

BAM

**Victoria North Infrastructure and
Enabling Works**

Flood Risk Assessment

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

P03 | 11 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.

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Contents

	Page
1 Introduction	1
2 Site location	3
3 Development proposals	4
4 Site specific flood risk	5
4.1 Fluvial flood risk	5
4.2 Surface water flood risk	7
4.3 Ground water flood risk	8
4.4 Flooding from public sewers	8
4.5 Reservoir flood risk	8
4.6 Existing flood risk conclusions	8
5 Impact of proposed scheme	10
5.1 Fluvial	10
5.2 Surface water	12
6 Flood risk management measures	12
6.1 Fluvial	12
6.2 Surface water	15
6.3 Summary	16
7 Conclusion	18

Figures

Figure 1 Victoria North HIF Works Boundary	1
Figure 2 Victoria North HIF Infrastructure Works Site Location	3
Figure 3 Victoria North development proposed arrangement	4
Figure 4 Flood Zones 2 and 3 from the EA Flood Map for Planning	5
Figure 5 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)	6
Figure 6 Surface Water Flood Extents extracted from EA Flood Map for Planning (High Risk $\geq 3.3\%$, 1 < Medium Risk $< 3.3\%$, 0.1% < Low Risk $< 1\%$, Very Low Risk $\leq 0.1\%$)	7
Figure 7 Impacts of scheme on flood depth and extent from interim 2021 modelling for 100 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.	10
Figure 8 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.	11

Figure 9 Figure 9 Interim 2021 modelled out of bank flow (1000 year) under
existing condition (left) and proposed removal of river wall (right).
11

Figure 10 Proposed bund wall location 14

Figure 11 Proposed bund typical section 14

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 16.63ha, a proportion of this area includes the future development plots and is will 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.

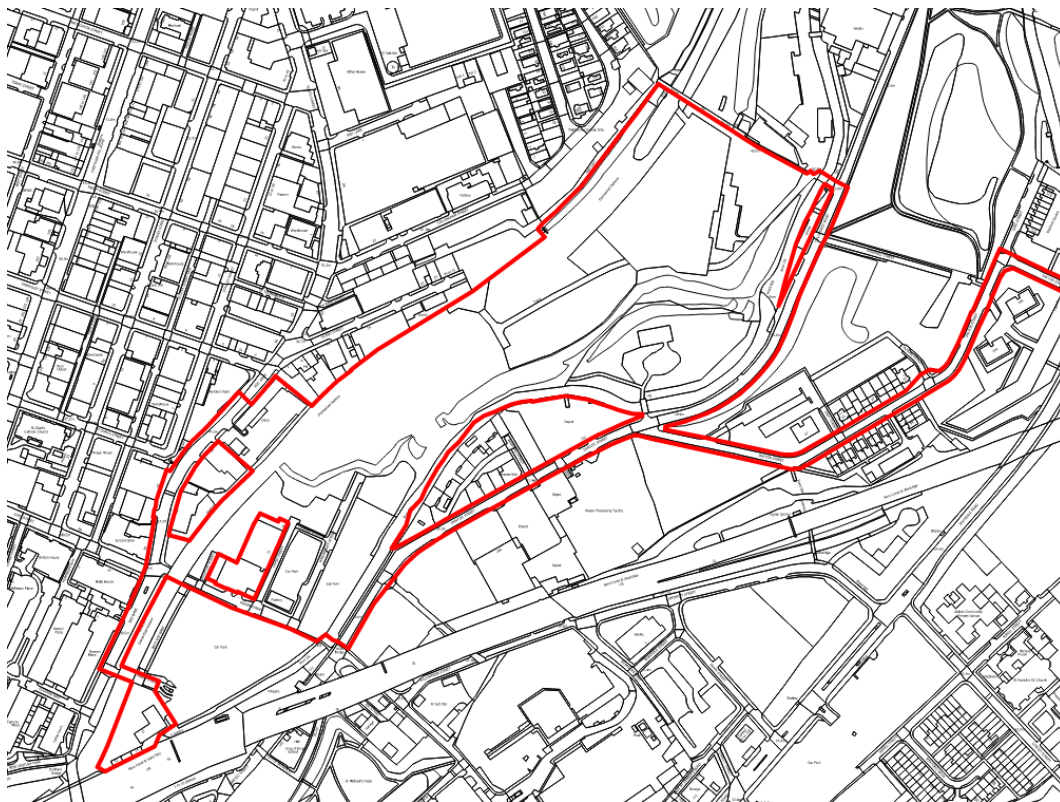


Figure 1 Victoria North HIF Works Boundary

This FRA will only assess the flood risk for elements of the scheme which are part of the HIF Infrastructure works, future FRA's for the later phases of the works will address the flood risk for the elements not included here, such as the development plots. The majority of the HIF Infrastructure Works are related to level and layout changes 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 the areas and therefore they have been excluded from the FRA as 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 Danzic 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. The potential mitigation options are likely to include using flood resilient and flood resistant building techniques and to identify safe egress and access routes for all future site occupants.

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 16.63ha and is shown by the red line boundary below. (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. The wider 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 a future planning application.

As part of the proposals for the infrastructure works, modifications to the existing river walls at St Catherine's Wood and adjacent to plots RB06 and RB07 have been proposed. This would include the removal of the existing masonry walls and the installation of landscaping, to improve the biodiversity and amenity value of the river.



Figure 3 Victoria North development proposed arrangement

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 4 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 5. 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.

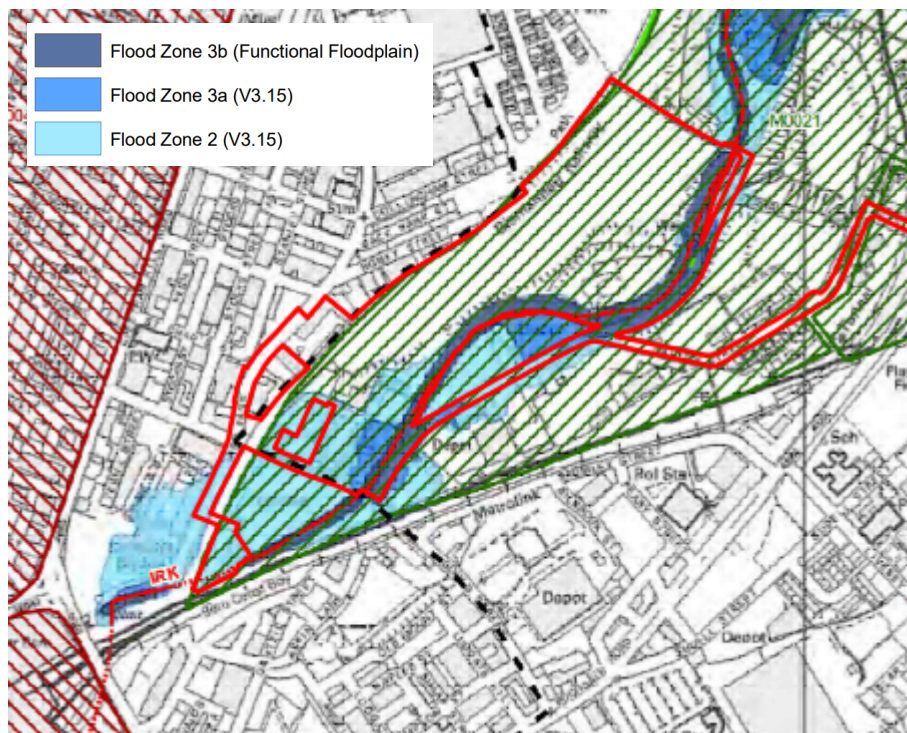


Figure 5 Flood Zone Extents identified in the Manchester, Salford and Trafford SFRA (note: flood zones 2 and 3a will be taken from EA flood maps and updated modelling)

As part of a separate commission in 2019, a baseline flood model was developed by Arup for the River Irk in consultation with the Environment Agency. It can be noted that it showed largely similar flood outlines when compared to the EA flood maps, however this modelling has not been formally accepted by the EA and is not considered any further as part of this FRA.

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 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 results of this model have been included in Appendix A. This interim model uses a “precautionary approach” to the hydrology, 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

withing 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 2 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 6 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.

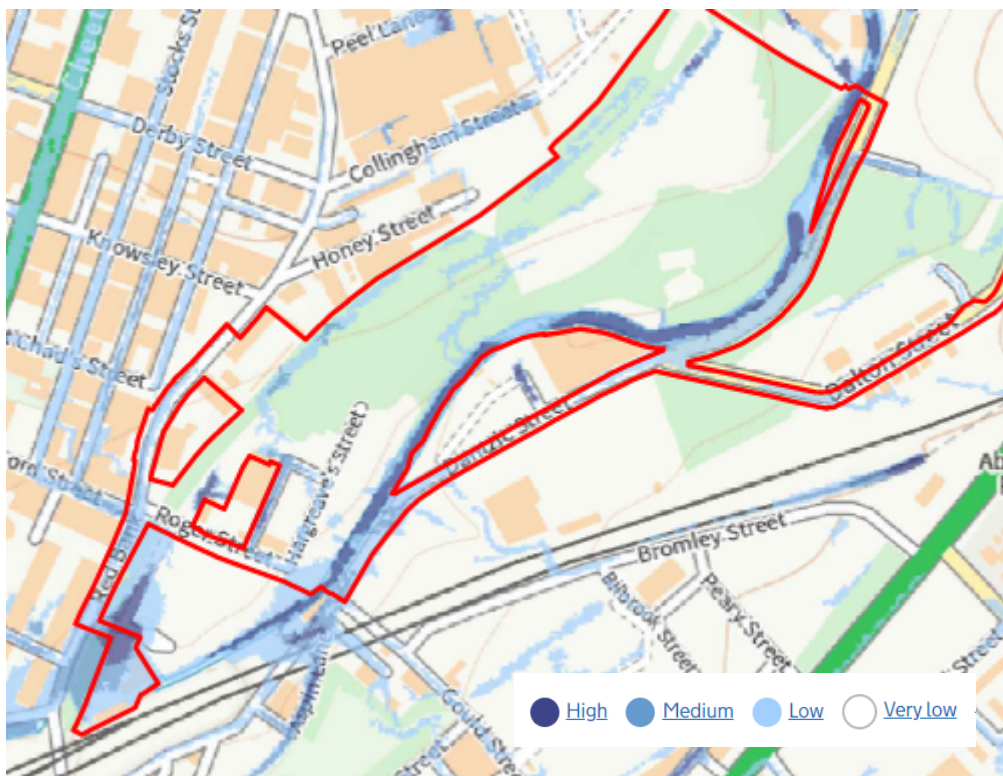


Figure 6 Surface Water Flood Extents extracted from EA Flood Map for Planning (High Risk $\geq 3.3\%$, $1 < \text{Medium Risk} < 3.3\%$, $0.1\% < \text{Low Risk} < 1\%$, Very Low Risk $\leq 0.1\%$)

The areas of high risk from surface water 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.

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. Measures to control groundwater inflow may be required where excavations are proposed.

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 hours¹, 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 Existing flood risk conclusions

The main flood risk mechanisms for the Victoria North HIF site have been identified as fluvial and surface water. The impact of both of these mechanisms

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

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 2019 river model. The interim model shows limited changes to these areas 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 sits mostly within flood zone 2, with an area in the south east corner of RB07 in flood zone 3. 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 and the 2019 river model. The interim "precautionary approach" model shows that the extent of flood zone 3 areas increases with the modified hydrology, due to the increased flow within the river channel. The proposed development for the HIF Infrastructure works are not impacted by the potential increase in the extents of zone 3 as all works are flood compatible. However the future development of the plots will need to take account of the potential increase in flood risk due to the updated hydrology, and the exception and sequential test will need to be undertaken to confirm these sites are suitable for development.

5 Impact of proposed scheme

5.1 Fluvial

The 2021 interim model shows that in-channel flood levels are generally decreased slightly upstream of the works, and there is generally a negligible increase of in-channel levels downstream of the proposals. The extents of potential flooding downstream of Union Bridge is larger due to the removal of the river wall. The opening up of the river banks at St Catherine's Wood and adjacent to plots RB06 and RB07 will increase the volume available within the river during extreme events, however due to the volume within the river channel and the limited scope of these changes the improvement is small.

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 7 and 8. This also increases flows on to the development plots RB06, 07 and 08. Flows within the river downstream of Union bridge are decreased as the water is allowed to freely re-enter the channel under the proposed scenario. Flood depths within the site are increased by 0.35m-0.55m compared to the existing scenario with the wall in place to the north of Union Bridge.

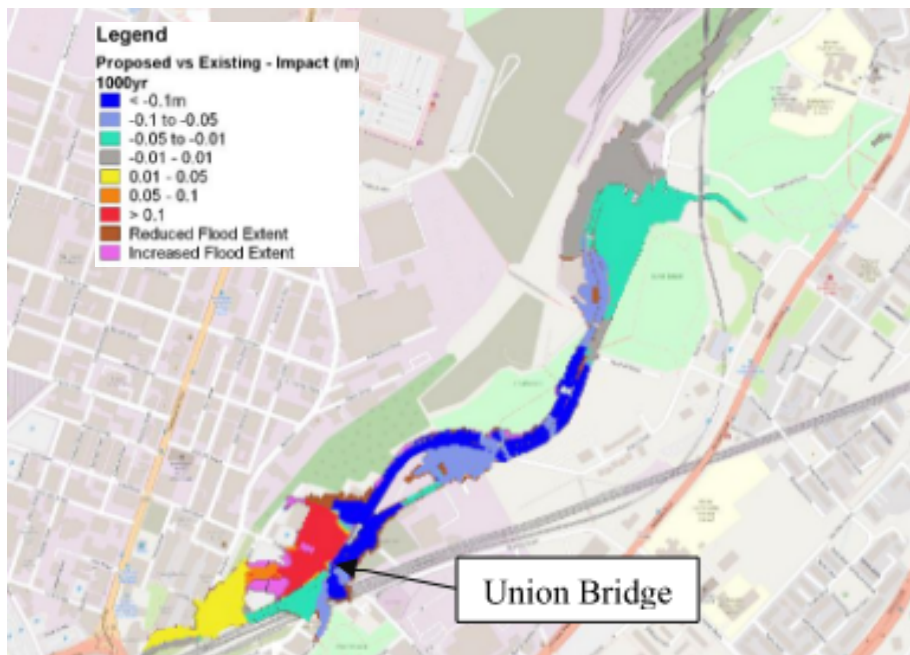


Figure 7 Impacts of scheme on flood depth and extent from interim 2021 modelling for 100 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

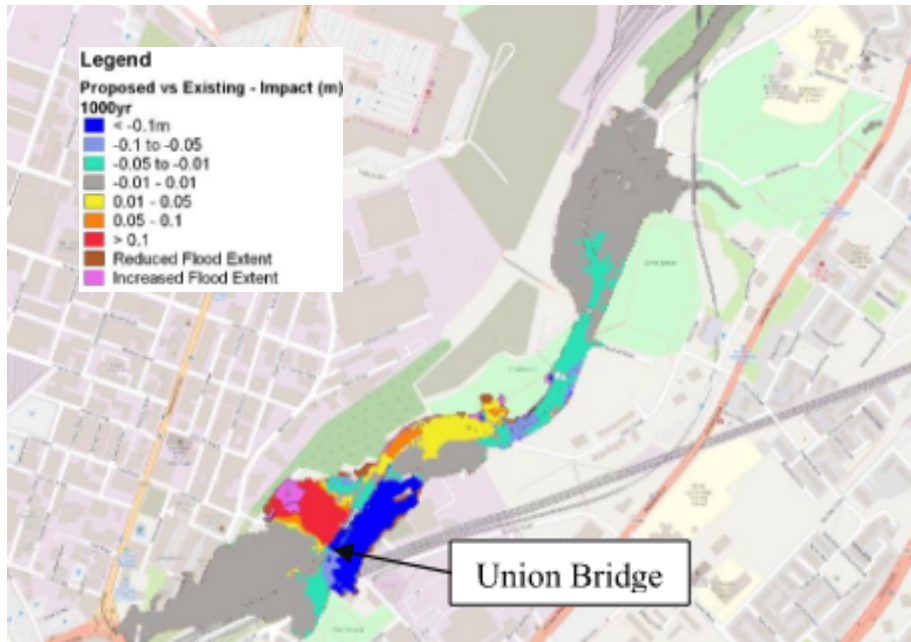


Figure 8 Impacts of scheme on flood depth and extent from interim 2021 modelling for 1000 year event. Note that extents are indicative only as this model uses a 'precautionary approach' to the hydrology.

Downstream of Union Bridge

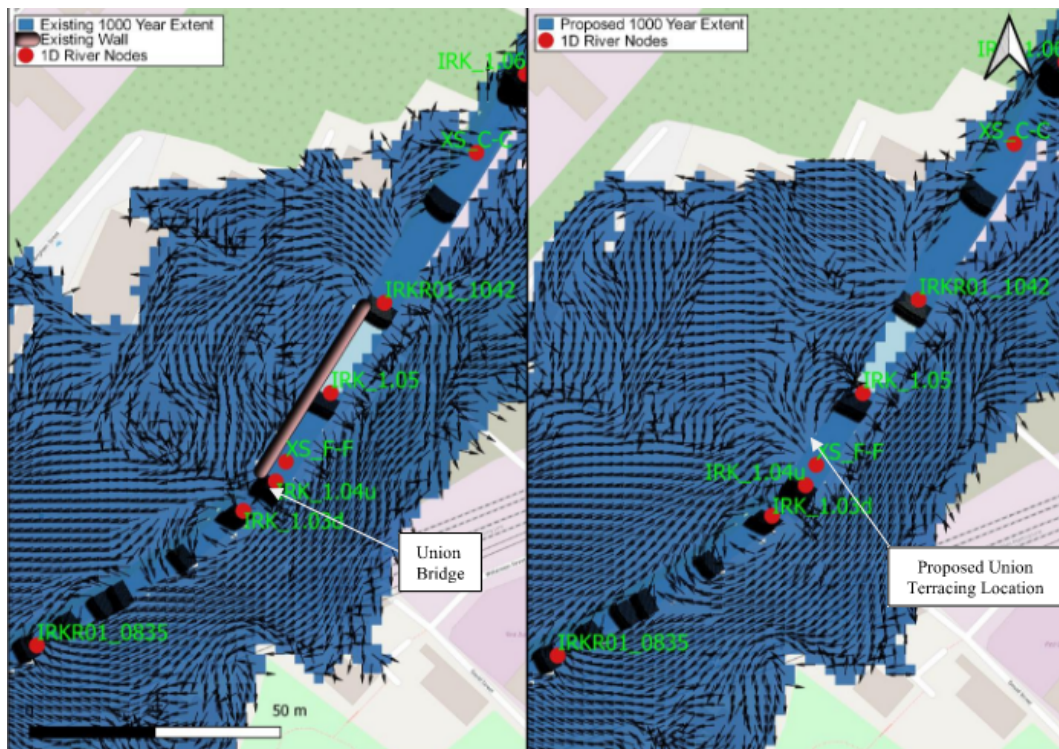


Figure 9 Interim 2021 modelled out of bank flow (1000 year) under existing condition (left) and proposed removal of river wall (right).

Flood levels are increased downstream of Union Bridge (Figure 9) as a result of proposals upstream in all return periods other than the 1000-year event where changes to flood level are negligible. There is an increase in flood level of approximately 0.1-0.15m south of Roger Street for the 100-year event, which also increases the flood extent within plot RB09 and, due to a south-west overland flow direction, increases depths by approximately 0.02m south-west of the site along Scotland Street. These increases in flood level are as a result of the existing wall being removed, which allows an increase in flow into the RB07 plot, which then flows overland south towards Scotland Street.

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.

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 sits in 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.

South of river and Dantzic Street

Most of the area south of the river lies in flood zone 2, there is a small section in flood zone 1 on the west edge of Travis Island. Two areas to the west and east of Dantzic Street lie within flood zone 3a. Dantzic Street is also identified as an area of increased surface water risk due to topographical low points.

Development in flood zone 2 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 to prevent worsening the fluvial flood risk. This 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.

There are no plots within flood zone 3 south of the river. Dantzic Street sits within flood zone 3, this is considered water compatible development. Surface water management for Dantzic Street should make consideration of the high flood risk, by ensuring that the area is developed with falls to allow any flood waters to drain away quickly following a flood event.

North of the river (west, within the site boundary)

Most of the area north of the river, around plots RB06, 07 and 08 sits within flood zone 2. Some zones further from the river are in flood zone 1, including the bottom section of the proposed Red Bank Terraces. A small section of site North of Union Bridge is in flood zone 3. The 2021 interim flood model indicates that flood levels and extents will be worsened locally both upstream and downstream of Union Bridge on the right bank of the river due to the removal of an existing river wall with terracing at this location. Mitigation will be required to prevent worsening flood risk both off and on site, as discussed below.

The proposed development within flood zone 2 will follow the Environment Agency Standing Advice. The HIF Infrastructure works will adopt a suitable surface water management strategy which will include the use of SuDS features to attenuate surface water and restrict discharge from the site to greenfield rates. This will be integrated with the on-plot drainage strategy which will also be restricted to greenfield runoff. In line with the discharge hierarchy, the surface water management plan proposes all surface water to be discharged to the River Irk; restricting the site to greenfield discharge.

The HIF scheme will not include development of on-plot infrastructure or any groundwork for the plots within flood zone 2. The development of these plots will be covered by a separate FRA as discussed above.

A small section within the proposed plot RB07 boundary is within flood zone 3a, less vulnerable development is permitted here. The masterplan should prioritise buildings which meet this classification including shops, restaurants and offices within flood zone 3. Residential dwellings will not be permitted in flood zone 3a unless the exception test is applied. The on-plot developer should prioritise water compatible development such as amenity space in this area where possible.

Areas of the HIF infrastructure works within flood zone 3 are considered as water compatible development and the surface water management strategy will be developed with consideration of the flood risk.

South west of site (area affected by proposed removal of wall upstream of Union Bridge)

As discussed in section 5.1 the 2021 interim model shows that the removal of the existing river wall upstream of Union Bridge causes a slight increase to flooding levels to the south west of site (around Scotland Street), mitigation measures are required in order to not worsen the existing condition. The mechanism for the increase in flood levels is due to the removal of the existing wall and opening up of the river bank allowing more flow to enter the area of the site adjacent to RB07.

The diagram shows a cross-section of an earth bund. The top of the bund is 0.5m high with 1:3 slopes. The total width of the bund is 10.22 m. The water level is 31.620 m AOD. The bund profile starts at 30.200 m AOD on the left, rises to a peak of 31.720 m AOD, and then descends to 30.000 m AOD on the right. The bund ties in to existing levels on the right. The distance from the left edge to the peak is 10.22 m, and the distance from the peak to the right edge is 5.23 m.

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As discussed above the proposed river works 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 should the works in the River be delayed a sound and robust solution is available 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.

6.3 Summary

Table 1 Flood risk management measures summary table

Site Area	Flood zone(s)	Potential impacts of HIF infrastructure works	Mitigation measures required assuming removal of river wall upstream of Union Bridge
Upper Plateau	Flood zone 1 for whole area	No anticipated impact on flood risk	- Maintain existing flow regime - Adopt a suitable drainage strategy including a 40% allowance for climate change
South of river & Dantzic Street	Flood zone 1 along West edge of Travis Island Flood zone 2 in majority of area Flood Zone 3 on Dantzic Street	Negligible impact on flood risk	Within all flood zones: - Maintain existing flow regime - Adopt a suitable drainage strategy including a 40% allowance for climate change Within flood zone 2: - Development to follow Environment Agency standing Advice - On-plot building levels and evacuation routes designed to appropriate levels Within flood zone 3: - Surface water management on Dantzic Street to consider water levels in drainage design
North of river (west)	Flood zone 1 at proposed red bank terraces Flood zone 2 in majority of area Flood zone 3 immediately North of Union Bridge	Increased flood depth of >0.1m upstream and downstream of Union bridge for 100-year event, and upstream of bridge only for 1000-year event. Flood extents likely increased South of Roger Street for 100-year event and North of Roger Street for 1000-year event.	Within all flood zones: - Maintain existing flow regime - Adopt a suitable drainage strategy including a 40% allowance for climate change Within flood zone 2: - Development to follow Environment Agency standing Advice - On-plot building levels and evacuation routes designed to appropriate levels - Drainage design and building levels both on and off plot should consider increased flood depths resulting from the removal of the river wall upstream of Union bridge. Within flood zone 3: - Surface water management to be designed considering flood depths and extents - On-plot land uses to be designated to prioritise less vulnerable building types within flood zone 3 Mitigation measures due to impact of works: - Drainage design and building levels both on and off plot should consider increased flood depths resulting from the removal of the river wall upstream of Union bridge for all flood zones. - Temporary bunding may be used to replicate the function of the existing river wall and avoid worsening flood risk.

			- Phasing of the river wall removal should be developed in coordination with confirmation of the river works design solution to ensure flood risk is not worsened as a result of the scheme without permanent mitigation which may be achieved through the river works.
Off site (along Scotland Street)	N/A	Increased flood depth of approximately 0.02m due to additional fluvial flooding originating from out of channel flows enabled by removal of river wall upstream of Union Bridge.	Temporary bunding may be used to replicate the function of the existing river wall upstream of Union Bridge and avoid worsening flood risk off site. Phasing of the river wall removal should be developed in coordination with confirmation of the river works design solution to ensure flood risk is not worsened as a result of the scheme without permanent mitigation which may be achieved through the river works.

7 Conclusion

This FRA has assessed all potential sources of flooding for the Victoria North 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. This FRA outlines measures which should be taken by the on-plot developer to mitigate flood risk. This should include evaluation of finished floor levels within flood zone 2 and locating less vulnerable land uses in flood zone 3.

The impacts of the proposed development on flood risk has been shown by the 2021 interim “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 RB07 plot boundary has been proposed to replicate the current wall which will reduce the flow from the River Irk during extreme events and prevent additional flooding beyond the site boundary.

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

Interim 2021 Hydraulic Modelling Report

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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	20 December 2021
Subject	Hydraulic Assessment of HIF Infrastructure Proposals		

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.

Technical Note

281943

20 December 2021

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. The current responses to the EA actions can be found in **Appendix B**.

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**.

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.

Technical Note

281943

20 December 2021

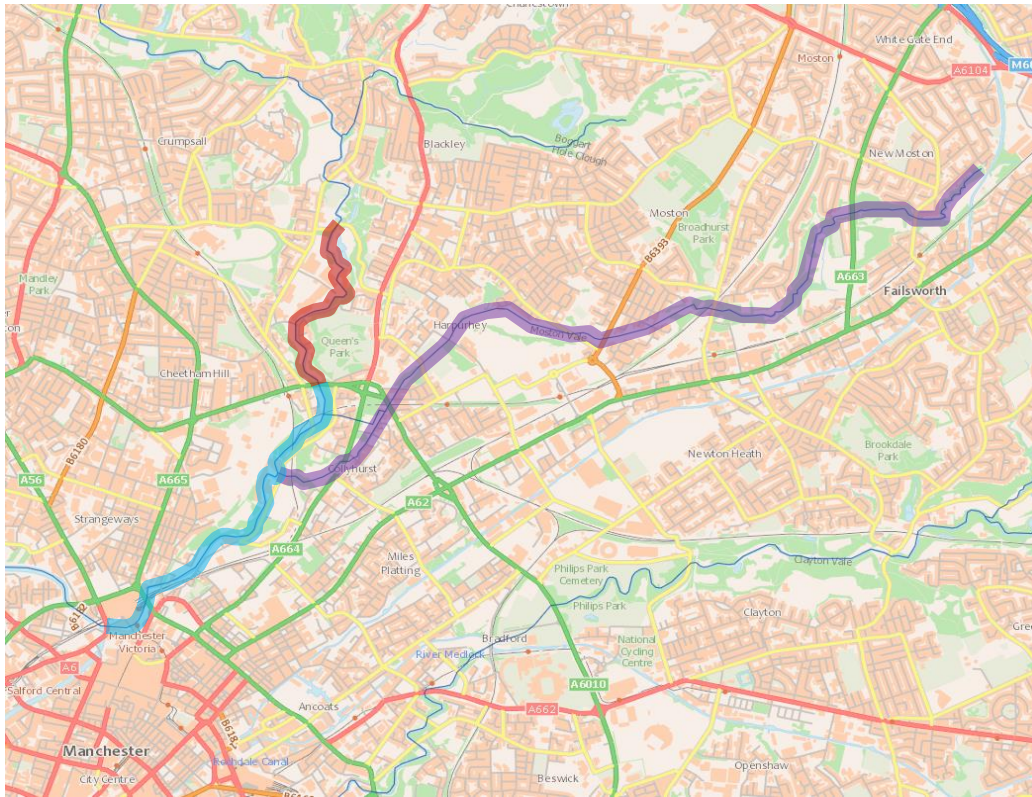


Figure 1: Extents of existing EA models used

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 EA, 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**.

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).

Technical Note

281943

20 December 2021

		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	44.6
10		45	44.2	52.1
20			50.9	60.0
50		62	60.6	71.4
75		63	65.2	76.8
100	Flood Zone 3	66	68.7	80.9
100+CC (2080 Epoc)				109.2
1000	Flood Zone 2		112.5	132.6

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 are currently completing a topographical survey of the river channel in December 2021.

Technical Note

281943

20 December 2021

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.

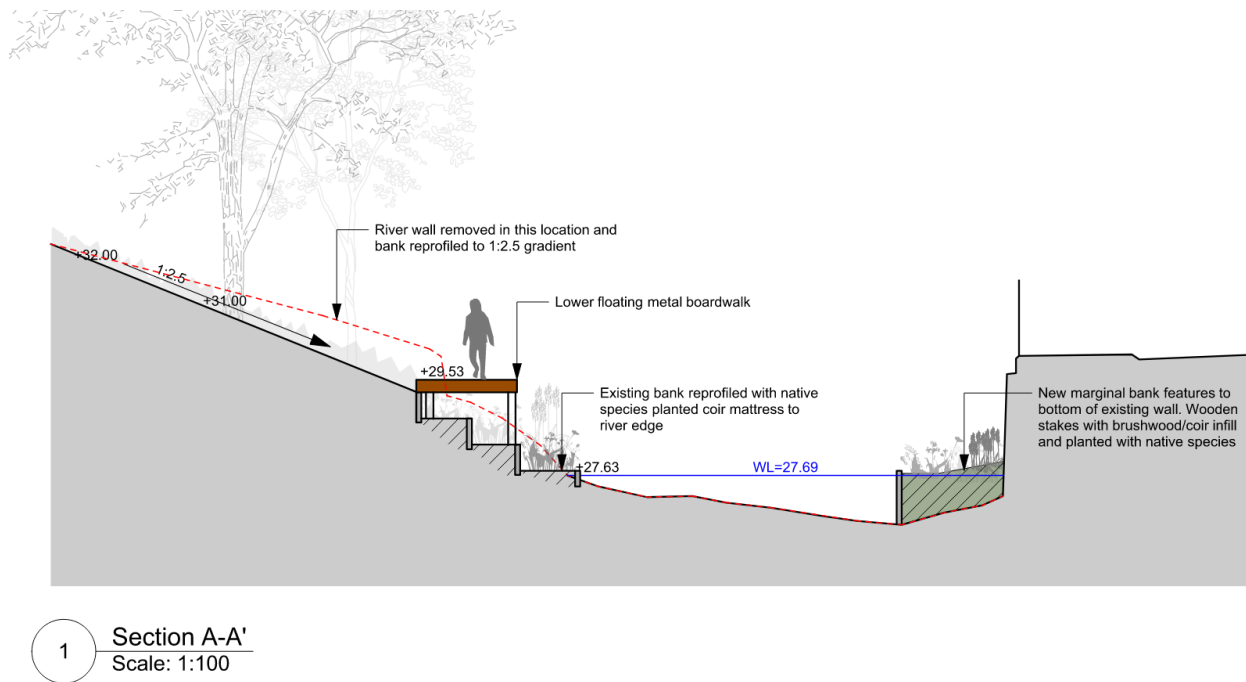


Figure 2 - St Catherine's Wood Typical X-Section

- 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 Dantzie 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.

Technical Note

281943

20 December 2021

Table 4 in **Appendix A** documents how the changes proposed by the HIF Infrastructure Works have been incorporated within the Hydraulic Model.

4 Model Results

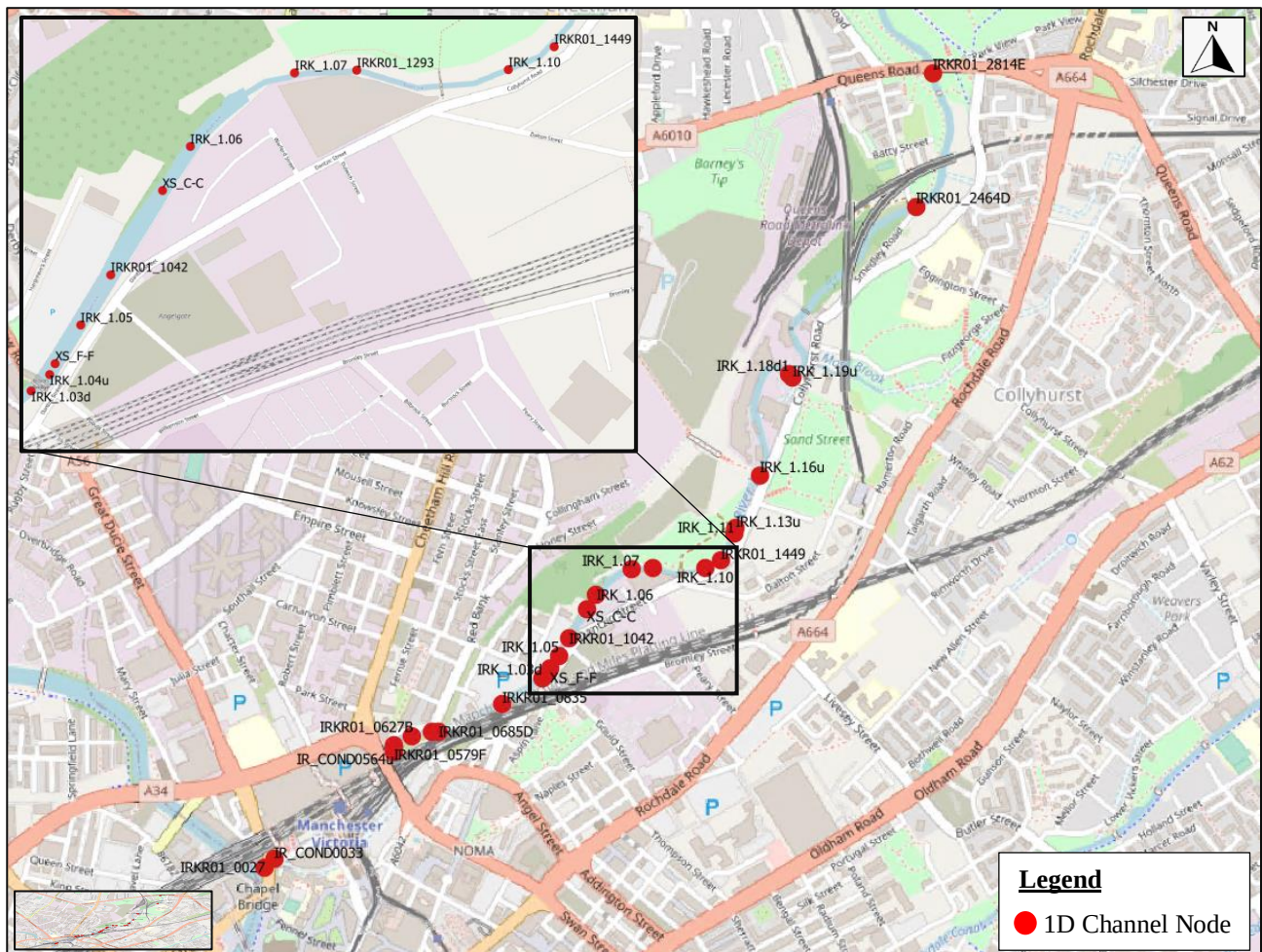


Figure 3 - Model Node Location Plan

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.

These 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.

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Location	Label	20 Year Stage (mAOD)			100 Year Stage (mAOD)			100 Year + CC (2080) Stage (mAOD)			1000 Year Stage (mAOD)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Queens Road U/S	IRKR01_2814E	36.64	36.64	0.00	37.06	37.06	0.00	38.30	38.30	0.00	39.17	39.17	0.00
Smedley Rd D/S	IRKR01_2464E	35.10	35.10	0.00	35.90	35.90	0.00	36.73	36.73	0.00	37.67	37.66	0.00
HMG Paints Weir U/S	IRK_1.19u	33.02	33.00	-0.01	33.68	33.67	-0.01	34.13	34.13	0.00	34.53	34.52	0.00
HMG Paints Weir D/S	IRK_1.18d1	32.86	32.84	-0.01	33.57	33.55	-0.02	34.04	34.04	0.00	34.46	34.45	0.00
P&P Bridge U/S	IRK_1.16u	31.54	31.49	-0.05	32.64	32.56	-0.07	33.22	33.21	-0.01	34.04	34.02	-0.01
Collyhurst Weir U/S	IRK_1.13u	31.30	31.20	-0.10	31.82	31.71	-0.11	32.10	32.05	-0.05	32.45	32.40	-0.04
Collyhurst Weir D/S	IRK_1.11	31.28	31.17	-0.10	31.79	31.68	-0.11	32.05	32.00	-0.05	32.38	32.34	-0.04
Location of Planit Cross-section A-A	IRKR01_1449	31.24	31.15	-0.09	31.77	31.67	-0.10	32.04	32.00	-0.04	32.34	32.32	-0.03
	IRK_1.10	31.22	31.10	-0.11	31.68	31.56	-0.12	31.72	31.67	-0.05	32.15	32.05	-0.10
Location of Planit Cross-section B-B	IRKR01_1293	30.97	30.83	-0.15	31.54	31.42	-0.11	31.75	31.73	-0.03	32.04	32.06	0.01
	IRK_1.07	30.88	30.71	-0.17	31.42	31.31	-0.11	31.58	31.60	0.02	31.83	31.86	0.03
	IRK_1.06	30.81	30.63	-0.17	31.33	31.23	-0.10	31.41	31.45	0.04	31.60	31.66	0.06
Location of Planit Cross-section C-C	XS_C-C		30.63			31.22			31.44			31.63	
	IRKR01_1042	30.79	30.62	-0.17	31.39	31.22	-0.16	31.50	31.46	-0.05	31.71	31.69	-0.02
Location of Planit Cross-section D-D	IRK_1.05	30.76	30.55	-0.22	31.38	31.16	-0.22	31.54	31.36	-0.18	31.76	31.46	-0.30
Location of Planit Cross-section F-F	XS_F-F		30.54			31.18			31.40			31.64	

Technical Note

281943

20 December 2021

Location	Label	20 Year Stage (mAOD)			100 Year Stage (mAOD)			100 Year + CC (2080) Stage (mAOD)			1000 Year Stage (mAOD)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff
Union Bridge U/S	IRK_1.04u	30.75	30.56	-0.19	31.41	31.24	-0.17	31.62	31.54	-0.08	31.91	31.80	-0.11
Union Bridge D/S	IRK_1.03d	29.65	29.73	0.08	30.54	30.53	-0.01	30.99	30.99	0.00	31.32	31.32	-0.01
	IRKR01_0835	29.28	29.29	0.01	30.00	29.98	-0.02	30.37	30.38	0.01	31.03	31.03	0.00
Aspin Lane U/S	IRKR01_0685D	28.96	28.97	0.01	29.72	29.70	-0.02	30.33	30.33	0.00	31.03	31.03	0.00
Aspin Lane D/S	IRKR01_0685E	28.50	28.51	0.00	28.96	28.96	0.00	29.61	29.63	0.02	30.58	30.58	0.00
	IRKR01_0627B	28.23	28.23	0.00	28.66	28.66	0.00	29.19	29.21	0.02	30.23	30.23	0.00
Scotland Weir U/S	IRKR01_0579F	28.10	28.10	0.00	28.49	28.49	0.00	28.95	28.96	0.01	29.91	29.90	0.00
Scotland Weir D/S	IRKR01_0579G	25.54	25.54	0.00	26.38	26.38	0.00	27.22	27.23	0.01	29.39	29.39	0.00
Irk Culvert beneath Victoria Station U/S Face	IR_COND0564u	25.46	25.46	0.00	26.34	26.34	0.00	27.19	27.20	0.01	29.38	29.38	0.00
Irk Culvert D/S Face	IR_COND0033	25.20	25.20	0.00	26.07	26.07	0.00	26.84	26.84	0.00	28.90	28.90	0.00
Irk/Irwell Confluence	IRKR01_0027	25.17	25.17	0.00	26.03	26.03	0.00	26.80	26.80	0.00	28.87	28.87	0.00

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

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]

Technical Note



Location	Label	20 Year Flow (m3/s)			100 Year Flow (m3/s)			100 Year + CC (2080) Flow (m3/s)			1000 Year Flow (m3/s)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	BAS	PROP	Diff
Queens Road U/S	IRKR01_2814E	38.1	38.1	0.0	52.7	52.7	0.0	83.3	83.3	0.0	99.6	99.6	-0.1
Smedley Rd D/S	IRKR01_2464E	46.1	46.1	0.0	66.8	66.8	0.0	95.5	95.5	0.0	117.2	117.2	0.0
HMG Paints Weir U/S	IRK_1.19u	46.0	46.0	0.0	55.4	56.9	1.5	57.7	59.2	1.5	58.6	59.7	1.1
HMG Paints Weir D/S	IRK_1.18d1	46.0	46.0	0.0	55.4	56.9	1.5	57.7	59.2	1.5	58.6	59.7	1.1
P&P Bridge U/S	IRK_1.16u	59.8	60.0	0.2	77.9	77.9	-0.1	95.1	95.5	0.4	122.9	122.3	-0.7
Collyhurst Weir U/S	IRK_1.13u	59.7	60.1	0.4	80.2	79.6	-0.7	107.6	107.2	-0.5	148.0	148.7	0.6
Collyhurst Weir D/S	IRK_1.11	59.7	60.1	0.4	80.2	79.6	-0.7	107.6	107.2	-0.5	148.0	148.7	0.6
Location of Planit Cross-section A-A	IRKR01_1449	53.5	55.0	1.5	69.7	72.9	3.2	94.0	99.2	5.2	131.1	137.5	6.5
	IRK_1.10	52.5	51.6	-0.9	75.9	75.1	-0.8	118.2	114.5	-3.6	138.5	139.5	1.0
Location of Planit Cross-section B-B	IRKR01_1293	60.7	60.9	0.2	77.8	79.3	1.6	97.8	99.0	1.3	120.1	121.5	1.4
	IRK_1.07	60.7	60.1	-0.5	79.0	76.2	-2.7	100.3	94.3	-6.0	122.3	119.7	-2.6
	IRK_1.06	60.7	60.9	0.2	79.8	78.4	-1.4	103.9	100.4	-3.6	127.3	125.7	-1.5
Location of Planit Cross-section C-C	XS_C-C		60.3			79.2			101.4			127.6	
	IRKR01_1042	60.6	61.2	0.6	69.3	78.1	8.8	89.8	99.1	9.3	112.0	118.7	6.7
Location of Planit Cross-section D-D	IRK_1.05	60.9	61.6	0.7	63.9	74.9	11.0	74.2	95.2	21.0	89.3	126.0	36.7
Location of Planit Cross-section F-F	XS_F-F		57.3			65.5			83.3	83.3		91.1	

Technical Note

281943

20 December 2021

Location	Label	20 Year Flow (m3/s)			100 Year Flow (m3/s)			100 Year + CC (2080) Flow (m3/s)			1000 Year Flow (m3/s)		
		EXIST	PROP	Diff	EXIST	PROP	Diff	EXIST	PROP	Diff	BAS	PROP	Diff
Union Bridge U/S	IRK_1.04u	60.4	55.0	-5.4	63.5	55.5	-8.0	64.8	56.3	-8.6	61.0	49.1	-11.9
Union Bridge D/S	IRK_1.03d	60.4	55.0	-5.4	63.5	55.5	-8.0	64.8	56.3	-8.6	61.0	49.1	-11.9
	IRKR01_0835	61.3	61.4	0.1	80.6	78.9	-1.7	93.4	91.8	-1.6	89.8	87.8	-1.9
Aspin Lane U/S	IRKR01_0685D	60.0	60.2	0.3	78.1	77.0	-1.1	82.2	80.6	-1.6	75.5	73.4	-2.1
Aspin Lane D/S	IRKR01_0685E	60.0	60.2	0.3	78.1	77.0	-1.1	82.2	80.6	-1.6	75.5	73.4	-2.1
	IRKR01_0627B	61.7	61.6	-0.1	79.8	79.6	-0.1	101.2	101.6	0.4	115.5	115.3	-0.2
Scotland Weir U/S	IRKR01_0579F	61.0	61.0	0.0	79.8	79.6	-0.1	103.4	104.2	0.8	132.2	132.1	-0.1
Scotland Weir D/S	IRKR01_0579G	61.0	61.0	0.0	79.8	79.6	-0.1	103.4	104.2	0.8	132.2	132.1	-0.1
Irk Culvert beneath Victoria Station U/S Face	IR_COND0564u	60.8	60.7	-0.1	79.8	79.6	-0.1	103.4	104.2	0.8	132.2	132.2	-0.1
Irk Culvert D/S Face	IR_COND0033	59.9	60.1	0.2	79.7	79.5	-0.2	103.3	104.1	0.8	132.0	132.0	0.0
Irk/Irwell Confluence	IRKR01_0027	64.8	64.8	0.0	79.7	79.5	-0.2	103.3	104.1	0.8	132.0	132.0	0.0

Table 3: Results table (flow)

Red = increase in peak flow compared with existing (worsening) of $>0.1\text{m}^3/\text{s}$.

Yellow = nominal increase in peak flow compared with existing (worsening) of less than $0.1\text{m}^3/\text{s}$.

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]

4.1 Flood extents

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

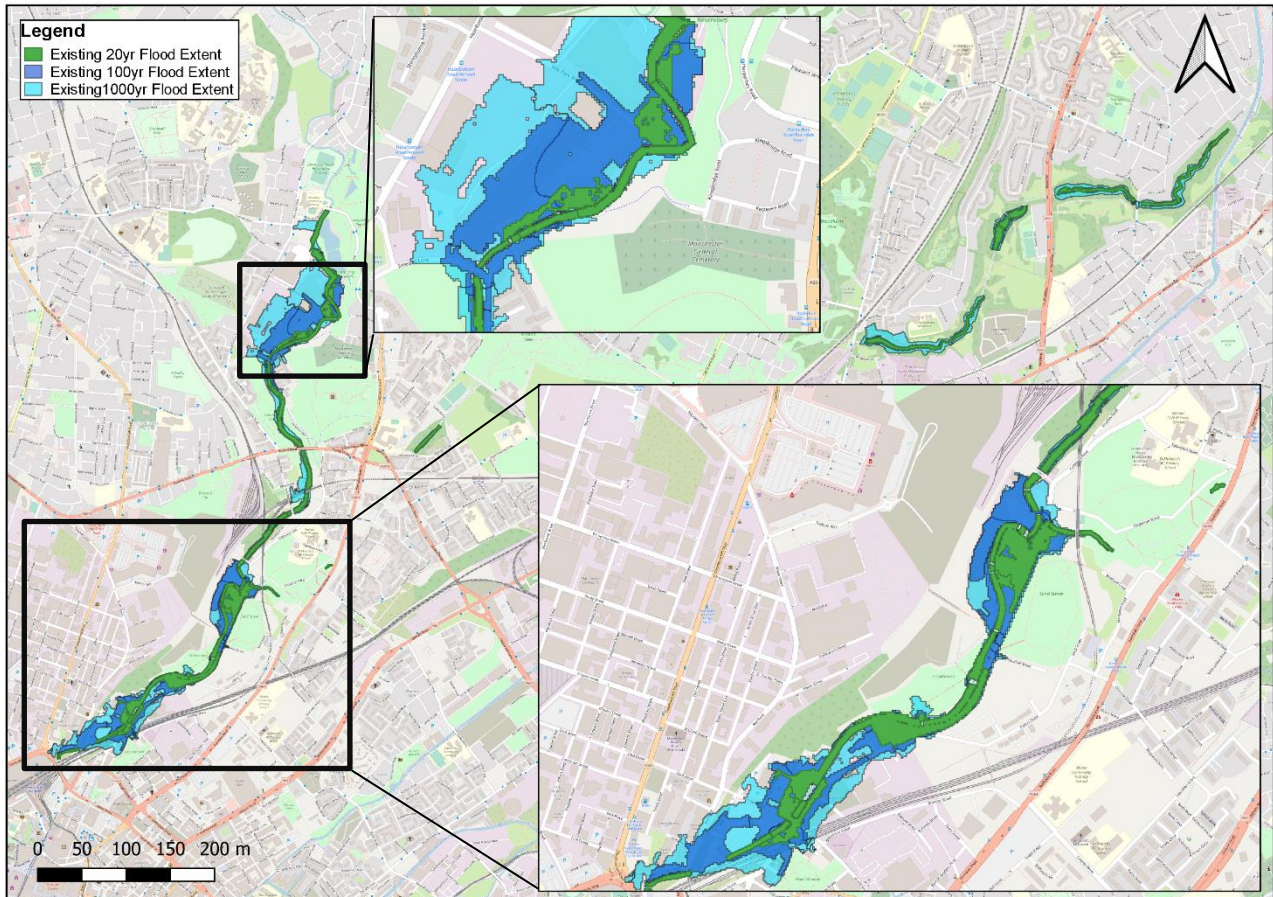


Figure 4: 20 year, 100 year and 1000 year events for the Existing Condition Interim 2021 model.

Technical Note

281943 20 December 2021

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.

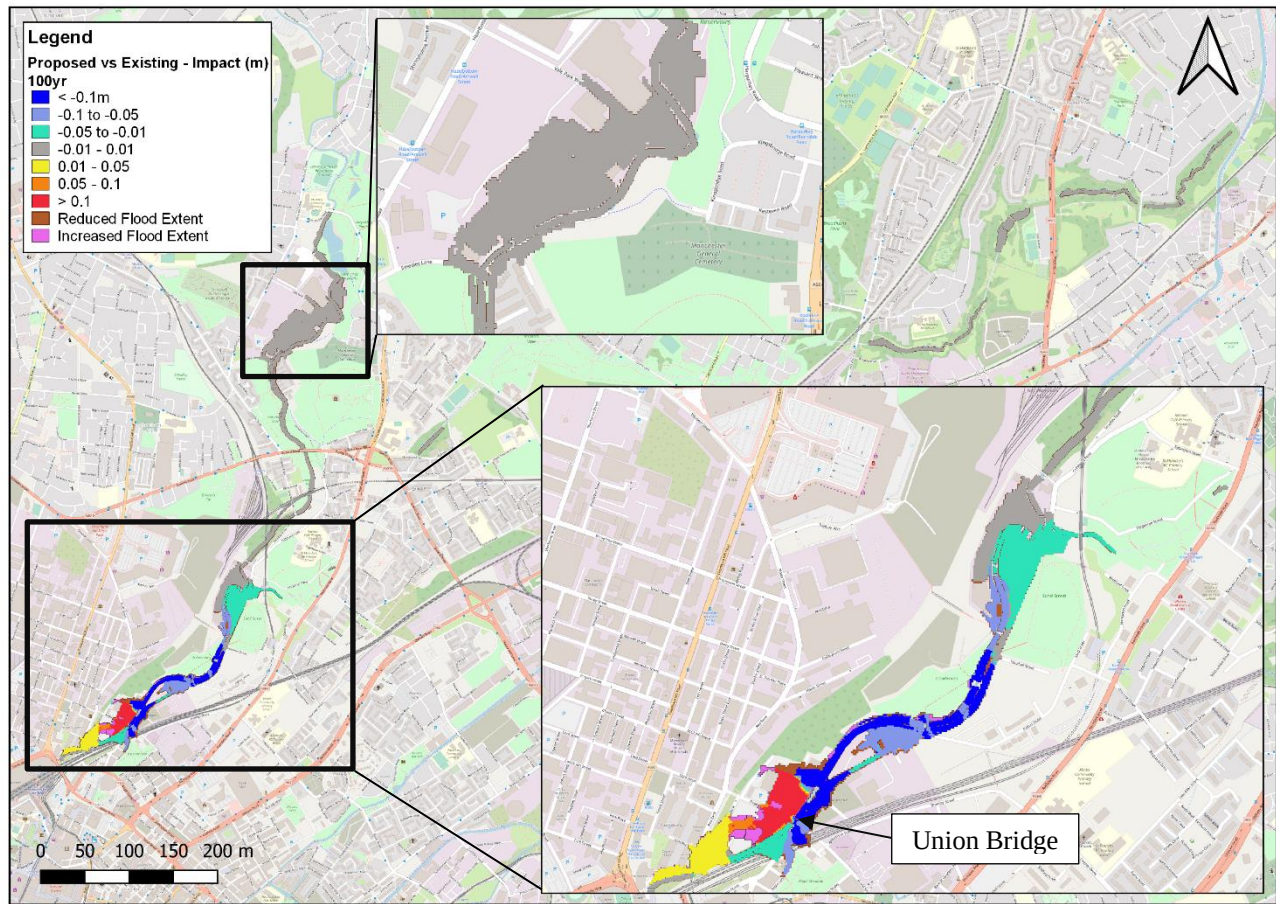


Figure 5: 100 year event Proposed vs Existing

Technical Note

281943

20 December 2021

Figure 6 shows the change in levels for the 1000 year event comparing the Proposed HIF Infrastructure Works to the Existing using the Interim 2021 model.

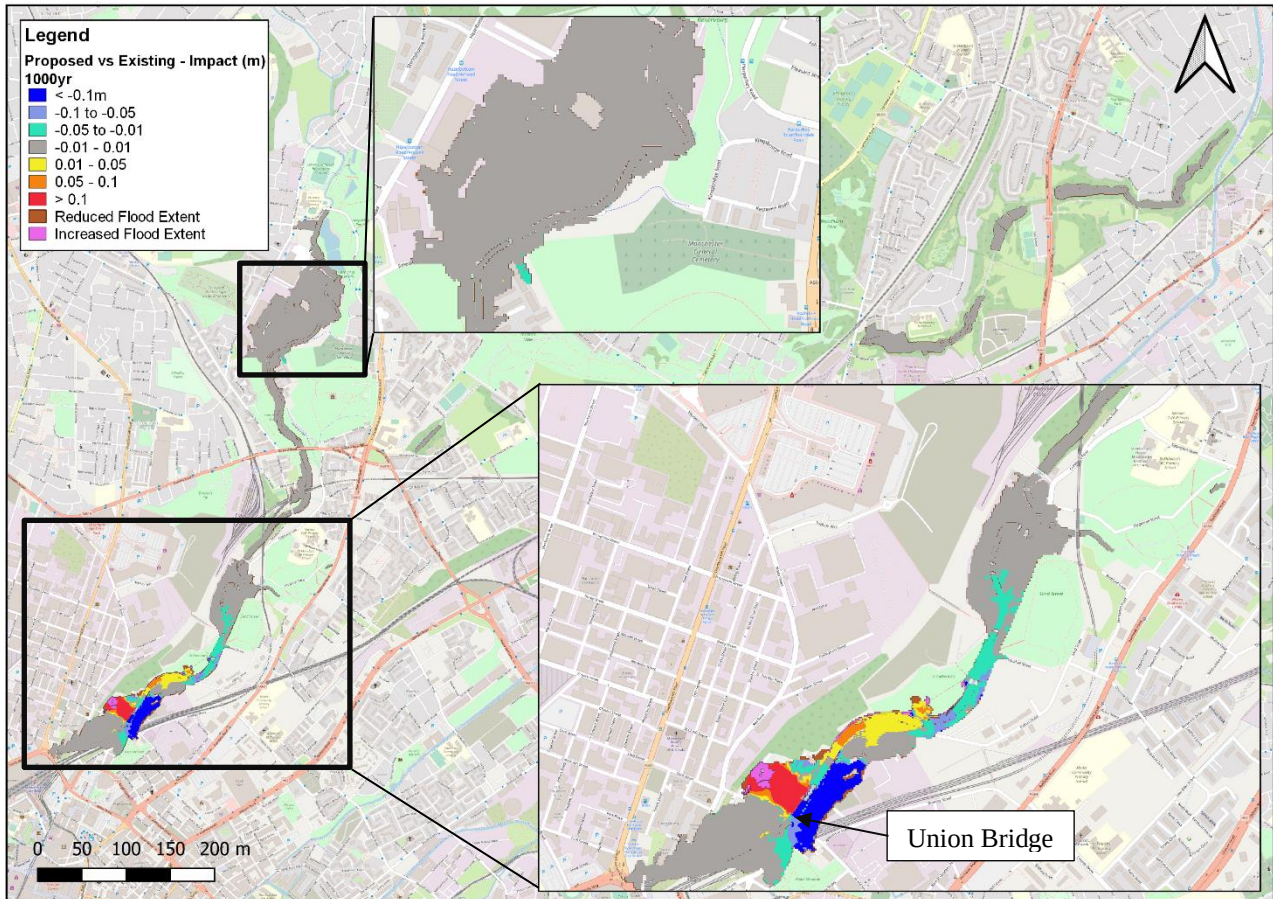


Figure 6: 1000 year Proposed vs Existing

Technical Note

281943

20 December 2021

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 Overview

Figure 5, Figure 6 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 there is no appreciable change in flow at the upstream or downstream extents of the study area.

5.2 Location specific comments

At Collyhurst Weir, there is a small reduction in flood level by approximately 0.1m in channel and 0.05m in the floodplain (reducing from a floodplain depth of 1.10m to 1.05m) 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** and **Figure 6** 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 4** in **Appendix A**. The removal of this wall allows more flow to propagate into the floodplain on the right bank, due to proposed changes in topography as shown in **Figure 9**. The removal of the wall also explains the large spike in flow observed locally at the upstream of Union Bridge, as noted in **Table 3**, as overland flow trapped behind the wall in the existing case can now freely re-enter the channel. This is shown in **Figure 7** where the existing flood extent for the 1000 year event is on the left and the proposed is on the right. Velocity vectors are also added to show the direction of flow.

Technical Note

281943

20 December 2021

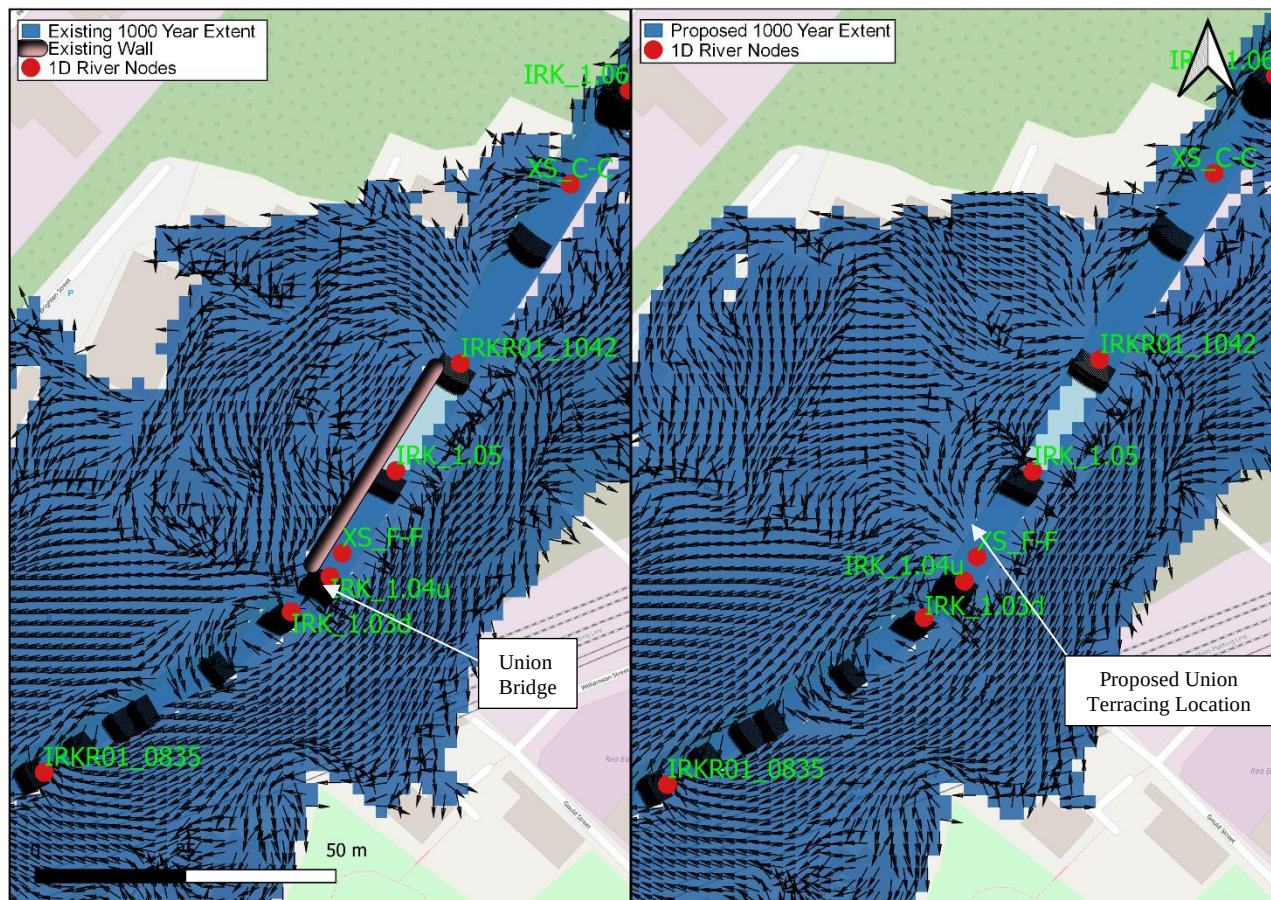


Figure 7: Direction of flow (1000 year event) Existing vs Proposed showing additional out of bank flows

Modelling shows this causes a reduction in flows downstream of Union Bridge as (in existing conditions), this was the first point of re-entry into the channel for overland flow, and following HIF works, more flow has entered the floodplain. Increases in flood depths in the floodplain on the right bank, immediately upstream of Union Bridge are in the magnitude of 0.35m-0.55m (from existing condition depth of 0.15m-0.45m over the plot) for the 100 year and 0.1m-0.3m (from existing condition depth of 0.8m-1.2m over the plot) 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 depths of approximately 0.1m-0.15m, (from typically 0.5m to 0.6-0.65m) immediately south of Roger Street (Plot RB09) with large 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 0.02m 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.

Technical Note

281943

20 December 2021

The timing and sequencing of construction works are currently unknown. However, if the HIF Infrastructure Works are constructed in isolation, it is recommended mitigation measures are included at the south-western boundary of the HIF site around Roger Street/behind proposed Union terracing to prevent overland flow entering into RB09 and RB10. This could be achieved through temporary bunding or raising of ground levels once the wall around Union Bridge is removed.

Technical Note

281943

20 December 2021

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 8: 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 4**.

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.

Technical Note

281943

20 December 2021

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 9** shows a comparison of the existing and proposed levels within the study area.



Figure 9: 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' 1 Section A-A' Scale: 1:100	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 ¹ . Metal boardwalk not physically represented, rather with an increase in roughness. Roughness increased where vegetation is shown on both sides of the bank. A value of 0.1 used as per 1h in Chow tables ² . 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 8 , a new Mastermap layer was created to assign current roughness values.
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. Roughness increased where vegetation is shown on the right bank. A value of 0.1 used as per 1h 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 8 , a new Mastermap layer was created to assign current roughness values.

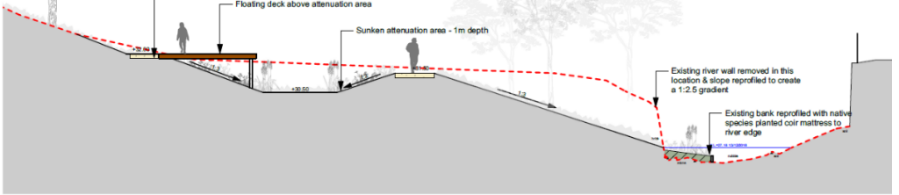
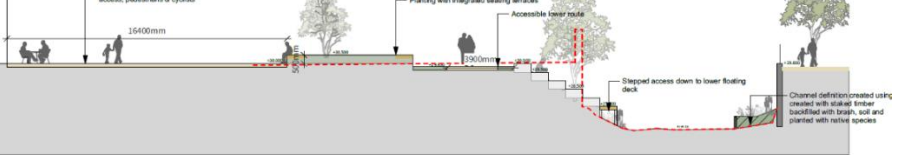
¹ <https://nrfa.ceh.ac.uk/data/station/meanflow/69043>

² http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Technical Note

281943

20 December 2021

Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
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 0.1 used as per 1h 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 8, a new Mastermap layer was created to assign current roughness values.
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. Floating deck not physically represented, rather with an increase in roughness. Roughness increased where vegetation is shown on both sides of the bank. A value of 0.1 used as per 1h 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 8, a new Mastermap layer was created to assign current roughness values.

Technical Note

281943

20 December 2021

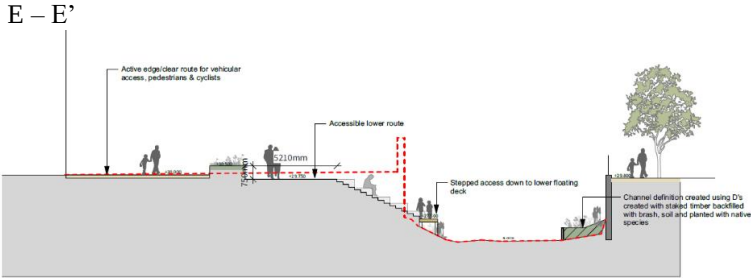
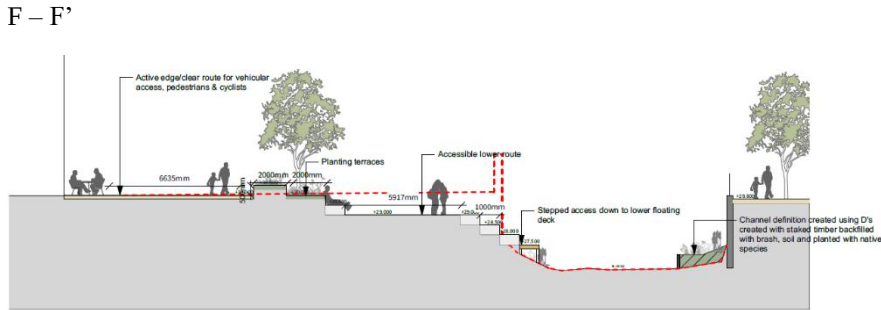
Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
E – E'  Active edge/dear route for vehicular access, pedestrians & cyclists Accessible lower route 6210mm Stepped access down to lower floating deck Channel definition created using D's created with staked timber backfilled with brush, soil and planted with native species 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 brush modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA. Floating deck not physically represented, rather with an increase in roughness. Roughness increased where vegetation is shown on both sides of the bank. A value of 0.1 used as per 1h 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 8 , a new Mastermap layer was created to assign current roughness values.
F – F'  Active edge/dear route for vehicular access, pedestrians & cyclists 6635mm 2000mm 2000mm Planting terraces Accessible lower route 5917mm 1000mm Stepped access down to lower floating deck Channel definition created using D's created with staked timber backfilled with brush, soil and planted with native species 6 Section F-F' Scale: 1:150	IRK_1.05 and XS_F-F	Channel manually edited to include steps noted in cross-section F-F. Wooden Staked timber backfilled with brush modelled as a constriction in the channel with level corresponding to the flow at Q95, as defined by NRFA. Floating deck not physically represented, rather with an increase in roughness. Roughness increased where vegetation is shown on both sides of the bank. A value of 0.1 used as per 1h 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 8 , a new Mastermap layer was created to assign current roughness values.

Table 4 - Summary of HIF Infrastructure Works modelled

Technical Note

281943

20 December 2021



Figure 10 - Plot Boundaries

Technical Note

281943

20 December 2021

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.	20 year added. More to be added for the full modelling exercise in 2022
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.	Give further detail on the survey used for the hydraulic model in the reporting. Review cross section widths on Moston Brook.	Completed – deactivation markers for IRKR01_1788D, MOST01_5400 and MOST01_5337 set to top of bank

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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 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.	Review deactivation markers for IRKR01_1788D, MOST01_5400 and MOST01_5337.	
Conveyance: Generally smooth. A handful of sections have minor "wobbles" in conveyance - IRKR01_3652, IRKR01_3520, IRKR01_1188A, MOST01_5900, MOST01_5892A, MOST01_5270, MOST01_4212A and MOST02_0000H.	Review sections and add panel markers as appropriate.	Completed – all addressed
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.	Existing values appraised for appropriateness. Aerial photography and online images reviewed against the values noted in Chow tables.
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	Review all manning's values, describe and justify values in the reporting along with example photos.	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

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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 the same, so suspicious that this was not checked during the baseline model development.		
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 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 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. Confirm if the MSC model is required and add detail to the justification within the main report.	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 •The shape will be further scaled to cover 16hrs as opposed to the previous 10hrs

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
		•This approach will be revised for the full modelling exercise in the new year.
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: - 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:	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 surrounding topography, it's believed the flows are well represented here U/S of bridges or bridges amended so they match

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
- 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 at MOST01_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. - stability spills used, not necessarily unacceptable, but needs highlighting in report.		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
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, spill IRK_1.20su	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

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Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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.		
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_007_R.shp.	Ensure that all buildings are represented, including their full footprint.	Completed – buildings now represented

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
It looks as if the polygons were cropped to the previous domain boundary, but have not been reinstated for a larger 2D domain.		
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.	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.
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.	Manning's n values attributed to polygons using .TMF. Will be updated in corresponding reporting.
Representation of different 2D roughness areas: As with 7.8, the previous model's polygons do not match the 2D domain boundary. 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?	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 were updated based on OS Open Map – Local, and satellite imagery upstream of Queens Road
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).	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

Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?																																								
Unclear if this has been represented in the bank crest elevations used.																																										
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: <table><tr><td></td><td>1d</td><td>2d</td><td>Diff</td></tr><tr><td>IRKR01_4091</td><td>- 28.12</td><td>- 28.60</td><td>- 0.48</td></tr><tr><td>IRKR01_2888</td><td>- 19.16</td><td>- 20.42</td><td>- 1.26</td></tr><tr><td>IRKR01_2612</td><td>- 29.07</td><td>- 32.88</td><td>- 3.81</td></tr><tr><td>IRK_1.25</td><td>- 27.31</td><td>- 26.21</td><td>- 1.1</td></tr><tr><td>IRK_1.21</td><td>- 24.90</td><td>- 34.72</td><td>- 9.82</td></tr><tr><td>IRKR01_1878</td><td>- 10.10</td><td>- 14.78</td><td>- 4.68</td></tr><tr><td>IRKR01_1449</td><td>- 22.64</td><td>- 20.31</td><td>- 2.33</td></tr><tr><td>IRKR01_0627</td><td>- 17.13</td><td>- 08.84</td><td>- 8.29</td></tr><tr><td>MOST01_6250</td><td>- 15.80</td><td>- 13.80</td><td>- 2.00</td></tr></table>		1d	2d	Diff	IRKR01_4091	- 28.12	- 28.60	- 0.48	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	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. All cross section widths need to be checked and corrected.	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, 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,
	1d	2d	Diff																																							
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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																																							

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Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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		IRK_1.13u, IRK_1.11, IRK_1.09u, IRK_1.08d, IRKR01_1293, IRK_1.07, IRKR01_1188A, IRKR01_1188B, IRK_1.06
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.	Completed – added throughout
1D Comments and warnings: zsd 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 warnings and make updates as appropriate.	Modelling/hydrology updated so original warnings not relevant. Updated model checked and warnings addressed where possible.

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Technical Note

281943

20 December 2021

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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. 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.	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.
1D 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.	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.

Technical Note

281943

20 December 2021

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. It is unclear if any changes have been made to the model in response to validation or verification of outputs.	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
Comparison of hydrograph peaks:	Compare modelled and gauged data to increase confidence in modelled results.	Flows scaled to match gauge records at Collyhurst Weir

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EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
There is a gauge in the modelled study reach. No comparison between modelled and recorded peaks has been included.		
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.	Will be completed for the next stage of modelling, in 2022
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.	Updates will be made to corresponding reporting

Table 5 - Hydraulic modelling review commentary

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			