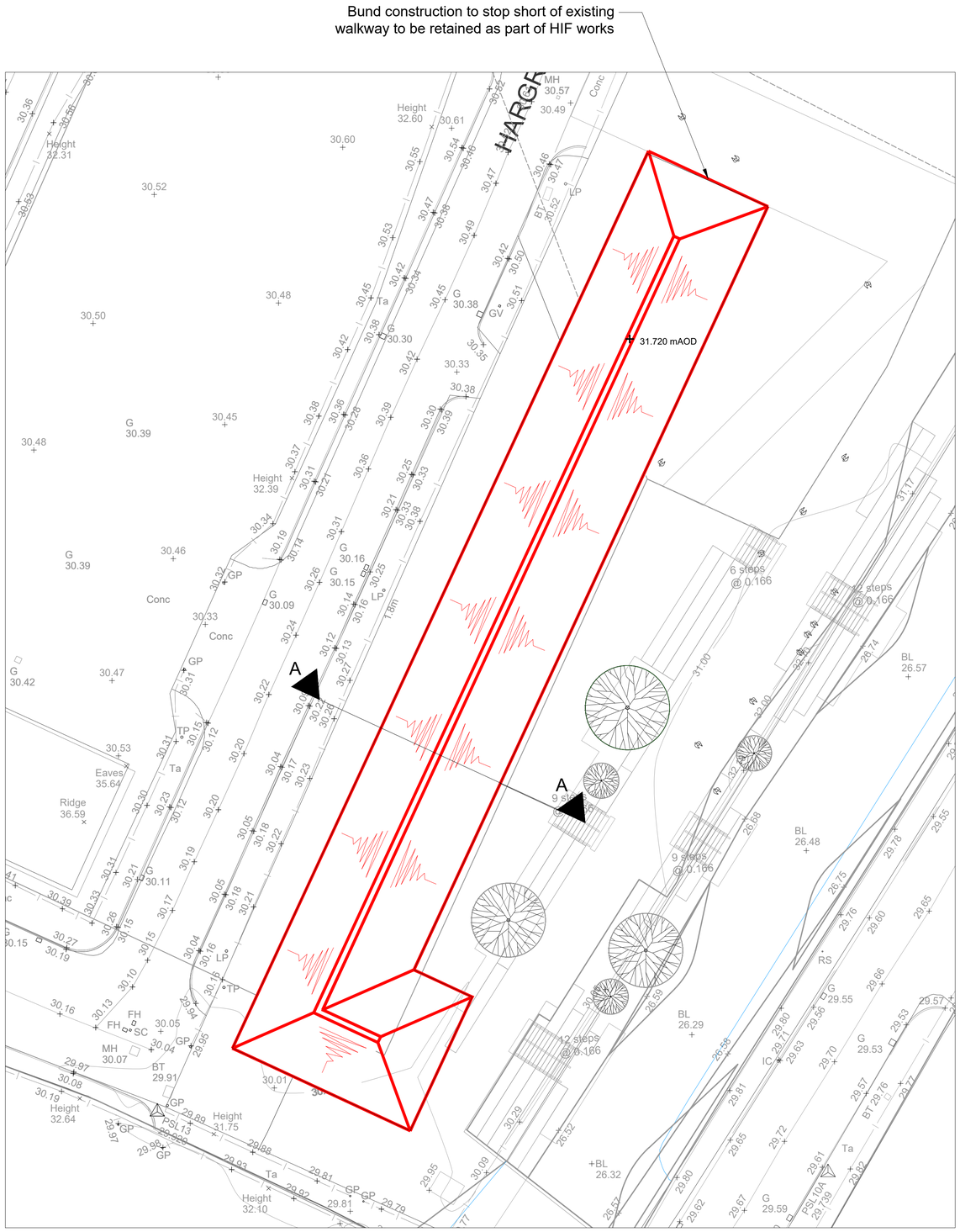
Rev	Author	Check	Approve
001	**RP**	**TS**	**TS**

Contains Ordnance Survey data © Crown copyright and database right [year]. © Crown copyright and database rights [year of supply] Ordnance Survey [licence number]. You are permitted to use this data solely to enable you to respond to, or interact with, the organisation that provided you with the data. You are not permitted to copy, sub-licence, distribute or sell any of this data to third parties in any form.
Contains Environment Agency information © Environment Agency and/or database right.
© OpenStreetMap contributors

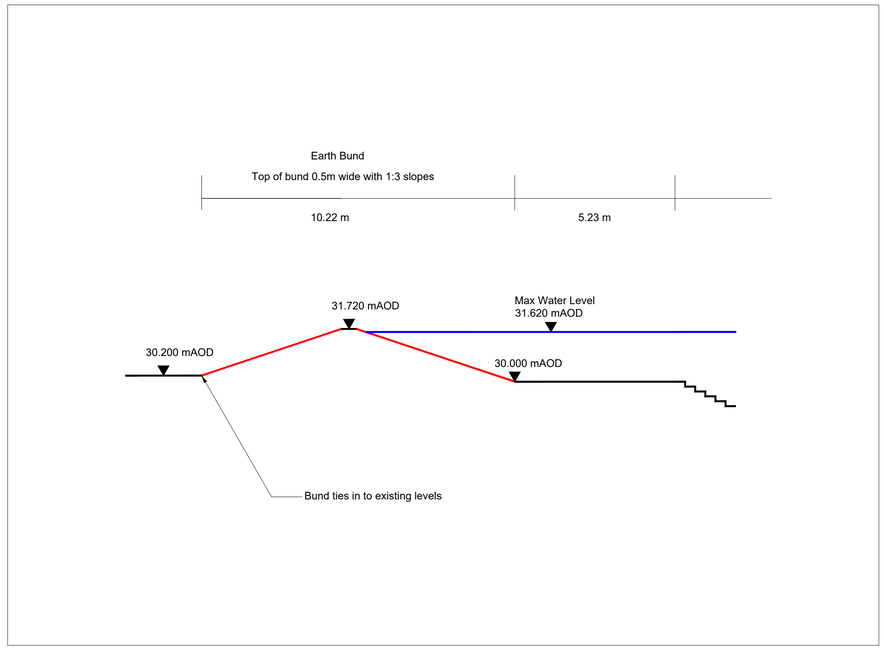
© Arup

Appendix C – Proposed mitigation bund drawing

A1



Bund Plan View
1:200



Section A-A
1:100

Notes

1. To be read in conjunction with all relevant project drawings and specifications.
2. Do not scale from this drawing or the digital data. Only figured dimensions are to be used.
3. All dimensions are in millimetres (mm), unless noted otherwise. All elevations are in metres above ordnance datum (mAOD), unless noted otherwise.
4. Bund to be constructed from site won material and to remain in position until river works have been fully undertaken.
5. This drawing has been issued for informative purposes within the Flood Risk Assessment document only. This drawing shall not be used for any other purposes.

Key

Proposed Bund

N

0 1000 2000 3000 4000 5000 mm
SCALE 1:100

0 2 4 6 8 10 m
SCALE 1:200

Rev	Date	By	Chkd	Appd
P02	10/03/22	ES	DH	RG
Updated to reflect hydraulic modelling				
P01	10/02/22	AM	DH	RG
Issued for Information				

ARUP

9th Floor, 3 St Paul's Place,
Norfolk Street, Sheffield S1 2JE
Tel +44 (0)114 2728247 Fax +44 (0)114 2759553
www.arup.com

Client
Manchester City Council
BAM

Project Title
Victoria North HIF Infrastructure and Enabling Works

Drawing Title
Bund Location and Details

Scale at A1: As shown
Role: Civils
Suitability: - S2- For Information
Arup Job No: 282022
Rev: P02
Name: VNIF-ARP-00-YYY-SK-CE-0001

Do not scale

© Arup

Appendix D – HIF Infrastructure Drainage Strategy

Manchester City Council

Victoria North HIF

Drainage Strategy

VNIF-ARP-ZZ-YYY-RP-CD-0003

P03 | 18 February 2022

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 282022

Ove Arup & Partners Ltd
13 Fitzroy Street
London W1T 4BQ
United Kingdom
www.arup.com

ARUP

Document verification

ARUP

Job title		Victoria North HIF			**Job number** 282022
Document title		Drainage Strategy			**File reference**
Document ref		VNIF-ARP-ZZ-YYY-RP-CD-0003			
Revision	**Date**	**Filename**	VNIF-ARP-ZZ-YYY-RP-CD-0003 - Drainage Strategy.docx		
P01	17 Dec 2021	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Drew Hunter/Emily Stoddart	Ryan Griffiths	Michael Wilton
		Signature			
P02	28 Jan 2022	Filename	VNIF-ARP-ZZ-YYY-RP-CD-0003 - Drainage Strategy.docx		
		Description	Issued for Planning		
			Prepared by	Checked by	Approved by
		Name	Emily Stoddart/Drew Hunter	Ryan Griffiths	Michael Wilton
		Signature			
P03	18 Feb 2022	Filename	VNIF-ARP-ZZ-YYY-RP-CD-0003 - Drainage Strategy.docx		
		Description	Updated for Planning		
			Prepared by	Checked by	Approved by
		Name	Emily Stoddart/Drew Hunter	Ryan Griffiths	Michael Wilton
		Signature			
P04	27/04/22	Filename	VNIF-ARP-ZZ-YYY-RP-CD-0003 - Drainage Strategy.docx		
		Description	Updated for Planning		
			Prepared by	Checked by	Approved by
		Name	Drew Hunter	Ryan Griffiths	Michael Wilton
		Signature			
			Issue Document verification with document		✓

Contents

		Page
1	**Introduction**	**1**
2	**Site overview**	**1**
2.1	Site description	1
2.2	Scope of works	3
3	**Existing Drainage**	**4**
3.1	Combined sewer network	4
3.2	Surface water drainage regime	7
4	**Geotechnics and Geo-Environmental**	**8**
5	**Surface water hierarchy**	**10**
6	**Flood Risk Assessment**	**11**
7	**Proposed drainage strategy**	**11**
7.1	Discharge restrictions	11
7.2	Climate change	11
7.3	Surface water strategy	12
7.4	Foul water strategy	15
8	**Sustainable drainage systems (SuDS)**	**17**
8.1	Plateau Road and Red Bank Square	17
8.2	Dantzic Street Swales	17
8.3	Detention basin	18
8.4	Water treatment capabilities and the Simple Index Approach	18
9	**Phased development and maintenance**	**19**
9.1	Interim construction phase maintenance regime	20
9.2	Post site completion maintenance regime	20
10	**Conclusions**	**22**

1 Introduction

Arup have been commissioned by BAM on behalf of Manchester City Council (MCC) to provide design services for the 'Design and Build' Infrastructure Works for the Victoria North HIF[1] masterplan (see Figure 1). This is funded under Homes England for the development of a 14.3ha site within the Lower Irk Valley in Manchester. Infrastructure works are being carried out to support a subsequent residential led development being planned for Victoria North by a Joint Venture between MCC and FEC. This development is part of a wider Victoria North masterplan redevelopment to the North of Manchester centre. This report provides an overview to the Drainage Strategy to be inputted into the Environmental Impact Assessment, the Planning Application and the Stage 3 report.



Figure 1 Proposed Victoria North Masterplan

2 Site overview

2.1 Site description

The Site comprises an area of circa 14.3 hectares within the Lower Irk Valley, predominately within the Red Bank and New Town neighbourhoods, which form

[1] Housing Infrastructure Funding

part of the extended Manchester City Centre. The Site location and proposed redline boundary is provided in Figure 2.

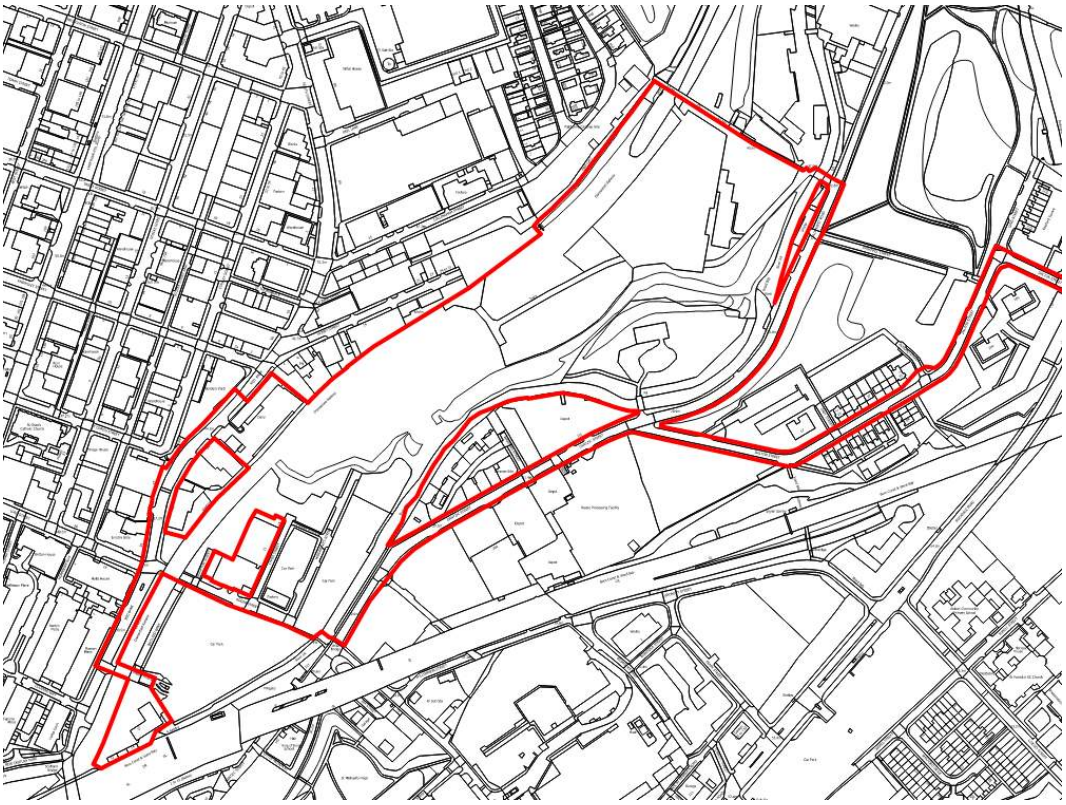


Figure 2 Victoria North site location and boundary

The site comprises features that represent more than 150 years of industrial history and infrastructure. Features include; modified waterways, significant operational and redundant rail infrastructure, utilities infrastructure and contaminated sites associated with textile manufacturing and other heavy industries. These features may present constraints and influence future development proposals.

2.1.1 Historic development of the Victoria North masterplan area

Development of the site is shown on the earliest available Ordnance Survey maps (c. 1850)[2]. At that time, areas to the south of the River Irk had been developed for housing, with several larger industrial premises shown. The railway viaduct outside of the site boundary to the south (that remains active today) is shown on this earliest map. North of the river, the eastern half of the site was largely undeveloped in 1850, however, the western half of the site contained both residential and industrial properties. A mill race is identified to the north of the river, serving several mills.

Industrial development continued across the site throughout the second half of the 1800s, often displacing areas of housing. Most notably this development involved

[2] Groundsure (2017) Northern Gateway EnviroInsight Report.

the construction of extensive railway sidings and rail infrastructure across previously undeveloped areas of the site north of the river (in the NW area of the site). These were connected to Victoria Station by a railway viaduct (Red Bank) along the southern part of the western site boundary. The need for level ground for this rail infrastructure led to extensive cut and fill operations across the area north of the River Irk, with the infilling of a former meander bend on the river and the eastern section of the mill race.

The various maps and aerial photographs that are available show that industrial activity has continued to the present. Rail infrastructure at the site continued to expand until the 1940s.

2.2 Scope of works

2.2.1 Victoria North HIF infrastructure works

The masterplan for the Victoria North Works RIBA Stage 3 review is presented in Figure 1. The Infrastructure works comprise preparation of the existing landscape for the development of new plots, to be accessed by new and existing highways. Existing access points will be maintained across the River Irk, one additional bridge is also proposed. The works also include development of a central park area.

The proposed drainage strategy for the Infrastructure Works will take account of connections and diversions of existing drainage infrastructure required for the future development of the plots within the site.

The joint venture (MCC/FEC) have stated an aspiration for a net zero carbon development for the Victoria North masterplan in line with MCC strategy on sustainable development and carbon management. It should be noted that the HIF Victoria North Infrastructure Works delivery is aiming to be carbon positive due to the nature of the work and will only be 'part' of the wider environmental strategy of the Victoria North Masterplan (an overall net zero carbon target).

2.2.2 River works

As part of the HIF scheme, there is a separate commission which includes works to the River Irk with the aim of reducing flood risk and increasing the water quality of the river. These works are being delivered under a separate project and are not covered in this report. However, there are multiple interfaces between this project and the infrastructure scheme, as all surface water is proposed to drain directly to the River Irk. Coordination with the river works team is ongoing to ensure that an integrated drainage strategy is achieved between both work packages. The extent of the river works scheme is shown in Figure 3.

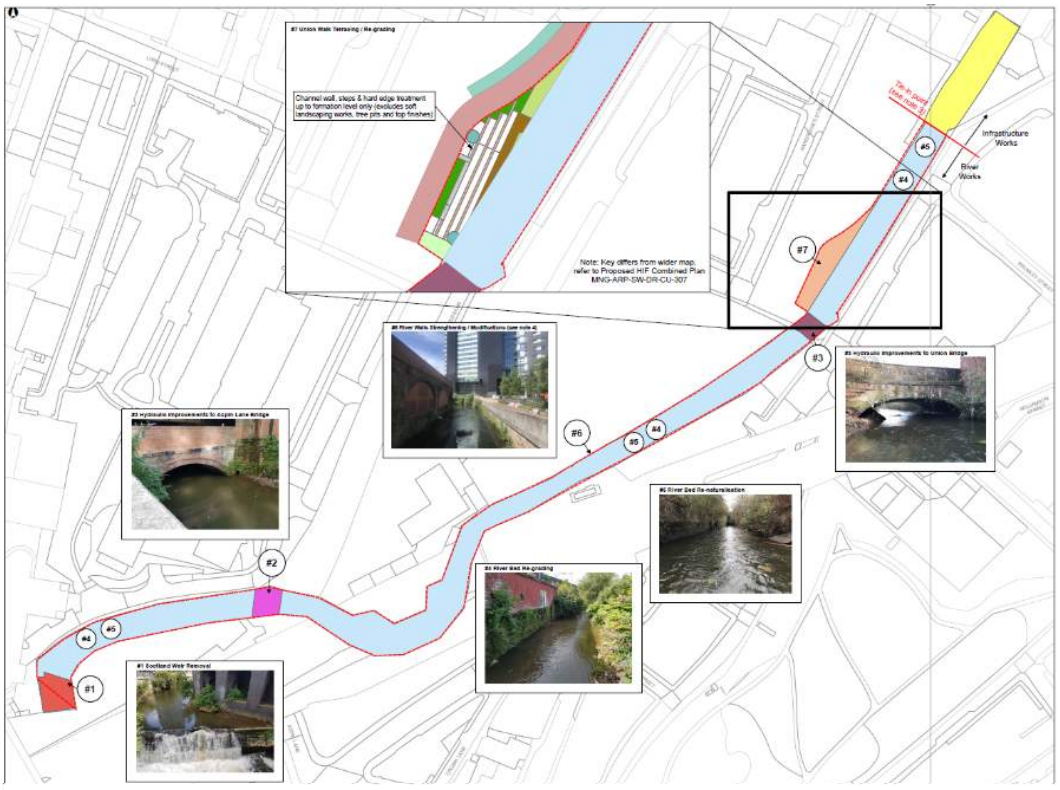


Figure 3 River Works scope as defined by the HIF river works package

3 Existing Drainage

3.1 Combined sewer network

The existing network within the HIF Red Bank and New Town areas consists of combined sewers with overflows into the River Irk. The site sits within multiple existing drainage catchments as identified in the site wide drainage strategy (MNG-ARP-SW-FN-GX-0008). Drawing VNIF-ARP-ZZ-YYY-DR-CD-0001 in Appendix A shows the existing catchments.

The existing drainage network on site consists of combined public sewers, owned by United Utilities who are the statutory undertaker. The features of the existing network have been identified from statutory records provided by United Utilities, these are summarised below and shown on Figure 4:

- 380x480mm box culvert, circa 5m deep and flowing South beneath Red Bank at the North of site
- 1500mm diameter sewer pipe, circa 5m deep and flowing South beneath Dantzic street at the South of site
- 550mmx640mm box culvert, circa 5m deep, flowing South running through the centre of the site, with an overflow into, and passage under the River Irk. There is a storage tank at the head of this culvert
- A small network of sub-carriageway box culverts between Brighton street and Hargreaves street, circa 3m deep, ranging from 375mmx500mm to 550mmx750mm in cross section

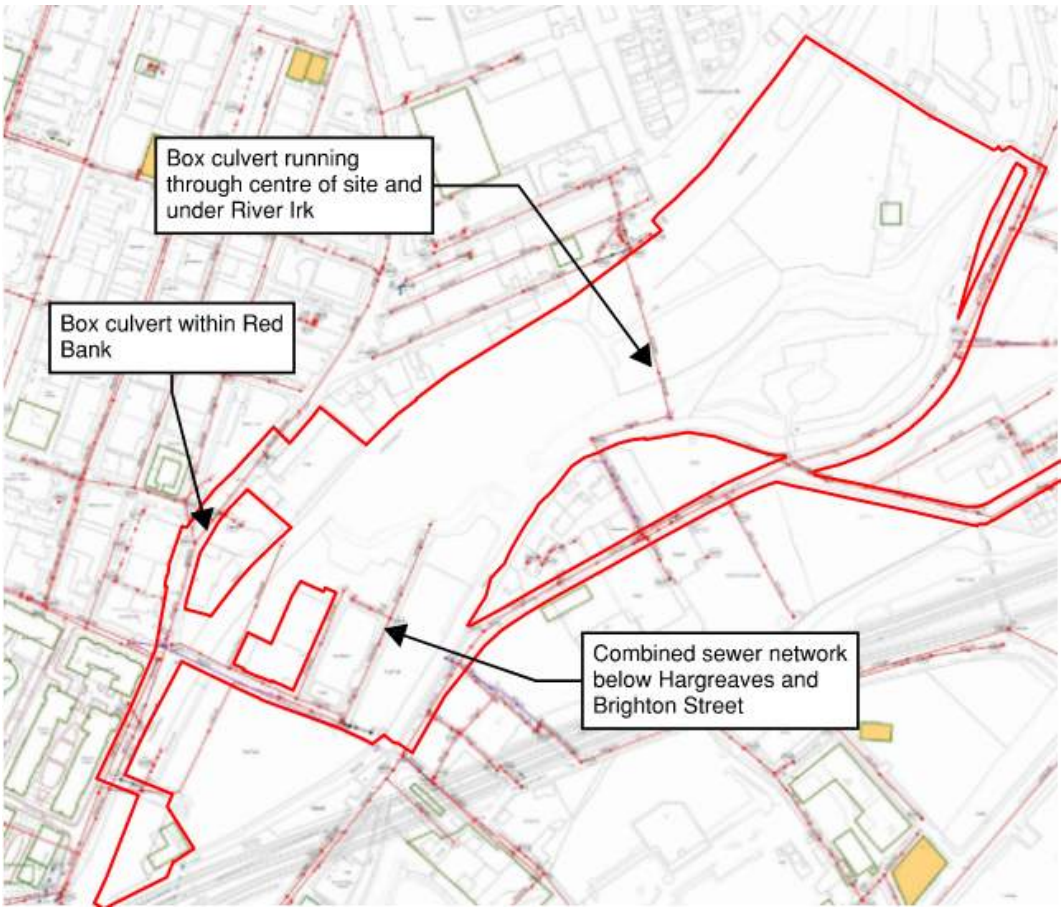


Figure 4 Existing sewer networks

There are several Combined Sewer Overflows (CSOs) to the river within the site boundary, these act as strategic contingency overflows when the capacity of the connected sewer is surcharged in periods of extreme precipitation or due to back-up from blockages. These prevent flooding from sewers in populated areas and can prevent damage to the sewer network and allow efficient design of sewers. The CSOs on the Victoria North site outfall into the River Irk. The details of the CSOs are as follows:

- 2 overflows which outfall on opposite riverbanks, North of Warford Street;
- an overflow from Roger Street, which outfalls on the North bank of the River Irk;
- an overflow perpendicular to Dantzic Street, from underneath the proposed NT01 plot, which outfalls from the South bank of the River Irk;
- an overflow on the South bank of the river South of Collyhurst Weir, underneath Dantzic Street.

In 2020 the CSOs within the site boundary spilled a total of 108 times for a total of 660 hours[3], with the most spills occurring at the Dantzic Street/Warford Street CSO. This indicates that there may be reduced capacity in the combined sewers, potentially as a result of blockages.

Passing through the centre of site is an existing watercourse, the River Irk. Historic records indicate that historically a mill race ran from the River Irk to the north east of site and reconnected to the River Irk towards the south west of the site. Records suggest that this channel was infilled following the creation of the rail sidings within the site. This can be seen in Figure 5.

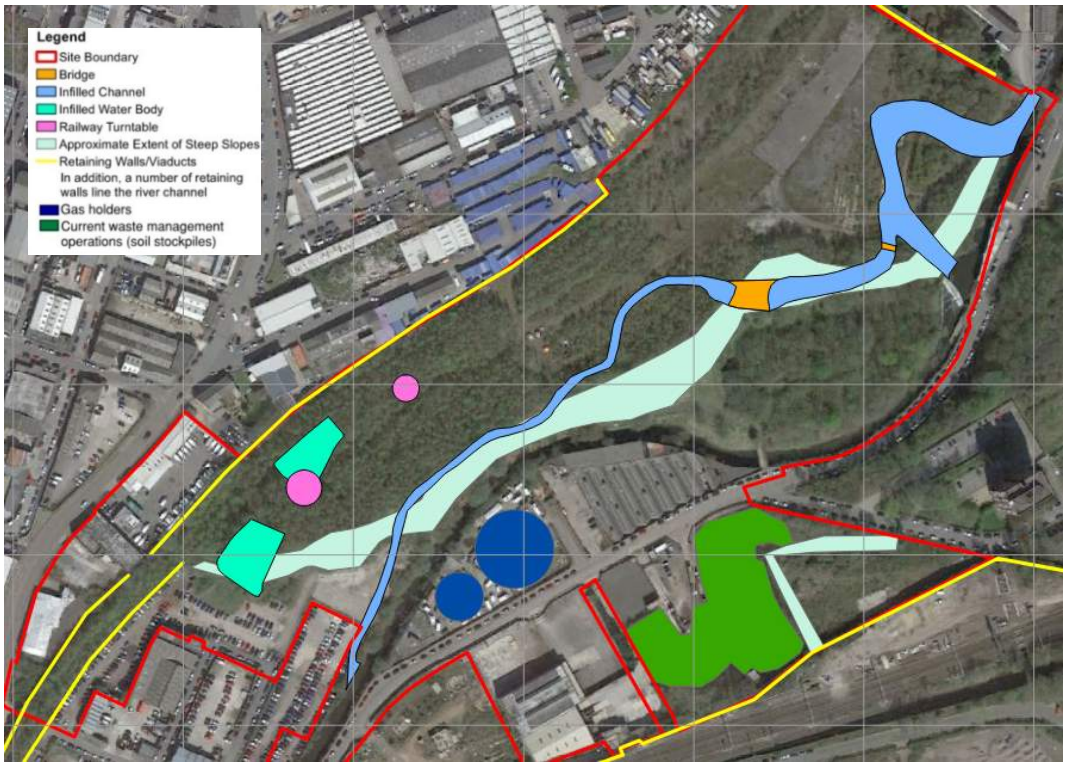


Figure 5 Historic site profile (note: plan shows outdated site boundary)

[3] The Rivers Trust: https://www.theriverstrust.org/key-issues/sewage-in-rivers

3.2 Surface water drainage regime

There are no known existing surface water drains in or around the site. All surface water is assumed to either infiltrate, drain to the River Irk or to the combined sewer network. There are three surface water catchments within the site boundary, these are indicated on Drawing VNIF-ARP-ZZ-YYY-DR-CD-0001 in Appendix A, note that greenfield extents shown relate to areas which are not actively drained, rather than previously undeveloped land.

Based on the site topography and location of existing sewers, it is likely that catchment 4 (Plateau East and St Catherine's Wood) does not drain to the combined sewer and instead is drained through infiltration or directly to the river. Catchment 1 (Plateau West down to Satnam) is likely to be at least partially drained by the combined sewers in Roger Street and Red Bank, infiltration is also likely in some areas of catchment 1.

3.3 Cheetham Hill Culvert

Based on a historic 1984 map provided and annotated on by MCC LLFA, Figure 6, the Cheetham Hill Culvert is assumed to pass through site. As part of the works being undertaken prior to the Enabling Works, the exact location of the ordinary watercourse will be identified and also the requirement for a diversion will be assessed. If a diversion is required, this will be discussed and agreed with the LLFA.

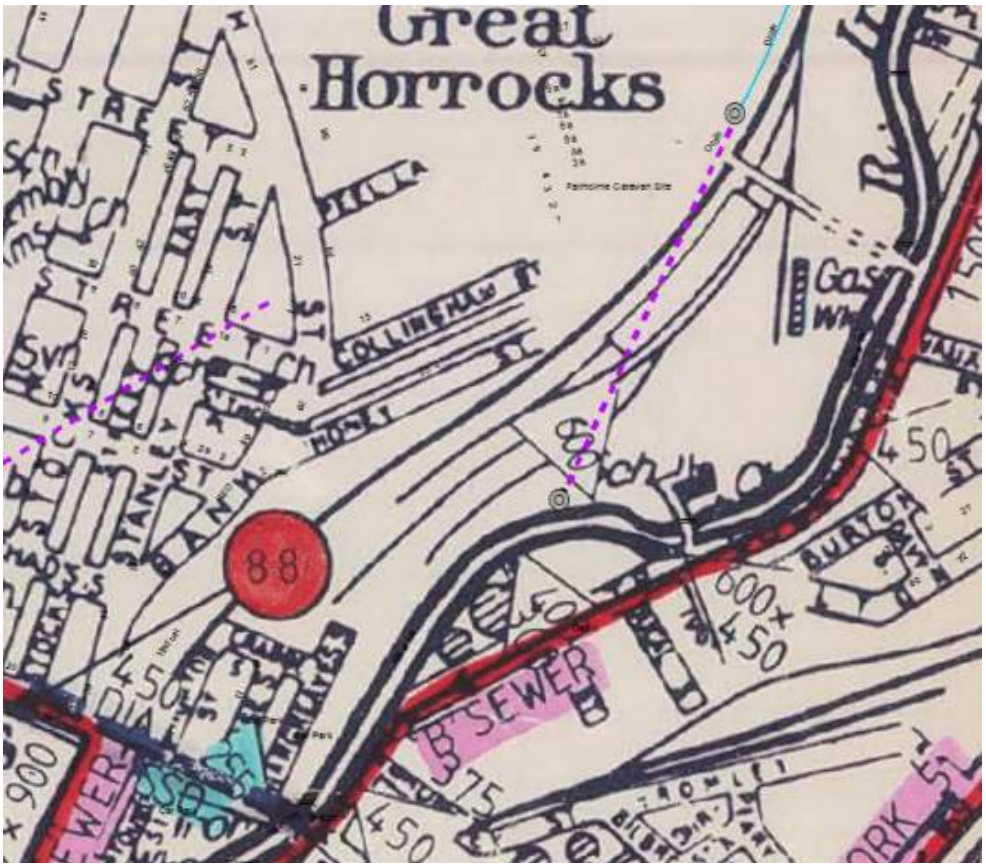


Figure 6 - Historic 1984 Map with Culvert Annotated

4 Geotechnics and Geo-Environmental

This section presents a high-level review of the key geotechnical and geo-environmental considerations relating to the Victoria North Infrastructure Works site.

Further Ground Investigations (GI) have been undertaken and are in the process of being analysed and the results being consolidated and put into the Stage 3 Geotechnical report. The findings will be found in report – VNIF-ARP-00-YY-RP-CG-0001.

4.1.1 Overview of site topography

The site occupies the north-east/south-west orientated valley of the River Irk. Areas of the site are characterised by steep slopes. North of the river, ground levels fall from approximately 50m AOD in the north to approximately 30m AOD along the river channel. South of the river, ground levels rise from river level to approximately 40m AOD at the southern site boundary. Levels are based off a Topographical Survey received 29-09-21.

4.1.2 Overview of ground conditions

Existing GI data suggests that made ground (associated with historic development) covers most of the site. North of the river, made ground varies in thickness, locally being in excess of 10m thick and is generally associated with filling undertaken in the late 1800s to enable the development of railway sidings. South of the river, the thickest made ground deposits are likely to be in plots NT03 and NT04.

Existing GI data suggests that glacial till deposits are present underlying made ground in areas north of the river. Close to the river in areas to the south of the river channel, glacial till appears to be generally absent. Limited alluvial deposits have been identified associated with the River Irk. According to published geological maps, bedrock underlying most of the site consists of sandstones of the Chester Pebble Beds Formation, with coal measures strata (Manchester Marl and Collyhurst Sandstone Formations) sub-cropping below superficial deposits in the north eastern area of the site. Published geological maps indicate that two north west to south east oriented faults are present within or close to the site.

4.1.3 Overview of Groundwater conditions

The main aquifers beneath the site are the Chester Pebble Beds and Collyhurst formations (Principal Aquifers) with the Manchester Marl a Secondary B Aquifer. Available GI data suggests groundwater is present at between 40m AOD in the north east and 28m AOD in the south west of the site and appears to be associated with both made ground and Glacial Till, though groundwater is also likely to be encountered in alluvial deposits. The principal groundwater level is anticipated as

being below most proposed structures and excavations (except for piled foundations). However, localised perched groundwater is anticipated within the made ground (along with the relatively high water table to the north east of site) and this may limit the potential for infiltration to be used in certain areas within site.

4.1.4 Potential for contamination

Key historical features shown on Figure 5 may represent geo-environmental constraints to future development. For example:

- Gas works and gas holders are associated with a range of contaminants that are likely to present risks to human health and/or controlled waters;
- Existing buildings and the remains of buildings that have been demolished may contain asbestos;
  Stockpiled soils associated with licensed recovery operations (plots NT03 and NT04) may contain potentially hazardous materials and/or elevated concentrations of contaminants that may present risks to human health and/or controlled waters.

All the above are likely sources of contamination. Contaminated soils provide a high risk to the groundwater. Infiltration can only be utilised where the risk of transferring contamination to water bodies is mitigated by an adequate depth of soil between the SuDS and the groundwater.

Areas of potential contamination have been previously assessed in 2017 through soil and water sampling and analysis, the outcome of this assessment is shown in Figure 7. Both Plateau East and Plateau West are considered at least moderately contaminated. With the high risk of contamination on Plateau East it is unlikely that infiltration will be possible. Moderate risk is indicated on Plateau West, further investigation is required to confirm the infiltration potential and depth to groundwater to inform the type of SuDS which can be used. In addition, several historic landfill sites have been identified, adjacent to the northern site boundaries.

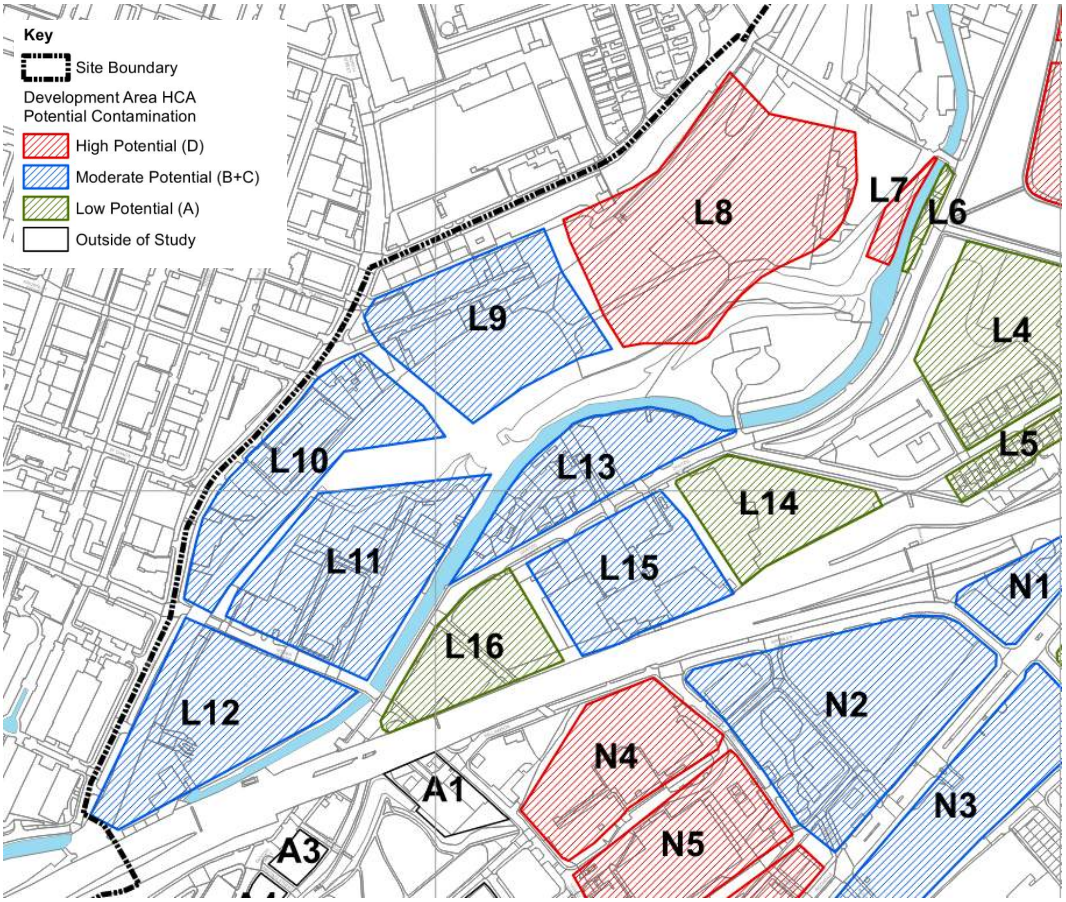


Figure 7 Extract from NGA-ARP-SW-DR-CG-100 showing current understanding of contamination levels within Victoria North site

5 Surface water hierarchy

The surface water hierarchy is summarised below, discharge mechanisms should be prioritised with 1 being most favourable to 4 being least favourable.

(1) Infiltration > (2) Discharge to surface water body > (3) Discharge to surface water sewer > (4) Discharge to combined sewer

Following the discharge hierarchy, infiltration will be utilised where possible. Due to the contamination status of the site as summarised in section 4.1.4, infiltration is not feasible across the whole site.

Areas where infiltration is possible will be explored during the next stage of design. Where land is currently parkland and will remain as parkland, infiltration will remain the drainage mechanism and it is not proposed that these areas are actively drained.

All surface water will be discharged to the River Irk which passes through the site. A discharge restriction rate has been agreed with the LLFA (MCC) and the EA. This strategy will prevent the new outfalls to the River Irk from worsening fluvial flood risk.

Due to the types of contamination present on the site, relatively high water table in areas, and close proximity steep slopes – where it is later identified infiltration is a possible discharge mechanism the rate will be controlled such that it mimics the existing greenfield conditions.

6 Flood Risk Assessment

Arup have produced a Site Specific Flood Risk Assessment (SSFRA) – VNIF-ARP-ZZ-YYY-RP-CD-0002. The SSFRA shall be referred to in full for information.

7 Proposed drainage strategy

7.1 Discharge restrictions

All surface water runoff will discharge directly to the River Irk. All connections to the river will be new connections, therefore greenfield discharge rate restrictions have been specified by the LLFA in line with ambitions set out in the Manchester, Salford and Trafford SFRA. The discharge rate for the site has been agreed with the LLFA and is summarised later in the section.

Restrictions have been calculated based on the catchments shown by the drawing in Appendix A. Catchments 3 and 4 are included in the sitewide discharge calculations as the outfalls from these catchments will be progressed in future planning applications for the site. The restricted discharge rates are calculated as a wholly greenfield rate with an urbanisation factor of 0.75 applied to account for the existing urban nature of the site. The resulting restrictions will reduce discharge from the site by between 73% and 85% compared to existing. This excludes the park area which will continue to drain through infiltration as it does currently. Further reductions in discharge rates may be achievable if further investigation shows that infiltration is feasible, this will be confirmed at the next design stage.

The calculation of runoff rates is shown in Appendix C and summarised below:

- 1:100 year + 40% CC storm restricted to 22 l/s/ha (all catchments)
- 1:30 year storm restricted to 14 l/s/ha (Qbar) (catchments 1, 3 and 4)
- 1:30 year storm restricted to 13.3 l/s/ha (Qbar) (catchment 5)

These restrictions will also be applied to all plot connections into the network.

7.2 Climate change

In accordance with NPPF, runoff for the 100-year storm will include a 40% allowance for climate change.

7.3 Surface water strategy

7.3.1 Development plots

The arrangement of the surface water network and related details are shown in Appendix D. To provide flexibility for the connections from the future development plots the surface water network has been designed with a depth of 2.0-2.5m below cover level. Plots will be drained through connections to carrier pipes within the highway and public realm; one connection will be allowed per plot. Development plot surface water flow rates will be in line with the site wide discharge restrictions and the management of this will be the responsibility of the plot developer.

7.3.2 Infrastructure strategy

The carrier drain network downstream of plot connections is proposed to be adopted by United Utilities. Flow control devices will be applied at the outfall to the River Irk for each catchment, which will restrict flows to the following:

- Outfall 1 restricts part of Red Bank terraces and public realm zone to 11.9 l/s for the 100 year event
- Outfall 2 restricts Plateau road west zone, and part of Red Bank Terraces to 86.7 l/s for the 100 year event
- Outfall 3 restricts Plateau road east zone to 56 l/s for the 100 year event
- Outfall 4 restricts Dantzic Street to 86.2 l/s for the 100 year event.

These restrictions are calculated based on the area of each and the per ha restriction outlined in section 7.1.

The current proposal assumes no infiltration through the ground. All storm water is therefore proposed to discharge into the River Irk. This represents the worst case from a flow perspective and will be reviewed following updated geotechnical investigation. The strategy has been split into multiple drainage zones which also relate to the drainage catchments shown in Appendix A. The zones are shown in Figure 8.



Figure 8 Drainage zones

Outfalls to the river are assumed to discharge under surcharged conditions for the 1:100 year event due to high river levels. Exact river levels have not been modelled for the 1:30 year event but it is assumed that outfalls will discharge freely for this return period; due to the large upstream river catchment of the Irk, it is anticipated that the river hydrograph and the site hydrograph will not coincide for the 30-year storm.

Exceedance flow routes have been considered in the design for the drainage solution (Refer to Appendix F). The exceedance flow route in the event of system failure or larger storms will pass down Plateau Road and down Red Bank Terraces towards the River Irk. The on-plot developer should ensure buildings levels are raised from the surrounding levels to encourage water away from the proposed developments, and that plot levels route water away from steep slopes to reduce the risk of soil erosion.

7.3.3 Plateau Road East

The Plateau Road East will be drained through 2850m^2 of permeable paving which stores runoff before discharging to carrier pipes within the carriageway. The permeable layer will be lined to prevent infiltration. Flow controls at the inlet to carrier drains will allow water to be stored in the permeable road layer in order to achieve the proposed discharge restrictions. After the carrier pipes pass away

from the highway to the south-west, it will pass through a storage tank of 125m^3 before heading off towards the outfall.

The carrier system will convey runoff towards the outfall to the north east, which discharges to the River Irk as shown in Appendix D. All runoff from the Plateau Road will be discharged directly to the River Irk.

7.3.4 Plateau Road West

The drainage mechanism for Plateau Road West mirrors the mechanism for Plateau Road East. Highway runoff will be captured and stored in 3900m^2 of permeable paving and discharged to carrier pipes within the highway. This system is lined to prevent infiltration and flow control devices restrict the flow to allow water to be stored within the permeable layer. Plots will be drained into the carrier drain system.

The network passes under Red Bank Square and Red Bank Terraces and through a detention basin. The detention basin is an online feature which will provide approximately 108m^3 of storage. Flow controls are included at the outlet to provide storage within the basin and restrict the whole catchment to the agreed discharge rate. The network then outfalls to the River Irk as shown in Appendix D.

7.3.5 Red Bank Terraces and public realm

The Red Bank Terraces zone will be drained through two networks. The terraces are drained through a series of gullies feeding into a carrier drain down the slope and passing through a 55m3 storage tank. Plots RB06 and RB08 are collected in a separate carrier system which is proposed to be adopted by United Utilities. This system also picks up discharge from two sections of permeable paving (105m^2 and 321m^2). Both carrier systems combine and are discharged along the northern edge of RB06 and to the outfall downstream of the Plateau West detention basin.

The public realm area to the south of RB06 and RB07 is drained through two sections of permeable paving (220m^2 and 442m^2). The carrier drain which picks up drainage from RB07 collects the discharge from the permeable paving and discharges to the river.

7.3.6 Dantzic Street

Dantzic Street will be drained through a series of swales which provide 208m^3 of storage and feed into a carrier drain system within the highway. This carrier system also collects drainage from the plots and is proposed to be adopted by United Utilities. A hydrobrake restricts the whole system to the proposed discharge rate before outfalling to the river.

The drainage within Dantzic Street is proposed to be constructed prior to further landscaping and highways works which will be progressed at a later date. Therefore, the existing highway drainage system will remain operational until such time as the additional works are completed, at which point the highway will

drain to the new system. Above ground elements such as swales will not be able to be constructed prior to landscaping works being undertaken. Maintenance operations during the interim should take account of this, as outlined in section 9.

7.3.7 River Park

The River Park replaces an existing area with no active drainage mechanism; therefore, this area will continue to naturally drain, and no drainage infrastructure is proposed within the park. The proposed active travel route across the top edge of the park will be drained through filter drains which convey the surface water runoff to the proposed networks on Plateau East and West. The wet play area within the park will be drained through a small separate outfall to the river which will be privately adopted. The treatment requirements at this outfall will be further assessed during the next stage of design when more is understood about the intended use of the wet play area.

7.3.8 Summary

Surface water drainage infrastructure will be delivered under 6no. independent networks which all discharge to the river through 5no. outfalls (4no. adopted outfalls, plus 1no. private for the wet play outfall). Across the site a strategy has been adopted which collects highway drainage and plot drainage separately to provide the required storage to restrict flows to the proposed rates.

The available storage across the site is approximately 11014m^2 of permeable paving, which equates to 1652m^3 of storage at 30% porosity. Swales along Dantzic Street will provide 208m^3 of storage for this network. There is an additional 256m^2 for a detention basin, providing 108m^3 storage, which forms part of the Plateau Road West network.

7.3.9 Stage 3 Calculation Summary

As part of the Stage 3 surface water design, a set of calculations were produced. These can be found in Appendix C. In summary:

- In a 1 in 30-year storm, the system does not flood at any part of the system as required by United Utilities.
- In a 1 in 100-year storm, the system floods very minorly in a couple of areas but the flood water is controlled and kept within site as required by United Utilities.

7.4 Foul water strategy

Foul water from the plots will be connected to proposed foul water sewers, which will discharge to the existing combined sewer network which surrounds the site. The connection depth from plots has been agreed with the on-plot developers as 1.5m minimum depth to cover. The foul drainage arrangement can be seen in Appendix E. The foul network has been modelled based on the unit numbers provided by FEC on 23/09/2021 with an assumed split between 1, 2 and 3 bed

dwellings based on the Northern Gateway Strategic Regeneration Framework (SRF).

The expected foul peak flows from each plot are shown in Table 1. In line with the Sewers Design and Construction Guidance, these are calculated based on a peak rate of 0.05l/s per dwelling and 0.6l/s/ha for non-residential land uses

Table 1 Foul Generation per plot

Block ID	Residential Total	Non-residential total	Peak Foul Generation
	units	sqm	l/s
RB06	190	1402.6	9.6
RB07	406	2981.7	20.5
RB10*	282	1995.8	14.2
Park	0	0	0
NT02*	583	1743.1	29.3
NT03*	392	1775.8	19.7
NT04*	432	0	21.6
RB16*	137	1003.0	6.9
RB17*	171	1256.2	8.6
RB01	166	930.6	8.4
RB02	261	491.5	13.1
RB03	256	481.6	12.8
RB04a	388	2413.2	19.5
RB04b	403.5	819.0	20.2
RB05a	201.75	409.5	10.1
RB05b	201.75	409.5	10.1
RB12(b)	204	791.5	10.2
RB08	149.814	0	7.5
RB09*	384.5548	0	19.2
RB11&12(a)	123.5806	2265.1	6.3
Total			267.9

(* red cells denote plots within the wider masterplan which are not considered under the HIF Infrastructure works planning application)

Plots outside of the HIF boundary in immediate proximity to the existing combined system are assumed to connect into the existing system directly and do not connect to the proposed foul network.

Consultation is ongoing with United Utilities to understand the capacity of the existing sewers. A CCTV survey of the sewers has also been commissioned to advise on their current condition. Existing surface water connections from the site

to the combined sewer will be re-routed directly to the river, so the overall flow rate in the combined sewer will be reduced, this will be considered when assessing the sewer's capacity. Collaboration with United Utilities will be maintained to achieve a design which is adoptable by them.

8 Sustainable drainage systems (SuDS)

Sustainable drainage systems will be utilised across the site to treat and attenuate surface water runoff to the agreed flow rates. The SuDS which will be applied at each area of site (off-plot) are summarised below. The on-plot developer is responsible for developing attenuation on-plot to meet the required restrictions.

8.1 Plateau Road and Red Bank Square

Permeable Paving will be utilised for the Plateau Road and areas of public realm within the masterplan, including on-street car parking spaces and footways. This will provide a large volume for storage of storm water as well as wider benefits for water quality; permeable paving provides some treatment by trapping pollutants through adsorption and settlement within the permeable layer. Evapotranspiration is also a potential benefit of permeable paving due to the shallow depth of storage. Oversized pipes are used for storage on the entrance from Red Bank, as steep slopes make permeable paving unsuitable in this area.

The permeable paving is designed so that water infiltrates through voids in the paving and is stored in the voids in the sub-base. The sub-base will be lined to ensure there is no infiltration to the ground, potential for infiltration will be explored at the next stage. Surface water will exit through a filter pipe at the bottom of the sub-base to drain to the carrier system. A typical section of the permeable paving is shown in Figure 9, the sub-base will be shallower under the footways as there is less loading.

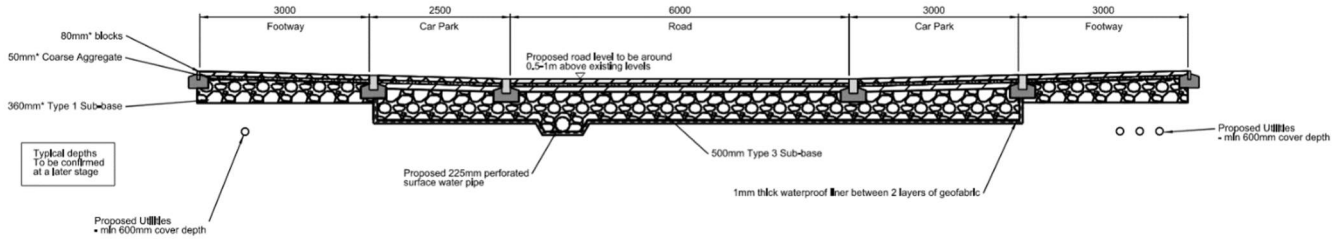


Figure 9 Typical permeable paving section

8.2 Dantzic Street Swales

Swales are proposed along Dantzic Street which will provide up to 208m^3 of storage, this will be achieved by implementing flow controls at the outlet of each swale. Swales will also be lined to prevent infiltration. Surface vegetation will provide filtration of coarse to medium sediments and associated pollutants, improving water quality at swale outlets.

8.3 Detention basin

The detention basin will store up to 108m^3 of water during storm events and will provide an area of amenity during prolonged periods of dry weather when flows will be lower. This will store runoff collected in the Plateau West network and a complex control will restrict outflow from the basin to provide the required storage for the 30 and 100-year storms. Infiltration from the basin will be prevented using impermeable lining. The basin will be an online feature and is proposed to be adopted by United Utilities.

The basin will be vegetated, which will provide filtration along the base, settling of particulate pollutants within the basin will also provide water treatment. The outfall will be designed to prevent the resuspension of solids before water outfalls to the river.

8.4 Water treatment capabilities and the Simple Index Approach

The Simple Index Approach (SIA) as defined in the CIRIA C753 SuDS manual has been used to determine the treatment efficiency of the proposed Sustainable drainage systems across the site.

Under the SIA, the site use has been designated as *'low traffic roads'* or *' Non-residential parking with infrequent change'* which are the site uses with the highest Pollution Hazard Indices of all proposed land uses within the development. The Pollution Hazard Indices for this land use are shown in Table 2.

Table 2 Land Use Pollution Hazard Indices

		Pollution Hazard Indices		
Runoff Area Land Use Description	Pollution Hazard Level	Total Suspended Solids	Metals	Hydrocarbons
Low traffic roads (e.g. residential roads and general access roads, < 300 traffic movements/day)	Low	0.5	0.4	0.4
Non-residential parking with infrequent change (e.g. schools, offices, < 300 traffic movements a day)	Low	0.5	0.4	0.4

The Pollution Mitigation Indices of the proposed SuDS features are shown in Table 3.

Table 3 Proposed SuDS Pollution Mitigation Indices

	Pollution Mitigation Indices		
	Total Suspended Solids	Metals	Hydrocarbons
Detention basin	0.5	0.5	0.6
Swale	0.5	0.6	0.6
Pervious pavement (where the pavement is not designed as an infiltration component)	0.7	0.6	0.7

Groundwater protection will be provided for all SuDS features through the use of lining to prevent infiltration to the ground.

As the pollution mitigation indices for each of the proposed SuDS elements are greater than the pollution hazard index, the proposed components are considered sufficient to provide pollution risk mitigation in isolation. Additionally, the SuDS features have been designed so that most of the surface water flows will pass through multiple SuDS elements before they are discharged. This will provide a robust treatment train and treat a broad range of pollutants; the proposed features will provide interception, primary and secondary treatment to most of the surface water flows as defined by the Ciria C753 SuDS Manual 2015.

9 Phased development and maintenance

The Victoria North site is to be developed in multiple different phases. The infrastructure works will form part of the first stage of development, on-plot development will be undertaken in subsequent phases. The construction phase will therefore continue after the completion of the HIF works, with the last plot being completed in 2032 according to the current phasing plan.

For both the surface and foul water network, construction activity in subsequent phases to their delivery could lead to increased sedimentation due to reduced flows which may result in blockages in the system. Blockages within the SuDS systems will reduce their storage and treatment capabilities which could lead to increased flood risk and pollution of surface water or other environmental receptors. Similarly, blockages within the foul network would exacerbate current capacity issues, likely leading to increased CSO spill rates and potential flooding. Construction debris may also cause erosion to pipe networks, particularly where

backdrops are included due to steep slopes. Construction traffic may induce higher highway loading on the network than it has been designed to carry, temporary traffic routes should be developed with consideration of the cover depths and load classes of the drainage network to prevent damage.

As the drainage networks will be installed prior to plots connecting to the system, self-cleansing velocities may not be achieved during all phases of the development in the foul system. The current proposed phasing plan indicates a seven-year gap between the completion of the first plot to the last one. Assuming that occupancy of the plots will follow a similar timeline to their completion, flow rates may be lower than the designed full flow rate for a number of years before all plots come online.

9.1 Interim construction phase maintenance regime

A sufficient maintenance plan should be developed in line with Ciria 753 which includes all phases of the development prior to eventual handover, including the interim period between HIF works delivery and full plot occupation, and prior to highways works on Dantzic Street. The frequency of maintenance activities should be increased during construction phases to prevent the need for remedial actions. Additional maintenance requirements of the system during the interim period will include:

- Visual inspection of all networks quarterly and following large storms
- Camera surveys prior to plot build outs to ensure the system is clear of debris and construction waste
- Rodding and jetting of drainage pipes and regular inspection/ sediment removal from chambers as needed following inspection
- Sweeping of permeable paving using a brush and suction cleaner twice yearly, after leaf fall and as required following inspection
- Monthly inspection and sediment removal from flow controls, inlets and outlets
- Mowing, vegetation management and debris removal in detention basin monthly or as required (less frequent during winter), regular inspection should inform the need for sediment excavation during subsequent construction and use phases

United Utilities will adopt the drainage mentioned above formally once the Section 104 has been agreed and the occupancy of the plots is 51% minimum. Before this point, the whole drainage system will need to be maintained privately by the Developer. The Developer should consider separate S104 applications in order to achieve adoption status sooner.

9.2 Post site completion maintenance regime

Upon completion of the wider site, the maintenance of drainage systems will be the responsibility of the asset owners. It is anticipated, that once the whole site has

been developed, the whole foul water system as well as the surface water system where plots are connected will be adopted by United Utilities; this also includes the online detention basin. The highway will be un-adopted and so maintenance of the highway drainage up to the connection with the carrier system will be the responsibility of the private owner. The maintenance regime once the site is completed should align with Ciria 753 and is summarised in Table 4.

Table 4 Basin typical Maintenance Regime

Basin - Maintenance Task	**Frequency**
Visually inspect inlet and outlet for blockages, remove silt and debris	Monthly
Mow and manage vegetation	Monthly (seasonal)
Re-seed areas of poor vegetation	As required

Table 5 Permeable Paving typical maintenance regime

Permeable Paving - Maintenance Task	**Frequency**
Visually inspect for blockages, remove silt and debris	Monthly
Mow and manage vegetation in areas adjacent to permeable paving	Monthly (seasonal)
Sweep using a brush and suction cleaner	Annually after leaf fall or as needed
Weed removal in permeable paving using glyophosphate	Annually or as required

Table 6 Swales typical maintenance regime

Swales - Maintenance Task	**Frequency**
Visually inspect inlet and outlet for blockages, remove silt and debris	Monthly
Mow and manage vegetation	Monthly (seasonal)
Re-seed areas of poor vegetation	As required

Table 7 Pipe network typical maintenance regime

Pipe Network - Maintenance Task	Frequency
Visually inspect access covers for structural damage and remove litter or debris	Monthly
Lift access covers to visually inspect condition of access chambers and presence of silt or debris, remove as necessary	Annually
Visually inspect flow control chambers, remove sediment. Maintain flow controls in accordance with manufacturers' recommendations	Biannually

10 Conclusions

The existing drainage on and around site consists of combined sewers as well as infiltration and runoff to the River Irk in the non-developed areas. In line with the drainage hierarchy, and with consideration of the potential for contamination, the proposed surface water drainage strategy is to discharge to the River Irk as the primary mechanism.

Discussions to agree discharge restrictions are ongoing with the LLFA and the EA. The site is proposed to be restricted to Qbar up to the 30-year event (14l/s/ha and 13.3l/s/ha) and will be restricted to the 100-year storm flow rate for the 100 year + 40% climate change event (22l/s/ha). To achieve these restrictions, SuDS are proposed across the site including permeable paving, swales and a detention basin to provide storage.

As a result of the site's industrial history, areas of potential contamination have been identified, further investigation is required to confirm the contamination levels within site – this will then govern our ability to introduce infiltration into the design at the next stage. Due to this, all SuDS features are designed with impermeable lining to prevent infiltration. Under the Simple Index Approach, the proposed SuDS are shown to be sufficient to mitigate pollution potential of the site to environmental receptors. The sitewide SuDS will drain highways and public realm only, attenuation for the plots will be achieved on-plot.

The SuDS features will drain to a carrier pipe system, which also connects with the plot surface water drainage. The carrier drains will convey all surface water to 5no. outfalls to the River Irk. Flow controls will be installed at each outfall to control the discharge in line with the sitewide restrictions for the 1:30 and 1:100+CC return periods.

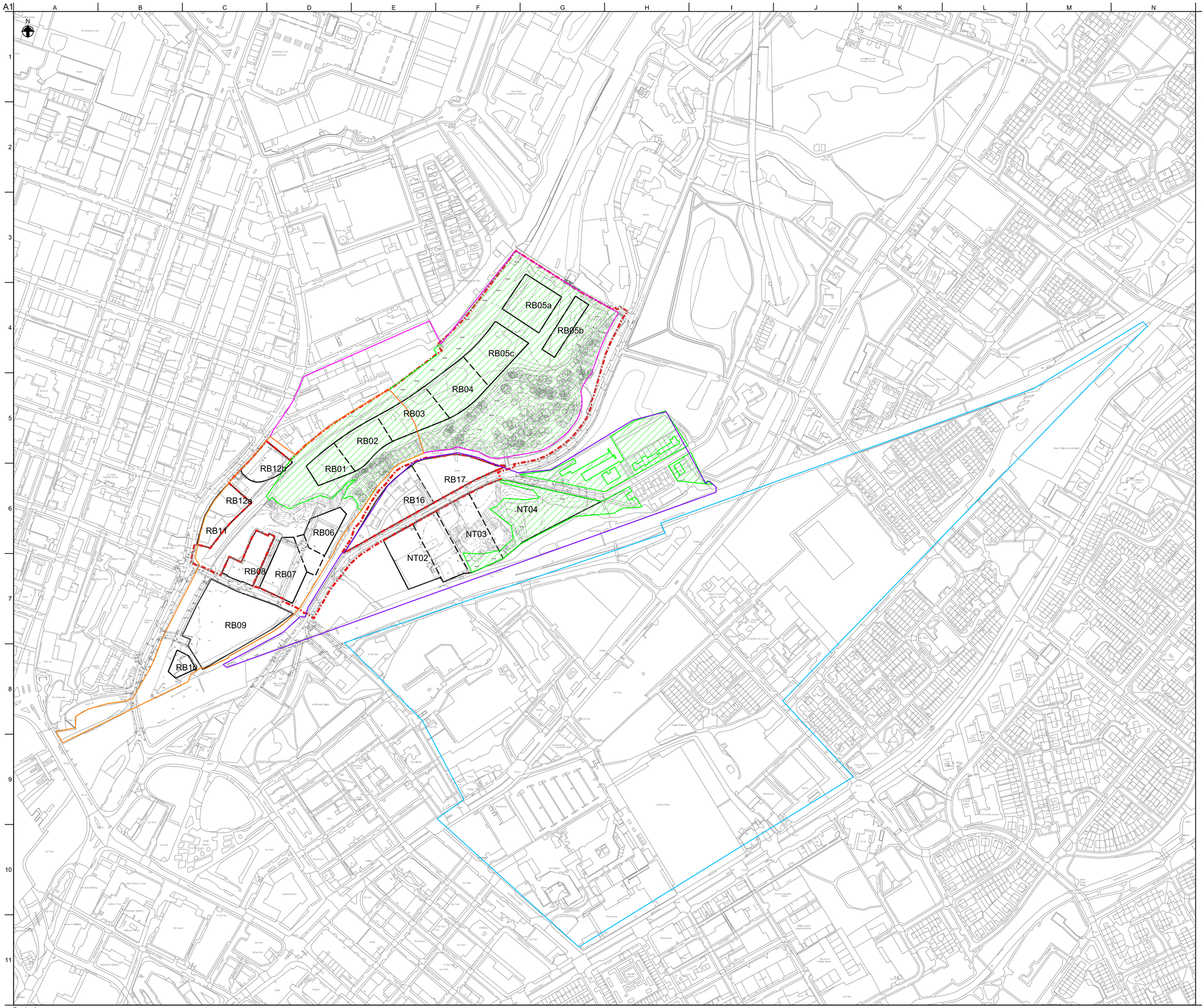
A new foul network will be installed to drain the plots, this will connect to the existing combined sewers in and around the site. Foul water generation has been calculated based on the proposed building uses, and a peak flow rate is applied for both residential and non-residential land uses. Consultation with United Utilities is ongoing to understand the capacity of existing sewers which the site will discharge to.

Maintenance of the proposed drainage systems should be prioritised during all phases to prevent blockages which could lead to the system not functioning as designed, causing potential flooding and pollution. This should particularly be considered during the construction of plots which are due to progress after the infrastructure works delivery.

Appendix A

Existing Drainage Catchments

A1



Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   - Landscape Architect masterplan drawing 2700-PLA-ZZ-YYY-DR-L-1011 Rev P01.01 dated 07/12/2021 by Planit.
   - Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. No guarantee is given for the accuracy of the information contained herein, which is provided for general guidance only and must not be relied upon for excavation or detailed design until apparatus locations are verified / validated through further site investigation works.
5. This drawing should be read with reference to VNIF-ARP-ZZ-YYY-CS-CD-0001 stage 3 drainage calculations
6. Greenfield assumed as areas which are not positively drained.
7. Greenfield extents are shown to catchment boundaries only.

Key

- HIF Site Boundary
- Plot Boundary
- Greenfield Extents
- Drainage Catchment 1
- Drainage Catchment 3
- Drainage Catchment 4
- Drainage Catchment 5

Rev	Date	Description	By	Chkd	Appd	Auth
P01	26/08/21		AS	AS	AS	---
P02	17/12/21		ES	DH	RG	---

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

HIF Existing Surface Water Catchments

Scale at A1	1:1250	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S0 - Initial Status or WIP		

Rev	By	Chkd	Appd	
P02	---	---	---	---
	Date	Date	Date	
	---	---	---	---

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0001
Project	Orlginator	Volume	Location	Type	Role	Number

Do not scale

© Arup

Appendix C

Drainage Calculations

Technical Note

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
United Kingdom
www.arup.com

t +44 161 228 2331
f +44 161 228 6879

Project title	Victoria North HIF Infrastructure Works	Job number	282022
cc		File reference	VNIF-ARP-ZZ-YYY-CS-CD-0001
Prepared by	Emily Stoddart Drew Hunter	Date	17 February 2022
Subject	Work Stage 3 drainage calculations		

This technical note has been prepared to summarise the calculations which support the work stage 3 drainage design for the Victoria North Infrastructure Works project.

1 Surface water

The surface water calculations are split into catchments which have been taken from the sitewide drainage strategy (MNG-ARP-SW-FN-GX-0008). The catchments are shown in . Note that greenfield extents indicated in refer only to land which is not actively drained and do not indicate previously undeveloped land.

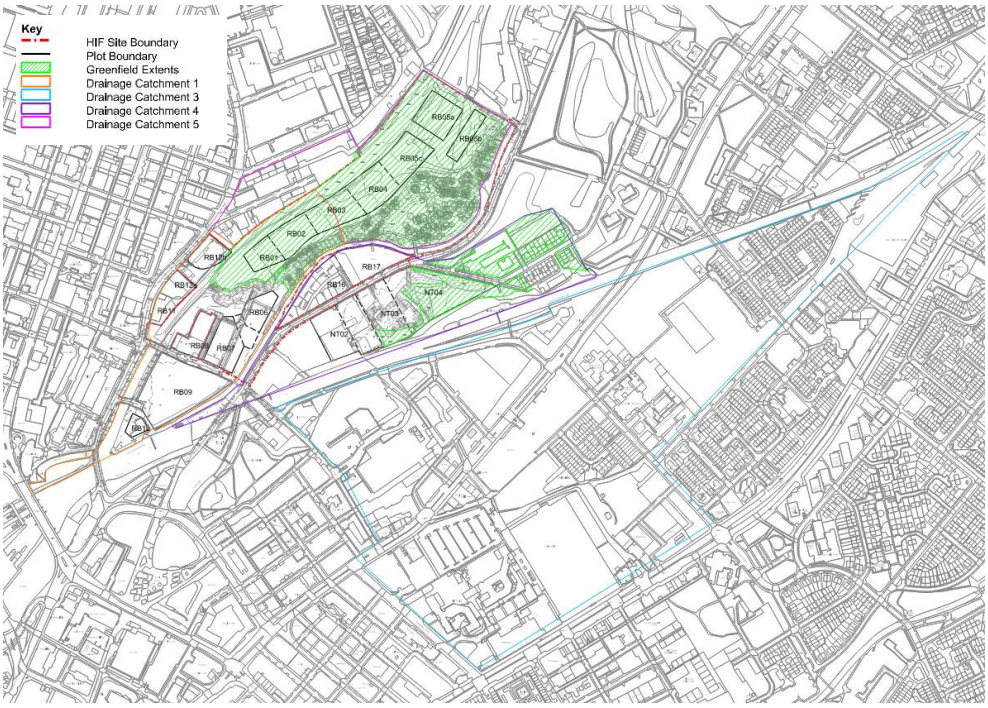


Figure 1 Existing drainage catchments

1.1 Discharge restrictions

Discharge restrictions have been calculated in consultation with the LLFA (MCC), the EA and the on-plot developer. MCC have indicated during previous engagement that greenfield discharge rates would be required for the site as all outfalls to the river are considered as new connections. This has been agreed in principle, the resulting discharge rates are still to be formally agreed by the LLFA.

The discharge restrictions are specified as a sitewide restriction per hectare. These restrictions will also be applied to the highways, footways, public spaces and development plots.

1.2 Catchment areas

Catchment areas have been calculated from the areas shown in . Areas which are not currently actively drained and will not be so under the proposed development (St Catherine's Wood) have not been included.

Table 1 - Areas Summary

Catchment	Area Total	Area Greenfield	Area Brownfield	Total area - Unchanged greenfield
	(ha)	(ha)	(ha)	(ha)
1	7.0	1.5	5.5	6.6
3	31.8	5.3	26.6	31.8
4	8.0	1.8	6.2	8.0
5	7.1	3.5	3.6	5.2
Total	**53.9**	**12.1**	**41.9**	**51.6**

1.3 Discharge rates (Existing)

As stated in the "SC030219 – Rainfall Management for Developments" EA document, QBar runoff rate has been calculated using the IH124 method through source control in Micro Drainage, based on the varying urbanisation factors (as stated in the guidance, the area is calculated for the larger catchment and interpolated for the smaller individual catchments) – the summary can be seen in the Appendix A. The 30-year and 100-year runoff rates are then calculated using the FSSR coefficients derived from Figure 2.

Based on the existing catchments shown in Figure 1 the urbanisation factors for each catchment have been calculated. The urbanisation factor has been calculated as a percentage of brownfield to the total area (minus the areas of greenfield remaining unchanged throughout the design). This percentage will be different for each catchment, but it is worth noting that the maximum recommended Urbanization Factor is 0.75. This means that for Catchments 1,3 and 4 – the urbanization factor has been reduced down to 0.75 for the simulation (providing an increased betterment to the River Irk).

Table 2 - Existing Data

	Qbar	Storm Event	FSSR Co-efficient
IH124 urban greenfield runoff rate (l/s) (0.70 Urbanization)	688.3	30 Yr	1.4
IH124 urban greenfield runoff rate (l/s) (0.75 Urbanization)	722.8	100 Yr	1.68

Table 3 - Existing Discharge/Volume Data

Outfall	Proposed Outfall Path	Catchment	Urbanization Factor	Existing Greenfield Run-Off (l/s/ha)			Existing Greenfield 6-hour Volume (m3)		
			Brownfield/(Total area - unchanged area)	Qbar	30 Year	100 Year	Qbar	30 Year	100 Year
1	River Irk (new outfall)	1	0.83	14	19.5	23.4	2000.26	2800.36	3360.43
3	River Irk (new outfall)	3	0.83	14	19.5	23.4	9595.80	13434.12	16120.95
4	River Irk (new outfall)	4	0.77	14	19.5	23.4	2397.90	3357.05	4028.46
5	River Irk (new outfall)	5	0.7	13.3	18.6	22.3	1487.59	2082.63	2499.16

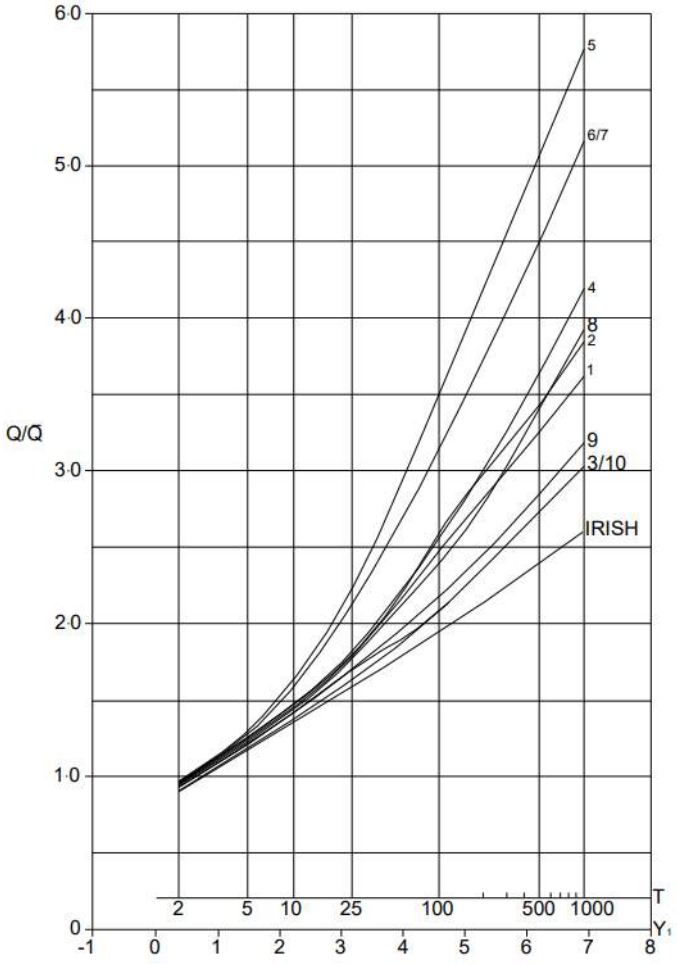


Figure 2 – Peak flow growth curves of UK (from FSSR 14)

1.4 Proposed restrictions

The proposed restrictions for the site are as follows:

- 30-year storm = **14 l/s/ha** (catchments 1, 3 and 4)
- 30-year storm = **13.3 l/s/ha** (catchment 5)
- 100-year storm = **22 l/s/ha** (all catchments)

Based on the values above, the 6-hour storm values and discharge volume reduction are as follows:

Table 4 – Proposed Discharge/Volume Data

Outfall	Proposed Outfall Path	Catchment	Urbanization Factor	Proposed Flow Rate (l/s/ha)			Proposed 6-hour Volume (m3)		Proposed Volume Reduction from Existing (%)	
			Brownfield/(Total area - unchanged area)	1 Year	30 Year	100 Year	30 Year	100 Year	30 Year	100 Year
1	River Irk (new outfall)	1	0.83	14.0	14.0	22.0	2008.3	3153.0	28.6	6.6
3	River Irk (new outfall)	3	0.83	14.0	14.0	22.0	9634.5	15125.6	28.6	6.6
4	River Irk (new outfall)	4	0.77	14.0	14.0	22.0	2407.6	3779.7	28.6	6.6
5	River Irk (new outfall)	5	0.70	13.3	13.3	22.0	1487.6	2452.5	28.6	1.9

As can be seen in the final 2 columns, the volume of water in a 6-hour event is reduced in the 30-year and the 100-year storm. This in turn complies with the EA guidance to have the developed discharge rate at no greater volume to the undeveloped discharge volume.

1.5 Network modelling

The storm water networks have been modelled to achieve the discharge restrictions presented above. The network is designed with minimum cover of 0.9m for non-trafficked areas, 1.2m for trafficked areas and 2.0 - 2.5m connections (to FFL) from the development plots, as agreed with the on-plot developer. A maximum backdrop height of 1.5m has been applied.

Vortex flow controls are included in the site wide model for all plot connections to the network. Plot specific restrictions are shown in Table 4 and are based on the current sitewide masterplan. Plots have also been modelled with an indicative storage structure equivalent to the required storage volume, this represents the storage which will be applied on-plot to restrict discharge. Vortex flow controls are also applied at the connections from online storage structures to control the volume stored in each structure, as well as at all outfalls to the river to ensure each catchment meets the required discharge restriction.

Table 4 Modelled plot restrictions

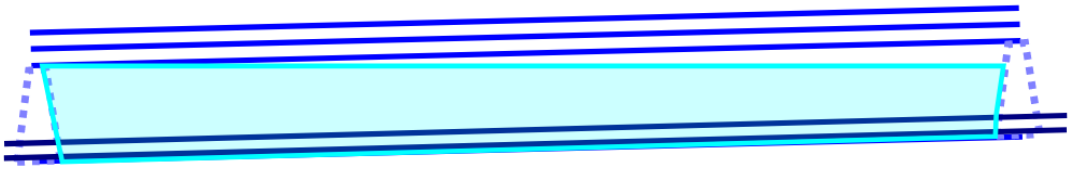
Plot	Area (ha)	Catchment	30 year restriction (l/s)	100 year restriction (l/s)
RB06	0.247	1	3.4	5.4
RB07	0.376	1	5.2	8.3
RB10	Drained to separate network			
NT02	0.771	4	10.8	16.9
NT03	0.537	4	7.5	11.8
NT04	1.012	4	14.1	22.2
RB16	0.537	4	7.5	11.8
RB17	0.461	4	6.4	10.1
RB01	0.288	1	4.0	6.3
RB02	0.326	1	4.5	7.2
RB03	0.403	5	5.4	8.9
RB04	0.415	5	5.5	9.1
RB05a	0.369	5	4.9	8.1
RB05b	0.237	5	3.2	5.2
RB05c	0.410	5	5.5	9.0
RB12(b)	0.235	1	3.3	5.2
RB08	0.444	1	6.2	9.8
RB09	Drained to separate network			
RB11	0.156	1	2.2	3.4
RB12a	0.163	1	2.3	3.6

The network has been designed to minimise flooding during the 100-year storm as much as possible, and any flooding is designed such that it will stay within the site boundary. No flooding occurs within the network for the 30-year storm event. The model network results are split into 4no. surface water catchments and are shown in Appendix 1 – Appendix 4. Note that layouts shown provide a representation of the network for modelling purposes only, for full proposed layouts refer to drainage strategy VNIF-ARP-ZZ-YYY-RP-CD-0003.

1.6 Permeable Paving Calcs

Current working assumptions are as follows:

- Permeable paving depth – 500mm
- For Stage 3 permeable paving has been modelled as 4 separate storage units. During Stage 4 a more detailed model will be produced breaking down each storage unit to reflect the bund spacing.
- Permeable paving sub-base porosity – 30%
- Smaller localised areas of permeable paving to have a slope factor of 0.9. To be detailed further at Detailed Design Stage.



Plateau West

For Plateau Avenue the current slope is designed to be 1:150 and using the area method as shown below the sloping factor is calculated to be 0.83.
Available Storage – 3900m2 (area) x 0.5m (depth) x 0.3 (porosity) x 0.83 (slope factor)
= 485.55m3
MD Storage – (215x0.5)+(350x0.5)+(200x0.5)+(200x0.5)
= 482.5m3 < 485.55m3 (**OK**)

Plateau East

Available Storage (1) – 2850m2 (area) x 0.5m (depth) x 0.3 (porosity) x 0.83 (slope factor)
= 354.825m3
Available Storage (2) – 140m2 (area) x 0.8m (depth) x 0.95 (porosity)
= 106.4m3
Available Storage (1+2) = 461.225m3
MD storage – (225x0.5) + (62.5x0.5) + (175x0.5) + (62.5x0.5) + (255x0.5)
= 390m3 < 461.225m3 (**OK**)

Red Bank Avenue

Red Bank Avenue has been split into two separate storage areas. North of Plot RB06 and South of RB06.

North of Plot RB06

The storage in this section is broken down into a storage tank and 2 permeable paving areas.
The tank has been modelled with the dimensions 9mx8mx0.8m (95% porosity).
Permeable paving available storage (1) – 321.262m2 (area) x 0.5m (Depth) x 0.3 (porosity) x 0.9 (sloping factor)
= 43.37m3
Permeable paving available storage (2) – 104.642m2 (area) x 0.5m (depth) x 0.3 (porosity) x 0.9 (sloping factor)
= 14.40m3

Available storage (1+2) – 57.77m3
MD provided storage 57.50m3 < 57.77m3 (**OK**)

South of Plot RB06

The storage in this section is broken down into 2 permeable paving areas
Permeable paving available storage (1) – 442.490m2 (area) x 0.5m (depth) x 0.3 (porosity) x 0.9 (sloping factor)
= 59.74m3
Permeable paving available storage (2) –218.738m2 (area) x 0.5m (depth) x 0.3 (porosity) x 0.9 (sloping factor)
= 29.53m3
Available storage (1+2) – 89.27m3
MD provided storage – 89m3 < 89.27m3 (**OK**)

2 Foul water

The foul network has been modelled based on the unit numbers provided by FEC on 23/09/2021 with an assumed split between 1, 2 and 3 bed dwellings based on the Northern Gateway Strategic Regeneration Framework (SRF).

2.1 Foul water generation

In line with the Sewerage Sector Design and Construction Guidance v2-1, a peak flow rate of 0.05l/s/dwelling and 0.6l/s/ha for non-residential land use have been applied, giving the flow rates shown in Table 6.

Table 6 Foul water flows

Block ID	Residential	Non-residential	Foul generation
	units	**sqm**	**l/s**
RB06	179	1403	9.1
RB07	457	2982	22.8
RB10	Drained to separate network		
NT02	583	1743	29.1
NT03	392	1776	19.6
NT04	432	0	21.6
RB16	137	1003	6.9
RB17	172	1256	8.6
RB01	166	931	8.3
RB02	261	492	13.1
RB03	256	482	12.8
RB04	388	2413	19.4
RB05a	404	819	20.2
RB05b	202	409	10.1
RB05c	202	409	10.1
RB12(b)	204	792	10.2
RB08	150	2265	7.5
RB09	Drained to a separate network		
RB11&12(a)	124	480	6.2
Total	**5335**	**24039**	**267**

2.2 Network modelling

Details of the foul network are shown in Appendix 5. The network has been designed to carry the flows shown above and discharge to existing combined sewers. Plot connections are set at a minimum of 1.5m deep, as agreed with the on-plot developer. Minimum depths for trafficked areas are set as 1.2m and for non-trafficked areas is 0.9m. A minimum self-cleansing velocity of 0.75m/s at 1/3 design flow has been achieved across the foul network in line with the Sewerage Sector Design and Construction Guidance.

A1 Appendix 1 Catchment 1 (north) surface network report

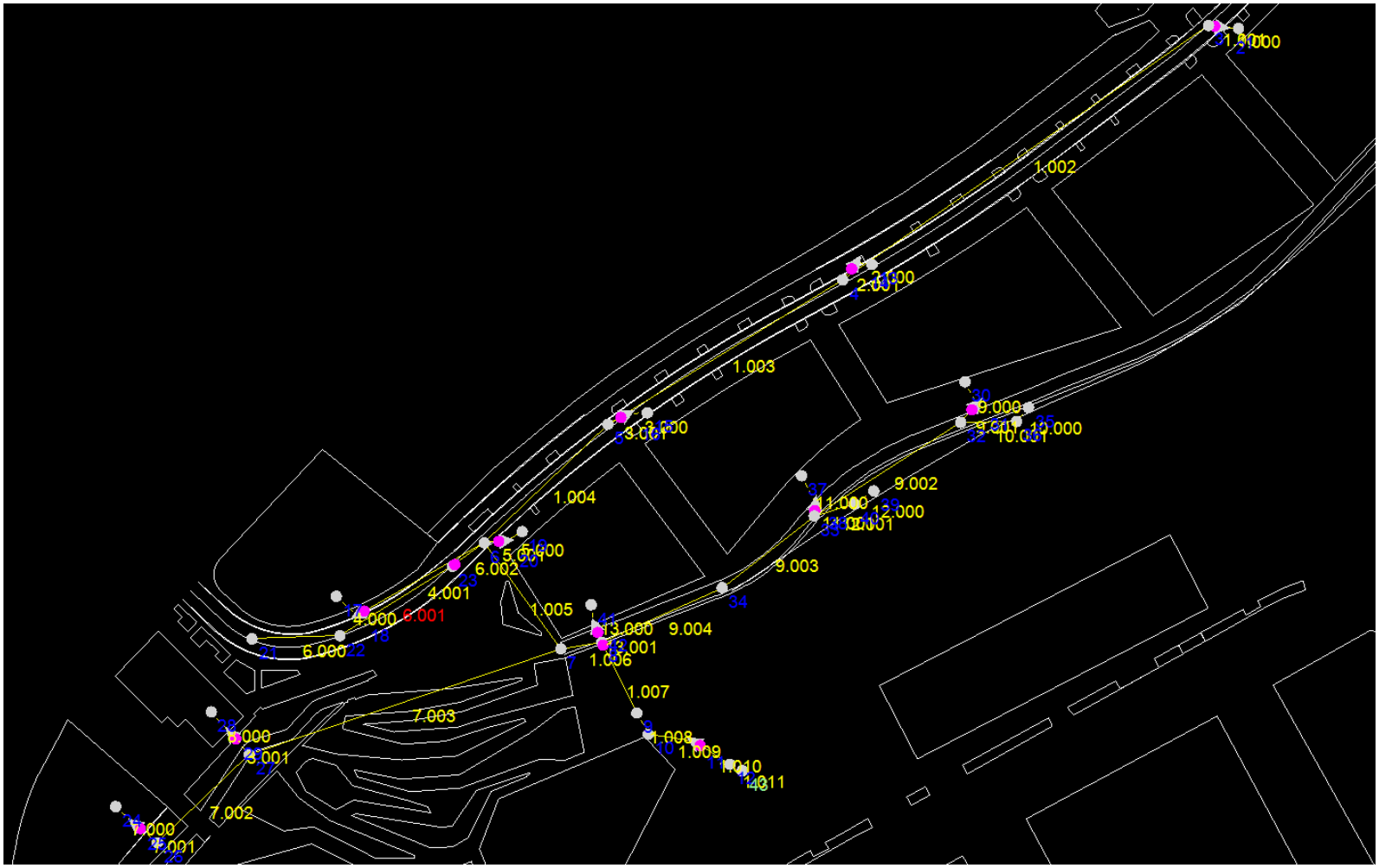


Figure 4 Catchment 1 north model layout

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	0
Ratio R	0.357	Minimum Backdrop Height (m)	0.000
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	0.000
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	0.900
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	100

Designed with Level Soffits

Network Design Table for Storm

- Indicates pipe length does not match coordinates

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	5.088	0.051	99.8	0.000	5.00	0.0	0.600	o	225	Pipe/Conduit	
1.001	4.385	0.044	99.7	0.283	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.002	140.566	1.017	138.2	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
2.000	10.000#	0.102	98.0	0.000	15.00	0.0	0.600	o	225	Pipe/Conduit	
2.001	6.945	0.061	113.9	0.304	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.003	87.000	0.580	150.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
3.000	10.000#	0.100	100.0	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
3.001	7.128	0.240	29.7	0.192	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.004	54.011	0.360	150.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
4.000	10.000#	0.200	50.0	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	

Dummy pipe upstream of permeable paving

Dummy pipe upstream of permeable paving

Dummy pipe upstream of permeable paving

Dummy pipe upstream of indicative plot storage/flow control

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	46.36	5.06	41.351	0.000	0.0	0.0	0.0	1.31	52.0	0.0
1.001	46.14	5.12	41.300	0.283	0.0	0.0	0.0	1.31	52.1	35.3
1.002	39.46	7.23	41.256	0.283	0.0	0.0	0.0	1.11	44.1	35.3
2.000	26.63	15.13	40.402	0.000	0.0	0.0	0.0	1.32	52.5	0.0
2.001	26.53	15.22	40.300	0.304	0.0	0.0	0.0	1.22	48.7	21.8
1.003	25.48	16.35	40.239	0.587	0.0	0.0	0.0	1.28	90.6	40.5
3.000	26.59	15.17	40.000	0.000	0.0	0.0	0.0	1.00	17.8	0.0
3.001	26.52	15.23	39.900	0.192	0.0	0.0	0.0	1.85	32.8	13.8
1.004	24.87	17.05	39.510	0.778	0.0	0.0	0.0	1.28	90.6	52.4
4.000	26.64	15.12	38.500	0.000	0.0	0.0	0.0	1.43	25.2	0.0

©1982-2020 Innovyze

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
4.001	46.084	0.307	150.1	0.235	0.00	0.0	0.600	o	225	Pipe/Conduit	
5.000	5.650	0.038	148.7	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
5.001	7.050	0.807	8.7	0.107	0.00	0.0	0.600	o	225	Pipe/Conduit	
6.000	27.739	0.055	504.3	0.090	5.00	0.0	0.600	o	900	Pipe/Conduit	
6.001	41.740	0.083	502.9	0.056	0.00	0.0	0.600	o	900	Pipe/Conduit	
6.002	12.475	0.114	109.4	0.072	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.005	41.216	0.724	56.9	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
7.000	10.000#	0.100	100.0	0.000	15.00	0.0	0.600	o	225	Pipe/Conduit	
7.001	10.000#	0.100	100.0	0.156	0.00	0.0	0.600	o	225	Pipe/Conduit	
7.002	40.188	0.241	166.8	0.040	0.00	0.0	0.600	o	450	Pipe/Conduit	
8.000	10.000#	0.699	14.3	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
8.001	10.000#	2.439	4.1	0.163	0.00	0.0	0.600	o	150	Pipe/Conduit	
7.003	103.792	0.622	166.9	0.035	0.00	0.0	0.600	o	450	Pipe/Conduit	
1.006	13.057	0.526	24.8	0.073	0.00	0.0	0.600	o	450	Pipe/Conduit	
9.000	10.000#	0.400	25.0	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
9.001	7.831	1.144	6.8	0.403	0.00	0.0	0.600	o	150	Pipe/Conduit	
10.000	10.000#	0.313	31.9	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
10.001	17.659	1.262	14.0	0.038	0.00	0.0	0.600	o	150	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
4.001	25.94	15.84	38.225	0.235	0.0	0.0	0.0	1.06	42.3	16.5
5.000	26.64	15.11	40.413	0.000	0.0	0.0	0.0	0.82	14.5	0.0
5.001	26.61	15.14	40.300	0.107	0.0	0.0	0.0	4.45	177.1	7.7
6.000	45.35	5.33	38.200	0.090	0.0	0.0	0.0	1.39	883.2	11.0
6.001	43.60	5.83	38.145	0.146	0.0	0.0	0.0	1.39	884.5	17.3
6.002	43.15	5.97	38.062	0.218	0.0	0.0	0.0	1.50	106.2	25.5
1.005	24.59	17.38	37.918	1.338	0.0	0.0	0.0	2.09	147.6	89.1
7.000	26.63	15.13	37.000	0.000	0.0	0.0	0.0	1.31	52.0	0.0
7.001	26.50	15.25	36.900	0.156	0.0	0.0	0.0	1.31	52.0	11.2
7.002	26.09	15.68	36.800	0.196	0.0	0.0	0.0	1.57	249.9	13.8
8.000	46.37	5.06	39.723	0.000	0.0	0.0	0.0	2.68	47.3	0.0
8.001	46.24	5.10	39.024	0.163	0.0	0.0	0.0	5.01	88.6	20.4
7.003	25.10	16.78	36.285	0.394	0.0	0.0	0.0	1.57	249.9	26.8
1.006	24.55	17.44	35.663	1.805	0.0	0.0	0.0	4.09	651.1	120.0
9.000	26.67	15.08	38.500	0.000	0.0	0.0	0.0	2.02	35.7	0.0
9.001	26.64	15.12	38.100	0.403	0.0	0.0	0.0	3.88	68.5	29.1
10.000	46.25	5.09	40.106	0.000	0.0	0.0	0.0	1.79	31.6	0.0
10.001	45.83	5.20	39.793	0.038	0.0	0.0	0.0	2.71	47.8	4.7

©1982-2020 Innovyze

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
9.002	54.826	0.372	147.4	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
11.000	10.000#	0.156	64.1	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
11.001	4.209	0.071	59.3	0.326	0.00	0.0	0.600	o	225	Pipe/Conduit	
12.000	10.000#	0.074	135.1	0.029	5.00	0.0	0.600	o	150	Pipe/Conduit	
12.001	13.164	1.000	13.2	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
9.003	36.816	0.326	112.9	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
9.004	41.714	0.226	184.6	0.020	0.00	0.0	0.600	o	450	Pipe/Conduit	
13.000	10.000#	0.085	117.6	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
13.001	5.861	0.550	10.7	0.288	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.007	24.884	1.945	12.8	0.020	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.008	10.000#	1.000	10.0	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.009	14.381	0.144	99.9	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.010	13.612	0.972	14.0	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.011	4.000#	0.021	190.5	0.000	0.00	20.7	0.600	o	450	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Dummy pipe upstream of indicative plot storage/flow control

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
9.002	25.96	15.82	36.956	0.441	0.0	0.0	0.0	1.29	91.4	31.0
11.000	26.62	15.13	37.507	0.000	0.0	0.0	0.0	1.26	22.2	0.0
11.001	26.58	15.17	37.351	0.326	0.0	0.0	0.0	1.70	67.7	23.5
12.000	45.87	5.19	38.938	0.029	0.0	0.0	0.0	0.86	15.2	3.6
12.001	45.57	5.27	38.864	0.029	0.0	0.0	0.0	2.79	49.3	3.6
9.003	25.66	16.14	36.359	0.796	0.0	0.0	0.0	1.91	304.2	55.3
9.004	25.25	16.61	36.033	0.816	0.0	0.0	0.0	1.49	237.5	55.8
13.000	26.57	15.18	37.735	0.000	0.0	0.0	0.0	0.93	16.4	0.0
13.001	26.54	15.21	37.650	0.288	0.0	0.0	0.0	3.10	54.9	20.7
1.007	24.48	17.52	35.137	2.929	0.0	0.0	0.0	5.09	562.1	194.2
1.008	24.46	17.55	32.211	2.929	0.0	0.0	0.0	5.76	635.9	194.2
1.009	24.35	17.68	31.211	2.929	0.0	0.0	0.0	1.81	200.3	194.2
1.010	24.32	17.73	30.000	2.929	0.0	0.0	0.0	4.86	537.2	194.2
1.011	24.28	17.77	27.431	2.929	20.7	0.0	0.0	1.47	233.7	213.3

©1982-2020 Innovyze

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	-	-	100	0.000	0.000	0.000
1.001	User	-	100	0.283	0.283	0.283
1.002	-	-	100	0.000	0.000	0.000
2.000	-	-	100	0.000	0.000	0.000
2.001	User	-	100	0.304	0.304	0.304
1.003	-	-	100	0.000	0.000	0.000
3.000	-	-	100	0.000	0.000	0.000
3.001	User	-	100	0.192	0.192	0.192
1.004	-	-	100	0.000	0.000	0.000
4.000	-	-	100	0.000	0.000	0.000
4.001	User	-	100	0.235	0.235	0.235
5.000	-	-	100	0.000	0.000	0.000
5.001	User	-	100	0.107	0.107	0.107
6.000	User	-	100	0.090	0.090	0.090
6.001	User	-	100	0.056	0.056	0.056
6.002	User	-	100	0.072	0.072	0.072
1.005	-	-	100	0.000	0.000	0.000
7.000	-	-	100	0.000	0.000	0.000
7.001	User	-	100	0.156	0.156	0.156
7.002	User	-	100	0.040	0.040	0.040
8.000	-	-	100	0.000	0.000	0.000
8.001	User	-	100	0.163	0.163	0.163
7.003	User	-	100	0.035	0.035	0.035
1.006	User	-	100	0.073	0.073	0.073
9.000	-	-	100	0.000	0.000	0.000
9.001	User	-	100	0.403	0.403	0.403
10.000	-	-	100	0.000	0.000	0.000
10.001	User	-	100	0.038	0.038	0.038
9.002	-	-	100	0.000	0.000	0.000
11.000	-	-	100	0.000	0.000	0.000
11.001	User	-	100	0.326	0.326	0.326
12.000	User	-	100	0.029	0.029	0.029
12.001	-	-	100	0.000	0.000	0.000
9.003	-	-	100	0.000	0.000	0.000
9.004	User	-	100	0.020	0.020	0.020
13.000	-	-	100	0.000	0.000	0.000
13.001	User	-	100	0.288	0.288	0.288
1.007	User	-	100	0.020	0.020	0.020
1.008	-	-	100	0.000	0.000	0.000
1.009	-	-	100	0.000	0.000	0.000
1.010	-	-	100	0.000	0.000	0.000
1.011	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				2.929	2.929	2.929

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.011	43	30.000	27.410	27.160	0	0

©1982-2020 Innovyze

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.840	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	240
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	4

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	13	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Winter
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	120
Ratio R	0.357		

©1982-2020 Innovyze

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 2, DS/PN: 1.001, Volume (m³): 0.9

Flow control for permeable paving

Unit Reference	MD-SHE-0130-7200-0700-7200
Design Head (m)	0.700
Design Flow (l/s)	7.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	130
Invert Level (m)	41.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	7.2	Kick-Flo®	0.499	6.1
Flush-Flo™	0.228	7.2	Mean Flow over Head Range	-	6.1

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)	Depth (m)	Flow (l/s)
0.100	4.7	0.800	7.7	2.000	11.8	4.000	16.4	7.000	21.5
0.200	7.2	1.000	8.5	2.200	12.3	4.500	17.4	7.500	22.1
0.300	7.1	1.200	9.3	2.400	12.9	5.000	18.2	8.000	22.8
0.400	6.9	1.400	10.0	2.600	13.4	5.500	19.1	8.500	23.6
0.500	6.2	1.600	10.6	3.000	14.3	6.000	19.9	9.000	24.2
0.600	6.7	1.800	11.2	3.500	15.4	6.500	20.7	9.500	24.9

Hydro-Brake® Optimum Manhole: 14, DS/PN: 2.001, Volume (m³): 1.1

Flow control for permeable paving

Unit Reference	MD-SHE-0128-7000-0700-7000
Design Head (m)	0.700
Design Flow (l/s)	7.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	128
Invert Level (m)	40.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	7.0	Kick-Flo®	0.496	6.0
Flush-Flo™	0.225	7.0	Mean Flow over Head Range	-	5.9

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.6	0.600	6.5	1.600	10.3	2.600	13.0	5.000	17.7
0.200	7.0	0.800	7.5	1.800	10.9	3.000	13.9	5.500	18.6
0.300	6.9	1.000	8.3	2.000	11.5	3.500	15.0	6.000	19.4
0.400	6.7	1.200	9.0	2.200	12.0	4.000	16.0	6.500	20.1
0.500	6.0	1.400	9.7	2.400	12.5	4.500	16.9	7.000	20.9

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 14, DS/PN: 2.001, Volume (m³): 1.1

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
7.500	21.5	8.000	22.2	8.500	22.9	9.000	23.6	9.500	24.2

Hydro-Brake® Optimum Manhole: 16, DS/PN: 3.001, Volume (m³): 0.9

Flow control for permeable paving

Unit Reference	MD-SHE-0104-4400-0700-4400
Design Head (m)	0.700
Design Flow (l/s)	4.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	104
Invert Level (m)	39.900
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	4.4	Kick-Flo®	0.480	3.7
Flush-Flo™	0.214	4.4	Mean Flow over Head Range	-	3.8

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)	Depth (m)	Flow (l/s)
0.100	3.5	0.800	4.7	2.000	7.2	4.000	9.9	7.000	13.0
0.200	4.4	1.000	5.2	2.200	7.5	4.500	10.5	7.500	13.4
0.300	4.3	1.200	5.6	2.400	7.8	5.000	11.1	8.000	13.8
0.400	4.1	1.400	6.1	2.600	8.1	5.500	11.6	8.500	14.3
0.500	3.8	1.600	6.5	3.000	8.7	6.000	12.1	9.000	14.7
0.600	4.1	1.800	6.8	3.500	9.3	6.500	12.5	9.500	15.1

Hydro-Brake® Optimum Manhole: 18, DS/PN: 4.001, Volume (m³): 3.3

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0099-5200-1600-5200
Design Head (m)	1.600
Design Flow (l/s)	5.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	99
Invert Level (m)	38.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.600	5.2	Kick-Flo®	0.880	3.9
Flush-Flo™	0.432	4.9	Mean Flow over Head Range	-	4.4

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)	Depth (m)	Flow (l/s)
0.100	3.2	0.300	4.8	0.500	4.9	0.800	4.4	1.200	4.5
0.200	4.5	0.400	4.9	0.600	4.8	1.000	4.2	1.400	4.9

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 18, DS/PN: 4.001, Volume (m³): 3.3

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
1.600	5.2	2.400	6.3	4.000	8.0	6.000	9.7	8.000	11.1
1.800	5.5	2.600	6.5	4.500	8.4	6.500	10.1	8.500	11.4
2.000	5.8	3.000	7.0	5.000	8.9	7.000	10.4	9.000	11.7
2.200	6.0	3.500	7.5	5.500	9.3	7.500	10.8	9.500	12.1

Hydro-Brake® Optimum Manhole: 20, DS/PN: 5.001, Volume (m³): 0.9

Flow control for permeable paving

Unit Reference	MD-SHE-0080-2500-0700-2500
Design Head (m)	0.700
Design Flow (l/s)	2.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	80
Invert Level (m)	40.300
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	2.5	Kick-Flo®	0.456	2.1
Flush-Flo™	0.207	2.5	Mean Flow over Head Range	-	2.2

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)	Depth (m)	Flow (l/s)
0.100	2.3	0.800	2.7	2.000	4.1	4.000	5.6	7.000	7.3
0.200	2.5	1.000	2.9	2.200	4.2	4.500	5.9	7.500	7.5
0.300	2.4	1.200	3.2	2.400	4.4	5.000	6.2	8.000	7.8
0.400	2.3	1.400	3.4	2.600	4.6	5.500	6.5	8.500	8.0
0.500	2.1	1.600	3.7	3.000	4.9	6.000	6.8	9.000	8.3
0.600	2.3	1.800	3.9	3.500	5.3	6.500	7.0	9.500	8.5

Hydro-Brake® Optimum Manhole: 23, DS/PN: 6.002, Volume (m³): 35.4

Flow control for oversized pipe

Unit Reference	MD-SHE-0187-2000-1800-2000
Design Head (m)	1.800
Design Flow (l/s)	20.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	187
Invert Level (m)	38.062
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.800	20.0	Kick-Flo®	1.126	16.0
Flush-Flo™	0.522	20.0	Mean Flow over Head Range	-	17.4

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 23, DS/PN: 6.002, Volume (m³): 35.4

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.5	0.800	19.3	2.000	21.0	4.000	29.3	7.000	38.4
0.200	17.0	1.000	17.9	2.200	22.0	4.500	31.0	7.500	39.7
0.300	19.0	1.200	16.5	2.400	22.9	5.000	32.6	8.000	40.9
0.400	19.7	1.400	17.7	2.600	23.8	5.500	34.1	8.500	42.1
0.500	20.0	1.600	18.9	3.000	25.5	6.000	35.6	9.000	43.3
0.600	19.9	1.800	20.0	3.500	27.5	6.500	37.0	9.500	44.5

Hydro-Brake® Optimum Manhole: 25, DS/PN: 7.001, Volume (m³): 3.2

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0074-3400-2155-3400
Design Head (m)	2.155
Design Flow (l/s)	3.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	74
Invert Level (m)	36.900
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.155	3.4	Kick-Flo®	0.656	2.0
Flush-Flo™	0.319	2.5	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)	Depth (m)	Flow (l/s)
0.100	2.0	0.800	2.2	2.000	3.3	4.000	4.5	7.000	5.9
0.200	2.4	1.000	2.4	2.200	3.4	4.500	4.8	7.500	6.1
0.300	2.5	1.200	2.6	2.400	3.6	5.000	5.0	8.000	6.3
0.400	2.4	1.400	2.8	2.600	3.7	5.500	5.3	8.500	6.5
0.500	2.4	1.600	3.0	3.000	4.0	6.000	5.5	9.000	6.6
0.600	2.2	1.800	3.1	3.500	4.3	6.500	5.7	9.500	6.8

Hydro-Brake® Optimum Manhole: 29, DS/PN: 8.001, Volume (m³): 1.3

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0092-3600-0900-3600
Design Head (m)	0.900
Design Flow (l/s)	3.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	92
Invert Level (m)	39.024
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.900	3.6	Kick-Flo®	0.574	2.9
Flush-Flo™	0.267	3.6	Mean Flow over Head Range	-	3.1

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 29, DS/PN: 8.001, Volume (m³): 1.3

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	2.9	0.800	3.4	2.000	5.2	4.000	7.2	7.000	9.4
0.200	3.5	1.000	3.8	2.200	5.4	4.500	7.6	7.500	9.7
0.300	3.6	1.200	4.1	2.400	5.7	5.000	8.0	8.000	10.0
0.400	3.5	1.400	4.4	2.600	5.9	5.500	8.4	8.500	10.3
0.500	3.3	1.600	4.7	3.000	6.3	6.000	8.7	9.000	10.6
0.600	3.0	1.800	5.0	3.500	6.8	6.500	9.1	9.500	10.9

Hydro-Brake® Optimum Manhole: 31, DS/PN: 9.001, Volume (m³): 3.4

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0119-8900-2300-8900
Design Head (m)	2.300
Design Flow (l/s)	8.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	119
Invert Level (m)	38.100
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.300	8.9	Kick-Flo®	1.068	6.2
Flush-Flo™	0.524	7.8	Mean Flow over Head Range	-	7.2

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)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	7.5	2.000	8.3	4.000	11.6	7.000	15.1
0.200	6.7	1.000	6.7	2.200	8.7	4.500	12.2	7.500	15.6
0.300	7.4	1.200	6.6	2.400	9.1	5.000	12.9	8.000	16.1
0.400	7.7	1.400	7.0	2.600	9.4	5.500	13.5	8.500	16.6
0.500	7.8	1.600	7.5	3.000	10.1	6.000	14.0	9.000	17.0
0.600	7.8	1.800	7.9	3.500	10.9	6.500	14.6	9.500	17.5

Hydro-Brake® Optimum Manhole: 38, DS/PN: 11.001, Volume (m³): 3.3

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0108-7200-2200-7200
Design Head (m)	2.200
Design Flow (l/s)	7.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	108
Invert Level (m)	37.351
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.200	7.2	Kick-Flo®	0.963	4.9
Flush-Flo™	0.468	6.2	Mean Flow over Head Range	-	5.8

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 38, DS/PN: 11.001, Volume (m³): 3.3

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.7	0.800	5.7	2.000	6.9	4.000	9.5	7.000	12.4
0.200	5.5	1.000	5.0	2.200	7.2	4.500	10.1	7.500	12.9
0.300	6.0	1.200	5.4	2.400	7.5	5.000	10.6	8.000	13.3
0.400	6.1	1.400	5.8	2.600	7.8	5.500	11.1	8.500	13.7
0.500	6.2	1.600	6.2	3.000	8.3	6.000	11.6	9.000	14.0
0.600	6.1	1.800	6.6	3.500	9.0	6.500	12.0	9.500	14.4

Hydro-Brake® Optimum Manhole: 42, DS/PN: 13.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0118-6300-1000-6300
Design Head (m)	1.000
Design Flow (l/s)	6.3
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	118
Invert Level (m)	37.650
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.3	Kick-Flo®	0.652	5.2
Flush-Flo™	0.299	6.3	Mean Flow over Head Range	-	5.4

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)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	5.7	2.000	8.7	4.000	12.1	7.000	15.8
0.200	6.1	1.000	6.3	2.200	9.1	4.500	12.8	7.500	16.3
0.300	6.3	1.200	6.8	2.400	9.5	5.000	13.4	8.000	16.8
0.400	6.2	1.400	7.4	2.600	9.8	5.500	14.1	8.500	17.3
0.500	6.0	1.600	7.8	3.000	10.5	6.000	14.7	9.000	17.8
0.600	5.6	1.800	8.3	3.500	11.3	6.500	15.2	9.500	18.3

Hydro-Brake® Optimum Manhole: 8, DS/PN: 1.007, Volume (m³): 23.5

Flow control to restrict flows down hillside

Unit Reference	MD-SHE-0305-7500-4200-7500
Design Head (m)	4.200
Design Flow (l/s)	75.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	305
Invert Level (m)	35.137
Minimum Outlet Pipe Diameter (mm)	Site Specific Design (Contact Hydro International)
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	4.200	75.0	Kick-Flo®	2.489	58.2
Flush-Flo™	1.194	74.8	Mean Flow over Head Range	-	65.4

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 8, DS/PN: 1.007, Volume (m³): 23.5

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	9.3	0.800	72.7	2.000	69.7	4.000	73.2	7.000	96.1
0.200	31.3	1.000	74.4	2.200	66.3	4.500	77.5	7.500	99.4
0.300	53.5	1.200	74.8	2.400	61.2	5.000	81.6	8.000	102.5
0.400	62.0	1.400	74.5	2.600	59.4	5.500	85.4	8.500	105.6
0.500	66.0	1.600	73.5	3.000	63.7	6.000	89.1	9.000	108.6
0.600	69.0	1.800	72.0	3.500	68.6	6.500	92.7	9.500	111.5

Hydro-Brake® Optimum Manhole: 11, DS/PN: 1.010, Volume (m³): 3.1

Flow control for network outfall

Unit Reference	MD-SHE-0324-6550-1500-6550
Design Head (m)	1.500
Design Flow (l/s)	65.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	324
Invert Level (m)	30.000
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	65.5	Kick-Flo®	1.097	56.3
Flush-Flo™	0.542	65.5	Mean Flow over Head Range	-	54.8

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)	Depth (m)	Flow (l/s)
0.100	9.7	0.800	63.8	2.000	75.3	4.000	105.4	7.000	138.5
0.200	33.1	1.000	60.2	2.200	78.8	4.500	111.6	7.500	143.3
0.300	58.7	1.200	58.8	2.400	82.2	5.000	117.5	8.000	147.9
0.400	64.4	1.400	63.4	2.600	85.5	5.500	123.1	8.500	152.3
0.500	65.4	1.600	67.6	3.000	91.7	6.000	128.5	9.000	156.6
0.600	65.4	1.800	71.5	3.500	98.8	6.500	133.6	9.500	160.8

©1982-2020 Innovyze

Storage Structures for Storm

Tank or Pond Manhole: 2, DS/PN: 1.001

Invert Level (m) 41.500

Depth (m)	Area (m²)
0.000	215.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 14, DS/PN: 2.001

Invert Level (m) 40.500

Depth (m)	Area (m²)
0.000	350.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 16, DS/PN: 3.001

Invert Level (m) 40.100

Depth (m)	Area (m²)
0.000	200.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 18, DS/PN: 4.001

Invert Level (m) 39.306

Depth (m)	Area (m²)
0.000	160.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 20, DS/PN: 5.001

Invert Level (m) 40.500

Depth (m)	Area (m²)
0.000	181.5

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 25, DS/PN: 7.001

Invert Level (m) 38.448

Depth (m)	Area (m²)
0.000	100.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 29, DS/PN: 8.001

Invert Level (m) 39.024

Depth (m)	Area (m²)
0.000	80.0

Tank to indicatively represent Plot storage.

©1982-2020 Innovyze

Tank or Pond Manhole: 31, DS/PN: 9.001

Invert Level (m) 39.772

Depth (m)	Area (m²)
0.000	217.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 38, DS/PN: 11.001

Invert Level (m) 39.076

Depth (m)	Area (m²)
0.000	191.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 42, DS/PN: 13.001

Invert Level (m) 37.650

Depth (m)	Area (m²)
0.000	142.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 11, DS/PN: 1.010

Invert Level (m) 31.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	178.0	0.600	0.0	1.200	0.0	1.800	0.0	2.400	0.0
0.100	193.6	0.700	0.0	1.300	0.0	1.900	0.0	2.500	0.0
0.200	209.2	0.800	0.0	1.400	0.0	2.000	0.0		
0.300	224.8	0.900	0.0	1.500	0.0	2.100	0.0		
0.400	240.4	1.000	0.0	1.600	0.0	2.200	0.0		
0.500	256.0	1.100	0.0	1.700	0.0	2.300	0.0		

Tank to represent storage basin

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	13	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR	M5-60 (mm)	18.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R		0.357	Cv (Winter) 0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480
Return Period(s) (years)	100
Climate Change (%)	40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
1.000	1	120 Winter	100	+40%	100/15 Summer				41.942	0.366
1.001	2	120 Winter	100	+40%	100/15 Summer				41.942	0.417
1.002	3	360 Summer	100	+40%					41.317	-0.164
2.000	13	120 Winter	100	+40%	100/15 Summer				40.812	0.185
2.001	14	120 Winter	100	+40%	100/15 Summer				40.812	0.287
1.003	4	240 Summer	100	+40%					40.324	-0.215
3.000	15	120 Winter	100	+40%	100/15 Summer				40.447	0.297
3.001	16	120 Winter	100	+40%	100/15 Summer				40.447	0.397
1.004	5	360 Winter	100	+40%					39.606	-0.204
4.000	17	120 Winter	100	+40%	100/15 Summer				39.849	1.199
4.001	18	120 Winter	100	+40%	100/15 Summer				39.849	1.399
5.000	19	120 Winter	100	+40%	100/15 Summer				40.708	0.145
5.001	20	120 Winter	100	+40%	100/15 Summer				40.708	0.183
6.000	21	60 Winter	100	+40%					39.006	-0.094
6.001	22	60 Winter	100	+40%					39.005	-0.040
6.002	23	60 Winter	100	+40%	100/15 Summer				39.003	0.641
1.005	6	60 Winter	100	+40%	100/30 Summer				38.847	0.629
7.000	24	240 Winter	100	+40%	100/15 Summer				39.021	1.796
7.001	25	240 Winter	100	+40%	100/15 Summer				39.021	1.896
7.002	26	60 Winter	100	+40%	100/15 Summer				38.815	1.565
8.000	28	120 Winter	100	+40%					39.807	-0.066
8.001	29	120 Winter	100	+40%	100/15 Summer				39.807	0.633
7.003	27	60 Winter	100	+40%	100/15 Summer				38.812	2.077
1.006	7	60 Winter	100	+40%	100/15 Summer				38.803	2.690
9.000	30	120 Winter	100	+40%	100/15 Summer				40.448	1.798
9.001	31	120 Winter	100	+40%	100/15 Summer				40.449	2.199
10.000	35	15 Summer	100	+40%					40.106	-0.150
10.001	36	15 Winter	100	+40%					39.867	-0.076
9.002	32	60 Winter	100	+40%	100/15 Summer				38.832	1.576
11.000	37	120 Winter	100	+40%	100/15 Summer				39.704	2.047
11.001	38	120 Winter	100	+40%	100/15 Summer				39.704	2.128
12.000	39	15 Winter	100	+40%	100/15 Summer				39.103	0.015
12.001	40	15 Winter	100	+40%					38.932	-0.082
9.003	33	60 Winter	100	+40%	100/15 Summer				38.812	2.003

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	0.000	0.00			0.0	FLOOD RISK	
1.001	2	0.000	0.24			7.2	FLOOD RISK	
1.002	3	0.000	0.16			7.2	OK	
2.000	13	0.000	0.00			0.0	FLOOD RISK	
2.001	14	0.000	0.20			7.0	FLOOD RISK	
1.003	4	0.000	0.18			14.1	OK	
3.000	15	0.000	0.00			0.0	FLOOD RISK	
3.001	16	0.000	0.15			4.3	FLOOD RISK	
1.004	5	0.000	0.23			18.4	OK	
4.000	17	0.000	0.00			0.0	SURCHARGED	
4.001	18	0.000	0.12			5.0	SURCHARGED	
5.000	19	0.000	0.00			0.0	FLOOD RISK	
5.001	20	0.000	0.02			2.5	FLOOD RISK	
6.000	21	0.000	0.04			23.8	OK	
6.001	22	0.000	0.03			23.7	OK	
6.002	23	0.000	0.24			20.0	SURCHARGED	
1.005	6	0.000	0.33			45.4	SURCHARGED	
7.000	24	0.000	0.00			0.0	SURCHARGED	
7.001	25	0.000	0.08			3.3	SURCHARGED	
7.002	26	0.000	0.07			14.0	SURCHARGED	
8.000	28	0.000	0.00			0.0	FLOOD RISK	
8.001	29	0.000	0.05			3.6	FLOOD RISK	
7.003	27	0.000	0.10			23.3	SURCHARGED	
1.006	7	0.000	0.16			65.5	SURCHARGED	
9.000	30	0.000	0.00			0.0	SURCHARGED	
9.001	31	0.000	0.15			8.8	SURCHARGED	
10.000	35	0.000	0.00			0.0	OK	
10.001	36	0.000	0.48			21.6	OK	
9.002	32	0.000	0.25			19.1	SURCHARGED	
11.000	37	0.000	0.00			0.0	SURCHARGED	
11.001	38	0.000	0.24			7.2	SURCHARGED	
12.000	39	0.000	1.10			15.0	SURCHARGED	
12.001	40	0.000	0.41			15.2	OK	
9.003	33	0.000	0.11			29.9	SURCHARGED	

Any exceedance will flow down Plateau Road and pass into downstream permeable paving.

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
9.004	34	60 Winter	100	+40%	100/15 Summer				38.802	2.319
13.000	41	120 Winter	100	+40%	100/15 Summer				38.637	0.752
13.001	42	120 Winter	100	+40%	100/15 Summer				38.637	0.837
1.007	8	60 Winter	100	+40%	100/15 Summer				38.787	3.275
1.008	9	120 Summer	100	+40%					32.321	-0.265
1.009	10	480 Winter	100	+40%					31.436	-0.150
1.010	11	480 Winter	100	+40%	100/15 Summer				31.397	1.022
1.011	12	360 Winter	100	+40%					27.711	-0.170

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
9.004	34	0.000	0.15			25.4	SURCHARGED	
13.000	41	0.000	0.00			0.0	SURCHARGED	
13.001	42	0.000	0.19			6.3	SURCHARGED	
1.007	8	0.000	0.17			72.4	SURCHARGED	
1.008	9	0.000	0.19			72.9	OK	
1.009	10	0.000	0.54			72.9	OK	
1.010	11	0.000	0.23			65.5	FLOOD RISK	
1.011	12	0.000	0.71			86.2	OK	

©1982-2020 Innovyze

A4 Appendix 5 Catchment 5 surface network report

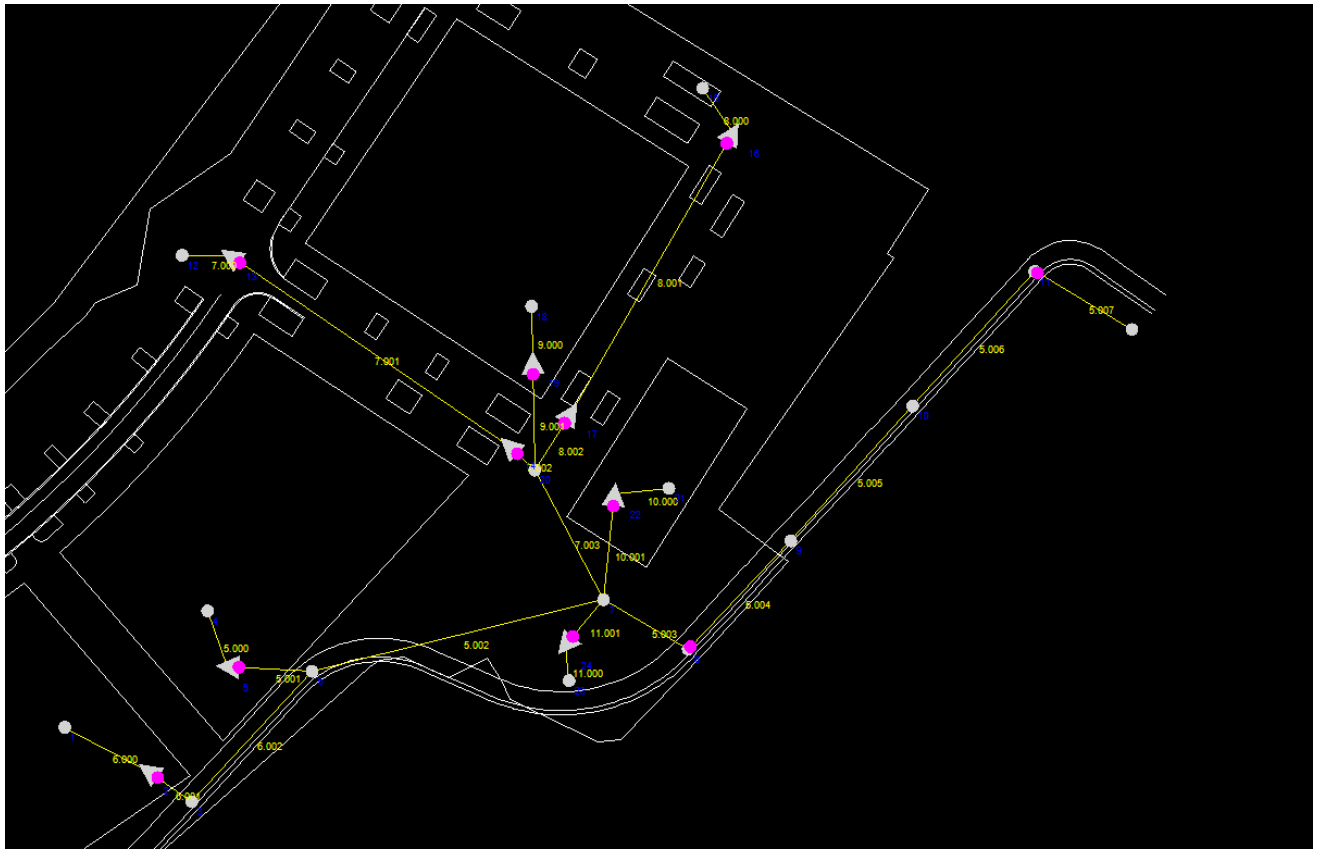


Figure 7 Catchment 5 model layout

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	40
Ratio R	0.357	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	150

Designed with Level Soffits

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
5.000	12.576	0.080	157.2	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
5.001	18.098	0.300	60.3	0.410	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.000	20.031	0.200	100.2	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
6.001	11.360	0.113	100.5	0.415	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.002	37.779	0.252	149.9	0.034	0.00	0.0	0.600	o	300	Pipe/Conduit	
5.002	63.874	0.386	165.5	0.045	0.00	0.0	0.600	o	375	Pipe/Conduit	
7.000	10.216	0.100	102.2	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
7.001	71.762	0.478	150.1	0.215	0.00	0.0	0.600	o	225	Pipe/Conduit	
7.002	7.570	0.076	99.6	0.139	0.00	0.0	0.600	o	225	Pipe/Conduit	
8.000	11.511	0.115	100.1	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
8.001	68.841	0.459	150.0	0.171	0.00	0.0	0.600	o	225	Pipe/Conduit	
8.002	14.379	0.144	99.9	0.129	0.00	0.0	0.600	o	225	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
5.000	45.61	5.26	39.778	0.000	0.0	0.0	0.0	0.80	14.1	0.0
5.001	45.07	5.41	39.548	0.410	0.0	0.0	20.0	2.03	143.3	70.1
6.000	45.35	5.33	39.963	0.000	0.0	0.0	0.0	1.00	17.7	0.0
6.001	44.91	5.45	39.613	0.415	0.0	0.0	20.2	1.57	110.8	70.6
6.002	43.24	5.94	39.500	0.448	0.0	0.0	21.0	1.28	90.6	73.5
5.002	40.91	6.70	39.173	0.904	0.0	0.0	40.1	1.41	155.3	140.2
7.000	26.58	15.17	42.475	0.000	0.0	0.0	0.0	0.99	17.6	0.0
7.001	25.53	16.29	42.300	0.215	0.0	0.0	6.0	1.06	42.3	20.8
7.002	25.44	16.39	41.822	0.355	0.0	0.0	9.8	1.31	52.1	34.2
8.000	26.56	15.19	42.490	0.000	0.0	0.0	0.0	1.00	17.7	0.0
8.001	25.55	16.27	42.300	0.171	0.0	0.0	4.7	1.07	42.4	16.6
8.002	25.39	16.45	41.841	0.300	0.0	0.0	8.3	1.31	52.0	28.9

©1982-2020 Innovyze

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
9.000	11.979	0.120	99.8	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
9.001	22.901	0.303	75.6	0.369	0.00	0.0	0.600	o	300	Pipe/Conduit	
7.003	31.225	1.488	21.0	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
10.000	11.653	0.117	99.6	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
10.001	22.543	0.300	75.1	0.237	0.00	0.0	0.600	o	225	Pipe/Conduit	
11.000	7.501	0.075	100.0	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
11.001	12.683	1.212	10.5	0.260	0.00	0.0	0.600	o	150	Pipe/Conduit	
5.003	20.862	0.298	70.0	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
5.004	31.740	0.212	149.7	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.005	38.687	0.258	149.9	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.006	38.687	0.258	149.9	0.026	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.007	24.121	0.500	48.2	0.024	0.00	0.0	0.600	o	450	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
9.000	45.85	5.20	40.923	0.000	0.0	0.0	0.0	1.01	17.8	0.0
9.001	45.07	5.41	40.653	0.369	0.0	0.0	18.0	1.81	128.0	63.0
7.003	25.25	16.60	40.350	1.023	0.0	0.0	28.0	3.45	243.7	98.0
10.000	45.87	5.19	40.420	0.000	0.0	0.0	0.0	1.01	17.8	0.0
10.001	44.96	5.44	40.228	0.237	0.0	0.0	11.5	1.51	60.0	40.3
11.000	46.13	5.12	41.500	0.000	0.0	0.0	0.0	1.00	17.8	0.0
11.001	45.87	5.19	41.425	0.260	0.0	0.0	12.9	3.13	55.4	45.3
5.003	25.12	16.76	38.787	2.424	0.0	0.0	65.9	2.17	239.5	230.8
5.004	24.84	17.08	38.414	2.424	0.0	0.0	65.9	1.66	263.9	230.8
5.005	24.52	17.47	36.728	2.424	0.0	0.0	65.9	1.66	263.7	230.8
5.006	24.21	17.86	34.996	2.450	0.0	0.0	65.9	1.66	263.7	230.8
5.007	24.10	18.00	33.265	2.474	0.0	0.0	65.9	2.93	466.5	230.8

©1982-2020 Innovyze

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
5.000	-	-	100	0.000	0.000	0.000
5.001	User	-	100	0.410	0.410	0.410
6.000	-	-	100	0.000	0.000	0.000
6.001	User	-	100	0.415	0.415	0.415
6.002	User	-	100	0.034	0.034	0.034
5.002	User	-	100	0.045	0.045	0.045
7.000	-	-	100	0.000	0.000	0.000
7.001	User	-	100	0.215	0.215	0.215
7.002	User	-	100	0.139	0.139	0.139
8.000	-	-	100	0.000	0.000	0.000
8.001	User	-	100	0.171	0.171	0.171
8.002	User	-	100	0.129	0.129	0.129
9.000	-	-	100	0.000	0.000	0.000
9.001	User	-	100	0.369	0.369	0.369
7.003	-	-	100	0.000	0.000	0.000
10.000	-	-	100	0.000	0.000	0.000
10.001	User	-	100	0.237	0.237	0.237
11.000	-	-	100	0.000	0.000	0.000
11.001	User	-	100	0.260	0.260	0.260
5.003	-	-	100	0.000	0.000	0.000
5.004	-	-	100	0.000	0.000	0.000
5.005	-	-	100	0.000	0.000	0.000
5.006	User	-	100	0.026	0.026	0.026
5.007	User	-	100	0.024	0.024	0.024
				Total	Total	Total
				2.474	2.474	2.474

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
5.007		33.500	32.765	29.500	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs 0	Number of Offline Controls 0	Number of Time/Area Diagrams 0
Number of Online Controls 11	Number of Storage Structures 9	Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.357		

©1982-2020 Innovyze

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 5, DS/PN: 5.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0139-9000-1000-9000
Design Head (m)	1.000
Design Flow (l/s)	9.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	139
Invert Level (m)	39.548
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	9.0	Kick-Flo®	0.668	7.5
Flush-Flo™	0.301	9.0	Mean Flow over Head Range	-	7.7

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)	Depth (m)	Flow (l/s)
0.100	5.0	0.800	8.1	2.000	12.5	4.000	17.4	7.000	22.7
0.200	8.7	1.000	9.0	2.200	13.1	4.500	18.4	7.500	23.5
0.300	9.0	1.200	9.8	2.400	13.6	5.000	19.3	8.000	24.2
0.400	8.9	1.400	10.5	2.600	14.1	5.500	20.2	8.500	24.9
0.500	8.6	1.600	11.2	3.000	15.1	6.000	21.1	9.000	25.6
0.600	8.2	1.800	11.9	3.500	16.3	6.500	21.9	9.500	26.3

Hydro-Brake® Optimum Manhole: 2, DS/PN: 6.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0132-9100-1500-9100
Design Head (m)	1.500
Design Flow (l/s)	9.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	132
Invert Level (m)	39.613
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	9.1	Kick-Flo®	0.931	7.3
Flush-Flo™	0.443	9.1	Mean Flow over Head Range	-	7.9

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.8	0.600	9.0	1.600	9.4	2.600	11.8	5.000	16.1
0.200	8.2	0.800	8.3	1.800	9.9	3.000	12.6	5.500	16.9
0.300	8.9	1.000	7.5	2.000	10.4	3.500	13.6	6.000	17.6
0.400	9.1	1.200	8.2	2.200	10.9	4.000	14.5	6.500	18.3
0.500	9.1	1.400	8.8	2.400	11.4	4.500	15.3	7.000	18.9

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 2, DS/PN: 6.001, Volume (m³): 3.0

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
7.500	19.6	8.000	20.2	8.500	20.8	9.000	21.3	9.500	21.9

Hydro-Brake® Optimum Manhole: 13, DS/PN: 7.001, Volume (m³): 1.0

Flow control for permeable paving

Unit Reference	MD-SHE-0111-5100-0700-5100
Design Head (m)	0.700
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	111
Invert Level (m)	42.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	5.1	Kick-Flo®	0.482	4.3
Flush-Flo™	0.214	5.1	Mean Flow over Head Range	-	4.3

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)	Depth (m)	Flow (l/s)
0.100	3.8	0.800	5.4	2.000	8.3	4.000	11.6	7.000	15.1
0.200	5.1	1.000	6.0	2.200	8.7	4.500	12.2	7.500	15.6
0.300	5.0	1.200	6.6	2.400	9.1	5.000	12.9	8.000	16.1
0.400	4.8	1.400	7.0	2.600	9.4	5.500	13.5	8.500	16.6
0.500	4.4	1.600	7.5	3.000	10.1	6.000	14.0	9.000	17.1
0.600	4.7	1.800	7.9	3.500	10.9	6.500	14.6	9.500	17.6

Hydro-Brake® Optimum Manhole: 14, DS/PN: 7.002, Volume (m³): 4.1

Flow control for permeable paving

Unit Reference	MD-SHE-0132-8400-1200-8400
Design Head (m)	1.200
Design Flow (l/s)	8.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	132
Invert Level (m)	41.822
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	8.4	Kick-Flo®	0.768	6.8
Flush-Flo™	0.357	8.4	Mean Flow over Head Range	-	7.3

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)	Depth (m)	Flow (l/s)
0.100	4.7	0.300	8.3	0.500	8.2	0.800	6.9	1.200	8.4
0.200	7.9	0.400	8.4	0.600	8.0	1.000	7.7	1.400	9.0

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 14, DS/PN: 7.002, Volume (m³): 4.1

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
1.600	9.6	2.400	11.6	4.000	14.8	6.000	18.0	8.000	20.7
1.800	10.2	2.600	12.1	4.500	15.7	6.500	18.7	8.500	21.3
2.000	10.7	3.000	12.9	5.000	16.5	7.000	19.4	9.000	21.9
2.200	11.2	3.500	13.9	5.500	17.3	7.500	20.1	9.500	22.5

Hydro-Brake® Optimum Manhole: 16, DS/PN: 8.001, Volume (m³): 1.0

Flow control for permeable paving

Unit Reference	MD-SHE-0097-3800-0700-3800
Design Head (m)	0.700
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	97
Invert Level (m)	42.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	3.8	Kick-Flo®	0.469	3.2
Flush-Flo™	0.210	3.8	Mean Flow over Head Range	-	3.3

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)	Depth (m)	Flow (l/s)
0.100	3.1	0.800	4.0	2.000	6.2	4.000	8.6	7.000	11.2
0.200	3.8	1.000	4.5	2.200	6.5	4.500	9.1	7.500	11.5
0.300	3.7	1.200	4.9	2.400	6.7	5.000	9.5	8.000	11.9
0.400	3.5	1.400	5.2	2.600	7.0	5.500	10.0	8.500	12.3
0.500	3.3	1.600	5.6	3.000	7.5	6.000	10.4	9.000	12.6
0.600	3.5	1.800	5.9	3.500	8.0	6.500	10.8	9.500	13.0

Hydro-Brake® Optimum Manhole: 17, DS/PN: 8.002, Volume (m³): 4.0

Flow control for permeable paving

Unit Reference	MD-SHE-0120-6900-1200-6900
Design Head (m)	1.200
Design Flow (l/s)	6.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	120
Invert Level (m)	41.841
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	6.9	Kick-Flo®	0.760	5.6
Flush-Flo™	0.356	6.9	Mean Flow over Head Range	-	6.0

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 17, DS/PN: 8.002, Volume (m³): 4.0

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	5.7	2.000	8.8	4.000	12.2	7.000	15.9
0.200	6.5	1.000	6.3	2.200	9.2	4.500	12.9	7.500	16.4
0.300	6.9	1.200	6.9	2.400	9.5	5.000	13.5	8.000	16.9
0.400	6.9	1.400	7.4	2.600	9.9	5.500	14.2	8.500	17.4
0.500	6.8	1.600	7.9	3.000	10.6	6.000	14.8	9.000	17.9
0.600	6.5	1.800	8.3	3.500	11.4	6.500	15.3	9.500	18.4

Hydro-Brake® Optimum Manhole: 19, DS/PN: 9.001, Volume (m³): 2.8

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0125-8100-1500-8100
Design Head (m)	1.500
Design Flow (l/s)	8.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	125
Invert Level (m)	40.803
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	8.1	Kick-Flo®	0.922	6.4
Flush-Flo™	0.437	8.1	Mean Flow over Head Range	-	7.1

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)	Depth (m)	Flow (l/s)
0.100	4.5	0.800	7.3	2.000	9.3	4.000	12.9	7.000	16.8
0.200	7.3	1.000	6.7	2.200	9.7	4.500	13.6	7.500	17.4
0.300	7.9	1.200	7.3	2.400	10.1	5.000	14.3	8.000	17.9
0.400	8.1	1.400	7.8	2.600	10.5	5.500	15.0	8.500	18.5
0.500	8.1	1.600	8.3	3.000	11.2	6.000	15.6	9.000	19.0
0.600	7.9	1.800	8.8	3.500	12.1	6.500	16.2	9.500	19.5

Hydro-Brake® Optimum Manhole: 22, DS/PN: 10.001, Volume (m³): 3.3

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0108-5200-1000-5200
Design Head (m)	1.000
Design Flow (l/s)	5.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	108
Invert Level (m)	40.230
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.2	Kick-Flo®	0.641	4.2
Flush-Flo™	0.296	5.2	Mean Flow over Head Range	-	4.5

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 22, DS/PN: 10.001, Volume (m³): 3.3

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.7	0.800	4.7	2.000	7.2	4.000	10.0	7.000	13.0
0.200	5.1	1.000	5.2	2.200	7.5	4.500	10.5	7.500	13.4
0.300	5.2	1.200	5.7	2.400	7.8	5.000	11.1	8.000	13.9
0.400	5.1	1.400	6.1	2.600	8.1	5.500	11.6	8.500	14.3
0.500	4.9	1.600	6.5	3.000	8.7	6.000	12.1	9.000	14.7
0.600	4.5	1.800	6.8	3.500	9.4	6.500	12.6	9.500	15.1

Hydro-Brake® Optimum Manhole: 24, DS/PN: 11.001, Volume (m³): 1.3

Flow control for permeable paving

Unit Reference	MD-SHE-0119-6500-1000-6500
Design Head (m)	1.000
Design Flow (l/s)	6.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	119
Invert Level (m)	41.425
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.5	Kick-Flo®	0.649	5.3
Flush-Flo™	0.296	6.5	Mean Flow over Head Range	-	5.6

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)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	5.9	2.000	9.0	4.000	12.5	7.000	16.3
0.200	6.3	1.000	6.5	2.200	9.4	4.500	13.2	7.500	16.9
0.300	6.5	1.200	7.1	2.400	9.8	5.000	13.9	8.000	17.4
0.400	6.4	1.400	7.6	2.600	10.2	5.500	14.5	8.500	17.9
0.500	6.2	1.600	8.1	3.000	10.9	6.000	15.2	9.000	18.4
0.600	5.8	1.800	8.6	3.500	11.7	6.500	15.7	9.500	18.9

Hydro-Brake® Optimum Manhole: 8, DS/PN: 5.004, Volume (m³): 8.2

Flow control to restrict flows down hillside

Unit Reference	MD-SHE-0267-4750-2484-4750
Design Head (m)	2.484
Design Flow (l/s)	47.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	267
Invert Level (m)	38.414
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.484	47.3	Kick-Flo®	1.561	37.8
Flush-Flo™	0.727	47.2	Mean Flow over Head Range	-	41.0

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 8, DS/PN: 5.004, Volume (m³): 8.2

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.5	0.800	47.1	2.000	42.6	4.000	59.5	7.000	78.1
0.200	27.5	1.000	46.4	2.200	44.6	4.500	63.0	7.500	80.7
0.300	41.6	1.200	44.9	2.400	46.5	5.000	66.3	8.000	83.3
0.400	44.5	1.400	42.1	2.600	48.3	5.500	69.4	8.500	85.8
0.500	46.1	1.600	38.3	3.000	51.8	6.000	72.4	9.000	88.2
0.600	46.9	1.800	40.5	3.500	55.8	6.500	75.3	9.500	90.6

Hydro-Brake® Optimum Manhole: 11, DS/PN: 5.007, Volume (m³): 9.1

Flow control for network outfall

Unit Reference	MD-SHE-0299-5600-1808-5600
Design Head (m)	1.808
Design Flow (l/s)	56.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	299
Invert Level (m)	33.265
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.808	56.0	Kick-Flo®	1.248	46.8
Flush-Flo™	0.575	56.0	Mean Flow over Head Range	-	47.8

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)	Depth (m)	Flow (l/s)
0.100	9.2	0.800	55.1	2.000	58.8	4.000	82.2	7.000	107.9
0.200	30.8	1.000	53.2	2.200	61.5	4.500	87.0	7.500	111.6
0.300	52.2	1.200	48.8	2.400	64.2	5.000	91.6	8.000	115.2
0.400	54.7	1.400	49.5	2.600	66.7	5.500	96.0	8.500	118.7
0.500	55.8	1.600	52.8	3.000	71.5	6.000	100.1	9.000	122.0
0.600	56.0	1.800	55.8	3.500	77.0	6.500	104.1	9.500	125.3

©1982-2020 Innovyze

Storage Structures for Storm

Tank or Pond Manhole: 5, DS/PN: 5.001

Invert Level (m) 39.548

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	180.0	1.000	180.0	1.001	0.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 2, DS/PN: 6.001

Invert Level (m) 39.613

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	170.0	1.000	170.0	1.001	0.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 13, DS/PN: 7.001

Invert Level (m) 42.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	225.0	0.500	225.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 14, DS/PN: 7.002

Invert Level (m) 42.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	62.5	0.500	62.5

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 16, DS/PN: 8.001

Invert Level (m) 42.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	175.0	0.500	175.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 17, DS/PN: 8.002

Invert Level (m) 42.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	62.5	0.500	62.5

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 19, DS/PN: 9.001

Invert Level (m) 40.728

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	150.0	1.000	150.0	1.001	0.0

Tank to indicatively represent Plot storage.

©1982-2020 Innovyze

Tank or Pond Manhole: 22, DS/PN: 10.001

Invert Level (m) 40.230

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	180.0	1.000	180.0	1.001	0.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 24, DS/PN: 11.001

Invert Level (m) 42.000

Depth (m)	Area (m²)
0.000	255.0

Tank to represent 0.5m deep permeable paving

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	11	Number of Storage Structures	9	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR M5-60 (mm)	18.000	Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.357	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	100
Climate Change (%)	40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
5.000	4	240 Winter	100	+40%	100/15 Summer				41.677	1.749
5.001	5	240 Winter	100	+40%	100/15 Summer				41.677	1.829
6.000	1	240 Winter	100	+40%	100/15 Winter				41.942	1.829
6.001	2	240 Winter	100	+40%	100/15 Summer				41.942	2.029
6.002	3	240 Winter	100	+40%	100/15 Summer				40.868	1.068
5.002	6	240 Winter	100	+40%	100/15 Summer				40.856	1.308
7.000	12	120 Winter	100	+40%	100/15 Summer				42.939	0.314
7.001	13	120 Winter	100	+40%	100/15 Summer				42.939	0.414
7.002	14	60 Winter	100	+40%	100/15 Summer				42.939	0.892
8.000	15	120 Winter	100	+40%	100/15 Summer				42.951	0.311
8.001	16	120 Winter	100	+40%	100/15 Summer				42.952	0.427
8.002	17	60 Winter	100	+40%	100/15 Summer				42.937	0.871
9.000	18	240 Winter	100	+40%	100/15 Summer				42.365	1.292
9.001	19	240 Winter	100	+40%	100/15 Summer				42.365	1.412
7.003	20	240 Winter	100	+40%	100/120 Winter				40.866	0.216
10.000	21	240 Winter	100	+40%	100/30 Summer				40.868	0.298
10.001	22	240 Winter	100	+40%	100/15 Summer				40.868	0.415
11.000	23	120 Winter	100	+40%	100/15 Summer				42.350	0.700
11.001	24	120 Winter	100	+40%	100/15 Summer				42.350	0.775
5.003	7	240 Winter	100	+40%	100/15 Summer				40.839	1.677
5.004	8	240 Winter	100	+40%	100/15 Summer				40.811	1.947
5.005	9	360 Winter	100	+40%					36.865	-0.313
5.006	10	15 Winter	100	+40%					35.152	-0.294
5.007	11	30 Winter	100	+40%	100/15 Summer				35.081	1.366

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
5.000	4	0.000	0.10			1.3	SURCHARGED	
5.001	5	0.000	0.07			9.0	SURCHARGED	
6.000	1	0.000	0.08			1.3	FLOOD RISK	
6.001	2	0.000	0.11			9.1	FLOOD RISK	

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
6.002	3	0.000	0.14			12.0	SURCHARGED	
5.002	6	0.000	0.16			22.9	SURCHARGED	
7.000	12	0.000	0.00			0.0	FLOOD RISK	
7.001	13	0.000	0.12			5.1	FLOOD RISK	
7.002	14	0.000	0.22			8.4	FLOOD RISK	
8.000	15	0.000	0.00			0.0	FLOOD RISK	
8.001	16	0.000	0.09			3.8	FLOOD RISK	
8.002	17	0.000	0.15			6.9	FLOOD RISK	
9.000	18	0.000	0.06			0.9	SURCHARGED	
9.001	19	0.000	0.07			8.2	SURCHARGED	
7.003	20	0.000	0.10			22.6	SURCHARGED	
10.000	21	0.000	0.00			0.0	SURCHARGED	
10.001	22	0.000	0.09			5.2	SURCHARGED	
11.000	23	0.000	0.00			0.0	FLOOD RISK	
11.001	24	0.000	0.13			6.5	FLOOD RISK	
5.003	7	0.000	0.24			48.5	SURCHARGED	
5.004	8	0.000	0.21			47.2	SURCHARGED	
5.005	9	0.000	0.20			47.2	OK	
5.006	10	0.000	0.26			60.5	OK	
5.007	11	0.000	0.14			56.1	SURCHARGED	

©1982-2020 Innovyze

A2 Appendix 2 Catchment 1 (south) surface network report

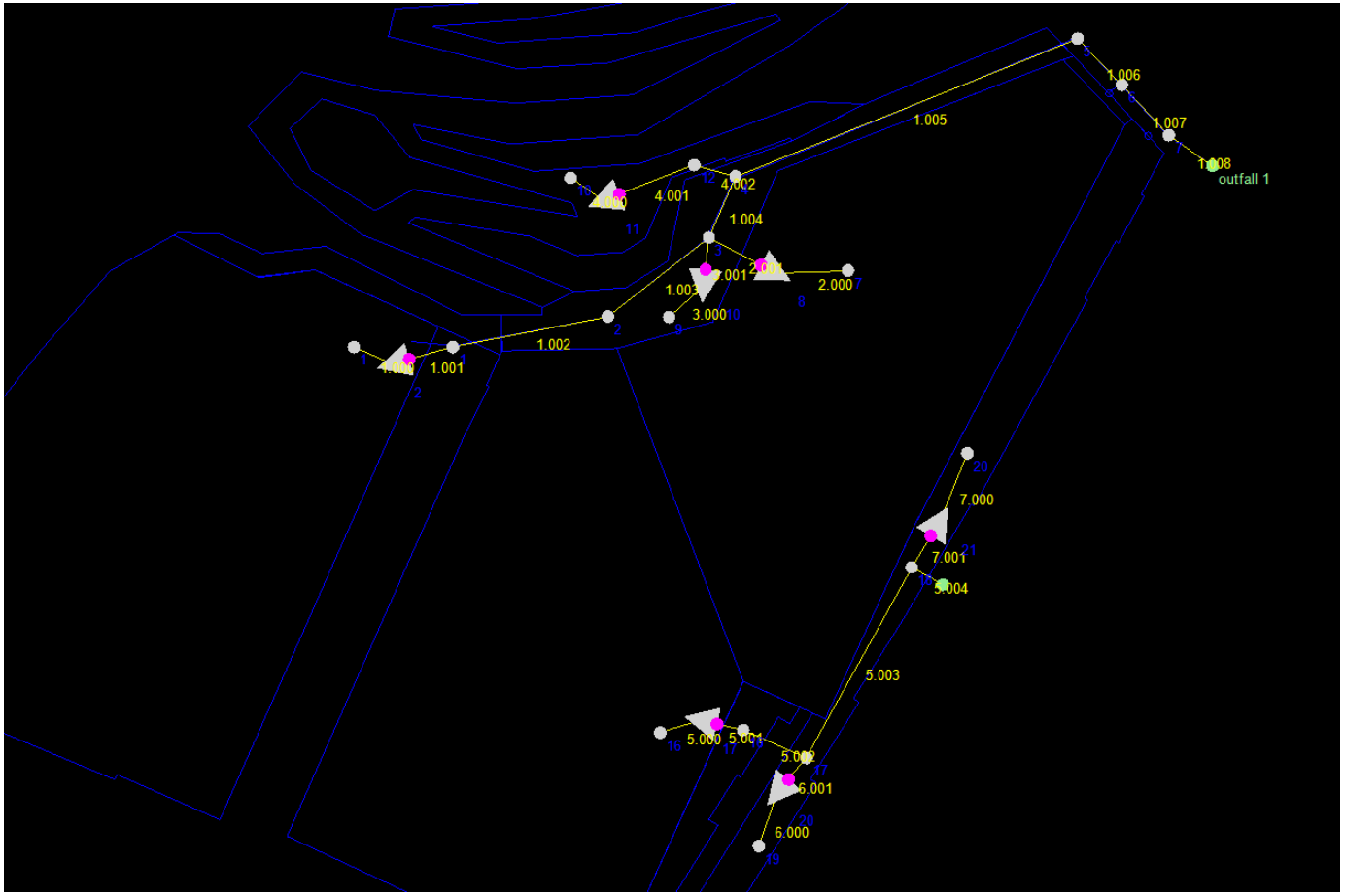


Figure 5 Catchment 1 south model layout

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

« - Indicates pipe capacity < flow

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	6.260	0.063	99.4	0.434	5.00	0.0	0.600	o	300	Pipe/Conduit	
1.001	9.161	0.092	99.6	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.002	23.298	0.155	150.3	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.003	18.884	0.126	149.9	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
2.000	10.645	0.106	100.4	0.294	5.00	0.0	0.600	o	300	Pipe/Conduit	
2.001	11.157	0.112	99.6	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
3.000	6.836	0.068	100.5	0.109	5.00	0.0	0.600	o	225	Pipe/Conduit	
3.001	7.213	0.072	100.2	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.004	9.849	0.066	149.2	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
4.000	5.890	0.075	78.5	0.127	5.00	0.0	0.600	o	150	Pipe/Conduit	
4.001	14.346	0.359	40.0	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
4.002	6.318	0.158	40.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.005	54.338	0.362	150.1	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
1.006	9.441	0.063	149.9	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Dummy pipe upstream of attenuation tank

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	46.55	5.07	28.655	0.434	0.0	0.0	0.0	1.58	111.5	54.7
1.001	46.10	5.18	28.592	0.434	0.0	0.0	0.0	1.31	52.1«	54.7
1.002	44.76	5.55	28.500	0.434	0.0	0.0	0.0	1.06	42.3«	54.7
1.003	43.75	5.84	28.345	0.434	0.0	0.0	0.0	1.07	42.4«	54.7
2.000	46.36	5.11	28.437	0.294	0.0	0.0	0.0	1.57	110.9	36.9
2.001	45.83	5.26	28.331	0.294	0.0	0.0	0.0	1.31	52.1	36.9
3.000	46.46	5.09	30.500	0.109	0.0	0.0	0.0	1.30	51.8	13.7
3.001	46.11	5.18	30.432	0.109	0.0	0.0	0.0	1.31	51.9	13.7
1.004	43.24	6.00	28.219	0.836	0.0	0.0	0.0	1.07	42.5«	97.9
4.000	46.47	5.09	31.875	0.127	0.0	0.0	0.0	1.14	20.1	16.0
4.001	45.90	5.24	30.800	0.127	0.0	0.0	0.0	1.60	28.2	16.0
4.002	45.71	5.29	29.941	0.127	0.0	0.0	0.0	2.07	82.5	16.0
1.005	40.66	6.85	28.153	0.963	0.0	0.0	0.0	1.06	42.3«	106.1
1.006	40.31	6.97	27.791	0.963	0.0	0.0	0.0	1.28	90.6«	106.1

©1982-2020 Innovyze

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.007	10.124	0.067	151.1	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
1.008	7.860	0.052	151.2	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
5.000	6.202	0.041	151.3	0.426	5.00	0.0	0.600	o	300	Pipe/Conduit	
5.001	6.459	0.043	150.2	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
5.002	10.188	0.068	149.8	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.000	8.345	0.083	100.5	0.065	5.00	0.0	0.600	o	150	Pipe/Conduit	
6.001	6.617	0.066	100.3	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
5.003	32.070	0.214	149.9	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	
7.000	10.856	0.186	58.4	0.054	5.00	0.0	0.600	o	150	Pipe/Conduit	
7.001	7.929	0.136	58.3	0.000	0.00	0.0	0.600	o	150	Pipe/Conduit	
5.004	5.255	0.053	99.2	0.000	0.00	0.0	0.600	o	300	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.007	39.95	7.10	27.653	0.963	0.0	0.0	0.0	1.28	90.2«	106.1
1.008	39.67	7.20	27.586	0.963	0.0	0.0	0.0	1.28	90.2«	106.1
5.000	46.49	5.08	27.584	0.426	0.0	0.0	0.0	1.28	90.2	53.7
5.001	46.17	5.17	27.543	0.426	0.0	0.0	0.0	1.28	90.5	53.7
5.002	45.67	5.30	27.500	0.426	0.0	0.0	0.0	1.28	90.6	53.7
6.000	46.27	5.14	28.950	0.065	0.0	0.0	0.0	1.00	17.7	8.1
6.001	45.85	5.25	28.867	0.065	0.0	0.0	0.0	1.00	17.7	8.1
5.003	44.18	5.71	27.432	0.491	0.0	0.0	0.0	1.28	90.6	58.7
7.000	46.27	5.14	30.186	0.054	0.0	0.0	0.0	1.32	23.3	6.7
7.001	45.89	5.24	30.000	0.054	0.0	0.0	0.0	1.32	23.3	6.7
5.004	43.99	5.77	27.218	0.545	0.0	0.0	0.0	1.58	111.6	64.9

©1982-2020 Innovyze

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	User	-	100	0.434	0.434	0.434
1.001	-	-	100	0.000	0.000	0.000
1.002	-	-	100	0.000	0.000	0.000
1.003	-	-	100	0.000	0.000	0.000
2.000	User	-	100	0.294	0.294	0.294
2.001	-	-	100	0.000	0.000	0.000
3.000	User	-	100	0.099	0.099	0.099
	User	-	100	0.010	0.010	0.109
3.001	-	-	100	0.000	0.000	0.000
1.004	-	-	100	0.000	0.000	0.000
4.000	User	-	100	0.127	0.127	0.127
4.001	-	-	100	0.000	0.000	0.000
4.002	-	-	100	0.000	0.000	0.000
1.005	-	-	100	0.000	0.000	0.000
1.006	-	-	100	0.000	0.000	0.000
1.007	-	-	100	0.000	0.000	0.000
1.008	-	-	100	0.000	0.000	0.000
5.000	User	-	100	0.426	0.426	0.426
5.001	-	-	100	0.000	0.000	0.000
5.002	-	-	100	0.000	0.000	0.000
6.000	User	-	100	0.065	0.065	0.065
6.001	-	-	100	0.000	0.000	0.000
5.003	-	-	100	0.000	0.000	0.000
7.000	User	-	100	0.054	0.054	0.054
7.001	-	-	100	0.000	0.000	0.000
5.004	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				1.508	1.508	1.508

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.008	outfall 1	31.000	27.534	0.000	0	0

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
5.004		30.500	27.165	0.000	0	0

©1982-2020 Innovyze

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Storage Structures	7
Number of Online Controls	7	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.360		

©1982-2020 Innovyze

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 2, DS/PN: 1.001, Volume (m³): 3.1

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0125-9500-2184-9500
Design Head (m)	2.184
Design Flow (l/s)	9.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	125
Invert Level (m)	28.592
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.184	9.5
Flush-Flo™	0.547	8.7
Kick-Flo®	1.118	6.9
Mean Flow over Head Range	-	7.9

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.5	1.200	7.2	3.000	11.0	7.000	16.5
0.200	7.4	1.400	7.7	3.500	11.9	7.500	17.1
0.300	8.2	1.600	8.2	4.000	12.6	8.000	17.6
0.400	8.6	1.800	8.7	4.500	13.4	8.500	18.1
0.500	8.7	2.000	9.1	5.000	14.1	9.000	18.6
0.600	8.7	2.200	9.5	5.500	14.7	9.500	19.1
0.800	8.5	2.400	9.9	6.000	15.3		
1.000	7.8	2.600	10.3	6.500	15.9		

Hydro-Brake® Optimum Manhole: 8, DS/PN: 2.001, Volume (m³): 3.7

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0100-6500-2401-6500
Design Head (m)	2.401
Design Flow (l/s)	6.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	100
Invert Level (m)	28.331
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 8, DS/PN: 2.001, Volume (m³): 3.7

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.401	6.5
Flush-Flo™	0.437	5.2
Kick-Flo®	0.896	4.1
Mean Flow over Head Range	-	5.1

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	3.3	1.200	4.7	3.000	7.2	7.000	10.8
0.200	4.7	1.400	5.1	3.500	7.8	7.500	11.1
0.300	5.0	1.600	5.4	4.000	8.3	8.000	11.5
0.400	5.2	1.800	5.7	4.500	8.7	8.500	11.8
0.500	5.1	2.000	6.0	5.000	9.2	9.000	12.1
0.600	5.1	2.200	6.2	5.500	9.6	9.500	12.5
0.800	4.6	2.400	6.5	6.000	10.0		
1.000	4.3	2.600	6.7	6.500	10.4		

Hydro-Brake® Optimum Manhole: 10, DS/PN: 3.001, Volume (m³): 0.9

Flow control for permeable paving

Unit Reference	MD-SHE-0081-2400-0500-2400
Design Head (m)	0.500
Design Flow (l/s)	2.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	81
Invert Level (m)	30.432
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	2.4
Flush-Flo™	0.151	2.4
Kick-Flo®	0.349	2.0
Mean Flow over Head Range	-	2.0

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	0.300	2.2	0.500	2.4	0.800	3.0
0.200	2.4	0.400	2.2	0.600	2.6	1.000	3.3

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 10, DS/PN: 3.001, Volume (m³): 0.9

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
1.200	3.6	2.400	4.9	5.000	7.0	8.000	8.8
1.400	3.9	2.600	5.1	5.500	7.3	8.500	9.1
1.600	4.1	3.000	5.5	6.000	7.6	9.000	9.4
1.800	4.3	3.500	5.9	6.500	7.9	9.500	9.6
2.000	4.5	4.000	6.3	7.000	8.3		
2.200	4.8	4.500	6.7	7.500	8.5		

Hydro-Brake® Optimum Manhole: 11, DS/PN: 4.001, Volume (m³): 2.6

Flow control for attenuation tank

Unit Reference	MD-SHE-0083-2800-0800-2800
Design Head (m)	0.800
Design Flow (l/s)	2.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	83
Invert Level (m)	31.800
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	2.8
Flush-Flo™	0.238	2.8
Kick-Flo®	0.514	2.3
Mean Flow over Head Range	-	2.4

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	2.4	1.200	3.4	3.000	5.2	7.000	7.7
0.200	2.8	1.400	3.6	3.500	5.5	7.500	8.0
0.300	2.8	1.600	3.9	4.000	5.9	8.000	8.2
0.400	2.7	1.800	4.1	4.500	6.2	8.500	8.4
0.500	2.4	2.000	4.3	5.000	6.6	9.000	8.7
0.600	2.5	2.200	4.5	5.500	6.9	9.500	8.9
0.800	2.8	2.400	4.7	6.000	7.2		
1.000	3.1	2.600	4.8	6.500	7.4		

Hydro-Brake® Optimum Manhole: 17, DS/PN: 5.001, Volume (m³): 4.3

Unit Reference	MD-SHE-0142-9400-1000-9400
Design Head (m)	1.000
Design Flow (l/s)	9.4
Flush-Flo™	Calculated

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 17, DS/PN: 5.001, Volume (m³): 4.3

Flow control to represent flow from Plot

Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	142
Invert Level (m)	27.543
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	9.4
Flush-Flo™	0.302	9.4
Kick-Flo®	0.672	7.8
Mean Flow over Head Range	-	8.1

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	5.1	1.200	10.2	3.000	15.8	7.000	23.7
0.200	9.1	1.400	11.0	3.500	17.0	7.500	24.5
0.300	9.4	1.600	11.7	4.000	18.1	8.000	25.3
0.400	9.3	1.800	12.4	4.500	19.2	8.500	26.1
0.500	9.0	2.000	13.0	5.000	20.2	9.000	26.8
0.600	8.6	2.200	13.6	5.500	21.1	9.500	27.5
0.800	8.5	2.400	14.2	6.000	22.0		
1.000	9.4	2.600	14.8	6.500	22.9		

Hydro-Brake® Optimum Manhole: 20, DS/PN: 6.001, Volume (m³): 0.8

Flow control for permeable paving

Unit Reference	MD-SHE-0063-1400-0500-1400
Design Head (m)	0.500
Design Flow (l/s)	1.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	63
Invert Level (m)	28.867
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	1.4
Flush-Flo™	0.148	1.4
Kick-Flo®	0.334	1.2
Mean Flow over Head Range	-	1.2

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 20, DS/PN: 6.001, Volume (m³): 0.8

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	1.4	1.200	2.1	3.000	3.2	7.000	4.7
0.200	1.4	1.400	2.2	3.500	3.4	7.500	4.9
0.300	1.3	1.600	2.4	4.000	3.6	8.000	5.1
0.400	1.3	1.800	2.5	4.500	3.8	8.500	5.2
0.500	1.4	2.000	2.6	5.000	4.0	9.000	5.4
0.600	1.5	2.200	2.7	5.500	4.2	9.500	5.5
0.800	1.7	2.400	2.9	6.000	4.4		
1.000	1.9	2.600	3.0	6.500	4.6		

Hydro-Brake® Optimum Manhole: 21, DS/PN: 7.001, Volume (m³): 0.7

Flow control for permeable paving

Unit Reference	MD-SHE-0058-1200-0500-1200
Design Head (m)	0.500
Design Flow (l/s)	1.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	58
Invert Level (m)	30.000
Minimum Outlet Pipe Diameter (mm)	75
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.500	1.2
Flush-Flo™	0.148	1.2
Kick-Flo®	0.331	1.0
Mean Flow over Head Range	-	1.0

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	1.2	1.200	1.8	3.000	2.7	7.000	4.1
0.200	1.2	1.400	1.9	3.500	2.9	7.500	4.2
0.300	1.1	1.600	2.0	4.000	3.1	8.000	4.3
0.400	1.1	1.800	2.1	4.500	3.3	8.500	4.5
0.500	1.2	2.000	2.2	5.000	3.4	9.000	4.6
0.600	1.3	2.200	2.3	5.500	3.6	9.500	4.7
0.800	1.5	2.400	2.4	6.000	3.8		
1.000	1.6	2.600	2.5	6.500	3.9		

©1982-2020 Innovyze

Storage Structures for Storm

Tank or Pond Manhole: 2, DS/PN: 1.001

Invert Level (m) 30.000

Tank to indicatively represent Plot storage.

Depth (m)	Area (m²)
0.000	200.0

Tank or Pond Manhole: 8, DS/PN: 2.001

Invert Level (m) 30.000

Tank to indicatively represent Plot storage.

Depth (m)	Area (m²)
0.000	140.0

Tank or Pond Manhole: 10, DS/PN: 3.001

Invert Level (m) 30.432

Tank to represent 0.5m deep permeable paving

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	118.0	0.500	118.0

Tank or Pond Manhole: 11, DS/PN: 4.001

Tank to represent 0.8m deep attenuation tank.

Invert Level (m) 31.800

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	68.4	0.800	68.4	0.801	0.0

Tank or Pond Manhole: 17, DS/PN: 5.001

Invert Level (m) 27.543

Tank to indicatively represent Plot storage.

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	200.0	1.000	200.0

Tank or Pond Manhole: 20, DS/PN: 6.001

Invert Level (m) 28.867

Tank to represent 0.5m deep permeable paving

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	59.0	0.500	59.0

©1982-2020 Innovyze

Tank or Pond Manhole: 21, DS/PN: 7.001

Invert Level (m) 30.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	119.0	0.500	119.0

Tank to represent 0.5m deep permeable paving

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Storage Structures	7
Number of Online Controls	7	Number of Time/Area Diagrams	0
Number of Offline Controls	0	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Ratio R	0.360
Region	England and Wales	Cv (Summer)	0.750
M5-60 (mm)	18.000	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0	DVD Status	OFF
Analysis Timestep	Fine	Inertia Status	OFF
DTS Status	ON		

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	100
Climate Change (%)	40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.
1.000	1	15 Winter	100	+40%	100/15 Summer	100/15 Winter		
1.001	2	120 Winter	100	+40%	100/15 Summer			
1.002	1	120 Winter	100	+40%				
1.003	2	120 Winter	100	+40%				
2.000	7	120 Winter	100	+40%	100/15 Summer			
2.001	8	120 Winter	100	+40%	100/15 Summer			
3.000	9	15 Winter	100	+40%	100/15 Summer			
3.001	10	240 Winter	100	+40%	100/30 Summer			
1.004	3	120 Winter	100	+40%				
4.000	10	15 Winter	100	+40%	100/15 Summer			
4.001	11	120 Winter	100	+40%	100/15 Summer			
4.002	12	960 Winter	100	+40%				
1.005	4	120 Winter	100	+40%				
1.006	5	120 Winter	100	+40%				
1.007	6	120 Winter	100	+40%				
1.008	7	120 Winter	100	+40%				
5.000	16	15 Winter	100	+40%	100/15 Summer			
5.001	17	240 Winter	100	+40%	100/15 Summer			
5.002	16	30 Winter	100	+40%				
6.000	19	15 Winter	100	+40%	100/15 Summer			
6.001	20	240 Winter	100	+40%	100/15 Summer			
5.003	17	960 Summer	100	+40%				

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

Small amount of flooding at dummy connection to plot. Exceedance will flow towards permeable paving below Red Bank Terraces

PN	US/MH Name	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status
1.000	1	31.000	2.045	0.026	3.52			221.1	FLOOD
1.001	2	30.781	1.964	0.000	0.22			9.5	FLOOD RISK
1.002	1	28.575	-0.150	0.000	0.24			9.5	OK
1.003	2	28.421	-0.149	0.000	0.25			9.5	OK
2.000	7	30.738	2.001	0.000	0.64			52.1	FLOOD RISK
2.001	8	30.733	2.177	0.000	0.15			6.5	FLOOD RISK
3.000	9	30.816	0.091	0.000	1.56			57.2	FLOOD RISK
3.001	10	30.805	0.148	0.000	0.06			2.4	FLOOD RISK
1.004	3	28.333	-0.111	0.000	0.51			18.1	OK
4.000	10	32.982	0.957	0.000	3.54			59.1	FLOOD RISK
4.001	11	32.506	1.556	0.000	0.11			2.8	SURCHARGED
4.002	12	29.973	-0.193	0.000	0.05			2.8	OK
1.005	4	28.267	-0.111	0.000	0.51			20.7	OK
1.006	5	27.909	-0.182	0.000	0.33			20.7	OK
1.007	6	27.769	-0.184	0.000	0.32			20.7	OK
1.008	7	27.706	-0.180	0.000	0.34			20.7	OK
5.000	16	28.665	0.781	0.000	3.64			223.2	SURCHARGED
5.001	17	28.409	0.566	0.000	0.15			9.4	SURCHARGED
5.002	16	27.575	-0.225	0.000	0.14			9.4	OK
6.000	19	29.377	0.277	0.000	2.08			32.1	FLOOD RISK
6.001	20	29.291	0.274	0.000	0.09			1.4	FLOOD RISK
5.003	17	27.503	-0.229	0.000	0.13			10.8	OK

PN	US/MH Name	Level Exceeded
1.000	1	1
1.001	2	
1.002	1	
1.003	2	
2.000	7	
2.001	8	
3.000	9	
3.001	10	
1.004	3	
4.000	10	
4.001	11	
4.002	12	
1.005	4	
1.006	5	
1.007	6	
1.008	7	
5.000	16	
5.001	17	
5.002	16	
6.000	19	

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Level Exceeded
6.001	20	
5.003	17	

©1982-2020 Innovyze

Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)
7.000	20	15 Winter	100	+40%	100/15 Summer				30.471
7.001	21	240 Winter	100	+40%	100/60 Winter				30.195
5.004	18	960 Winter	100	+40%					27.307

PN	US/MH Name	Surcharged Depth (m)	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
7.000	20	0.135	0.000	1.32			27.6	SURCHARGED	
7.001	21	0.045	0.000	0.06			1.2	SURCHARGED	
5.004	18	-0.211	0.000	0.19			11.9	OK	

©1982-2020 Innovyze

A3 Appendix 3 Catchment 4 surface network report

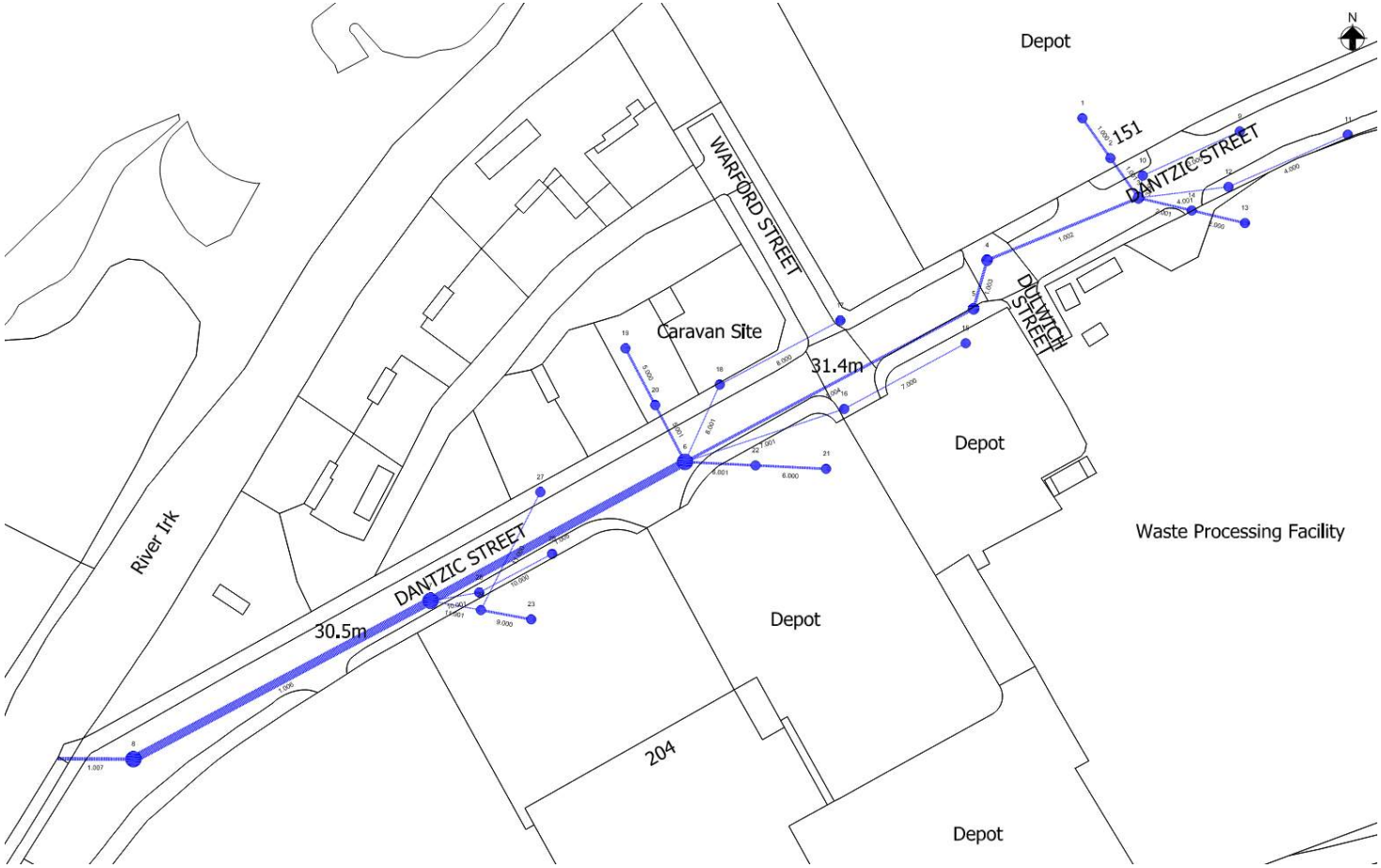


Figure 6 Catchment 4 model layout

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Refer to Plan on final page for Pipe Number reference

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	0
Ratio R	0.357	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	2.500
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
1.000	8.157	0.264	30.9	0.000	15.00	0.0	0.600	o	300	Pipe/Conduit	
1.001	8.157	0.264	30.9	0.461	0.00	0.0	0.600	o	300	Pipe/Conduit	
2.000	9.147	0.142	64.4	0.000	15.00	0.0	0.600	o	300	Pipe/Conduit	
2.001	9.147	0.142	64.4	1.012	0.00	0.0	0.600	o	300	Pipe/Conduit	
3.000	17.866	0.305	58.6	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
3.001	3.790	1.637	2.3	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
4.000	21.795	0.367	59.4	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
4.001	15.185	2.137	7.1	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.002	27.407	0.137	200.1	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.003	8.445	0.042	201.1	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
1.004	54.682	0.273	200.3	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
5.000	10.734	0.295	36.4	0.000	15.00	0.0	0.600	o	300	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of Swale

Dummy pipe upstream of indicative plot storage/flow control

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	26.70	15.05	29.066	0.000	0.0	0.0	0.0	2.84	200.7	0.0
1.001	26.66	15.10	28.802	0.461	0.0	0.0	0.0	2.84	200.7	33.3
2.000	26.68	15.08	28.822	0.000	0.0	0.0	0.0	1.96	138.7	0.0
2.001	26.60	15.16	28.680	1.012	0.0	0.0	0.0	1.96	138.7	72.9
3.000	45.74	5.23	30.630	0.000	0.0	0.0	0.0	1.32	23.3	0.0
3.001	45.71	5.24	30.325	0.100	0.0	0.0	0.0	6.68	118.0	12.4
4.000	45.55	5.28	31.192	0.000	0.0	0.0	0.0	1.31	23.1	0.0
4.001	45.31	5.34	30.825	0.100	0.0	0.0	0.0	3.80	67.2	12.3
1.002	26.25	15.51	28.463	1.673	0.0	0.0	0.0	1.28	141.1	118.9
1.003	26.14	15.62	28.326	1.673	0.0	0.0	0.0	1.27	140.7	118.9
1.004	25.49	16.34	28.284	1.673	0.0	0.0	0.0	1.28	141.0	118.9
5.000	26.68	15.07	29.101	0.000	0.0	0.0	0.0	2.61	184.8	0.0

©1982-2020 Innovyze

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
5.001	10.734	0.295	36.4	0.537	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.000	11.845	0.208	56.9	0.000	15.00	0.0	0.600	o	300	Pipe/Conduit	
6.001	11.845	0.208	56.9	0.537	0.00	0.0	0.600	o	300	Pipe/Conduit	
7.000	23.124	0.424	54.5	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
7.001	28.083	2.189	12.8	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
8.000	22.866	0.396	57.7	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
8.001	14.180	1.589	8.9	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.005	48.511	0.097	500.1	0.000	0.00	0.0	0.600	o	1200	Pipe/Conduit	
9.000	8.574	0.147	58.3	0.000	15.00	0.0	0.600	o	300	Pipe/Conduit	
9.001	8.574	0.147	58.3	0.771	0.00	0.0	0.600	o	300	Pipe/Conduit	
10.000	13.809	0.215	64.2	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
10.001	8.268	1.686	4.9	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
11.000	19.578	0.335	58.4	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
11.001	8.665	1.286	6.7	0.100	0.00	0.0	0.600	o	150	Pipe/Conduit	
1.006	56.351	0.111	507.7	0.000	0.00	0.0	0.600	o	1200	Pipe/Conduit	
1.007	12.625	0.047	268.6	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of Swale

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of Swale

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
5.001	26.62	15.14	28.806	0.537	0.0	0.0	0.0	2.61	184.8	38.7
6.000	26.66	15.09	28.927	0.000	0.0	0.0	0.0	2.09	147.6	0.0
6.001	26.56	15.19	28.719	0.537	0.0	0.0	0.0	2.09	147.6	38.6
7.000	45.54	5.28	31.274	0.000	0.0	0.0	0.0	1.37	24.1	0.0
7.001	44.93	5.45	30.850	0.100	0.0	0.0	0.0	2.83	50.0	12.2
8.000	45.52	5.29	30.646	0.000	0.0	0.0	0.0	1.33	23.4	0.0
8.001	45.26	5.36	30.250	0.100	0.0	0.0	0.0	3.39	60.0	12.3
1.005	25.06	16.82	27.611	2.947	0.0	0.0	0.0	1.67	1884.3	200.0
9.000	26.68	15.07	28.707	0.000	0.0	0.0	0.0	2.06	145.8	0.0
9.001	26.61	15.14	28.560	0.771	0.0	0.0	0.0	2.06	145.8	55.6
10.000	45.91	5.18	30.465	0.000	0.0	0.0	0.0	1.26	22.2	0.0
10.001	45.79	5.21	30.250	0.100	0.0	0.0	0.0	4.58	81.0	12.4
11.000	45.66	5.25	30.185	0.000	0.0	0.0	0.0	1.32	23.3	0.0
11.001	45.53	5.28	29.850	0.100	0.0	0.0	0.0	3.91	69.0	12.3
1.006	24.59	17.39	27.514	3.918	0.0	0.0	0.0	1.65	1870.1	260.9
1.007	26.58	15.17	27.403	0.000	86.2	0.0	0.0	1.24	196.5	86.2

©1982-2020 Innovyze

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
1.000	-	-	100	0.000	0.000	0.000
1.001	-	-	100	0.461	0.461	0.461
2.000	-	-	100	0.000	0.000	0.000
2.001	-	-	100	1.012	1.012	1.012
3.000	-	-	100	0.000	0.000	0.000
3.001	-	-	100	0.100	0.100	0.100
4.000	-	-	100	0.000	0.000	0.000
4.001	-	-	100	0.100	0.100	0.100
1.002	-	-	100	0.000	0.000	0.000
1.003	-	-	100	0.000	0.000	0.000
1.004	-	-	100	0.000	0.000	0.000
5.000	-	-	100	0.000	0.000	0.000
5.001	-	-	100	0.537	0.537	0.537
6.000	-	-	100	0.000	0.000	0.000
6.001	-	-	100	0.537	0.537	0.537
7.000	-	-	100	0.000	0.000	0.000
7.001	-	-	100	0.100	0.100	0.100
8.000	-	-	100	0.000	0.000	0.000
8.001	-	-	100	0.100	0.100	0.100
1.005	-	-	100	0.000	0.000	0.000
9.000	-	-	100	0.000	0.000	0.000
9.001	-	-	100	0.771	0.771	0.771
10.000	-	-	100	0.000	0.000	0.000
10.001	-	-	100	0.100	0.100	0.100
11.000	-	-	100	0.000	0.000	0.000
11.001	-	-	100	0.100	0.100	0.100
1.006	-	-	100	0.000	0.000	0.000
1.007	-	-	100	0.000	0.000	0.000
				Total	Total	Total
				3.918	3.918	3.918

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
1.007		29.600	27.356	0.000	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	12	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	1	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.357		

©1982-2020 Innovyze

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 2, DS/PN: 1.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0146-1010-1000-1010
Design Head (m)	1.000
Design Flow (l/s)	10.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	146
Invert Level (m)	28.802
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	10.1	Kick-Flo®	0.676	8.4
Flush-Flo™	0.305	10.1	Mean Flow over Head Range	-	8.7

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)	Depth (m)	Flow (l/s)
0.100	5.3	0.800	9.1	2.000	14.0	4.000	19.5	7.000	25.5
0.200	9.8	1.000	10.1	2.200	14.7	4.500	20.6	7.500	26.4
0.300	10.1	1.200	11.0	2.400	15.3	5.000	21.7	8.000	27.2
0.400	10.0	1.400	11.8	2.600	15.9	5.500	22.7	8.500	28.0
0.500	9.7	1.600	12.6	3.000	17.0	6.000	23.7	9.000	28.8
0.600	9.2	1.800	13.3	3.500	18.3	6.500	24.6	9.500	29.6

Hydro-Brake® Optimum Manhole: 14, DS/PN: 2.001, Volume (m³): 3.5

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0208-2230-1000-2230
Design Head (m)	1.000
Design Flow (l/s)	22.3
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	208
Invert Level (m)	28.680
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	22.3	Kick-Flo®	0.725	19.1
Flush-Flo™	0.348	22.3	Mean Flow over Head Range	-	18.7

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)	Depth (m)	Flow (l/s)
0.100	7.1	0.600	21.2	1.600	27.9	2.600	35.2	5.000	48.3
0.200	20.0	0.800	20.0	1.800	29.5	3.000	37.7	5.500	50.6
0.300	22.2	1.000	22.3	2.000	31.1	3.500	40.7	6.000	52.8
0.400	22.2	1.200	24.3	2.200	32.5	4.000	43.4	6.500	54.9
0.500	21.8	1.400	26.2	2.400	33.9	4.500	45.9	7.000	56.9

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 14, DS/PN: 2.001, Volume (m³): 3.5

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
7.500	58.8	8.000	60.7	8.500	62.5	9.000	64.3	9.500	66.0

Flow control for Swale

Orifice Manhole: 10, DS/PN: 3.001, Volume (m³): 1.1

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 30.325

Flow control for Swale

Orifice Manhole: 12, DS/PN: 4.001, Volume (m³): 1.1

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 30.825

Hydro-Brake® Optimum Manhole: 20, DS/PN: 5.001, Volume (m³): 3.6

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0157-1180-1000-1180
Design Head (m)	1.000
Design Flow (l/s)	11.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	157
Invert Level (m)	28.806
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	11.8	Kick-Flo®	0.683	9.9
Flush-Flo™	0.308	11.8	Mean Flow over Head Range	-	10.1

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)	Depth (m)	Flow (l/s)
0.100	5.6	0.800	10.6	2.000	16.4	4.000	22.8	7.000	29.9
0.200	11.4	1.000	11.8	2.200	17.1	4.500	24.1	7.500	30.9
0.300	11.8	1.200	12.9	2.400	17.9	5.000	25.4	8.000	31.9
0.400	11.7	1.400	13.8	2.600	18.6	5.500	26.6	8.500	32.8
0.500	11.4	1.600	14.7	3.000	19.9	6.000	27.7	9.000	33.7
0.600	10.9	1.800	15.6	3.500	21.4	6.500	28.8	9.500	34.6

Hydro-Brake® Optimum Manhole: 22, DS/PN: 6.001, Volume (m³): 4.1

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0157-1180-1000-1180
Design Head (m)	1.000
Design Flow (l/s)	11.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	157
Invert Level (m)	28.719
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 22, DS/PN: 6.001, Volume (m³): 4.1

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	11.8	Kick-Flo®	0.683	9.9
Flush-Flo™	0.308	11.8	Mean Flow over Head Range	-	10.1

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)	Depth (m)	Flow (l/s)
0.100	5.6	0.800	10.6	2.000	16.4	4.000	22.8	7.000	29.9
0.200	11.4	1.000	11.8	2.200	17.1	4.500	24.1	7.500	30.9
0.300	11.8	1.200	12.9	2.400	17.9	5.000	25.4	8.000	31.9
0.400	11.7	1.400	13.8	2.600	18.6	5.500	26.6	8.500	32.8
0.500	11.4	1.600	14.7	3.000	19.9	6.000	27.7	9.000	33.7
0.600	10.9	1.800	15.6	3.500	21.4	6.500	28.8	9.500	34.6

Flow control for Swale

Orifice Manhole: 16, DS/PN: 7.001, Volume (m³): 1.2

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 30.850

Flow control for Swale

Orifice Manhole: 18, DS/PN: 8.001, Volume (m³): 1.2

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 30.250

Hydro-Brake® Optimum Manhole: 24, DS/PN: 9.001, Volume (m³): 3.2

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0185-1700-1000-1700
Design Head (m)	1.000
Design Flow (l/s)	17.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	185
Invert Level (m)	28.560
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	17.0	Kick-Flo®	0.711	14.4
Flush-Flo™	0.330	17.0	Mean Flow over Head Range	-	14.4

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)	Depth (m)	Flow (l/s)
0.100	6.5	0.800	15.3	2.000	23.6	4.000	33.0	7.000	43.2
0.200	16.3	1.000	17.0	2.200	24.7	4.500	34.9	7.500	44.7
0.300	16.9	1.200	18.5	2.400	25.8	5.000	36.7	8.000	46.1
0.400	16.9	1.400	19.9	2.600	26.8	5.500	38.4	8.500	47.5
0.500	16.5	1.600	21.2	3.000	28.7	6.000	40.1	9.000	48.8
0.600	16.0	1.800	22.5	3.500	30.9	6.500	41.7	9.500	50.1

©1982-2020 Innovyze

Flow control for Swale

Orifice Manhole: 26, DS/PN: 10.001, Volume (m³): 1.1

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 30.250

Flow control for Swale

Orifice Manhole: 24, DS/PN: 11.001, Volume (m³): 1.2

Diameter (m) 0.150 Discharge Coefficient 0.600 Invert Level (m) 29.850

Hydro-Brake® Optimum Manhole: 8, DS/PN: 1.007, Volume (m³): 69.3

Flow control for network outfall

Unit Reference	MD-SHE-0354-8620-2297-8620
Design Head (m)	2.297
Design Flow (l/s)	86.2
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	354
Invert Level (m)	27.403
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.297	86.2	Kick-Flo®	1.548	71.2
Flush-Flo™	0.709	86.1	Mean Flow over Head Range	-	73.8

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)	Depth (m)	Flow (l/s)
0.100	10.2	0.800	85.9	2.000	80.6	4.000	112.9	7.000	148.3
0.200	35.7	1.000	84.5	2.200	84.4	4.500	119.5	7.500	153.4
0.300	66.1	1.200	82.2	2.400	88.0	5.000	125.8	8.000	158.3
0.400	81.5	1.400	77.8	2.600	91.5	5.500	131.8	8.500	163.0
0.500	84.3	1.600	72.3	3.000	98.1	6.000	137.5	9.000	167.7
0.600	85.7	1.800	76.6	3.500	105.7	6.500	143.0	9.500	172.2

©1982-2020 Innovyze

Storage Structures for Storm

Tank or Pond Manhole: 2, DS/PN: 1.001

Tank to indicatively represent Plot storage.

Invert Level (m) 28.802

Depth (m)	Area (m²)
0.000	200.0

Tank or Pond Manhole: 14, DS/PN: 2.001

Tank to indicatively represent Plot storage.

Invert Level (m) 28.680

Depth (m)	Area (m²)
0.000	500.0

Complex Manhole: 10, DS/PN: 3.001

Complex storage to represent Swale

Bio-Retention Area

Invert Level (m) 30.250 Infiltration Coefficient Side (m/hr) 0.00000
Porosity 0.30 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000

Depth (m)	Area (m²)	Perimeter (m)
0.000	84.0	88.000

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr) 0.00000 Length (m) 42.0
Infiltration Coefficient Side (m/hr) 0.00000 Side Slope (1:X) 3.0
Safety Factor 2.0 Slope (1:X) 0.0
Porosity 1.00 Cap Volume Depth (m) 0.000
Invert Level (m) 30.750 Cap Infiltration Depth (m) 0.000
Base Width (m) 0.5 Include Swale Volume Yes

Complex Manhole: 12, DS/PN: 4.001

Complex storage to represent Swale

Bio-Retention Area

Invert Level (m) 30.750 Infiltration Coefficient Side (m/hr) 0.00000
Porosity 0.30 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000

Depth (m)	Area (m²)	Perimeter (m)
0.000	135.0	113.000

©1982-2020 Innovyze

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	54.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	0.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	31.250	Cap Infiltration Depth (m)	0.000
Base Width (m)	1.0	Include Swale Volume	Yes

Tank or Pond Manhole: 20, DS/PN: 5.001

Tank to indicatively represent Plot storage.

Invert Level (m) 28.806

Depth (m)	Area (m²)
0.000	200.0

Tank or Pond Manhole: 22, DS/PN: 6.001

Tank to indicatively represent Plot storage.

Invert Level (m) 28.719

Depth (m)	Area (m²)
0.000	300.0

Complex Manhole: 16, DS/PN: 7.001

Complex storage to represent Swale

Bio-Retention Area

Invert Level (m)	30.850	Infiltration Coefficient Side (m/hr)	0.00000
Porosity	0.30	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000		

Depth (m)	Area (m²)	Perimeter (m)
0.000	187.5	155.000

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	75.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	0.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	31.350	Cap Infiltration Depth (m)	0.000
Base Width (m)	1.0	Include Swale Volume	Yes

Complex Manhole: 18, DS/PN: 8.001

Complex storage to represent Swale

©1982-2020 Innovyze

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	69.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	4.0
Safety Factor	2.0	Slope (1:X)	0.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	30.250	Cap Infiltration Depth (m)	0.000
Base Width (m)	1.0	Include Swale Volume	Yes

Bio-Retention Area

Invert Level (m)	30.250	Infiltration Coefficient Side (m/hr)	0.00000
Porosity	0.30	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000		

Depth (m)	Area (m²)	Perimeter (m)
0.000	138.0	142.000

Tank or Pond Manhole: 24, DS/PN: 9.001

Tank to indicatively represent Plot storage.

Invert Level (m) 28.560

Depth (m)	Area (m²)
0.000	400.0

Complex Manhole: 26, DS/PN: 10.001

Complex storage to represent Swale

Bio-Retention Area

Invert Level (m)	30.250	Infiltration Coefficient Side (m/hr)	0.00000
Porosity	0.30	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000		

Depth (m)	Area (m²)	Perimeter (m)
0.000	60.0	53.000

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	24.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	0.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	30.750	Cap Infiltration Depth (m)	0.000
Base Width (m)	1.0	Include Swale Volume	Yes

Complex Manhole: 24, DS/PN: 11.001

Complex storage to represent Swale

©1982-2020 Innovyze

Bio-Retention Area

Invert Level (m)	29.850	Infiltration Coefficient Side (m/hr)	0.00000
Porosity	0.30	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000		

Depth (m)	Area (m²)	Perimeter (m)
0.000	74.0	78.000

Swale

Warning:- Volume should always be included unless the upstream pipe is being used for storage and/or as a carrier

Infiltration Coefficient Base (m/hr)	0.00000	Length (m)	37.0
Infiltration Coefficient Side (m/hr)	0.00000	Side Slope (1:X)	3.0
Safety Factor	2.0	Slope (1:X)	0.0
Porosity	1.00	Cap Volume Depth (m)	0.000
Invert Level (m)	30.350	Cap Infiltration Depth (m)	0.000
Base Width (m)	0.5	Include Swale Volume	Yes

©1982-2020 Innovyze

1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	12	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR M5-60 (mm)	18.000	Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.358	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
1.000	1	15 Summer	1	+0%	100/30 Summer				29.066	-0.300
1.001	2	120 Winter	1	+0%	30/30 Summer				28.954	-0.148
2.000	13	120 Winter	1	+0%	100/15 Winter				28.839	-0.283
2.001	14	120 Winter	1	+0%	30/30 Winter				28.839	-0.141
3.000	9	15 Summer	1	+0%					30.630	-0.150
3.001	10	60 Winter	1	+0%	30/15 Summer				30.416	-0.059
4.000	11	15 Summer	1	+0%					31.192	-0.150
4.001	12	120 Winter	1	+0%	30/15 Winter				30.898	-0.077
1.002	3	120 Winter	1	+0%	100/30 Winter				28.586	-0.252
1.003	4	120 Winter	1	+0%	100/30 Winter				28.464	-0.237
1.004	5	120 Winter	1	+0%	100/30 Winter				28.403	-0.256
5.000	19	15 Summer	1	+0%	100/15 Winter				29.101	-0.300
5.001	20	120 Winter	1	+0%	30/15 Winter				28.975	-0.131
6.000	21	15 Summer	1	+0%	100/30 Winter				28.927	-0.300
6.001	22	120 Winter	1	+0%	30/60 Winter				28.854	-0.165
7.000	15	15 Summer	1	+0%					31.274	-0.150
7.001	16	60 Winter	1	+0%	30/15 Winter				30.932	-0.068
8.000	17	15 Summer	1	+0%					30.646	-0.150
8.001	18	120 Winter	1	+0%	100/30 Winter				30.307	-0.093
1.005	6	120 Winter	1	+0%	100/30 Winter				27.813	-0.998
9.000	23	120 Winter	1	+0%	100/30 Summer				28.707	-0.300
9.001	24	120 Winter	1	+0%	30/60 Summer				28.708	-0.152
10.000	25	15 Summer	1	+0%	100/15 Summer				30.465	-0.150
10.001	26	30 Winter	1	+0%	30/15 Summer				30.368	-0.032
11.000	27	15 Summer	1	+0%					30.185	-0.150
11.001	24	30 Winter	1	+0%	30/15 Summer				29.963	-0.037
1.006	7	120 Winter	1	+0%	100/30 Winter				27.764	-0.950
1.007	8	120 Winter	1	+0%	30/15 Summer				27.721	-0.132

©1982-2020 Innovyze

1 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	0.000	0.00			0.0	OK	
1.001	2	0.000	0.07			9.0	OK	
2.000	13	0.000	0.00			0.0	OK	
2.001	14	0.000	0.16			15.1	OK	
3.000	9	0.000	0.00			0.0	OK	
3.001	10	0.000	0.06			4.8	OK	
4.000	11	0.000	0.00			0.0	OK	
4.001	12	0.000	0.05			3.0	OK	
1.002	3	0.000	0.24			29.1	OK	
1.003	4	0.000	0.29			29.1	OK	
1.004	5	0.000	0.22			29.1	OK	
5.000	19	0.000	0.00			0.0	OK	
5.001	20	0.000	0.08			11.1	OK	
6.000	21	0.000	0.00			0.0	OK	
6.001	22	0.000	0.08			8.7	OK	
7.000	15	0.000	0.00			0.0	OK	
7.001	16	0.000	0.08		35	3.9	OK	
8.000	17	0.000	0.00			0.0	OK	
8.001	18	0.000	0.03		83	1.8	OK	
1.005	6	0.000	0.04			53.4	OK	
9.000	23	0.000	0.00			0.0	OK	
9.001	24	0.000	0.12			12.0	OK	
10.000	25	0.000	0.00			0.0	OK	
10.001	26	0.000	0.10		14	6.9	OK	
11.000	27	0.000	0.00			0.0	OK	
11.001	24	0.000	0.11		15	6.5	OK	
1.006	7	0.000	0.05			69.6	OK	
1.007	8	0.000	0.48			68.8	OK	

©1982-2020 Innovyze

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	12	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR M5-60 (mm)	18.000	Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.358	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
1.000	1	120 Winter	30	+0%	100/30 Summer				29.226	-0.140
1.001	2	120 Winter	30	+0%	30/30 Summer				29.226	0.124
2.000	13	120 Winter	30	+0%	100/15 Winter				29.070	-0.052
2.001	14	120 Winter	30	+0%	30/30 Winter				29.070	0.090
3.000	9	15 Summer	30	+0%					30.630	-0.150
3.001	10	30 Winter	30	+0%	30/15 Summer				30.537	0.062
4.000	11	15 Summer	30	+0%					31.192	-0.150
4.001	12	30 Winter	30	+0%	30/15 Winter				30.996	0.021
1.002	3	30 Winter	30	+0%	100/30 Winter				28.649	-0.189
1.003	4	30 Winter	30	+0%	100/30 Winter				28.538	-0.163
1.004	5	30 Winter	30	+0%	100/30 Winter				28.463	-0.196
5.000	19	120 Winter	30	+0%	100/15 Winter				29.299	-0.102
5.001	20	120 Winter	30	+0%	30/15 Winter				29.299	0.193
6.000	21	120 Winter	30	+0%	100/30 Winter				29.061	-0.166
6.001	22	120 Winter	30	+0%	30/60 Winter				29.061	0.042
7.000	15	15 Summer	30	+0%					31.274	-0.150
7.001	16	30 Winter	30	+0%	30/15 Winter				31.018	0.018
8.000	17	15 Summer	30	+0%					30.646	-0.150
8.001	18	60 Winter	30	+0%	100/30 Winter				30.355	-0.045
1.005	6	120 Winter	30	+0%	100/30 Winter				28.293	-0.518
9.000	23	120 Winter	30	+0%	100/30 Summer				28.929	-0.078
9.001	24	120 Winter	30	+0%	30/60 Summer				28.929	0.069
10.000	25	15 Winter	30	+0%	100/15 Summer				30.499	-0.116
10.001	26	15 Winter	30	+0%	30/15 Summer				30.513	0.113
11.000	27	15 Summer	30	+0%					30.185	-0.150
11.001	24	15 Winter	30	+0%	30/15 Summer				30.093	0.093
1.006	7	120 Winter	30	+0%	100/30 Winter				28.290	-0.424
1.007	8	120 Winter	30	+0%	30/15 Summer				28.285	0.432

©1982-2020 Innovyze

30 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	0.000	0.00			0.1	OK	
1.001	2	0.000	0.08			10.1	SURCHARGED	
2.000	13	0.000	0.00			0.0	OK	
2.001	14	0.000	0.24			22.2	SURCHARGED	
3.000	9	0.000	0.00			0.0	OK	
3.001	10	0.000	0.21		17	17.1	SURCHARGED	
4.000	11	0.000	0.00			0.0	OK	
4.001	12	0.000	0.20		27	12.7	SURCHARGED	
1.002	3	0.000	0.49			61.0	OK	
1.003	4	0.000	0.61			60.9	OK	
1.004	5	0.000	0.46			60.8	OK	
5.000	19	0.000	0.00			0.1	OK	
5.001	20	0.000	0.09			11.6	SURCHARGED	
6.000	21	0.000	0.00			0.0	OK	
6.001	22	0.000	0.10			11.8	SURCHARGED	
7.000	15	0.000	0.00			0.0	OK	
7.001	16	0.000	0.26		18	12.3	SURCHARGED	
8.000	17	0.000	0.00			0.0	OK	
8.001	18	0.000	0.11		47	5.9	OK	
1.005	6	0.000	0.06			85.6	OK	
9.000	23	0.000	0.00			0.0	OK	
9.001	24	0.000	0.18			16.9	SURCHARGED	
10.000	25	0.000	0.02			0.3	OK	
10.001	26	0.000	0.29		8	20.3	SURCHARGED	
11.000	27	0.000	0.00			0.0	OK	
11.001	24	0.000	0.32		8	19.2	SURCHARGED	
1.006	7	0.000	0.07			105.7	OK	
1.007	8	0.000	0.59			86.0	SURCHARGED	

©1982-2020 Innovyze

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs	0	Number of Offline Controls	0	Number of Time/Area Diagrams	0
Number of Online Controls	12	Number of Storage Structures	11	Number of Real Time Controls	0

Synthetic Rainfall Details

Rainfall Model		FSR M5-60 (mm)	18.000	Cv (Summer)	0.750
Region	England and Wales	Ratio R	0.358	Cv (Winter)	0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	1, 30, 100
Climate Change (%)	0, 0, 40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
1.000	1	120 Winter	100	+40%	100/30 Summer				29.721	0.355
1.001	2	120 Winter	100	+40%	30/30 Summer				29.721	0.619
2.000	13	240 Winter	100	+40%	100/15 Winter				29.570	0.448
2.001	14	240 Winter	100	+40%	30/30 Winter				29.570	0.590
3.000	9	30 Winter	100	+40%					30.730	-0.050
3.001	10	30 Winter	100	+40%	30/15 Summer				30.730	0.255
4.000	11	15 Summer	100	+40%					31.192	-0.150
4.001	12	30 Winter	100	+40%	30/15 Winter				31.144	0.169
1.002	3	120 Winter	100	+40%	100/30 Winter				29.460	0.622
1.003	4	120 Winter	100	+40%	100/30 Winter				29.441	0.740
1.004	5	120 Winter	100	+40%	100/30 Winter				29.431	0.772
5.000	19	120 Winter	100	+40%	100/15 Winter				29.869	0.468
5.001	20	120 Winter	100	+40%	30/15 Winter				29.869	0.763
6.000	21	240 Winter	100	+40%	100/30 Winter				29.493	0.266
6.001	22	240 Winter	100	+40%	30/60 Winter				29.494	0.475
7.000	15	15 Summer	100	+40%					31.274	-0.150
7.001	16	30 Winter	100	+40%	30/15 Winter				31.137	0.137
8.000	17	15 Summer	100	+40%					30.646	-0.150
8.001	18	60 Winter	100	+40%	100/30 Winter				30.413	0.013
1.005	6	120 Winter	100	+40%	100/30 Winter				29.404	0.593
9.000	23	240 Winter	100	+40%	100/30 Summer				29.459	0.452
9.001	24	240 Winter	100	+40%	30/60 Summer				29.459	0.599
10.000	25	15 Winter	100	+40%	100/15 Summer				30.749	0.134
10.001	26	15 Winter	100	+40%	30/15 Summer				30.750	0.350
11.000	27	15 Winter	100	+40%					30.299	-0.036
11.001	24	15 Winter	100	+40%	30/15 Summer				30.305	0.305
1.006	7	120 Winter	100	+40%	100/30 Winter				29.401	0.687
1.007	8	120 Winter	100	+40%	30/15 Summer				29.397	1.544

©1982-2020 Innovyze

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
1.000	1	0.000	0.00			0.1	SURCHARGED	
1.001	2	0.000	0.08			10.1	SURCHARGED	
2.000	13	0.000	0.00			0.1	SURCHARGED	
2.001	14	0.000	0.24			22.2	SURCHARGED	
3.000	9	0.000	0.02			0.5	FLOOD RISK	
3.001	10	0.000	0.34		12	26.9	FLOOD RISK	
4.000	11	0.000	0.00			0.0	OK	
4.001	12	0.000	0.37		17	23.2	SURCHARGED	
1.002	3	0.000	0.53			65.3	SURCHARGED	
1.003	4	0.000	0.66			65.4	SURCHARGED	
1.004	5	0.000	0.50			65.3	SURCHARGED	
5.000	19	0.000	0.00			0.1	SURCHARGED	
5.001	20	0.000	0.09			11.8	SURCHARGED	
6.000	21	0.000	0.00			0.0	SURCHARGED	
6.001	22	0.000	0.10			11.8	SURCHARGED	
7.000	15	0.000	0.00			0.0	OK	
7.001	16	0.000	0.45		15	21.6	SURCHARGED	
8.000	17	0.000	0.00			0.0	OK	
8.001	18	0.000	0.21		39	11.8	SURCHARGED	
1.005	6	0.000	0.07			102.5	SURCHARGED	
9.000	23	0.000	0.00			0.0	SURCHARGED	
9.001	24	0.000	0.18			16.9	SURCHARGED	
10.000	25	0.000	0.05			0.9	FLOOD RISK	
10.001	26	0.000	0.43		8	30.4	FLOOD RISK	
11.000	27	0.000	0.03			0.7	OK	
11.001	24	0.000	0.48		8	28.8	FLOOD RISK	
1.006	7	0.000	0.08			122.5	SURCHARGED	
1.007	8	0.000	0.59			86.0	SURCHARGED	

©1982-2020 Innovyze

A4 Appendix 5 Catchment 5 surface network report

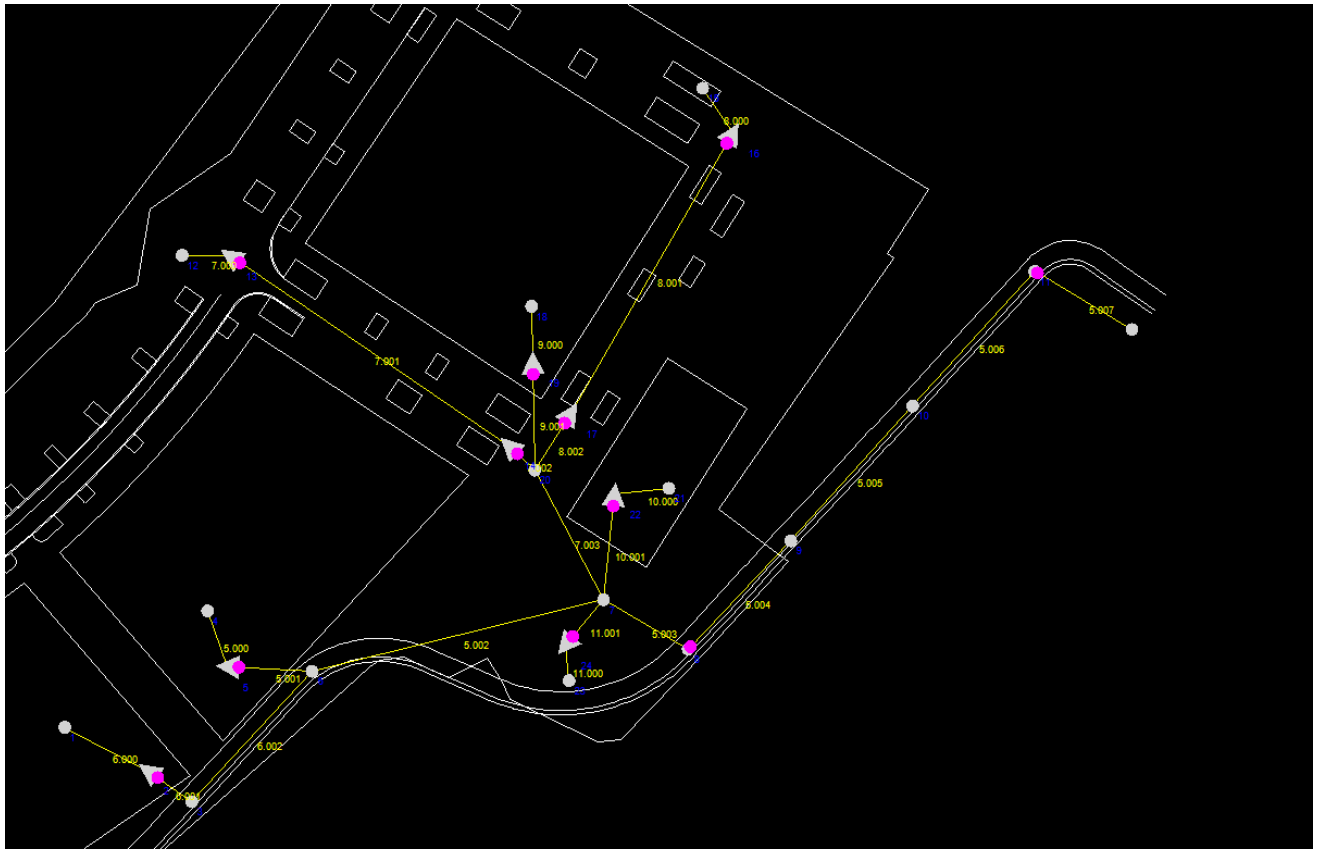


Figure 6 Catchment 5 model layout

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for Storm

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.000	Add Flow / Climate Change (%)	40
Ratio R	0.357	Minimum Backdrop Height (m)	0.200
Maximum Rainfall (mm/hr)	50	Maximum Backdrop Height (m)	1.500
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	1.200
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	0.750	Min Slope for Optimisation (1:X)	150

Designed with Level Soffits

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
5.000	12.576	0.080	157.2	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
5.001	18.098	0.300	60.3	0.401	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.000	20.031	0.200	100.2	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
6.001	11.360	0.113	100.5	0.409	0.00	0.0	0.600	o	300	Pipe/Conduit	
6.002	37.779	0.252	149.9	0.034	0.00	0.0	0.600	o	300	Pipe/Conduit	
5.002	63.874	0.386	165.5	0.041	0.00	0.0	0.600	o	375	Pipe/Conduit	
7.000	10.216	0.100	102.2	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
7.001	71.762	0.478	150.1	0.232	0.00	0.0	0.600	o	225	Pipe/Conduit	
7.002	7.570	0.076	99.6	0.151	0.00	0.0	0.600	o	225	Pipe/Conduit	
8.000	11.511	0.115	100.1	0.000	15.00	0.0	0.600	o	150	Pipe/Conduit	
8.001	68.841	0.459	150.0	0.175	0.00	0.0	0.600	o	225	Pipe/Conduit	
8.002	14.379	0.144	99.9	0.142	0.00	0.0	0.600	o	225	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
5.000	45.61	5.26	39.778	0.000	0.0	0.0	0.0	0.80	14.1	0.0
5.001	45.07	5.41	39.548	0.401	0.0	0.0	19.6	2.03	143.3	68.5
6.000	45.35	5.33	39.963	0.000	0.0	0.0	0.0	1.00	17.7	0.0
6.001	44.91	5.45	39.613	0.409	0.0	0.0	19.9	1.57	110.8	69.6
6.002	43.24	5.94	39.500	0.443	0.0	0.0	20.8	1.28	90.6	72.7
5.002	40.91	6.70	39.173	0.885	0.0	0.0	39.2	1.41	155.3	137.3
7.000	26.58	15.17	42.475	0.000	0.0	0.0	0.0	0.99	17.6	0.0
7.001	25.53	16.29	42.300	0.232	0.0	0.0	6.4	1.06	42.3	22.4
7.002	25.44	16.39	41.822	0.383	0.0	0.0	10.6	1.31	52.1	36.9
8.000	26.56	15.19	42.490	0.000	0.0	0.0	0.0	1.00	17.7	0.0
8.001	25.55	16.27	42.300	0.175	0.0	0.0	4.8	1.07	42.4	16.9
8.002	25.39	16.45	41.841	0.317	0.0	0.0	8.7	1.31	52.0	30.5

©1982-2020 Innovyze

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type	Auto Design
9.000	11.979	0.120	99.8	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
9.001	22.901	0.303	75.6	0.344	0.00	0.0	0.600	o	225	Pipe/Conduit	
7.003	31.225	1.488	21.0	0.000	0.00	0.0	0.600	o	225	Pipe/Conduit	
10.000	11.653	0.117	99.6	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
10.001	22.543	0.300	75.1	0.269	0.00	0.0	0.600	o	225	Pipe/Conduit	
11.000	7.501	0.075	100.0	0.000	5.00	0.0	0.600	o	150	Pipe/Conduit	
11.001	12.683	1.212	10.5	0.295	0.00	0.0	0.600	o	150	Pipe/Conduit	
5.003	20.862	0.298	70.0	0.000	0.00	0.0	0.600	o	375	Pipe/Conduit	
5.004	31.740	0.212	149.7	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.005	38.687	0.258	149.9	0.000	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.006	38.687	0.258	149.9	0.026	0.00	0.0	0.600	o	450	Pipe/Conduit	
5.007	24.121	0.500	48.2	0.024	0.00	0.0	0.600	o	450	Pipe/Conduit	

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of indicative plot storage/flow control

Dummy pipe upstream of permeable paving

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
9.000	45.85	5.20	40.923	0.000	0.0	0.0	0.0	1.01	17.8	0.0
9.001	44.92	5.45	40.728	0.344	0.0	0.0	16.7	1.51	59.9	58.6
7.003	25.23	16.63	40.425	1.044	0.0	0.0	28.5	2.87	114.1	99.8
10.000	45.87	5.19	40.420	0.000	0.0	0.0	0.0	1.01	17.8	0.0
10.001	44.96	5.44	40.228	0.269	0.0	0.0	13.1	1.51	60.0	45.9
11.000	46.13	5.12	41.500	0.000	0.0	0.0	0.0	1.00	17.8	0.0
11.001	45.87	5.19	41.425	0.295	0.0	0.0	14.7	3.13	55.4	51.3
5.003	25.09	16.79	38.787	2.493	0.0	0.0	67.8	2.17	239.5	237.2
5.004	24.82	17.11	38.414	2.493	0.0	0.0	67.8	1.66	263.9	237.2
5.005	24.50	17.50	36.728	2.493	0.0	0.0	67.8	1.66	263.7	237.2
5.006	24.19	17.89	34.996	2.520	0.0	0.0	67.8	1.66	263.7	237.2
5.007	24.08	18.03	33.265	2.543	0.0	0.0	67.8	2.93	466.5	237.2

©1982-2020 Innovyze

Area Summary for Storm

Pipe Number	PIMP Type	PIMP Name	PIMP (%)	Gross Area (ha)	Imp. Area (ha)	Pipe Total (ha)
5.000	-	-	100	0.000	0.000	0.000
5.001	User	-	100	0.401	0.401	0.401
6.000	-	-	100	0.000	0.000	0.000
6.001	User	-	100	0.409	0.409	0.409
6.002	User	-	100	0.034	0.034	0.034
5.002	User	-	100	0.041	0.041	0.041
7.000	-	-	100	0.000	0.000	0.000
7.001	User	-	100	0.232	0.232	0.232
7.002	User	-	100	0.151	0.151	0.151
8.000	-	-	100	0.000	0.000	0.000
8.001	User	-	100	0.175	0.175	0.175
8.002	User	-	100	0.142	0.142	0.142
9.000	-	-	100	0.000	0.000	0.000
9.001	User	-	100	0.344	0.344	0.344
7.003	-	-	100	0.000	0.000	0.000
10.000	-	-	100	0.000	0.000	0.000
10.001	User	-	100	0.269	0.269	0.269
11.000	-	-	100	0.000	0.000	0.000
11.001	User	-	100	0.295	0.295	0.295
5.003	-	-	100	0.000	0.000	0.000
5.004	-	-	100	0.000	0.000	0.000
5.005	-	-	100	0.000	0.000	0.000
5.006	User	-	100	0.026	0.026	0.026
5.007	User	-	100	0.024	0.024	0.024
				Total	Total	Total
				2.543	2.543	2.543

Free Flowing Outfall Details for Storm

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
5.007		33.500	32.765	29.500	0	0

Simulation Criteria for Storm

Volumetric Runoff Coeff	0.750	Additional Flow - % of Total Flow	0.000
Areal Reduction Factor	1.000	MADD Factor * 10m³/ha Storage	2.000
Hot Start (mins)	0	Inlet Coeffiecient	0.800
Hot Start Level (mm)	0	Flow per Person per Day (l/per/day)	0.000
Manhole Headloss Coeff (Global)	0.500	Run Time (mins)	60
Foul Sewage per hectare (l/s)	0.000	Output Interval (mins)	1

Number of Input Hydrographs 0	Number of Offline Controls 0	Number of Time/Area Diagrams 0
Number of Online Controls 11	Number of Storage Structures 9	Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	Profile Type	Summer
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	18.000	Storm Duration (mins)	30
Ratio R	0.357		

©1982-2020 Innovyze

Online Controls for Storm

Hydro-Brake® Optimum Manhole: 5, DS/PN: 5.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0137-8800-1000-8800
Design Head (m)	1.000
Design Flow (l/s)	8.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	137
Invert Level (m)	39.548
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	8.8	Kick-Flo®	0.664	7.3
Flush-Flo™	0.299	8.8	Mean Flow over Head Range	-	7.6

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)	Depth (m)	Flow (l/s)
0.100	5.0	0.800	7.9	2.000	12.2	4.000	17.0	7.000	22.2
0.200	8.5	1.000	8.8	2.200	12.8	4.500	18.0	7.500	22.9
0.300	8.8	1.200	9.6	2.400	13.3	5.000	18.9	8.000	23.7
0.400	8.7	1.400	10.3	2.600	13.8	5.500	19.8	8.500	24.4
0.500	8.4	1.600	11.0	3.000	14.8	6.000	20.6	9.000	25.0
0.600	7.9	1.800	11.6	3.500	15.9	6.500	21.4	9.500	25.7

Hydro-Brake® Optimum Manhole: 2, DS/PN: 6.001, Volume (m³): 3.0

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0131-9000-1500-9000
Design Head (m)	1.500
Design Flow (l/s)	9.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	131
Invert Level (m)	39.613
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	9.0	Kick-Flo®	0.927	7.2
Flush-Flo™	0.440	9.0	Mean Flow over Head Range	-	7.9

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

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.7	0.600	8.8	1.600	9.3	2.600	11.7	5.000	15.9
0.200	8.1	0.800	8.2	1.800	9.8	3.000	12.5	5.500	16.7
0.300	8.8	1.000	7.4	2.000	10.3	3.500	13.4	6.000	17.4
0.400	9.0	1.200	8.1	2.200	10.8	4.000	14.3	6.500	18.0
0.500	9.0	1.400	8.7	2.400	11.2	4.500	15.1	7.000	18.7

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 2, DS/PN: 6.001, Volume (m³): 3.0

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
7.500	19.3	8.000	19.9	8.500	20.5	9.000	21.1	9.500	21.7

Hydro-Brake® Optimum Manhole: 13, DS/PN: 7.001, Volume (m³): 1.0

Flow control for permeable paving

Unit Reference	MD-SHE-0111-5100-0700-5100
Design Head (m)	0.700
Design Flow (l/s)	5.1
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	111
Invert Level (m)	42.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	5.1	Kick-Flo®	0.482	4.3
Flush-Flo™	0.214	5.1	Mean Flow over Head Range	-	4.3

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)	Depth (m)	Flow (l/s)
0.100	3.8	0.800	5.4	2.000	8.3	4.000	11.6	7.000	15.1
0.200	5.1	1.000	6.0	2.200	8.7	4.500	12.2	7.500	15.6
0.300	5.0	1.200	6.6	2.400	9.1	5.000	12.9	8.000	16.1
0.400	4.8	1.400	7.0	2.600	9.4	5.500	13.5	8.500	16.6
0.500	4.4	1.600	7.5	3.000	10.1	6.000	14.0	9.000	17.1
0.600	4.7	1.800	7.9	3.500	10.9	6.500	14.6	9.500	17.6

Hydro-Brake® Optimum Manhole: 14, DS/PN: 7.002, Volume (m³): 4.1

Flow control for permeable paving

Unit Reference	MD-SHE-0132-8400-1200-8400
Design Head (m)	1.200
Design Flow (l/s)	8.4
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	132
Invert Level (m)	41.822
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	8.4	Kick-Flo®	0.768	6.8
Flush-Flo™	0.357	8.4	Mean Flow over Head Range	-	7.3

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)	Depth (m)	Flow (l/s)
0.100	4.7	0.300	8.3	0.500	8.2	0.800	6.9	1.200	8.4
0.200	7.9	0.400	8.4	0.600	8.0	1.000	7.7	1.400	9.0

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 14, DS/PN: 7.002, Volume (m³): 4.1

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
1.600	9.6	2.400	11.6	4.000	14.8	6.000	18.0	8.000	20.7
1.800	10.2	2.600	12.1	4.500	15.7	6.500	18.7	8.500	21.3
2.000	10.7	3.000	12.9	5.000	16.5	7.000	19.4	9.000	21.9
2.200	11.2	3.500	13.9	5.500	17.3	7.500	20.1	9.500	22.5

Hydro-Brake® Optimum Manhole: 16, DS/PN: 8.001, Volume (m³): 1.0

Flow control for permeable paving

Unit Reference	MD-SHE-0097-3800-0700-3800
Design Head (m)	0.700
Design Flow (l/s)	3.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	97
Invert Level (m)	42.300
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.700	3.8	Kick-Flo®	0.469	3.2
Flush-Flo™	0.210	3.8	Mean Flow over Head Range	-	3.3

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)	Depth (m)	Flow (l/s)
0.100	3.1	0.800	4.0	2.000	6.2	4.000	8.6	7.000	11.2
0.200	3.8	1.000	4.5	2.200	6.5	4.500	9.1	7.500	11.5
0.300	3.7	1.200	4.9	2.400	6.7	5.000	9.5	8.000	11.9
0.400	3.5	1.400	5.2	2.600	7.0	5.500	10.0	8.500	12.3
0.500	3.3	1.600	5.6	3.000	7.5	6.000	10.4	9.000	12.6
0.600	3.5	1.800	5.9	3.500	8.0	6.500	10.8	9.500	13.0

Hydro-Brake® Optimum Manhole: 17, DS/PN: 8.002, Volume (m³): 4.0

Flow control for permeable paving

Unit Reference	MD-SHE-0120-6900-1200-6900
Design Head (m)	1.200
Design Flow (l/s)	6.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	120
Invert Level (m)	41.841
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	6.9	Kick-Flo®	0.760	5.6
Flush-Flo™	0.356	6.9	Mean Flow over Head Range	-	6.0

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 17, DS/PN: 8.002, Volume (m³): 4.0

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	5.7	2.000	8.8	4.000	12.2	7.000	15.9
0.200	6.5	1.000	6.3	2.200	9.2	4.500	12.9	7.500	16.4
0.300	6.9	1.200	6.9	2.400	9.5	5.000	13.5	8.000	16.9
0.400	6.9	1.400	7.4	2.600	9.9	5.500	14.2	8.500	17.4
0.500	6.8	1.600	7.9	3.000	10.6	6.000	14.8	9.000	17.9
0.600	6.5	1.800	8.3	3.500	11.4	6.500	15.3	9.500	18.4

Hydro-Brake® Optimum Manhole: 19, DS/PN: 9.001, Volume (m³): 2.8

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0121-7600-1500-7600
Design Head (m)	1.500
Design Flow (l/s)	7.6
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	121
Invert Level (m)	40.803
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	7.6	Kick-Flo®	0.921	6.0
Flush-Flo™	0.440	7.6	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)	Depth (m)	Flow (l/s)
0.100	4.3	0.800	6.9	2.000	8.7	4.000	12.1	7.000	15.8
0.200	6.9	1.000	6.3	2.200	9.1	4.500	12.8	7.500	16.3
0.300	7.4	1.200	6.8	2.400	9.5	5.000	13.4	8.000	16.8
0.400	7.6	1.400	7.4	2.600	9.8	5.500	14.0	8.500	17.3
0.500	7.6	1.600	7.8	3.000	10.5	6.000	14.6	9.000	17.8
0.600	7.5	1.800	8.3	3.500	11.3	6.500	15.2	9.500	18.2

Hydro-Brake® Optimum Manhole: 22, DS/PN: 10.001, Volume (m³): 3.3

Flow control to represent flow from Plot

Unit Reference	MD-SHE-0114-5900-1000-5900
Design Head (m)	1.000
Design Flow (l/s)	5.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	114
Invert Level (m)	40.230
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	5.9	Kick-Flo®	0.645	4.8
Flush-Flo™	0.295	5.9	Mean Flow over Head Range	-	5.1

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 22, DS/PN: 10.001, Volume (m³): 3.3

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	4.0	0.800	5.3	2.000	8.2	4.000	11.3	7.000	14.8
0.200	5.7	1.000	5.9	2.200	8.5	4.500	12.0	7.500	15.3
0.300	5.9	1.200	6.4	2.400	8.9	5.000	12.6	8.000	15.8
0.400	5.8	1.400	6.9	2.600	9.2	5.500	13.2	8.500	16.2
0.500	5.6	1.600	7.3	3.000	9.9	6.000	13.7	9.000	16.7
0.600	5.2	1.800	7.8	3.500	10.6	6.500	14.3	9.500	17.1

Hydro-Brake® Optimum Manhole: 24, DS/PN: 11.001, Volume (m³): 1.3

Flow control for permeable paving

Unit Reference	MD-SHE-0119-6500-1000-6500
Design Head (m)	1.000
Design Flow (l/s)	6.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	119
Invert Level (m)	41.425
Minimum Outlet Pipe Diameter (mm)	150
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.000	6.5	Kick-Flo®	0.649	5.3
Flush-Flo™	0.296	6.5	Mean Flow over Head Range	-	5.6

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)	Depth (m)	Flow (l/s)
0.100	4.2	0.800	5.9	2.000	9.0	4.000	12.5	7.000	16.3
0.200	6.3	1.000	6.5	2.200	9.4	4.500	13.2	7.500	16.9
0.300	6.5	1.200	7.1	2.400	9.8	5.000	13.9	8.000	17.4
0.400	6.4	1.400	7.6	2.600	10.2	5.500	14.5	8.500	17.9
0.500	6.2	1.600	8.1	3.000	10.9	6.000	15.2	9.000	18.4
0.600	5.8	1.800	8.6	3.500	11.7	6.500	15.7	9.500	18.9

Hydro-Brake® Optimum Manhole: 8, DS/PN: 5.004, Volume (m³): 8.2

Flow control to restrict flows down hillside

Unit Reference	MD-SHE-0267-4750-2484-4750
Design Head (m)	2.484
Design Flow (l/s)	47.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	267
Invert Level (m)	38.414
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	Site Specific Design (Contact Hydro International)

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	2.484	47.3	Kick-Flo®	1.561	37.8
Flush-Flo™	0.727	47.2	Mean Flow over Head Range	-	41.0

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

©1982-2020 Innovyze

Hydro-Brake® Optimum Manhole: 8, DS/PN: 5.004, Volume (m³): 8.2

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.5	0.800	47.1	2.000	42.6	4.000	59.5	7.000	78.1
0.200	27.5	1.000	46.4	2.200	44.6	4.500	63.0	7.500	80.7
0.300	41.6	1.200	44.9	2.400	46.5	5.000	66.3	8.000	83.3
0.400	44.5	1.400	42.1	2.600	48.3	5.500	69.4	8.500	85.8
0.500	46.1	1.600	38.3	3.000	51.8	6.000	72.4	9.000	88.2
0.600	46.9	1.800	40.5	3.500	55.8	6.500	75.3	9.500	90.6

Hydro-Brake® Optimum Manhole: 11, DS/PN: 5.007, Volume (m³): 9.1

Flow control for network outfall

Unit Reference	MD-SHE-0299-5600-1808-5600
Design Head (m)	1.808
Design Flow (l/s)	56.0
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	299
Invert Level (m)	33.265
Minimum Outlet Pipe Diameter (mm)	375
Suggested Manhole Diameter (mm)	2100

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.808	56.0	Kick-Flo®	1.248	46.8
Flush-Flo™	0.575	56.0	Mean Flow over Head Range	-	47.8

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)	Depth (m)	Flow (l/s)
0.100	9.2	0.800	55.1	2.000	58.8	4.000	82.2	7.000	107.9
0.200	30.8	1.000	53.2	2.200	61.5	4.500	87.0	7.500	111.6
0.300	52.2	1.200	48.8	2.400	64.2	5.000	91.6	8.000	115.2
0.400	54.7	1.400	49.5	2.600	66.7	5.500	96.0	8.500	118.7
0.500	55.8	1.600	52.8	3.000	71.5	6.000	100.1	9.000	122.0
0.600	56.0	1.800	55.8	3.500	77.0	6.500	104.1	9.500	125.3

©1982-2020 Innovyze

Storage Structures for Storm

Tank or Pond Manhole: 5, DS/PN: 5.001

Invert Level (m) 39.548

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	180.0	1.000	180.0	1.001	0.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 2, DS/PN: 6.001

Invert Level (m) 39.613

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	170.0	1.000	170.0	1.001	0.0

Tank to indicatively represent Plot storage.

Tank or Pond Manhole: 13, DS/PN: 7.001

Invert Level (m) 42.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	150.0	0.500	150.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 14, DS/PN: 7.002

Invert Level (m) 41.822

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	40.0	0.500	40.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 16, DS/PN: 8.001

Invert Level (m) 42.300

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	120.0	0.500	120.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 17, DS/PN: 8.002

Invert Level (m) 41.841

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	40.0	0.500	40.0

Tank to represent 0.5m deep permeable paving

Tank or Pond Manhole: 19, DS/PN: 9.001

Invert Level (m) 40.728

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	150.0	1.000	150.0	1.001	0.0

Tank to indicatively represent Plot storage.

©1982-2020 Innovyze

Tank or Pond Manhole: 22, DS/PN: 10.001

Tank to indicatively represent Plot storage.

Invert Level (m) 40.230

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	180.0	1.000	180.0	1.001	0.0

Tank or Pond Manhole: 24, DS/PN: 11.001

Tank to represent 0.5m deep permeable paving

Invert Level (m) 42.000

Depth (m)	Area (m²)
0.000	255.0

©1982-2020 Innovyze

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

Simulation Criteria

Areal Reduction Factor	1.000	Additional Flow - % of Total Flow	0.000
Hot Start (mins)	0	MADD Factor * 10m³/ha Storage	2.000
Hot Start Level (mm)	0	Inlet Coeffiecient	0.800
Manhole Headloss Coeff (Global)	0.500	Flow per Person per Day (l/per/day)	0.000
Foul Sewage per hectare (l/s)	0.000		

Number of Input Hydrographs 0 Number of Offline Controls 0 Number of Time/Area Diagrams 0
Number of Online Controls 11 Number of Storage Structures 9 Number of Real Time Controls 0

Synthetic Rainfall Details

Rainfall Model	FSR	M5-60 (mm) 18.000	Cv (Summer) 0.750
Region	England and Wales	Ratio R 0.357	Cv (Winter) 0.840

Margin for Flood Risk Warning (mm)	300.0
Analysis Timestep	2.5 Second Increment (Extended)
DTS Status	OFF
DVD Status	OFF
Inertia Status	OFF

Profile(s)	Summer and Winter
Duration(s) (mins)	15, 30, 60, 120, 240, 360, 480, 960, 1440
Return Period(s) (years)	100
Climate Change (%)	40

PN	US/MH Name	Storm	Return Period	Climate Change	First (X) Surcharge	First (Y) Flood	First (Z) Overflow	Overflow Act.	Water Level (m)	Surcharged Depth (m)
5.000	4	240 Winter	100	+40%	100/15 Summer				41.537	1.609
5.001	5	240 Winter	100	+40%	100/15 Summer				41.537	1.689
6.000	1	240 Winter	100	+40%	100/15 Winter				41.732	1.619
6.001	2	240 Winter	100	+40%	100/15 Summer				41.732	1.819
6.002	3	240 Winter	100	+40%	100/15 Summer				40.954	1.154
5.002	6	240 Winter	100	+40%	100/15 Summer				40.941	1.393
7.000	12	240 Winter	100	+40%	100/15 Winter				42.977	0.352
7.001	13	240 Winter	100	+40%	100/15 Summer				42.977	0.452
7.002	14	120 Winter	100	+40%	100/15 Summer				42.902	0.855
8.000	15	240 Winter	100	+40%	100/30 Summer				42.950	0.310
8.001	16	240 Winter	100	+40%	100/15 Summer				42.950	0.425
8.002	17	120 Winter	100	+40%	100/15 Summer				42.889	0.823
9.000	18	240 Winter	100	+40%	100/15 Summer				41.693	0.620
9.001	19	240 Winter	100	+40%	100/15 Summer				41.693	0.740
7.003	20	240 Winter	100	+40%	100/120 Winter				40.984	0.334
10.000	21	240 Winter	100	+40%	100/15 Winter				40.940	0.370
10.001	22	240 Winter	100	+40%	100/15 Summer				40.940	0.487
11.000	23	120 Winter	100	+40%	100/15 Summer				42.414	0.764
11.001	24	120 Winter	100	+40%	100/15 Summer				42.414	0.839
5.003	7	240 Winter	100	+40%	100/15 Summer				40.923	1.761
5.004	8	240 Winter	100	+40%	100/15 Summer				40.895	2.031
5.005	9	240 Winter	100	+40%					36.865	-0.313
5.006	10	15 Winter	100	+40%					35.152	-0.294
5.007	11	30 Winter	100	+40%	100/15 Summer				35.076	1.361

PN	US/MH Name	Flooded Volume (m³)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
5.000	4	0.000	0.06			0.8	SURCHARGED	
5.001	5	0.000	0.07			8.8	SURCHARGED	
6.000	1	0.000	0.06			1.0	FLOOD RISK	

©1982-2020 Innovyze

100 year Return Period Summary of Critical Results by Maximum Level (Rank 1) for Storm

PN	US/MH Name	Flooded Volume (m^3)	Flow / Cap.	Overflow (l/s)	Half Drain Time (mins)	Pipe Flow (l/s)	Status	Level Exceeded
6.001	2	0.000	0.11			9.0	FLOOD RISK	
6.002	3	0.000	0.14			11.9	SURCHARGED	
5.002	6	0.000	0.15			22.5	SURCHARGED	
7.000	12	0.000	0.00			0.0	FLOOD RISK	
7.001	13	0.000	0.12			5.1	FLOOD RISK	
7.002	14	0.000	0.22			8.4	FLOOD RISK	
8.000	15	0.000	0.00			0.0	FLOOD RISK	
8.001	16	0.000	0.09			3.8	FLOOD RISK	
8.002	17	0.000	0.15			6.9	FLOOD RISK	
9.000	18	0.000	0.00			0.1	SURCHARGED	
9.001	19	0.000	0.14			7.6	SURCHARGED	
7.003	20	0.000	0.21			22.8	SURCHARGED	
10.000	21	0.000	0.00			0.0	SURCHARGED	
10.001	22	0.000	0.11			5.9	SURCHARGED	
11.000	23	0.000	0.00			0.0	FLOOD RISK	
11.001	24	0.000	0.13			6.5	FLOOD RISK	
5.003	7	0.000	0.24			48.6	SURCHARGED	
5.004	8	0.000	0.21			47.2	SURCHARGED	
5.005	9	0.000	0.20			47.2	OK	
5.006	10	0.000	0.26			60.5	OK	
5.007	11	0.000	0.14			56.0	SURCHARGED	

©1982-2020 Innovyze

A5 Appendix 6 foul network report

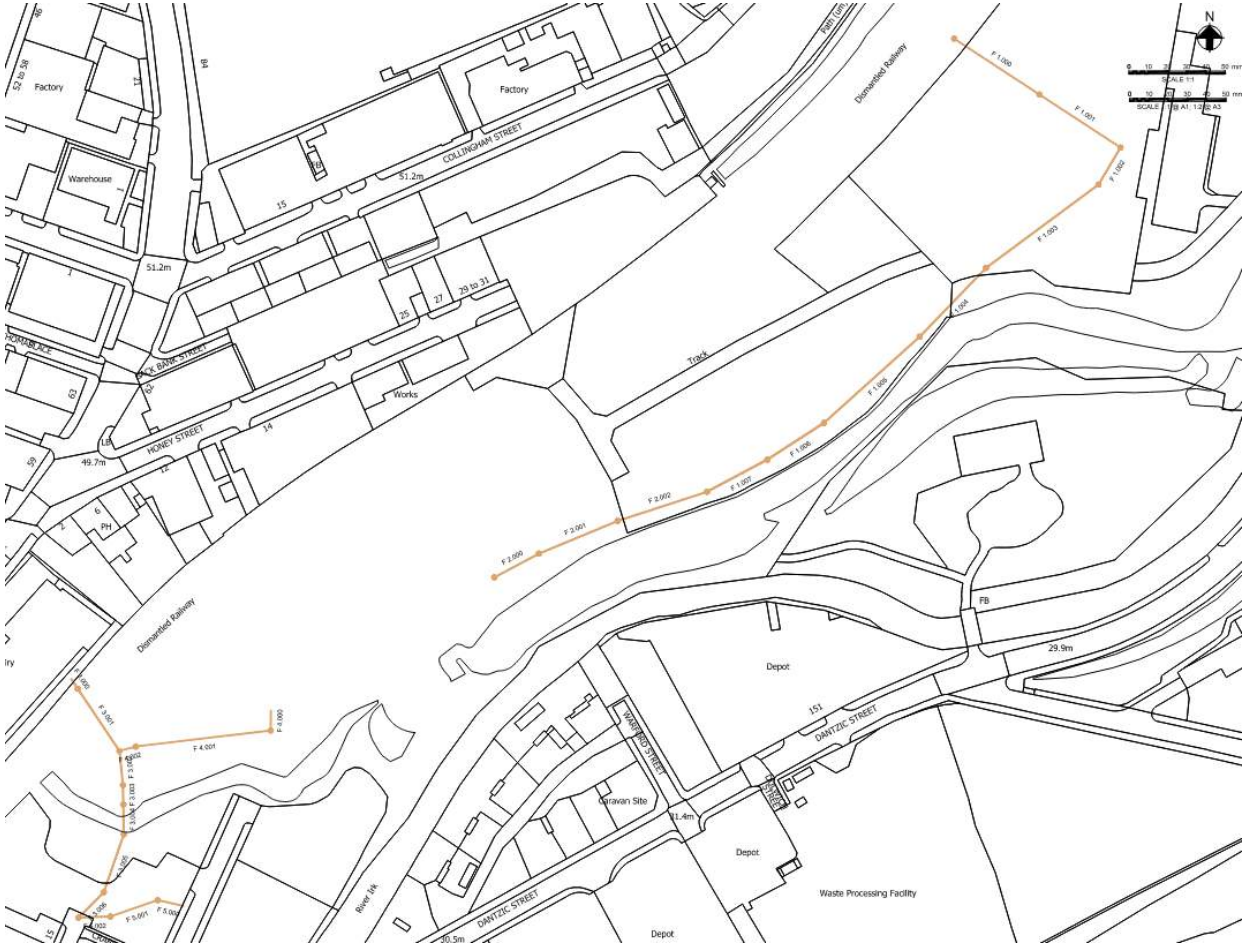


Figure 8 Foul model layout

FOUL SEWERAGE DESIGN

Network Design Table for Foul - Main

PN	Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Houses	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type
F1.000	26.111	0.348	75.0	0.041	202	0.0	1.500	o	150	Pipe/Conduit
F1.001	59.659	0.796	75.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F2.000	15.749	0.870	18.1	0.041	202	0.0	1.500	o	150	Pipe/Conduit
F1.002	73.682	0.737	100.0	0.000	0	0.0	1.500	o	225	Pipe/Conduit
F3.000	15.702	0.146	107.5	0.082	403	0.0	1.500	o	225	Pipe/Conduit
F1.003	67.321	2.324	29.0	0.000	0	0.0	1.500	o	225	Pipe/Conduit
F4.000	14.987	1.499	10.0	0.241	388	0.0	1.500	o	150	Pipe/Conduit
F5.000	13.915	0.155	89.8	0.048	261	0.0	1.500	o	225	Pipe/Conduit
F5.001	63.488	0.705	90.1	0.000	0	0.0	1.500	o	225	Pipe/Conduit
F6.000	12.048	0.142	85.0	0.049	256	0.0	1.500	o	225	Pipe/Conduit
F5.002	46.122	1.051	43.9	0.000	0	0.0	1.500	o	225	Pipe/Conduit
F1.004	64.823	0.259	250.3	0.000	0	0.0	1.500	o	375	Pipe/Conduit

Network Results Table

PN	US/IL (m)	Σ Area (ha)	Σ Base Flow (l/s)	Σ Hse	Add Flow (l/s)	P.Dep (mm)	P.Vel (m/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
F1.000	41.829	0.041	0.0	202	0.0	81	1.04	1.01	17.9	10.1
F1.001	41.481	0.041	0.0	202	0.0	81	1.04	1.01	17.9	10.1
F2.000	41.555	0.041	0.0	202	0.0	54	1.76	2.07	36.5	10.1
F1.002	40.610	0.082	0.0	404	0.0	105	1.11	1.15	45.6	20.2
F3.000	40.899	0.082	0.0	403	0.0	107	1.08	1.11	44.0	20.2
F1.003	39.873	0.164	0.0	807	0.0	109	2.11	2.14	85.0	40.4
F4.000	40.332	0.241	0.0	388	0.0	66	2.62	2.78	49.2	19.5
F5.000	39.460	0.048	0.0	261	0.0	80	1.03	1.21	48.2	13.0
F5.001	39.305	0.048	0.0	261	0.0	80	1.03	1.21	48.1	13.0
F6.000	39.796	0.049	0.0	256	0.0	78	1.05	1.25	49.5	12.8
F5.002	38.600	0.097	0.0	517	0.0	95	1.61	1.74	69.0	25.8
F1.004	37.399	0.502	0.0	1712	0.0	246	1.11	1.01	111.8	85.7

©1982-2020 Innovyze

FOUL SEWERAGE DESIGN

Network Design Table for Foul - Main

PN	Length (m)	Fall (m)	Slope (1:X)	Area (ha)	Houses	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)	Section Type
F1.005	17.354	0.069	251.5	0.000	0	0.0	1.500	o	375	Pipe/Conduit
F7.000	7.066	0.109	64.8	0.093	166	0.0	1.500	o	150	Pipe/Conduit
F7.001	47.754	0.735	65.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F7.002	19.753	0.304	65.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F8.000	28.892	1.860	15.5	0.048	204	0.0	1.500	o	150	Pipe/Conduit
F7.003	13.037	1.100	11.9	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F7.004	8.620	0.431	20.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F7.005	8.620	0.575	15.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F7.006	14.354	0.957	15.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F7.007	19.249	0.962	20.0	0.000	0	0.0	1.500	o	150	Pipe/Conduit
F9.000	31.865	0.437	72.9	0.140	179	0.0	1.500	o	150	Pipe/Conduit
F10.000	6.546	0.212	30.9	0.227	150	0.0	1.500	o	150	Pipe/Conduit
F11.000	5.764	0.140	41.2	0.298	457	0.0	1.500	o	150	Pipe/Conduit

Network Results Table

PN	US/IL (m)	Σ Area (ha)	Σ Base Flow (l/s)	Σ Hse	Add Flow (l/s)	P.Dep (mm)	P.Vel (m/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
F1.005	37.140	0.502	0.0	1712	0.0	247	1.11	1.01	111.5	85.7
F7.000	39.300	0.093	0.0	166	0.0	69	1.05	1.09	19.2	8.3
F7.001	39.191	0.093	0.0	166	0.0	69	1.05	1.09	19.2	8.3
F7.002	38.456	0.093	0.0	166	0.0	69	1.05	1.09	19.2	8.3
F8.000	41.510	0.048	0.0	204	0.0	52	1.87	2.23	39.4	10.2
F7.003	38.152	0.141	0.0	370	0.0	67	2.43	2.55	45.1	18.5
F7.004	36.150	0.141	0.0	370	0.0	78	2.00	1.96	34.7	18.5
F7.005	34.219	0.141	0.0	370	0.0	72	2.23	2.27	40.1	18.5
F7.006	32.288	0.141	0.0	370	0.0	72	2.23	2.27	40.1	18.5
F7.007	30.070	0.141	0.0	370	0.0	78	2.00	1.96	34.7	18.5
F9.000	29.515	0.140	0.0	179	0.0	75	1.03	1.03	18.1	9.0
F10.000	29.761	0.227	0.0	150	0.0	54	1.34	1.58	27.9	7.6
F11.000	29.069	0.298	0.0	457	0.0	117	1.56	1.37	24.2	23.0

©1982-2020 Innovyze

Free Flowing Outfall Details for Foul - Main

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
F1.005	F26	41.659	37.071	0.000	0	0

Free Flowing Outfall Details for Foul - Main

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
F7.007	F27	30.539	29.108	0.000	1200	0

Free Flowing Outfall Details for Foul - Main

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
F9.000	F28	30.538	29.078	0.000	0	0

Free Flowing Outfall Details for Foul - Main

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
F10.000	F29	30.899	29.549	0.000	0	0

Free Flowing Outfall Details for Foul - Main

Outfall Pipe Number	Outfall Name	C. Level (m)	I. Level (m)	Min I. Level (m)	D,L (mm)	W (mm)
F11.000	F30	30.279	28.929	0.000	0	0

©1982-2020 Innovyze

Technical Note

282022 17 February 2022

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Emily Stoddart	Ryan Griffiths	Mike Wilton
Signature			

Appendix D

Surface Water General Arrangements & Details

Plot	Area (ha)	Catchment	30 year restriction (l/s)	100 year restriction (l/s)
RB06	0.247	1	3.4	5.4
RB07	0.376	1	5.2	8.3
RB10	1.011	1	14.1	22.2
NT02	0.771	4	10.8	16.9
NT03	0.537	4	7.5	11.8
NT04	1.012	4	14.1	22.2
RB16	0.537	4	7.5	11.8
RB17	0.461	4	6.4	10.1
RB01	0.288	1	4.0	6.3
RB02	0.326	1	4.5	7.2
RB03	0.403	5	5.4	8.9
RB04	0.415	5	5.5	9.1
RB05a	0.369	5	4.9	8.1
RB05b	0.237	5	3.2	5.2
RB05c	0.410	5	5.5	9.0
RB12(b)	0.235	1	3.3	5.2
RB08	0.444	1	6.2	9.8
RB09	0.009	1	0.1	0.2
RB11	0.156	1	2.2	3.4
RB12a	0.163	1	2.3	3.6

See sheet 2 of 2

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   • Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 received 14/02/2022 by Planit.
   • Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. No guarantee is given for the accuracy of the information contained herein, which is provided for general guidance only and must not be relied upon for excavation or detailed design until apparatus locations are verified / validated through further site investigation works.
5. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
6. Existing Drainage layout based on the following information:
   - Utility Search Map drawing 97079 undertaken by Atkins dated 24/06/2021.
7. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.
8. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
9. Utilities have been drawn to PAS128 standard. The Located Service Classification table below gives a brief overview. For further details refer to document 'PAS 128:2014 Specification for underground utility detection, verification and location'.

Located Service Classification	Certainty/Risk
Type A Verification + Visual identification	
Type B Detection + Typically GPR and EML techniques are used	Data
Type C Site reconnaissance + Physical surface features identified	
Type D Desktop utility records search	

10. A connection point has been provided for each plot within the HIF Boundary at a minimum depth of 2.0-2.5m as agreed with WSP.
11. Drainage construction materials, unless otherwise stated:
   - Drainage pipes - Polyethylene in accordance with BS 13476
   - Manholes - Precast Concrete
   - Inspection Chambers - Polypropylene in accordance with BS 7158
12. As RB09/10 are outside the HIF Red Line Boundary, it has been areed that a connection to the River Irk will be provided/constructed as part of the Plot construction. Dischare Rates are to be agreed as part of the HIF works.
13. The finalised location of trees is to be confirmed at the next design stage.

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	---
P02	01/02/22		DH	RG	RG	---
P03.04	17/02/22		---	---	---	---

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Surface Water Drainage
Sheet 1 of 2

Scale at A1	1:500	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S0 - Initial Status or WIP		

Rev	By	Chkd	Appd	
P03.04	---	---	---	---
	Date	Date	Date	---
	---	---	---	

Name

VNIF - ARP - 00 - YYY - DR - CD - 0010
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup

A1

See sheet 1 of 2



Plot	Area (ha)	Catchment	30 year restriction (l/s)	100 year restriction (l/s)
RB06	0.247	1	3.4	5.4
RB07	0.376	1	5.2	8.3
RB10	1.011	1	14.1	22.2
NT02	0.771	4	10.8	16.9
NT03	0.537	4	7.5	11.8
NT04	1.012	4	14.1	22.2
RB16	0.537	4	7.5	11.8
RB17	0.461	4	6.4	10.1
RB01	0.288	1	4.0	6.3
RB02	0.326	1	4.5	7.2
RB03	0.403	5	5.4	8.9
RB04	0.415	5	5.5	9.1
RB05a	0.369	5	4.9	8.1
RB05b	0.237	5	3.2	5.2
RB05c	0.410	5	5.5	9.0
RB12(b)	0.235	1	3.3	5.2
RB08	0.444	1	6.2	9.8
RB09	0.009	1	0.1	0.2
RB11	0.156	1	2.2	3.4
RB12a	0.163	1	2.3	3.6

See sheet 1 of 2

Key

- HIF Site Boundary
- Plot Boundary
- Provision of Utility and Drainage Infrastructure Only
- Existing Drainage Combined Sewer
- Existing Drainage Surface Water Drain (Private)
- Proposed Surface Water Pipe
- Proposed Adopted Surface Water Pipe
- Proposed Surface Water Manhole
- Proposed Adopted Surface Water Manhole
- Proposed Outfall to River
- Area of permable paving
- Area of Adopted Attenuation Basin
- Proposed Channel Drain
- Proposed Adoptable Easement (3m)

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   • Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 dated 14/02/2022 by Planit.
   • Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. No guarantee is given for the accuracy of the information contained herein, which is provided for general guidance only and must not be relied upon for excavation or detailed design until apparatus locations are verified / validated through further site investigation works.
5. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
6. Existing Drainage layout based on the following information:
   - Utility Search Map drawing 97079 undertaken by Atkins dated 24/06/2021.
7. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.
8. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
9. Utilities have been drawn to PAS128 standard. The Located Service Classification table below gives a brief overview. For further details refer to document 'PAS 128:2014 Specification for underground utility detection, verification and location'.

Located Service Classification	Certainty/Risk	
Type A Verification + Visual Identification		
Type B Detection + Typically GPR and EML techniques are used	Data	
Type C Site reconnaissance + Physical surface features identified		
Type D Desktop utility records search		

10. A connection point has been provided for each plot within the HIF Boundary at a minimum depth of 2.0-2.5m as agreed with WSP.
11. Drainage construction materials, unless otherwise stated:
   - Drainage pipes - Polyethylene in accordance with BS 13476
   - Manholes - Precast Concrete
   - Inspection Chambers - Polypropylene in accordance with BS 7158
12. The finalised location of trees is to be confirmed at the next design stage.

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	---
P02	01/02/22		DH	RG	RG	---
P03.04	17/02/22		---	---	---	---

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Surface Water Drainage
Sheet 2 of 2

Scale at A1	1:500	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S0 - Initial Status or WIP		

Rev	By	Chkd	Appd	
P03.04	---	---	---	---
	Date	Date	Date	
	---	---	---	---

Name

VNIF - ARP - 00 - YYY - DR - CD - 0011
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup

A1

RB04

Plot	Area (ha)	Catchment	30 year restriction (l/s)	100 year restriction (l/s)
RB06	0.247	1	3.4	5.4
RB07	0.376	1	5.2	8.3
RB10	1.011	1	14.1	22.2
NT02	0.771	4	10.8	16.9
NT03	0.537	4	7.5	11.8
NT04	1.012	4	14.1	22.2
RB16	0.537	4	7.5	11.8
RB17	0.461	4	6.4	10.1
RB01	0.288	1	4.0	6.3
RB02	0.326	1	4.5	7.2
RB03	0.403	5	5.4	8.9
RB04	0.415	5	5.5	9.1
RB05a	0.369	5	4.9	8.1
RB05b	0.237	5	3.2	5.2
RB05c	0.410	5	5.5	9.0
RB12(b)	0.235	1	3.3	5.2
RB08	0.444	1	6.2	9.8
RB09	0.009	1	0.1	0.2
RB11	0.156	1	2.2	3.4
RB12a	0.163	1	2.3	3.6

RB06
RB16
RB17
NT02
NT03
NT04
Depot
Caravan Site
DANTZIC STREET
151
MSON STREET
37.2m
39.6m
Boro Const & Ward Bdy
CR
MP 0.5

Proposed outfall pipe to have non-return valve
Proposed Headwall
Proposed Outflow (1:100) - 86.2l/s
Proposed Outflow (1:30) - 53.9l/s
Proposed Outfall Level - 27.403mAOD

S7D
Hydrobrake
Design Head - 2.48m
Design Flow (1:100) - 86.2l/s
Design Flow (1:30) - 54.9l/s

S1.006 D
S11.000 D
S1.005 D
S10 D
S9.000 D
S1.004 D
S6 D
S7.000 D
S10.000 D
S8.000 D
S4.000 D
S5 D
S6.000 D
S3 D
S1.002 D
S4 D
S1.003 D
S1.001 D
S5.000 D
S1.000 D
S3.000 D
S2 D
S2.000 D

Key

- HIF Site Boundary
- Plot Boundary
- Provision of Utility and Drainage Infrastructure Only
- Existing Drainage Combined Sewer
- Existing Drainage Surface Water Drain (Private)
- Proposed Surface Water Pipe
- Proposed Adopted Surface Water Pipe
- Proposed Surface Water Manhole
- Proposed Adopted Surface Water Manhole
- Proposed Outfall to River
- Area of permable paving
- Area of Adopted Attenuation Basin

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   • Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 dated 14/02/2022 by Planit.
   • Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. No guarantee is given for the accuracy of the information contained herein, which is provided for general guidance only and must not be relied upon for excavation or detailed design until apparatus locations are verified / validated through further site investigation works.
5. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
6. Existing Drainage layout based on the following information:
   - Utility Search Map drawing 97079 undertaken by Atkins dated 24/06/2021.
7. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.
8. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
9. Utilities have been drawn to PAS128 standard. The Located Service Classification table below gives a brief overview. For further details refer to document 'PAS 128:2014 Specification for underground utility detection, verification and location'.

Located Service Classification	Certainty/Risk
Type A Verification - Visual identification	Quality
Type B Detection - Typically GPR and EML techniques are used	
Type C Site reconnaissance - Physical surface features identified	
Type D Desktop utility records search	

10. A connection point has been provided for each plot within the HIF Boundary at a minimum depth of 2.0-2.5m as agreed with WSP.
11. Drainage construction materials, unless otherwise stated:
   - Drainage pipes - Polyethylene in accordance with BS 13476
   - Manholes - Precast Concrete
   - Inspection Chambers - Polypropylene in accordance with BS 7158
12. The finalised location of trees is to be confirmed at the next design stage.

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	---
P02	01/02/22		DH	RG	RG	---
P03.02	17/02/22		---	---	---	---

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Surface Water Drainage
Dantzic Street

Scale at A1	1:500	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S0 - Initial Status or WIP		

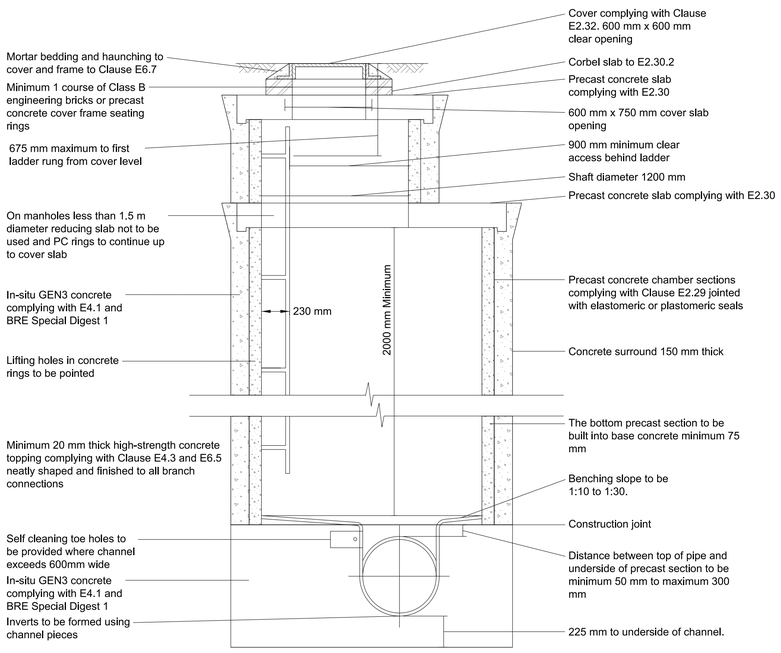
Rev	By	Chkd	Appd	
P03.02	---	---	---	---
	Date ---	Date ---	Date ---	---

Name

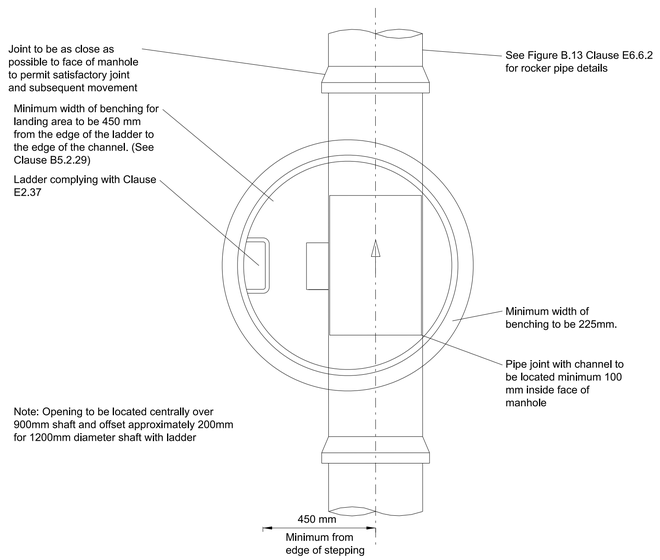
VNIF - ARP - 00 - YYY - DR - CD - 0012
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup



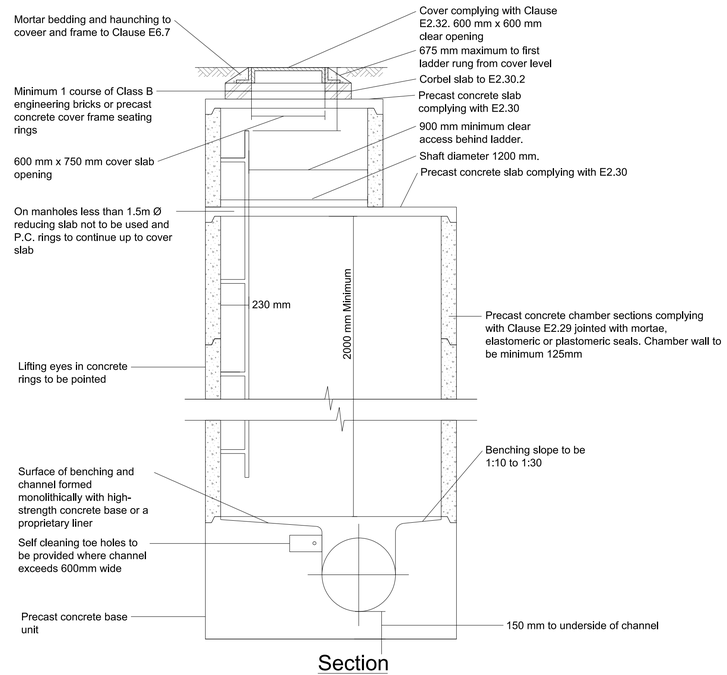
Section



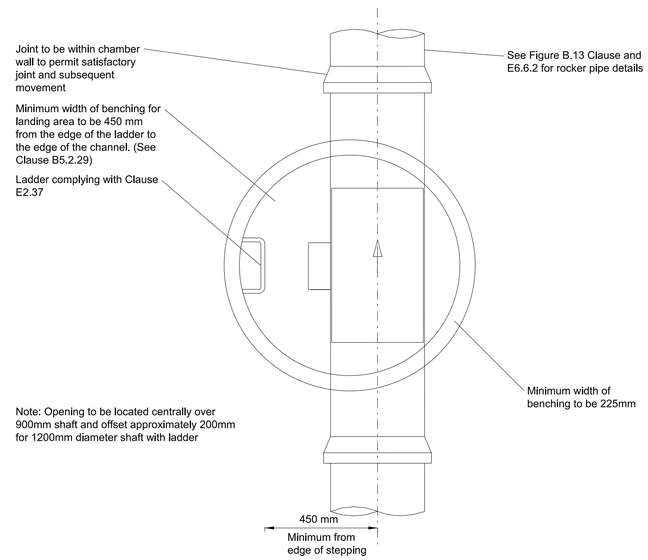
Plan

Typical manhole detail – Type A1
Depth from Cover Level to Soffit of Pipe 3 m to 6 m With Ladder and Reducing Slab
Rigid Material Construction With Concrete Surround

Scale 1:25



Section



Plan

Typical Manhole Detail Type 1A
Depth from Cover Level to Soffit of Pipe 3m to 6m with Ladder and Reduced Slab
Rigid Material Construction Without Concrete Surround

Scale 1:25

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.

2. Do not scale from this drawing.

3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

4. Concrete Requirements. Concrete to be in accordance with BS 8500 parts 1 and 2.
- Concrete chemcial class - DS-1 AC-1
- Blinding: GEN 0
- Bases and Surround: GEN 3.

5. Drainage construction materials, unless otherwise stated:
- Drainage pipes - Polyethylene in accordance with BS 13476
- Manholes - Precast Concrete
- Inspection Chambers - Polypropylene in accordance with BS 7158

6. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.

7. Bed and Surround Class A3 when:
- Cover level in trafficked areas < 1.2m
- Cover level in non-trafficked areas < 0.9m

Bed and Surround Class S when:
- Cover level in trafficked areas > 1.2m
- Cover level in non-trafficked areas > 0.9m

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—
P02	01/02/22		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Details
Sheet 1 of 5

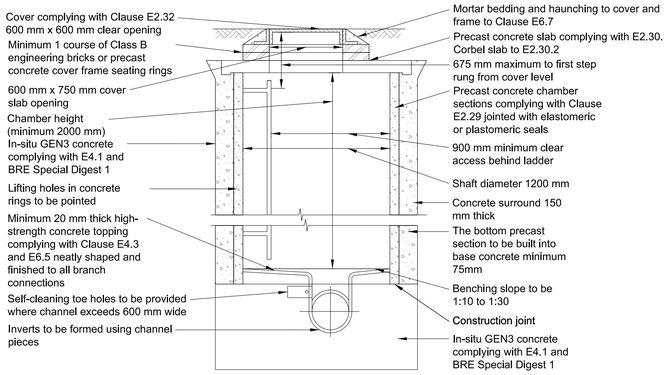
Scale at A1: 1:25		Arup Job No: 282022-00	
Role: Civil - Drainage			
Suitability: S3 - Issued for Review and Comment			
Rev: P02	By: DH	Chkd: RG	Appd: RG
	Date: 01/02/22	Date: 01/02/22	Date: 01/02/22

Name

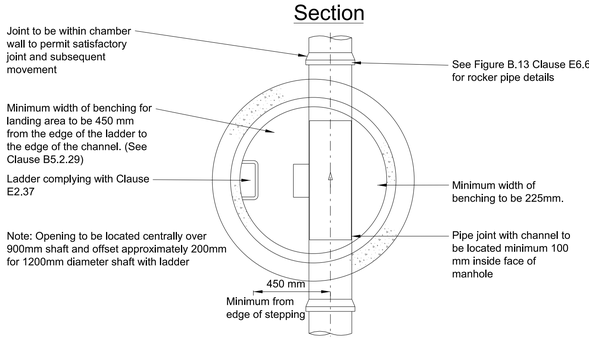
VNIF - ARP - 00 - YYY - DR - CD - 0004
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup



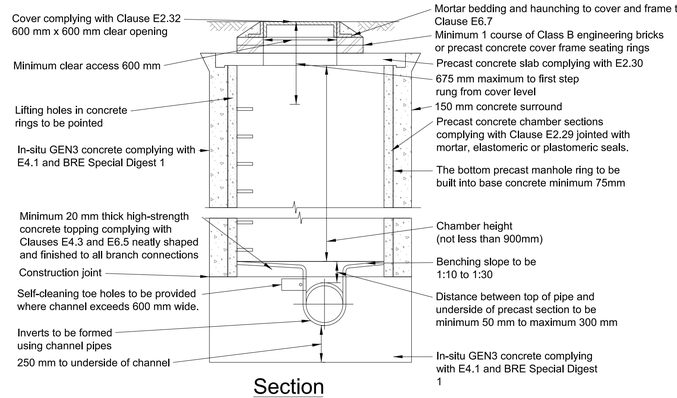
Section



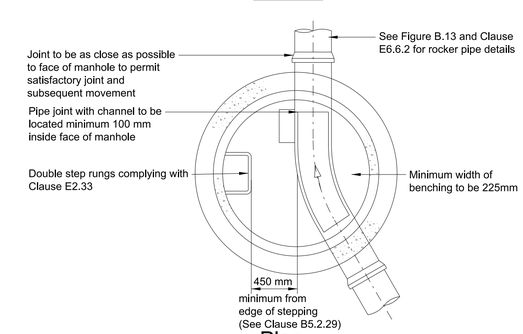
Plan

Typical Manhole Detail Type A2
Depth from Cover Level to Soffit of Pipe 3m to 6m with Ladder
Alternative Rigid Material Construction with Concrete Surround

Scale 1:25



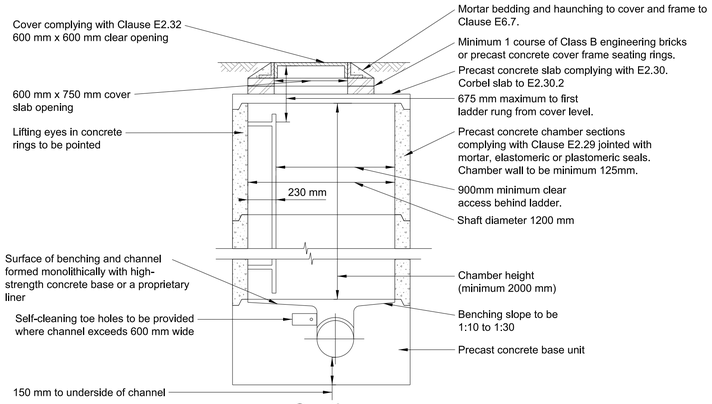
Section



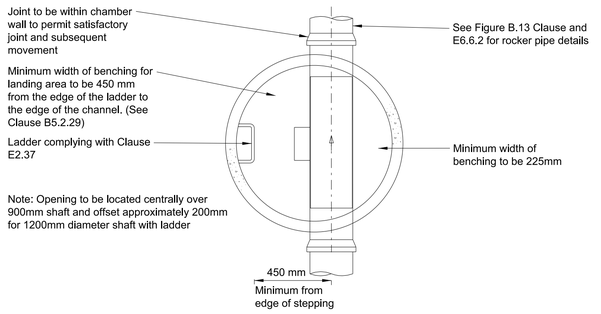
Plan

Typical Manhole Detail Type B
Depth from Cover Level to Soffit of Pipe 1.5m to 3m
Alternative Rigid Material Construction with Concrete Surround

Scale 1:25



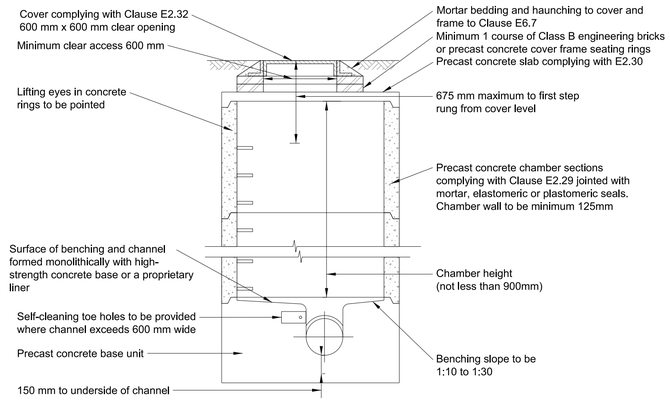
Section



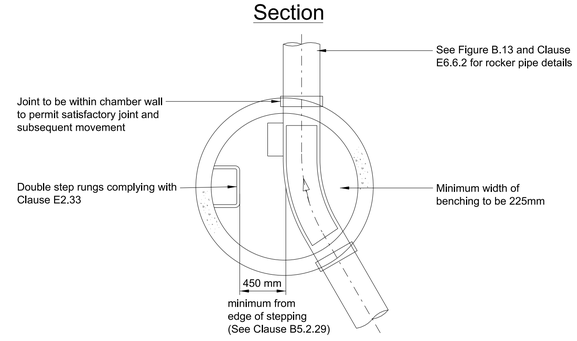
Plan

Typical Manhole Detail Type A2
Depth from Cover Level to Soffit of Pipe 3m to 6m with Ladder
Rigid Material Construction Without Concrete Surround

Scale 1:25



Section



Plan

Typical Manhole Detail Type B
Depth from Cover Level to Soffit of Pipe 1.5m to 3m
Rigid Material Construction Without Concrete Surround

Scale 1:25

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.

2. Do not scale from this drawing.

3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

4. Concrete Requirements. Concrete to be in accordance with BS 8500 parts 1 and 2.
- Concrete chemcial class - DS-1 AC-1
- Blinding: GEN 0
- Bases and Surround: GEN 3.

5. Drainage construction materials, unless otherwise stated:
- Drainage pipes - Polyethylene in accordance with BS 13476
- Manholes - Precast Concrete
- Inspection Chambers - Polypropylene in accordance with BS 7158

6. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.

7. Bed and Surround Class A3 when:
- Cover level in trafficked areas < 1.2m
- Cover level in non-trafficked areas < 0.9m

Bed and Surround Class S when:
- Cover level in trafficked areas > 1.2m
- Cover level in non-trafficked areas > 0.9m

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Details
Sheet 2 of 5

Scale at A1	1:25	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S3 - Issued for Review and Comment		

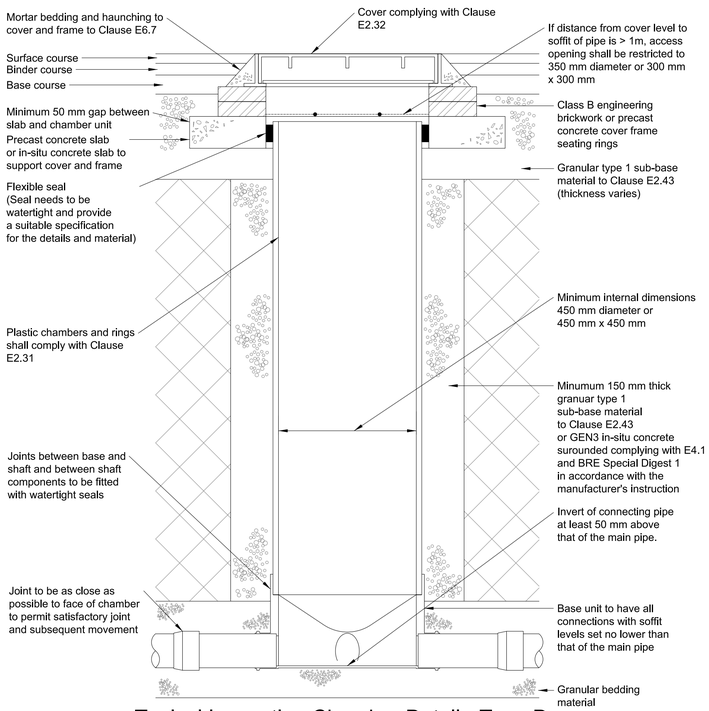
Rev	By	Chkd	Appd	
P01	DH	RG	RG	—
	Date 17/12/21	Date 17/12/21	Date 17/12/21	—

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0005
Project	Originator	Volume	Location	Type	Role	Number

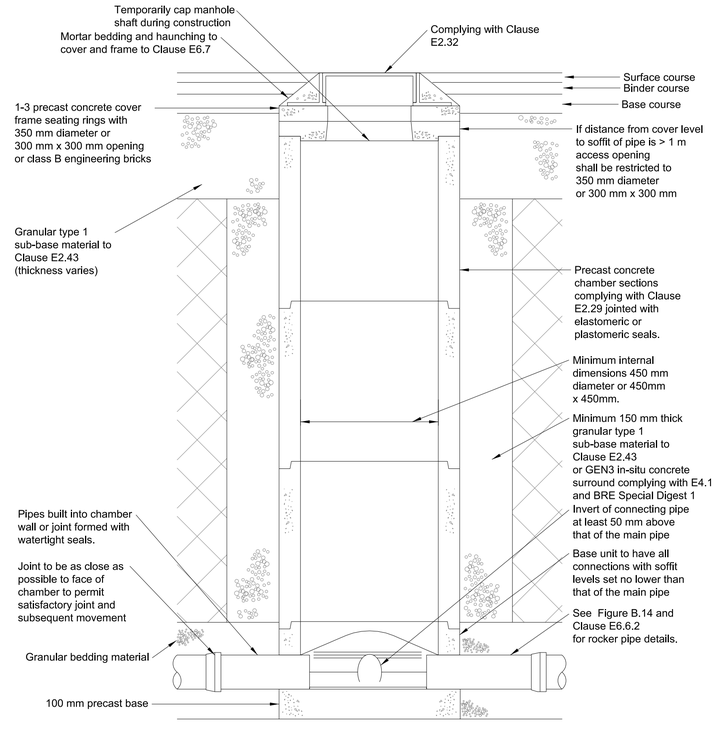
Do not scale

© Arup



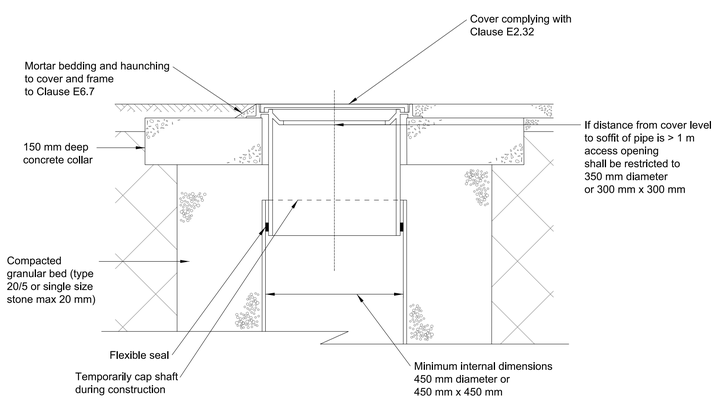
Typical Inspection Chamber Detail - Type D
Depth from Cover Level to Soffit of Pipe up to 3 m
Flexible Material Construction for use in Areas Subject to Vehicle Loading

Scale 1:10



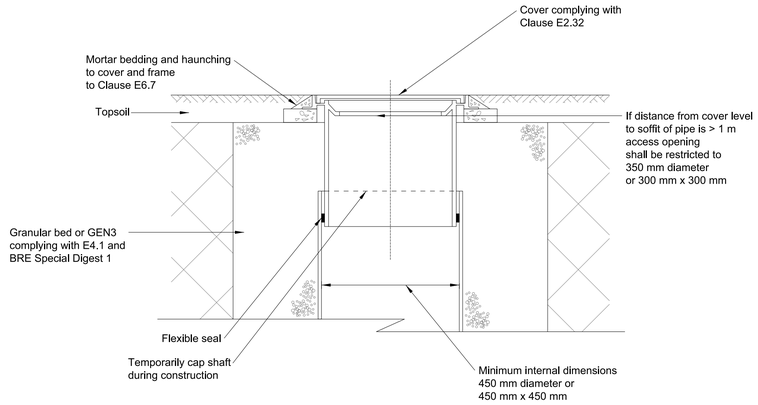
Typical Inspection Chamber Detail - Type D
Depth from Cover Level to Soffit of Pipe up to 3 m
Rigid Material Construction for use in Areas Subject to Vehicle Loading.

Scale 1:10



Alternative Top Details for Light Vehicle Loading and Landscaped Areas - Type D
Sited in domestic driveways or footways

Scale 1:10



Alternative Top Details for Light Vehicle Loading and Landscaped Areas - Type D
Sited in domestic gardens

Scale 1:10

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.

2. Do not scale from this drawing.

3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

4. Concrete Requirements. Concrete to be in accordance with BS 8500 parts 1 and 2.
- Concrete chemcial class - DS-1 AC-1
- Blinding: GEN 0
- Bases and Surround: GEN 3.

5. Drainage construction materials, unless otherwise stated:
- Drainage pipes - Polyethylene in accordance with BS 13476
- Manholes - Precast Concrete
- Inspection Chambers - Polypropylene in accordance with BS 7158

6. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.

7. Bed and Surround Class A3 when:
- Cover level in trafficked areas < 1.2m
- Cover level in non-trafficked areas < 0.9m

Bed and Surround Class S when:
- Cover level in trafficked areas > 1.2m
- Cover level in non-trafficked areas > 0.9m

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Details
Sheet 3 of 5

Scale at A1		Arup Job No	
	1:10		282022-00

Role: Civil - Drainage

Suitability: S3 - Issued for Review and Comment

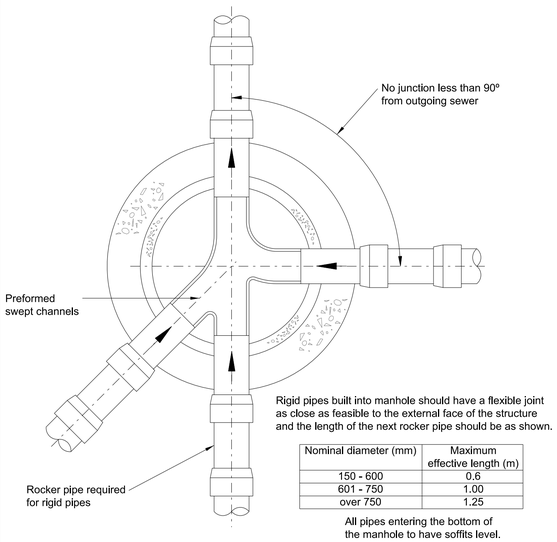
Rev	By	Chkd	Appd	
P01	DH	RG	RG	—
	Date 17/12/21	Date 17/12/21	Date 17/12/21	—

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0006
Project	Originator	Volume	Location	Type	Role	Number

Do not scale

© Arup



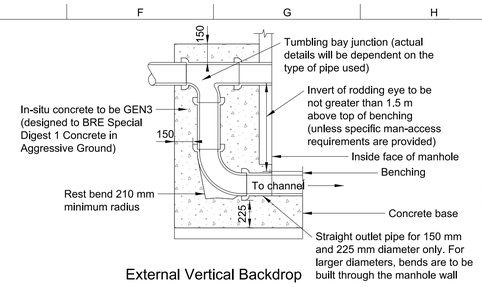
Rigid pipes built into manhole should have a flexible joint as close as feasible to the external face of the structure and the length of the next rocker pipe should be as shown.

Nominal diameter (mm)	Maximum effective length (m)
150 - 600	0.6
601 - 750	1.00
over 750	1.25

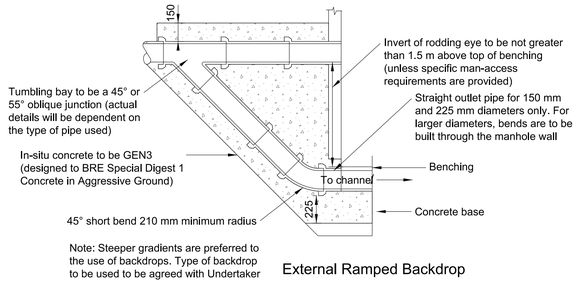
All pipes entering the bottom of the manhole to have soffits level.

Typical Arrangement of Pipe Junctions within Manholes

Scale 1:25



External Vertical Backdrop

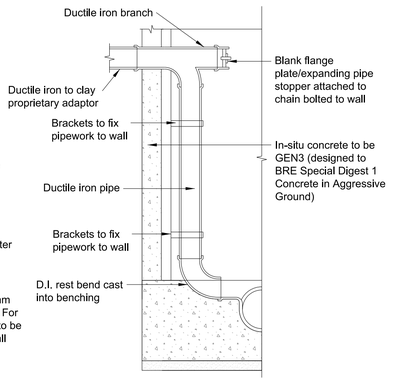


Note: Steeper gradients are preferred to the use of backdrops. Type of backdrop to be used to be agreed with Undertaker

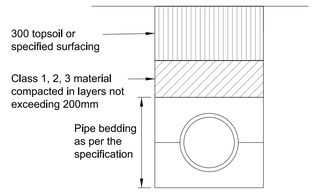
External Ramped Backdrop

Typical Vertical and Ramped Backdrop Detail

Scale 1:25

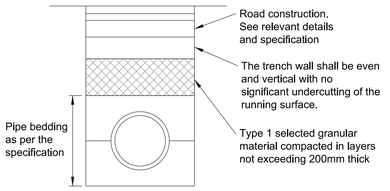


Internal backdrops may only be used if agreed with the adopting authority.



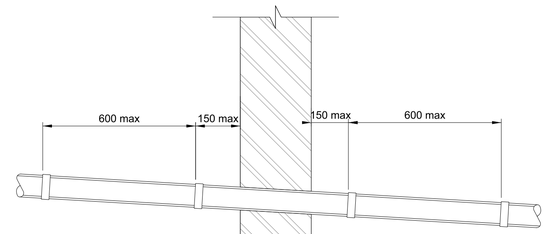
Detail D5.19 - Trench Reinstatement In Landscaped And Non Trafficked Areas

Scale 1:25

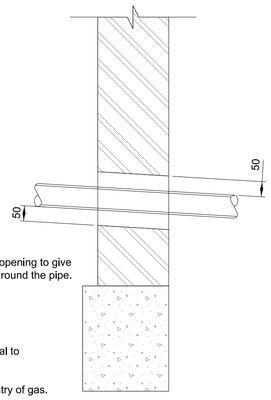


Detail D5.20 - Trench Reinstatement In Roads, Car Parks And Other Trafficked Areas

Scale 1:25



Short length of pipe bedded in wall, joints formed within 150mm of either wallface. Adjacent rocker pipes of max, length 600mm with flexible joints.



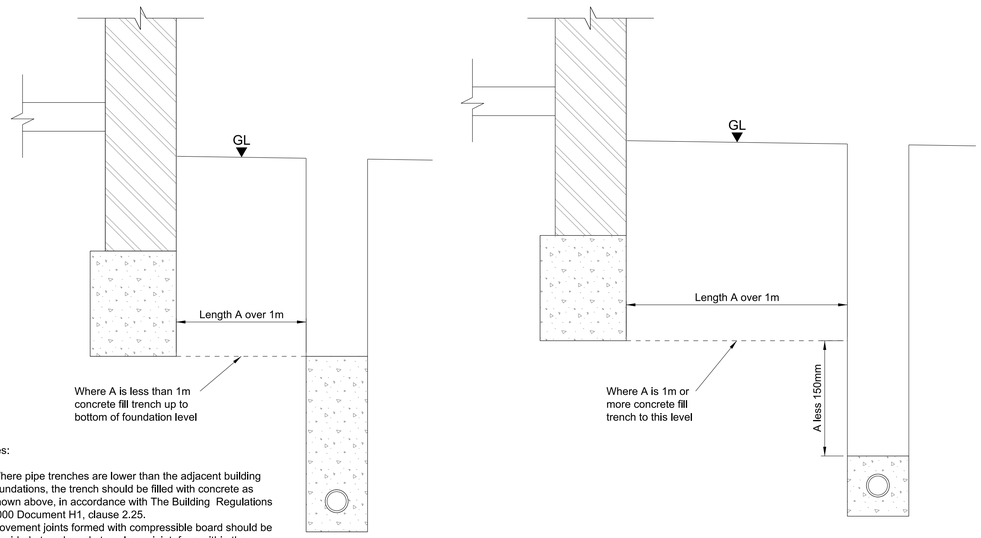
Arch of lintelled opening to give 50mm space all round the pipe.

Mask opening both sides with rigid sheet material to prevent entry of fill or vermin.

Fill void with compressible sealant to prevent entry of gas.

Detail D5.21 - Pipes Penetrating Walls

Not to scale

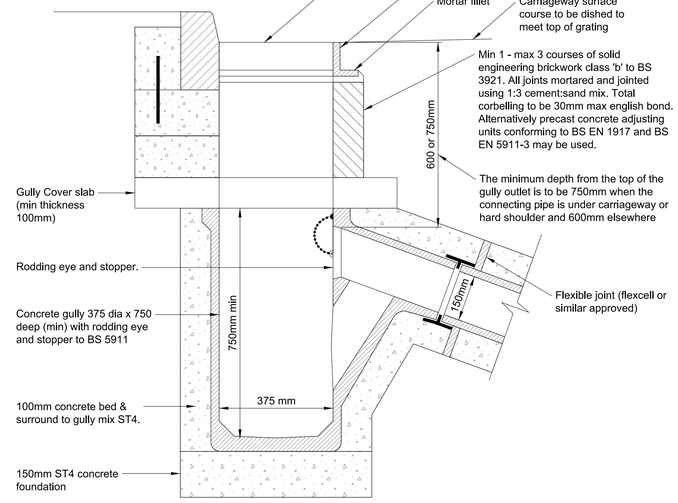


Notes:

1. Where pipe trenches are lower than the adjacent building foundations, the trench should be filled with concrete as shown above, in accordance with The Building Regulations 2000 Document H1, clause 2.25.
2. Movement joints formed with compressible board should be provided at each socket or sleeve joint face within the concrete filed trench.

Detail D5.22 - Pipe Runs Near Buildings

Not to scale



Typical Trapped Road Gully

Scale 1:10

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. Do not scale from this drawing.
3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications
4. Concrete Requirements. Concrete to be in accordance with BS 8500 parts 1 and 2.
   - Concrete chemcial class - DS-1 AC-1
   - Blinding: GEN 0
   - Bases and Surround: GEN 3.
5. Drainage construction materials, unless otherwise stated:
   - Drainage pipes - Polyethylene in accordance with BS 13476
   - Manholes - Precast Concrete
   - Inspection Chambers - Polypropylene in accordance with BS 7158
6. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.
7. Bed and Surround Class A3 when:
   - Cover level in trafficked areas < 1.2m
   - Cover level in non-trafficked areas < 0.9m

   Bed and Surround Class S when:
   - Cover level in trafficked areas > 1.2m
   - Cover level in non-trafficked areas > 0.9m

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Details
Sheet 4 of 5

Scale at A1	Arup Job No
AS SHOWN	282022-00

Role: Civil - Drainage

Suitability: S3 - Issued for Review and Comment

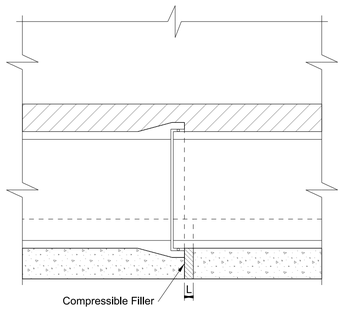
Rev	By	Chkd	Appd	
P01	DH	RG	RG	—
	Date 17/12/21	Date 17/12/21	Date 17/12/21	—

Name

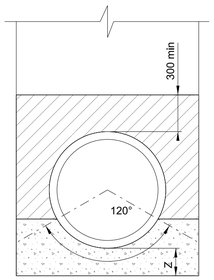
VNIF	- ARP -	00	- YYY -	DR	- CD -	0007
Project	Originator	Volume	Location	Type	Role	Number

Do not scale

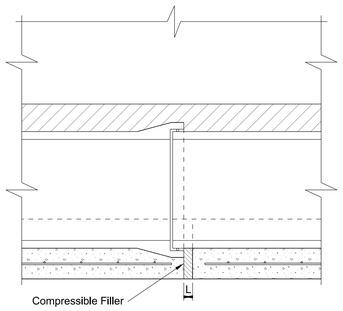
© Arup



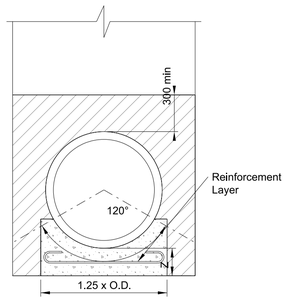
Plain Concrete Bed
Class A1
Spigot and Socket Pipes



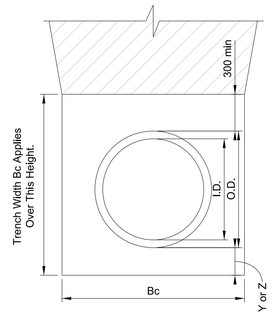
Plain Concrete Bed
Class A1
Bedding Factor 2.6



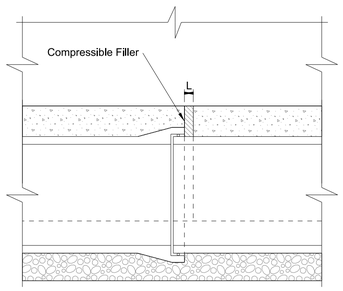
Reinforced Concrete Cradle
Class A4
Spigot and Socket Pipes



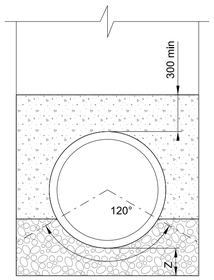
Reinforced Concrete Cradle
Class A4
Bedding Factor 3.4



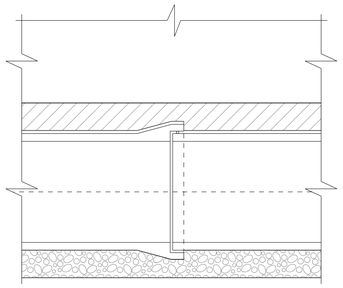
Typical Trench Section



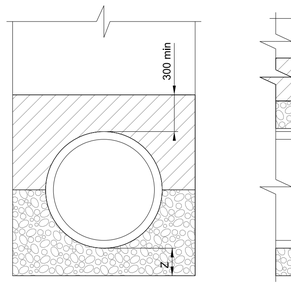
Plain Concrete Arch
Class A2
Spigot and Socket Pipes



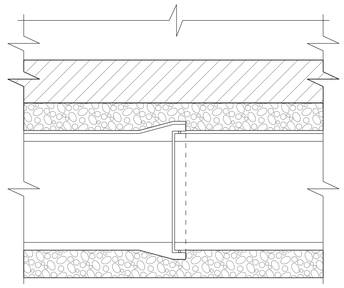
Plain Concrete Arch
Class A2
Bedding Factor 2.6



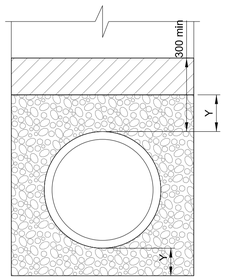
Granular Bed
Class B
Spigot and Socket Pipes



Granular Bed
Class B
Bedding Factor 1.9



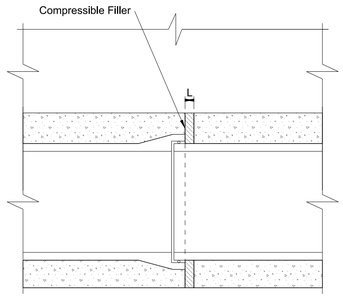
Granular Bed and Surround
Class S
Spigot and Socket Pipes



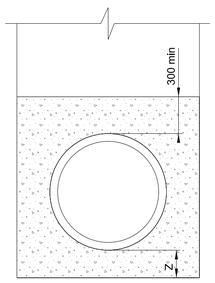
Granular Bed and Surround
Class S
Bedding Factor 2.2

PIPE DIA. (mm)	WIDTH Bc		Y		L (mm)	Z MIN
	MAX	MIN	Y1 (UNIFORM SOIL)	Y2 (ROCK) *		
100 150 225	550 600 700	450 490 580	100 100 150	200 200 200	18 36 54	100 100 100
300 375 450	750 1050 1150	680 950 1030	150 150 150	200 200 200		100 100 150
525 600 675	1200 1350 1450	1120 1240 1330	150 150 150	200 200 200		150 150 225
750 825 900	1500 1600 2100	1400 1490 1900	150 150 150	200 225 225		225 225 225
975 1050 1200	2150 2250 2500	1950 2050 2250	175 175 200	250 275 300		300 300 300
OVER 1200	O.D.+1000	O.D.+800	I.D./6	I.D./4		400

Table B
Trench Widths and Other Dimensions



Concrete Bed and Surround
Class A3
Spigot and Socket Pipes



Concrete Bed and Surround
Class A3
Bedding Factor 4.5

	Aggregate Size	
Pipe Dia (mm)	Graded (mm)	Single Sized (mm)
100	-	10
150	14-5	10 or 14
225-300	14-5 or 20-5	10,14 or 20
375-525	14-5 or 20-5	10,14 or 20
Exceeding 525	14-5 or 20-5 or 40-5	10,14,20 or 40

Table A
Granular pipe bedding material type 'A'

Legend:

Concrete Mix St4

Granular Pipe Bedding Material Type 'A'

Type 1 Granular Material

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.

2. Do not scale from this drawing.

3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

4. Concrete Requirements. Concrete to be in accordance with BS 8500 parts 1 and 2.
- Concrete chemcial class - DS-1 AC-1
- Blinding: GEN 0
- Bases and Surround: GEN 3.

5. Drainage construction materials, unless otherwise stated:
- Drainage pipes - Polyethylene in accordance with BS 13476
- Manholes - Precast Concrete
- Inspection Chambers - Polypropylene in accordance with BS 7158

6. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.

7. Bed and Surround Class A3 when:
- Cover level in trafficked areas < 1.2m
- Cover level in non-trafficked areas < 0.9m

Bed and Surround Class S when:
- Cover level in trafficked areas > 1.2m
- Cover level in non-trafficked areas > 0.9m

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Details
Sheet 5 of 5

Scale at A1	Arup Job No
1:25	282022-00

Role: Civil - Drainage

Suitability: S3 - Issued for Review and Comment

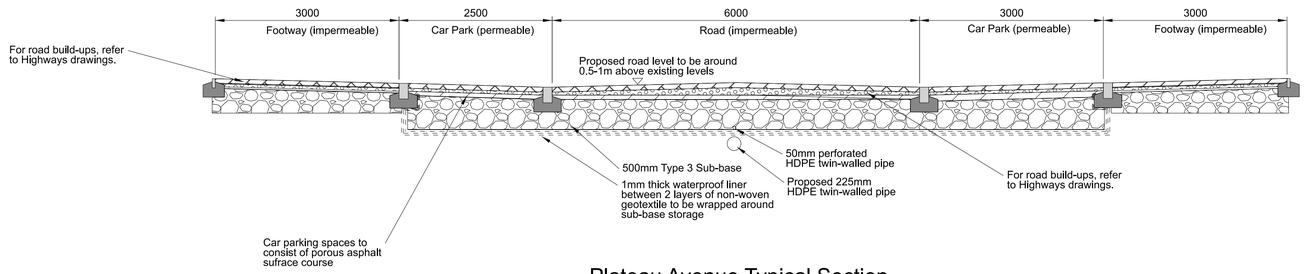
Rev	By	Chkd	Appd	
P01	DH	RG	RG	---
	Date 17/12/21	Date 17/12/21	Date 17/12/21	---

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0008
Project	Originator	Volume	Location	Type	Role	Number

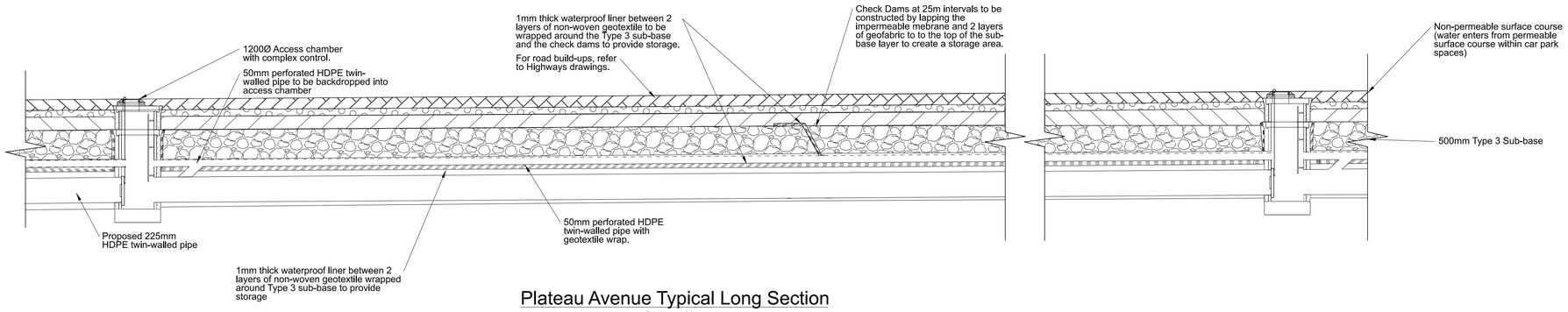
Do not scale

© Arup



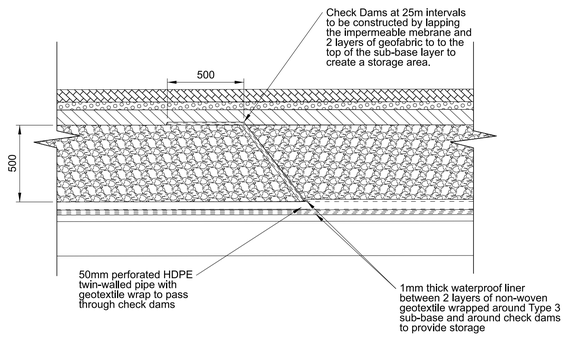
Plateau Avenue Typical Section

Scale 1:50



Plateau Avenue Typical Long Section

Scale 1:100
5x vertical exaggeration
(Long section taken down centreline of road)



Typical Lapping Detail

Scale 1:20
5x vertical exaggeration

Notes.

1. All dimensions are in millimeters unless noted otherwise.
2. All levels are given in meters (AOD).
3. This drawing should be read in conjunction with all relevant drawings, schedules, details and specifications:
   - VNIF-ARP-00-YYY-DR-CD-0001 to 0017
4. For CBR below 2.5%, remove and replace with capping material to a depth of 1.0m below base of sub base and assume just under 3% CBR for design of capping and sub-base.
5. Nonwoven polypropylene geotextile (Terram
   - T1000 GT or similar approved).
   - Tensile strength 8.0kN/m
   - Tensile elongation 60%
   - CBR puncture resistance 2kN
   - Mean pore size 75µm
   - Permeability (H50) 90l/m2.s
6. For details on road build-ups refer to Highways Engineering drawings.

Rev	Date	Description	By	Chkd	Appd	Auth
	17/12/21		DH	RG	RG	—
P02	11/03/22		DH	DH	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Drainage Sections
Sheet 1

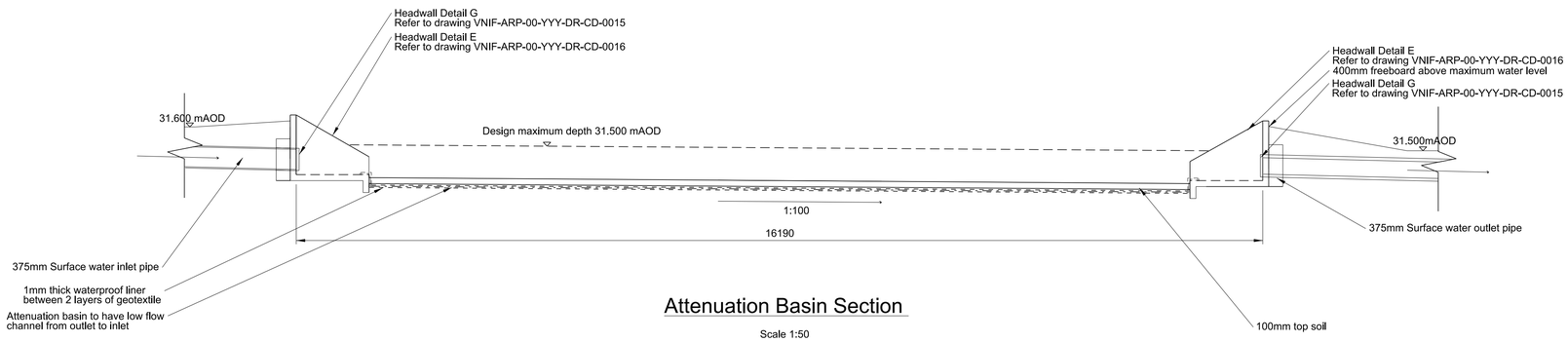
Scale at A1 1:25			Arup Job No 282022-00
Role: Civil - Drainage			
Suitability: S3 - Issued for Review and Comment			
Rev: P02	By: DH	Chkd: DH	Appd: RG
	Date: 10/03/22	Date: 10/03/22	Date: 11/03/22

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0013
Project	Originator	Volume	Location	Type	Role	Number

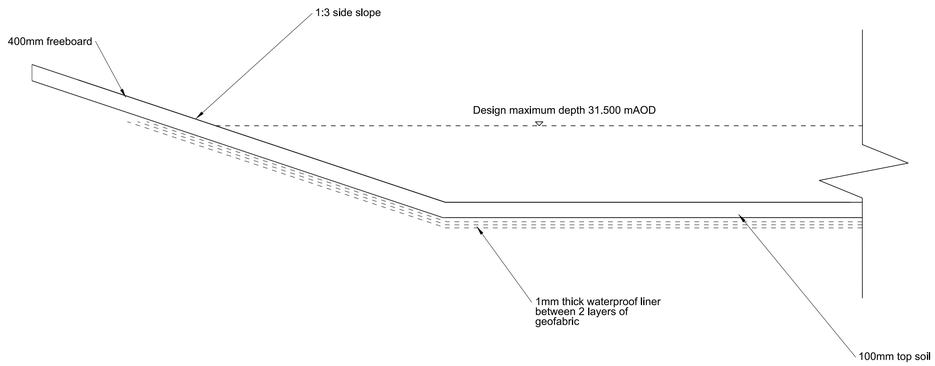
Do not scale

© Arup



Attenuation Basin Section

Scale 1:50



Typical Attenuation Basin Detail

Scale 1:20

Notes.

1. All dimensions are in millimeters unless noted otherwise.
2. All levels are given in meters (AOD).
3. This drawing should be read in conjunction with all relevant drawings, schedules, details and specifications:
   - VNIF-ARP-00-YYY-DR-CD-0001 - 0017
4. For CBR below 2.5%, remove and replace with capping material to a depth of 1.0m below base of sub base and assume just under 3% CBR for design of capping and sub-base.
5. Nonwoven polypropylene geotextile (Terram
   - T1000 GT or similar approved).
   - Tensile strength 8.0kN/m
   - Tensile elongation 60%
   - CBR puncture resistance 2kN
   - Mean pore size 75µm
   - Permeability (H50) 90l/m2.s
6. Refer to Landscape Architects details and specifications for detail for growing media and top soil.

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—
P02	01/02/22		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Drainage Pond Details

Scale at A1	1:25	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S3 - Issued for Review and Comment		

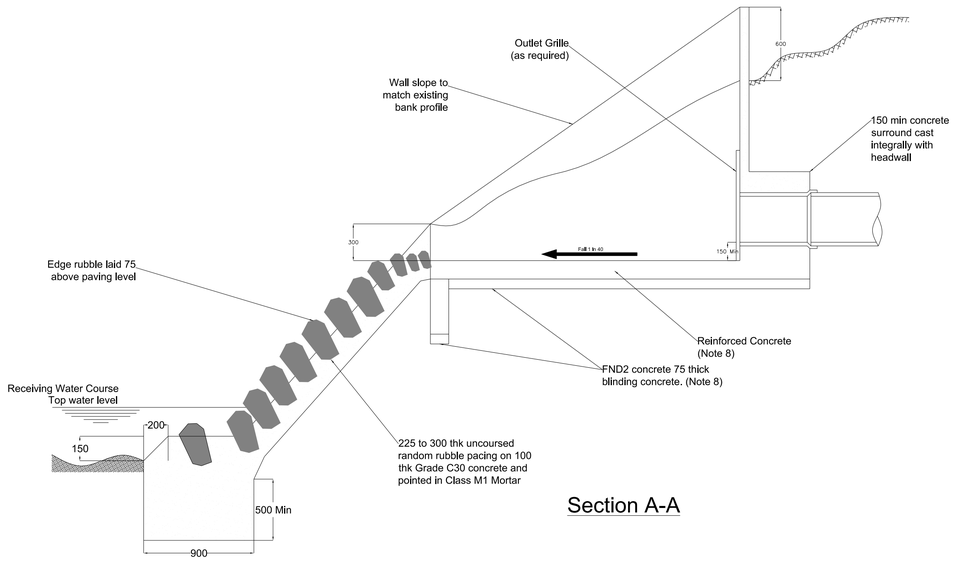
Rev	By	Chkd	Appd	
P02	DH	RG	RG	---
	Date 01/02/22	Date 01/02/22	Date 01/02/22	---

Name

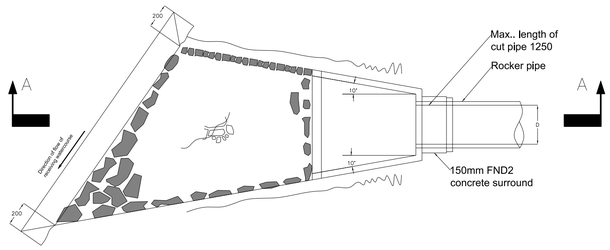
VNIF	- ARP -	00	- YYY -	DR	- CD -	0014
Project	Originator	Volume	Location	Type	Role	Number

Do not scale

© Arup



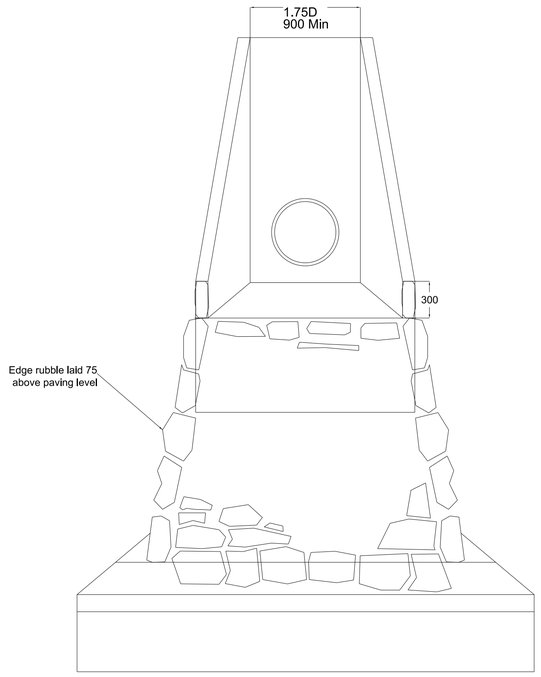
Section A-A



Plan

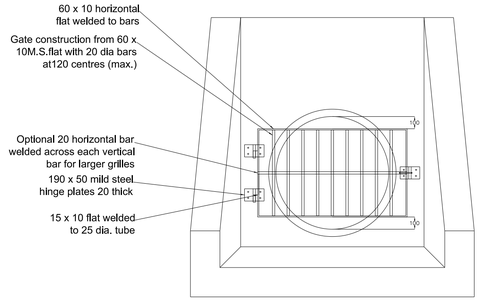
Notes

1. All dimensions in millimetres.
2. Generally the angle between the direction of flow od the receiving watercourse and the outfall pipe should be 45 degrees.
3. All reinforced concrete edges to be finished with a 25 x 25 fillet.
4. Min cover to reinforcement in the top face of the base slab to be 40.
5. The bed and opposite bank if the watercourse may, in certain circumstances need to be protected by 225 to 300 thick uncoursed rubble pitching laid on a 100 thick bed of FND2 concrete (Note 8) and pointed in Class M1 Mortar. The stone for pitching shall consist oflarge smooth faced stones roughly dressed square and shall be of a hard durable and inert material. Bunter sandstone, Keuper waterstones and Carboniferous shales and mudstones are not to be used.
6. An Outlet Grille as shown on Typical Detail G must be provided on all outfalls where the pipe size exceeds 459mm. Where pipe diameters are 375 to 450, 20 dia stainless steel bars are to be provided across outlet at max. 120mm c/c leaving 100mm max. clear opening.
7. Where outlets have a flap valve, a special detailed grille must be provided on all outlets 375mm diameter and above.
8. Secure handrailing shall be supplied where a person may fall 2 metres or more or where a fall of less than 2 metres carries an increased risk of injury due to the landing surface.
9. FND2 to be used for soil conditions Sulphate class 1 only. Designated mix references FND3, FND4A & FND4B to be used in soil conditions with sulphate classes 3 4A and 4B respectively (refer to specification clause 4.3.1).



Elevation

Typical Detail D
Typical Outfall Detail Type 1



Front Elevation

Notes

1. All dimensions in millimetres.
2. All grilles and fittings are to be manufactured with mild steel 'hot dip' galvanised to BS 729 and treated with 2 no coates of bituminous paint.
3. The sizes detailed on the grille indicate the preferred member size in normal locations. Consideration should be given to up-sizing members where the grille is in exposed locations or is of particularly large size.

Detail G
Typical Outlet Grille

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. Do not scale from this drawing.
3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Outfall Details
Sheet 1 of 2

Scale at A1		Arup Job No	
	NTS		282022-00

Role: Civil - Drainage

Suitability: S3 - Issued for Review and Comment

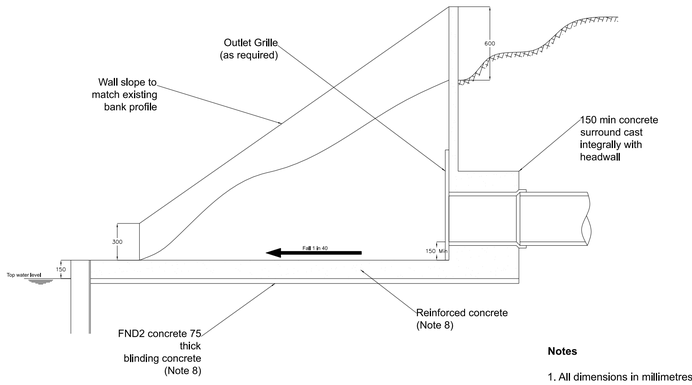
Rev	By	Chkd	Appd	
P01	DH	RG	RG	—
	Date 17/12/21	Date 17/12/21	Date 17/12/21	—

Name

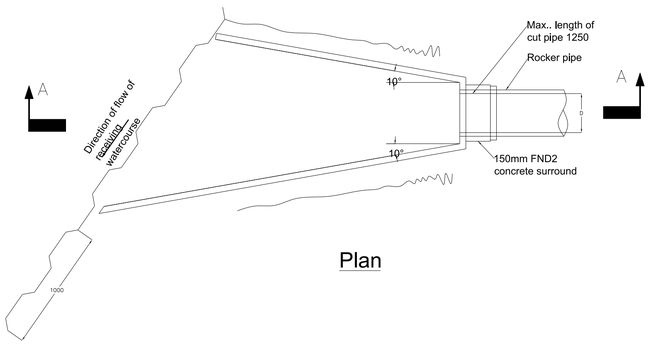
VNIF	- ARP -	00	- YYY -	DR	- CD -	0015
Project	Originator	Volume	Location	Type	Role	Number

Do not scale

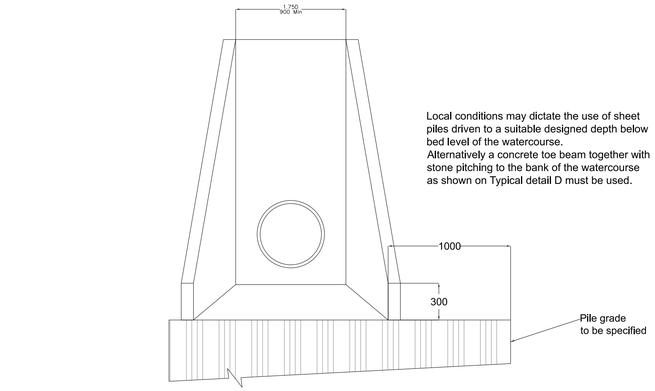
© Arup



Section A-A



Plan

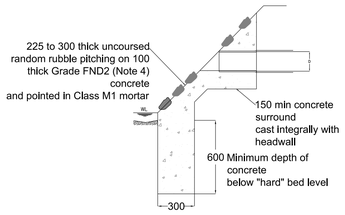


Elevation

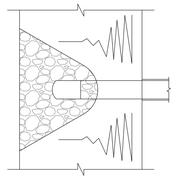
Typical Detail E
Typical Outfall Detail Type 2

Notes

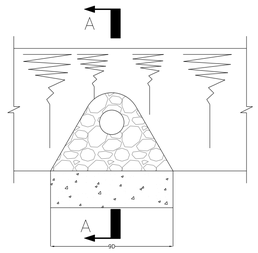
1. All dimensions in millimetres.
2. Generally the angle between the direction of flow of the receiving watercourse and the outfall pipe should be 45 degrees.
3. All reinforced concrete edges to be finished with a 25 x 25 fillet.
4. Min cover to reinforcement in the top face of the base slab to be 40.
5. The bed and opposite bank of the watercourse may,in certain circumstances need to be protected by 225 to 300 thick uncoursed rubble pitching laid on a 100 thick bed of FND2 concrete (Note 8)and pointed in Class M1 Mortar. The stone for pitching shall consist of large smooth faced stones roughly dressed square and shall be of a hard durable and inert material. Bunter sandstone, Keuper waterstones and Carboniferous shales and mudstones are not to be used.
6. An Outlet Grille as shown on Typical Detail G must be provided on all outfalls where the pipe size exceeds 450mm. Where pipe diameters are 375 to 450, 20 dia. stainless steel bars are to be provided across outlet at max. 120mm c/c leaving 100mm max. clear opening.
7. Where outlets have a flap valve, a special detailed grille must be provided on all outlets 375mm diameter and above.
8. Secure handrailing shall be supplied where a person may fall 2 metres or more or where a fall of less than 2 metres carries an increased risk of injury due to the landing surface.
9. FND2 to be used for soil conditions Sulphate class 1 only. Designated mix references FND3, FND4A & FND4B to be used in soil conditions with sulphate classes 3,4A and 4B respectively (refer to specification clause 4.3.1).



Sectional Elevation A-A



Plan



Section A-A

Typical Detail F
Typical Outfall Detail Type 3
(Maximum Pipe Size 225mm)

Notes

1. All dimensions in millimetres.
2. The bed and opposite bank of the watercourse may in certain circumstances, need to be protected by 225 to 300 thick uncoursed rubble pitching laid on 100 thick bed of FND2 concrete (Note 4) and bed of FND2 concrete (Note 4) and pointed in Class M1 mortar. The stone for pitching shall consist of large smooth faced stones roughly dressed square and shall be of a hard durable and inert material. Bunter sandstones, Keuper waterstones and carboniferous shales and mudstones are not to be used.
3. Maximum diameter 225mm.
4. FND2 to be used for soil conditions sulphate class 1 only. Designated mix references FND3, FND4A & FND4B to be used in soil conditions with sulphate classes 3,4A and 4B respectively (refer to specification clause 4.3.1).

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. Do not scale from this drawing.
3. This drawing should be read in conjunction with all relevant Engineer's and Architect's drawings, reports and specifications

Rev	Date	Description	By	Chkd	Appd	Auth
P01	17/12/21		DH	RG	RG	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Typical Drainage Outfall Details
Sheet 2 of 2

Scale at A1	Arup Job No
	282022-00

Role: Civil - Drainage

Suitability: S3 - Issued for Review and Comment

Rev	By	Chkd	Appd	
P01	DH	RG	RG	—
	Date	Date	Date	
	17/12/21	17/12/21	17/12/21	—

Name

VNIF	- ARP -	00	- YYY -	DR	- CD -	0016
Project	Originator	Volume	Location	Type	Role	Number

Do not scale

© Arup

Appendix E

Foul Water General Arrangement

A1

N

RB05a
RB05b
RB05c
RB04
RB03
RB02
RB01
RB17
RB16
NT04
NT03
NT02
RB12b
RB12a
RB11
RB10
RB09
RB08
RB07
RB06

F1
F1.000
F2
F1.001
F3
F1.002
F4
F1.003
F5
F1.004
F6
F1.005
F7
F1.006
F8
F1.007
F9
F2.002
F2.001
F2.000
F10
F11
F12
F3.000
F13
F3.001
F21
F4.000
F20
F4.001
F14
F3.002
F15
F3.003
F16
F3.004
F17
F3.005
F18
F3.006
F19
F5.000
F22
F5.001
F23
F5.002

Connection to sewer
Outfall invert - 35.226mAOD
Outfall design flow - 85.7l/s

Connection to sewer
Assumed outfall invert - 28.725mAOD
Outfall design flow - 27.5l/s

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   • Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 dated 14/02/2022 by Planit.
   • Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. No guarantee is given for the accuracy of the information contained herein, which is provided for general guidance only and must not be relied upon for excavation or detailed design until apparatus locations are verified / validated through further site investigation works.
5. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
6. Existing Drainage layout based on the following information:
   - Utility Search Map drawing 97079 undertaken by Atkins dated 24/06/2021.
7. For the Standard Drainage Specification refer to the "Design and Construction Guidance for foul and surface water sewers offered for adoption" - Rev 2.1 - dated 25th May 2021.
8. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
9. Utilities have been drawn to PAS128 standard. The Located Service Classification table below gives a brief overview. For further details refer to document 'PAS 128:2014 Specification for underground utility detection, verification and location'.

Located Service Classification	Certainty/Risk
Type A Verification - Visual Identification	
Type B Detection - Typically GPR and EML techniques are used	Depth
Type C Site reconnaissance + Physical surface features identified	
Type D Desktop utility records search	

10. A connection point has been provided for each plot within the HIF Boundary at a minimum depth of 2.0-2.5m as agreed with WSP.
11. Drainage construction materials, unless otherwise stated:
    - Drainage pipes - Polyethylene in accordance with BS 13476
    - Manholes - Precast Concrete
    - Inspection Chambers - Polypropylene in accordance with BS 7158
12. For drainage diversions and abandonments, refer to drawing VNIF-ARP-00-YYY-DR-CU-1001
13. The finalised location of trees is to be confirmed at the next design stage.

Key

- HIF Site Boundary
- Plot Boundary
- Provision of Utility and Drainage Infrastructure Only
- Existing Drainage Combined Sewer
- Existing Drainage Combined Sewer Outfall
- Existing Drainage Surface Water Drain (Private)
- Proposed Foul Sewer Pipe
- Proposed Foul Sewer Manhole
- Proposed Plot Connection
- Proposed Adoptable Easement (3m)

Rev	Date	Description	By	Chkd	Appd	Auth
P01	26/08/21		AS	AS	AS	---
P02	17/12/21		DH	RG	RG	---
P03	01/02/22		DH	RG	RG	---
P04.02	17/02/22		---	---	---	---

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Foul Drainage
General Arrangement

Scale at A1	1:1250	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S0 - Initial Status or WIP		

Rev	By	Chkd	Appd	
P04.02	---	---	---	---
	Date	Date	Date	---
	---	---	---	---

Name

VNIF - ARP - 00 - YYY - DR - CD - 0003
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup

Appendix F

Surface Water Exceedance Flow Drawings

A1



Key

- HIF Site Boundary
- Plot Boundary
- Provision of Utility and Drainage Infrastructure Only
- Exceedance Flow Path (Main Route)
- Exceedance Flow Path (Contributory Route)

Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   - Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 dated 14/02/2022 by Planit.
   - Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
5. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
6. The purpose of this drawing is to show the exceedance flow paths for Surface Water in the event of system failure or an extreme storm event (> 100yr +40%cc)

	01/02/22		DH	RG	RG	—
	01/02/22		DH	RG	RG	—
	18/02/22	Amended for Planning Comments	DH	DH	RG	—
P04	01/03/22		DH	DH	LS	—
Rev	Date	Description	By	Chkd	Appd	Auth

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Exceedance Route Drawing
Sheet 1 of 2

Scale at A1	1:500		Arup Job No	282022-00
Role	Civil - Drainage			
Suitability	S3 - Issued for Review and Comment			
Rev	By	Chkd	Appd	
P04	DH	DH	LS	—
	Date	Date	Date	
	01/03/22	01/03/22	01/03/22	—

Name

VNIF - ARP - 00 - YYY - DR - CD - 0018

Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup

A1



Notes

1. All dimensions are in mm, all levels in mAOD, unless specified otherwise.
2. This map is reproduced from Ordnance Survey Material with the permission of the Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office (c) Crown Copyright. License Number 100019568 (2021).
3. Layout is based on:
   - Landscape Architect masterplan drawing VNIF-PLA-ZZ-YYY-DR-L-1011 Rev P02.06 dated 14/02/2022 by Planit.
   - Topographical Survey drawing PS-2158-TS by Paragon Surveys dated September 2021.
4. Extents of road refurbishments, new roads, and street works are WIP based on WS3 Design.
5. This drawing should be read with reference to the Arup Stage 3 Report and Drainage Strategy.
6. The purpose of this drawing is to show the exceedance flow paths for Surface Water in the event of system failure or an extreme storm event (> 100yr +40%cc)

Key

- HIF Site Boundary
- Plot Boundary
- Provision of Utility and Drainage Infrastructure Only
- Exceedance Flow Path (Main Route)
- Exceedance Flow Path (Contributory Route)

Rev	Date	Description	By	Chkd	Appd	Auth
P01	01/02/22		DH	RG	RG	—
P02	01/02/22		DH	RG	RG	—
P03	01/02/22		DH	RG	RG	—
P04	18/02/22	Amended for Planning Comments	DH	DH	RG	—
P05	01/03/22		DH	DH	LS	—

ARUP

6th Floor 3 Piccadilly Place
Manchester M1 3BN
Tel +44 161 228 2331 Fax +44 161 228 6879
www.arup.com

Client

MANCHESTER CITY COUNCIL

bam nuttall

Project Title

Victoria North HIF Infrastructure & Enabling Works

Drawing Title

Proposed Exceedance Route Drawing
Sheet 2 of 2

Scale at A1	1:500	Arup Job No	282022-00
Role	Civil - Drainage		
Suitability	S3 - Issued for Review and Comment		

Rev	By	Chkd	Appd	
P05	DH	DH	LS	—
	Date 01/03/22	Date 01/03/22	Date 01/03/22	—

Name

VNIF - ARP - 00 - YYY - DR - CD - 0019
Project | Originator | Volume | Location | Type | Role | Number

Do not scale

© Arup