

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	2 March 2022
Subject	Hydraulic Assessment of HIF Infrastructure Proposals – Rev 2		

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

2 March 2022

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 tables¹. 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.

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
- 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

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLING\INFRA\WIF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLING\INFRA\PROPOSALS_ISSUE2A.DOCX

Arup | F0.15

Page 2 of 52

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

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLING\INFRA\WIF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLING\INFRA\PROPOSALS_ISSUE2A.DOCX

Arup | F0.15

Page 2 of 52

Technical Note

281943

2 March 2022

- 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.

Technical Note

281943

2 March 2022

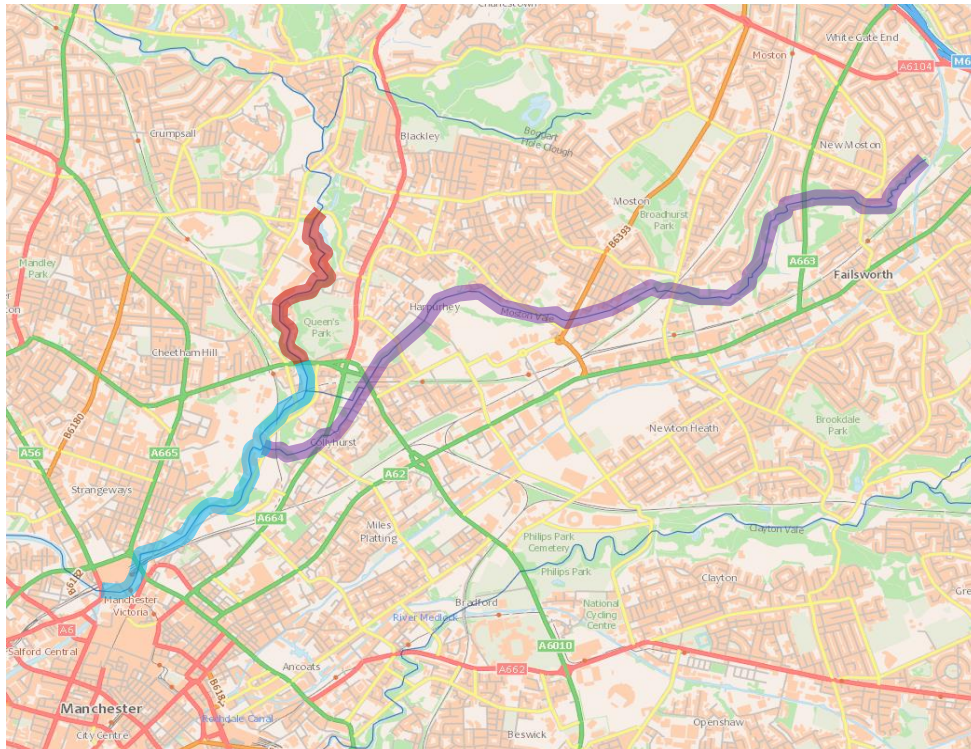


Figure 1 - Extents of existing EA models used

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.

Technical Note

281943

2 March 2022

		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 findings have not been incorporated into this work (planned for 2022 update).

Technical Note

281943

2 March 2022

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.

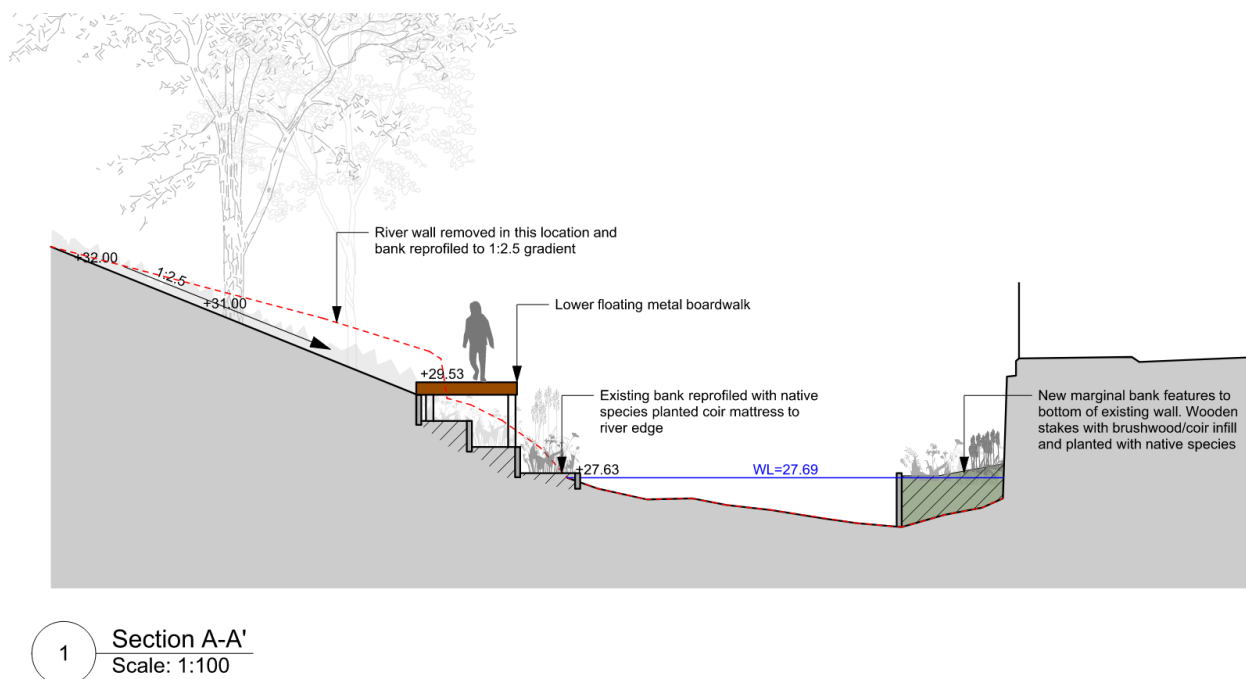


Figure 2 - St Catherine's Wood Typical X-Section

- 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.

Technical Note

281943 2 March 2022

4 Model Results

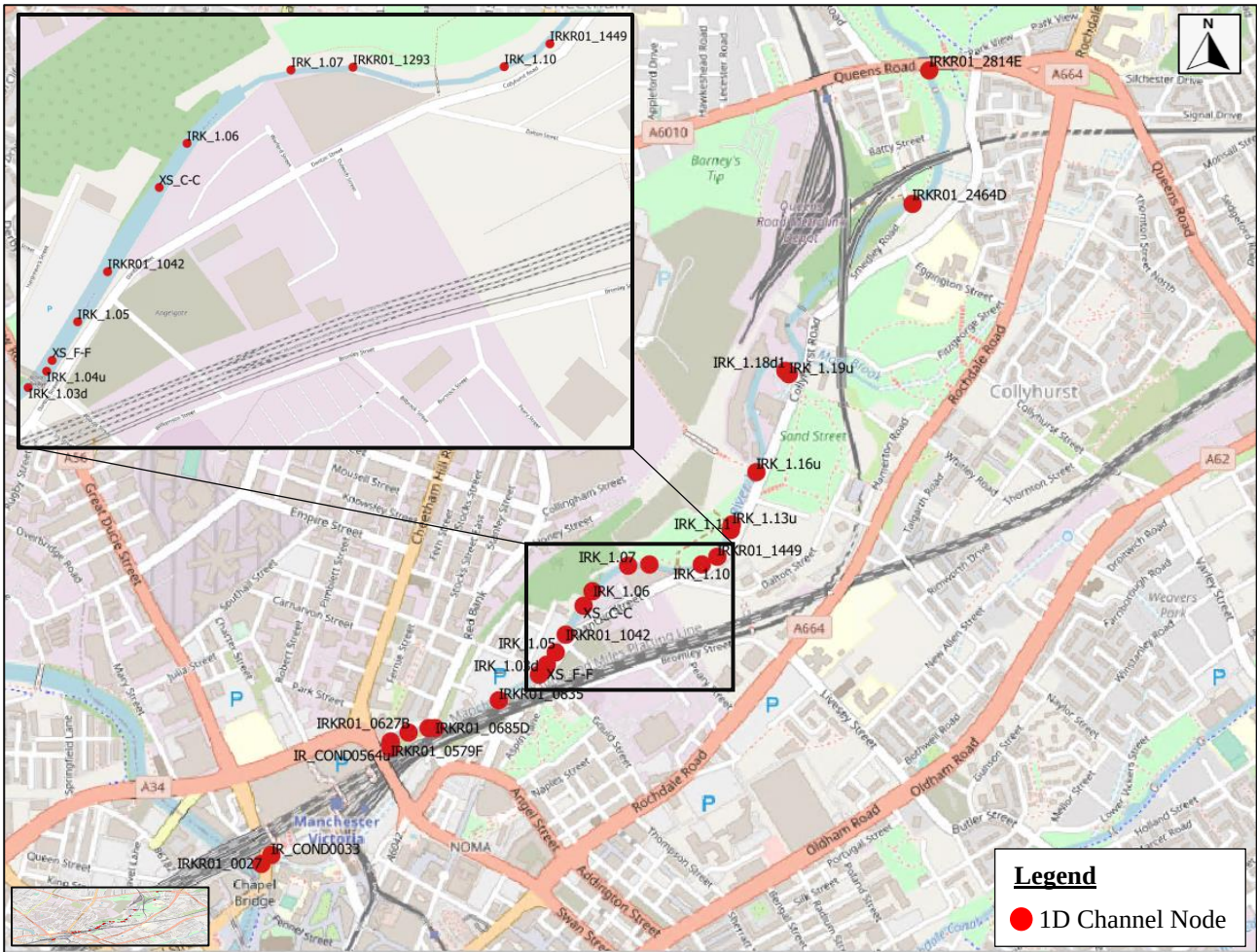


Figure 3 - Model Node Location Plan

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.

Technical Note



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	37.04	37.04	0.00	37.36	37.35	0.00	37.86	37.85	-0.01	38.31	38.31	0.00	39.03	39.02	0.00
Smedley Rd D/S	IRKR01_2464E	35.09	35.09	0.00	35.88	35.88	0.00	36.21	36.21	0.00	36.38	36.37	-0.01	36.81	36.81	0.00	37.72	37.72	-0.01
HMG Paints Weir U/S	IRK_1.19u	32.93	32.93	0.00	33.62	33.62	0.00	33.82	33.81	-0.01	33.92	33.91	-0.01	34.15	34.14	-0.01	34.53	34.51	-0.02
HMG Paints Weir D/S	IRK_1.18d1	32.77	32.77	0.00	33.49	33.49	0.00	33.72	33.71	-0.01	33.82	33.81	-0.01	34.06	34.05	-0.01	34.46	34.44	-0.02
P&P Bridge U/S	IRK_1.16u	31.43	31.43	-0.01	32.44	32.42	-0.02	32.80	32.76	-0.04	32.92	32.90	-0.02	33.23	33.23	-0.01	34.04	33.96	-0.08
Collyhurst Weir U/S	IRK_1.13u	31.11	31.10	-0.02	31.56	31.52	-0.04	31.78	31.68	-0.10	31.82	31.75	-0.07	32.02	31.93	-0.08	32.43	32.33	-0.11
Collyhurst Weir D/S	IRK_1.11	31.08	31.07	-0.02	31.52	31.48	-0.04	31.74	31.64	-0.11	31.78	31.71	-0.07	31.97	31.89	-0.09	32.38	32.27	-0.11
Location of Planit Cross-section A-A	IRKR01_1449	31.03	31.04	0.01	31.48	31.46	-0.02	31.67	31.62	-0.05	31.74	31.70	-0.05	31.94	31.87	-0.07	32.32	32.24	-0.09
	IRK_1.10	31.00	30.99	-0.01	31.44	31.35	-0.09	31.61	31.48	-0.13	31.63	31.53	-0.10	31.70	31.64	-0.06	32.14	31.97	-0.17
Location of Planit Cross-section B-B	IRKR01_1293	30.64	30.66	0.02	31.07	31.09	0.01	31.25	31.23	-0.02	31.32	31.30	-0.02	31.54	31.48	-0.06	31.99	31.91	-0.08
	IRK_1.07	30.48	30.52	0.04	30.84	30.92	0.08	30.98	31.05	0.07	31.03	31.11	0.08	31.21	31.28	0.07	31.60	31.71	0.11
	IRK_1.06	30.40	30.44	0.04	30.75	30.81	0.06	30.86	30.92	0.05	30.90	30.96	0.06	31.04	31.07	0.02	31.42	31.47	0.05
Location of Planit Cross-section C-C	XS_C-C		30.44			30.80			30.91			30.95			31.05			31.43	
	IRKR01_1042	30.37	30.42	0.05	30.71	30.80	0.09	30.82	30.91	0.09	30.85	30.95	0.10	30.97	31.05	0.08	31.38	31.44	0.05
Location of Planit Cross-section D-D	IRK_1.05	30.33	30.35	0.02	30.66	30.72	0.06	30.75	30.84	0.09	30.77	30.88	0.12	30.89	31.00	0.11	31.20	31.40	0.20
Location of Planit Cross-section F-F	XS_F-F		30.31			30.45			30.45			30.45			30.45			31.13	
Union Bridge U/S	IRK_1.04u	30.36	30.36	0.00	30.85	30.81	-0.04	31.01	30.94	-0.08	31.07	30.99	-0.08	31.24	31.11	-0.14	31.69	31.61	-0.09

Technical Note

281943

2 March 2022

Union Bridge D/S	IRK_1.03d	29.57	29.57	0.00	30.53	30.52	-0.02	30.77	30.74	-0.03	30.85	30.81	-0.04	30.98	30.96	-0.02	31.34	31.33	-0.01
	IRKR01_0835	29.06	29.06	0.00	29.94	29.93	-0.01	30.16	30.14	-0.02	30.24	30.22	-0.02	30.42	30.43	0.01	31.08	31.08	0.00
Aspin Lane U/S	IRKR01_0685D	28.66	28.66	0.00	29.65	29.64	-0.01	29.96	29.94	-0.02	30.08	30.06	-0.02	30.36	30.35	-0.01	31.05	31.04	0.00
Aspin Lane D/S	IRKR01_0685E	28.48	28.48	0.00	28.93	28.94	0.01	29.23	29.22	0.00	29.35	29.36	0.01	29.71	29.71	0.01	30.62	30.62	0.00
	IRKR01_0627B	28.19	28.19	0.00	28.63	28.63	0.00	28.87	28.86	-0.01	28.97	28.97	0.00	29.27	29.28	0.00	30.27	30.27	0.00
Scotland Weir U/S	IRKR01_0579F	28.06	28.06	0.00	28.46	28.46	0.00	28.67	28.67	-0.01	28.76	28.76	0.00	29.01	29.01	0.00	29.94	29.94	0.00
Scotland Weir D/S	IRKR01_0579G	25.54	25.54	0.00	26.39	26.38	0.00	26.70	26.69	-0.01	26.86	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	26.66	26.66	0.00	26.83	26.83	0.00	27.23	27.23	0.00	29.41	29.41	0.00
Irk Culvert D/S Face	IR_COND0033	25.22	25.22	0.00	26.08	26.08	0.00	26.35	26.35	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]

Technical Note

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	52.4	52.4	0.0	60.2	60.1	0.0	68.7	68.6	-0.2	81.3	81.2	-0.1	100.1	100.1	0.0
Smedley Rd D/S	IRKR01_2464E	44.9	44.9	0.0	65.2	65.2	0.0	75.7	75.7	0.0	81.7	81.2	-0.5	96.3	96.2	-0.1	118.4	118.3	-0.1
HMG Paints Weir U/S	IRK_1.19u	44.8	44.8	0.0	57.8	57.9	0.1	58.4	58.6	0.1	58.8	58.9	0.1	59.9	60.0	0.1	60.4	61.0	0.6
HMG Paints Weir D/S	IRK_1.18d1	44.8	44.8	0.0	57.8	57.9	0.1	58.4	58.6	0.1	58.8	58.9	0.1	59.9	60.0	0.1	60.4	61.0	0.6
P&P Bridge U/S	IRK_1.16u	58.7	58.7	0.0	76.6	76.6	0.0	86.8	86.2	-0.6	89.7	90.1	0.4	96.8	98.1	1.3	121.8	119.5	-2.3
Collyhurst Weir U/S	IRK_1.13u	58.7	58.7	0.0	77.8	78.0	0.2	90.5	89.0	-1.5	94.3	94.0	-0.3	108.7	109.2	0.5	148.9	146.9	-2.0
Collyhurst Weir D/S	IRK_1.11	58.7	58.7	0.0	77.8	78.0	0.2	90.5	89.0	-1.5	94.3	94.0	-0.3	108.7	109.2	0.5	148.9	146.9	-2.0
Location of Planit Cross-section A-A	IRKR01_1449	51.9	53.5	1.6	66.7	70.1	3.4	77.1	79.9	2.8	79.9	84.7	4.8	91.7	98.6	6.9	127.0	132.0	5.0
	IRK_1.10	51.6	50.8	-0.8	66.3	71.7	5.3	78.6	82.0	3.5	86.3	88.4	2.1	107.1	106.6	-0.5	134.4	138.9	4.5
Location of Planit Cross-section B-B	IRKR01_1293	59.4	59.4	0.0	78.9	78.9	0.0	89.2	89.2	0.0	93.0	93.9	0.9	102.9	105.5	2.6	121.8	123.8	2.0
	IRK_1.07	59.4	59.0	-0.4	79.1	77.0	-2.1	89.9	86.7	-3.2	94.0	91.0	-2.9	104.5	101.9	-2.6	124.8	118.1	-6.8
	IRK_1.06	59.4	59.4	0.0	79.2	78.7	-0.5	90.6	88.6	-2.0	95.5	93.7	-1.8	108.2	107.1	-1.1	130.3	126.6	-3.7
Location of Planit Cross-section C-C	XS_C-C		58.8			78.5			88.6			93.7			107.4			128.6	
	IRKR01_1042	59.4	59.4	0.0	79.2	77.8	-1.4	91.2	88.6	-2.7	96.6	93.8	-2.8	110.8	107.9	-2.9	130.1	130.0	-0.1
Location of Planit Cross-section D-D	IRK_1.05	59.4	59.4	0.0	79.2	76.3	-2.9	91.1	81.8	-9.3	96.6	84.9	-11.7	110.8	93.9	-16.9	138.3	109.4	-28.9
Location of Planit Cross-section F-F	XS_F-F		61.9			102.4			116.9			123.2			138.9			134.6	
Union Bridge U/S	IRK_1.04u	52.1	52.1	0.0	52.4	52.4	0.0	52.5	52.6	0.1	52.6	52.6	0.1	52.7	52.8	0.1	47.0	47.0	0.0
Union Bridge D/S	IRK_1.03d	52.1	52.1	0.0	52.4	52.4	0.0	52.5	52.6	0.1	52.6	52.6	0.1	52.7	52.8	0.1	47.0	47.0	0.0

Technical Note

281943

2 March 2022

	IRKR01_0835	59.2	59.1	-0.1	77.2	76.2	-1.0	83.3	81.4	-1.9	84.9	82.8	-2.2	86.9	84.3	-2.6	85.1	83.8	-1.3
Aspin Lane U/S	IRKR01_0685D	59.2	59.1	-0.1	75.9	75.1	-0.8	77.5	76.3	-1.2	77.9	76.7	-1.2	79.1	77.8	-1.3	72.1	71.5	-0.6
Aspin Lane D/S	IRKR01_0685E	59.2	59.1	-0.1	75.9	75.1	-0.8	77.5	76.3	-1.2	77.9	76.7	-1.2	79.1	77.8	-1.3	72.1	71.5	-0.6
	IRKR01_0627B	59.2	59.1	-0.1	78.2	78.2	0.0	88.6	88.1	-0.4	92.7	92.5	-0.3	103.3	103.3	0.0	115.5	115.4	-0.1
Scotland Weir U/S	IRKR01_0579F	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.6	-0.4	93.6	93.4	-0.1	106.8	106.9	0.2	133.4	133.6	0.1
Scotland Weir D/S	IRKR01_0579G	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.6	-0.4	93.6	93.4	-0.1	106.8	106.9	0.2	133.4	133.6	0.1
Irk Culvert U/S Face	IR_COND0564u	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.6	-0.4	93.6	93.4	-0.1	106.8	106.9	0.1	133.5	133.6	0.1
Irk Culvert D/S Face	IR_COND0033	59.2	59.1	-0.1	78.1	78.1	0.0	88.9	88.5	-0.3	93.5	93.4	-0.1	106.7	106.8	0.1	133.2	133.5	0.3
Irk/Irwell Confluence	IRKR01_0027	59.2	59.1	-0.1	78.1	78.1	0.0	88.9	88.5	-0.3	93.5	93.4	-0.1	106.7	106.8	0.1	133.2	133.5	0.3

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]

4.2 Flood extents

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

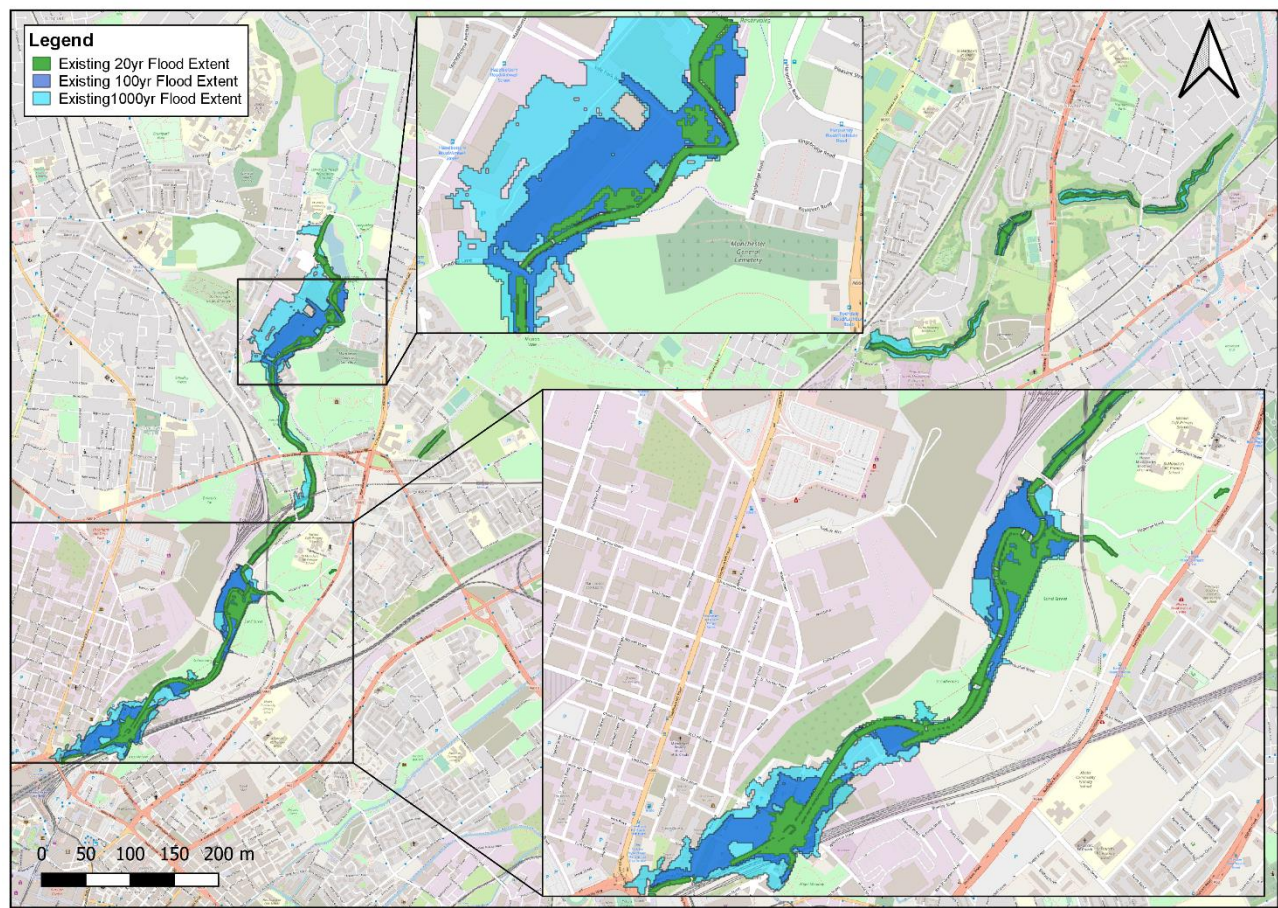


Figure 4: 20 year, 100 year and 1000 year events for the Existing Condition Interim 2021 model.

Technical Note

281943

2 March 2022

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.

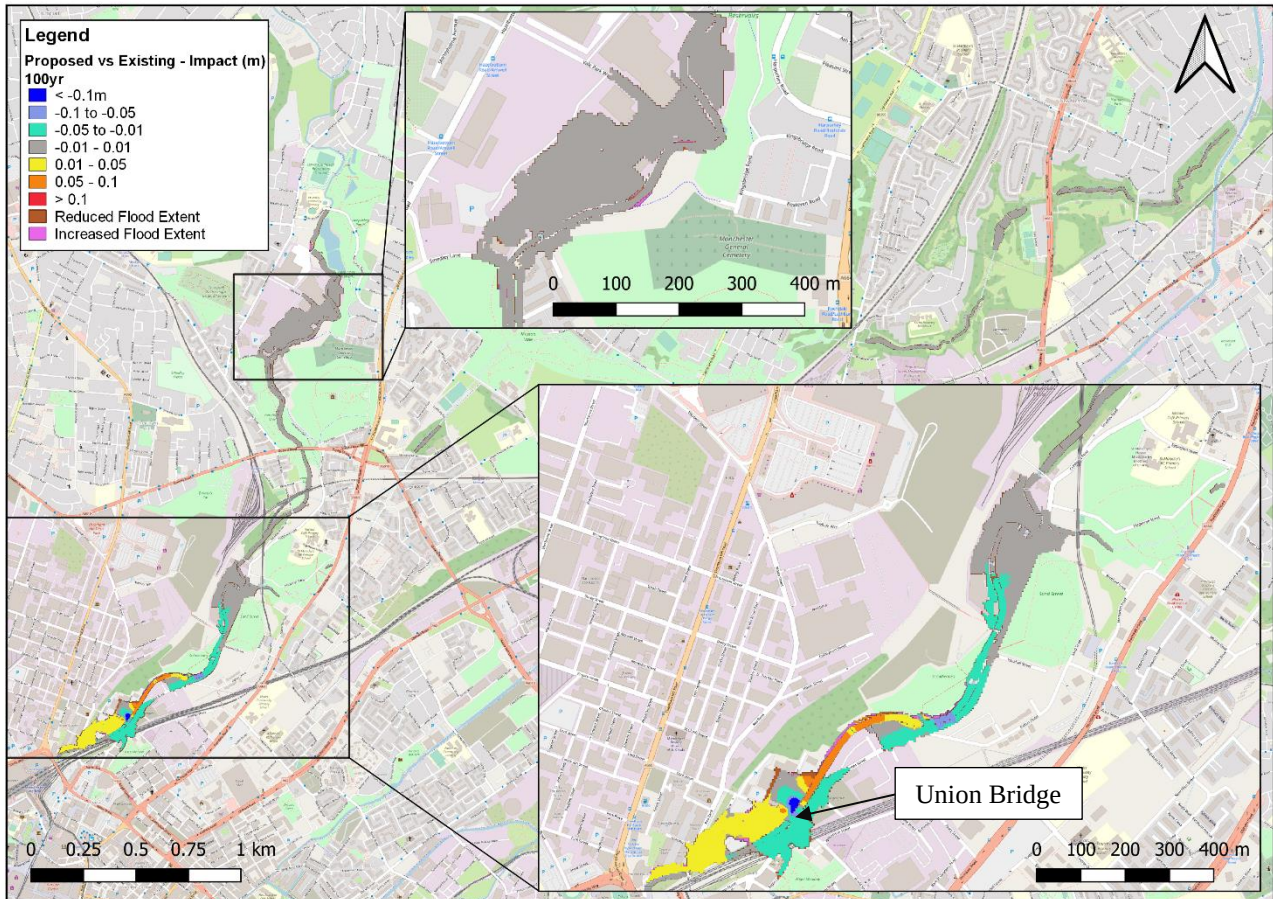


Figure 5: 100 year event Proposed vs Existing

Technical Note

281943

2 March 2022

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.

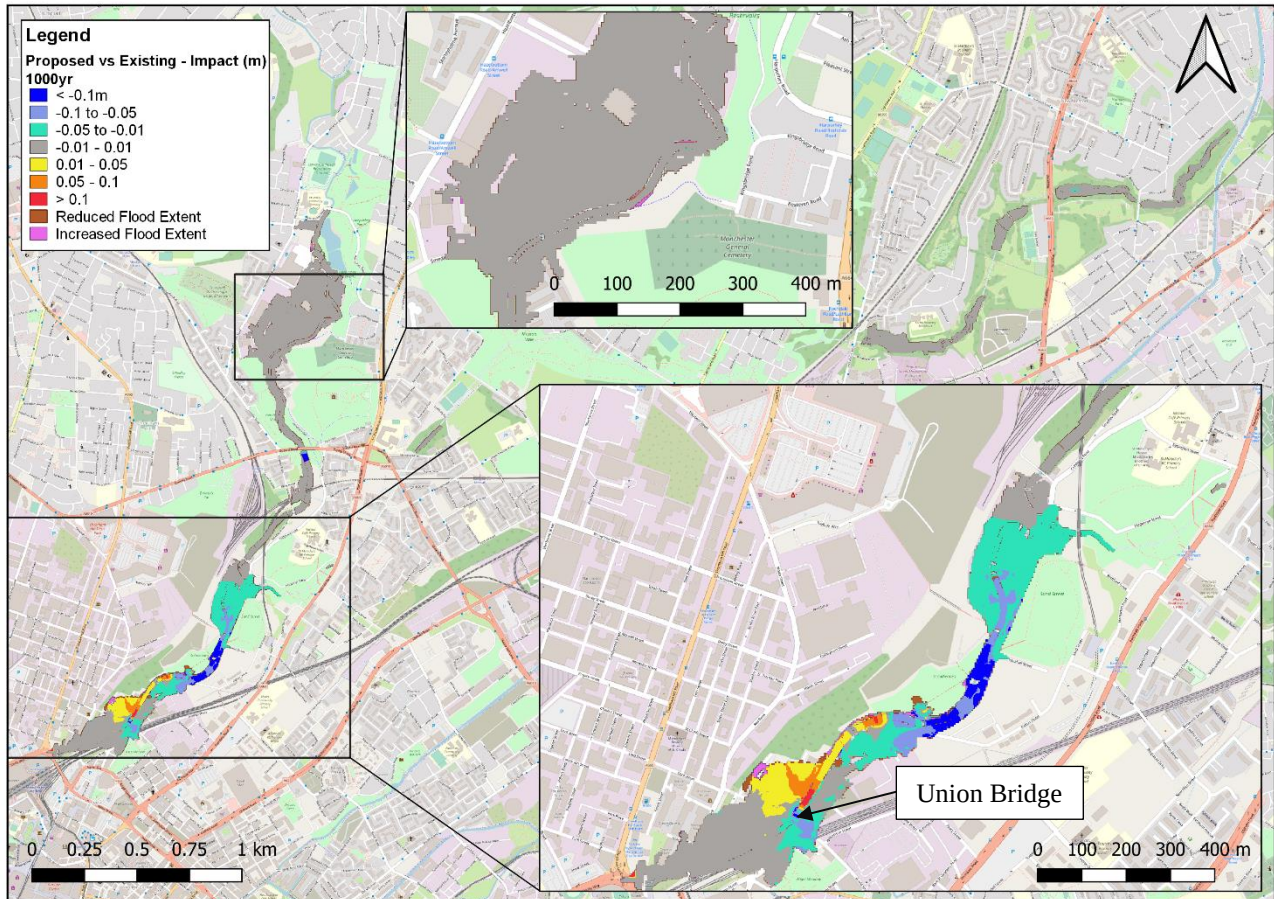


Figure 6: 1000 year Proposed vs Existing

Technical Note

281943 2 March 2022

4.3 Existing Condition vs HIF Works with Flood Mitigation Bund Inclusion

Due to the impact seen in **Figure 5** and **Figure 6** 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 7**.

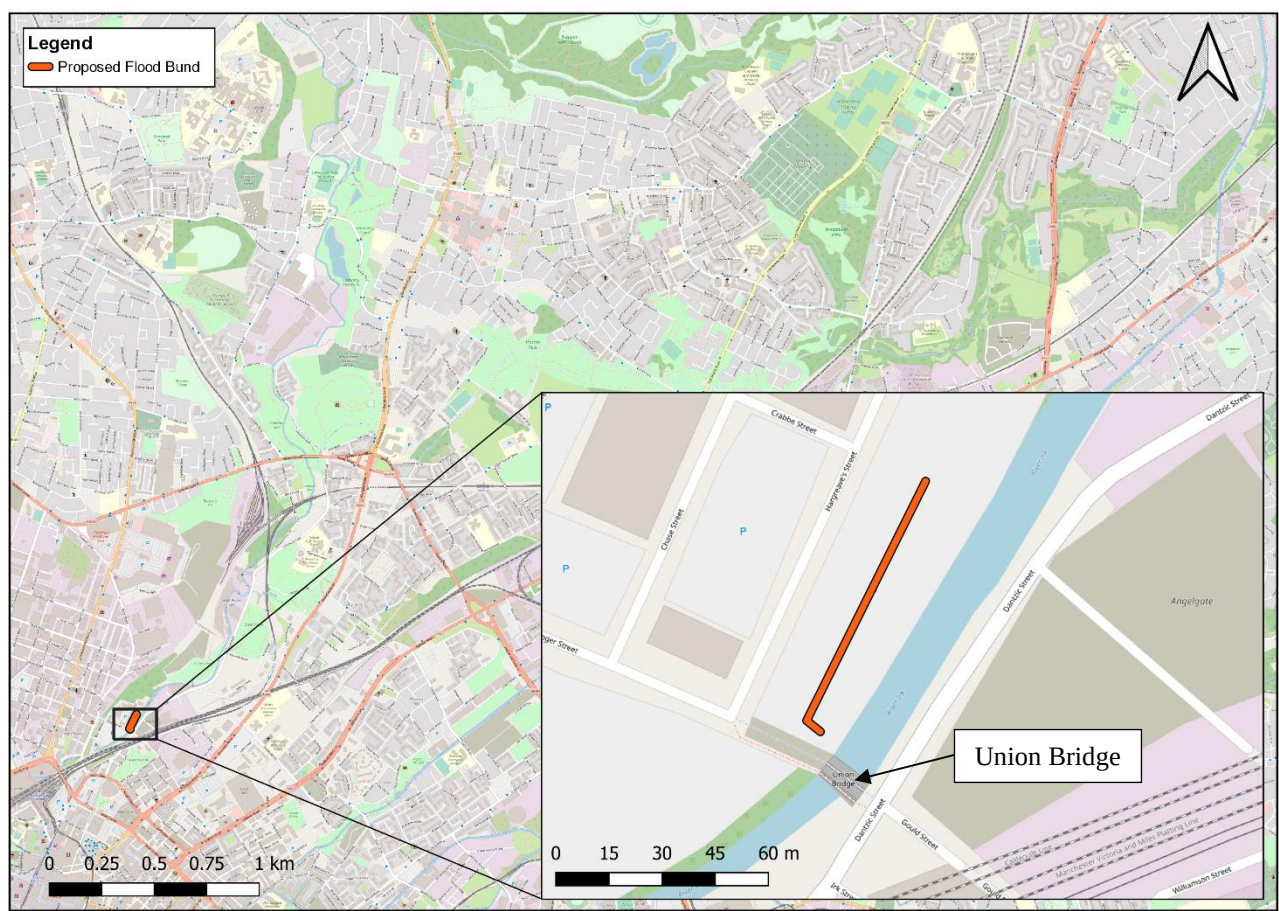


Figure 7: Location of proposed flood bund

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.

Technical Note



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	PROPM	Diff	EXIST	PROPM	Diff	EXIST	PROPM	Diff	EXIST	PROPM	Diff	EXIST	PROPM	Diff	EXIST	PROPM	Diff
Queens Road U/S	IRKR01_2814E	36.63	36.63	0.00	37.04	37.04	0.00	37.36	37.35	0.00	37.86	37.86	0.00	38.31	38.31	0.00	39.03	39.02	0.00
Smedley Rd D/S	IRKR01_2464E	35.09	35.09	0.00	35.88	35.88	0.00	36.21	36.21	0.00	36.38	36.39	0.00	36.81	36.80	0.00	37.72	37.72	-0.01
HMG Paints Weir U/S	IRK_1.19u	32.93	32.93	0.00	33.62	33.62	0.00	33.82	33.81	-0.01	33.92	33.92	0.00	34.15	34.14	-0.01	34.53	34.52	-0.01
HMG Paints Weir D/S	IRK_1.18d1	32.77	32.77	0.00	33.49	33.49	0.00	33.72	33.71	-0.01	33.82	33.82	0.00	34.06	34.05	-0.01	34.46	34.44	-0.01
P&P Bridge U/S	IRK_1.16u	31.43	31.43	-0.01	32.44	32.43	-0.02	32.80	32.77	-0.03	32.92	32.91	0.00	33.23	33.23	0.00	34.04	33.98	-0.06
Collyhurst Weir U/S	IRK_1.13u	31.11	31.10	-0.02	31.56	31.53	-0.03	31.78	31.69	-0.09	31.82	31.78	-0.05	32.02	31.97	-0.05	32.43	32.34	-0.09
Collyhurst Weir D/S	IRK_1.11	31.08	31.07	-0.02	31.52	31.49	-0.03	31.74	31.65	-0.09	31.78	31.73	-0.05	31.97	31.92	-0.05	32.38	32.28	-0.10
Location of Planit Cross-section A-A	IRKR01_1449	31.03	31.04	0.01	31.48	31.47	-0.01	31.67	31.64	-0.04	31.74	31.72	-0.02	31.94	31.91	-0.03	32.32	32.25	-0.08
	IRK_1.10	31.00	30.99	-0.01	31.44	31.36	-0.08	31.61	31.49	-0.11	31.63	31.55	-0.09	31.70	31.65	-0.05	32.14	31.98	-0.16
Location of Planit Cross-section B-B	IRKR01_1293	30.64	30.66	0.02	31.07	31.10	0.02	31.25	31.26	0.01	31.32	31.33	0.01	31.54	31.55	0.00	31.99	31.93	-0.06
	IRK_1.07	30.48	30.52	0.04	30.84	30.94	0.09	30.98	31.09	0.11	31.03	31.15	0.12	31.21	31.37	0.16	31.60	31.74	0.14
	IRK_1.06	30.40	30.44	0.04	30.75	30.83	0.08	30.86	30.95	0.09	30.90	31.01	0.11	31.04	31.17	0.13	31.42	31.51	0.09
Location of Planit Cross-section C-C	XS_C-C		30.43			30.82			30.94			30.99			31.15			31.46	
	IRKR01_1042	30.37	30.42	0.05	30.71	30.82	0.11	30.82	30.94	0.13	30.85	30.99	0.14	30.97	31.16	0.19	31.38	31.48	0.09
Location of Planit Cross-section D-D	IRK_1.05	30.33	30.35	0.02	30.66	30.73	0.08	30.75	30.87	0.12	30.77	30.91	0.14	30.89	31.10	0.21	31.20	31.44	0.24
Location of Planit Cross-section F-F	XS_F-F		30.31			30.55			30.62			30.63			30.77			31.14	

Technical Note

281943

2 March 2022

Union Bridge U/S	IRK_1.04u	30.36	30.36	0.00	30.85	30.85	0.00	31.01	31.00	-0.01	31.07	31.06	-0.01	31.24	31.26	0.01	31.69	31.64	-0.05
Union Bridge D/S	IRK_1.03d	29.57	29.57	0.00	30.53	30.53	0.00	30.77	30.77	0.00	30.85	30.84	0.00	30.98	30.98	0.00	31.34	31.33	-0.01
	IRKR01_0835	29.06	29.06	0.00	29.94	29.94	0.00	30.16	30.16	0.00	30.24	30.24	0.00	30.42	30.43	0.01	31.08	31.08	0.01
Aspin Lane U/S	IRKR01_0685D	28.66	28.66	0.00	29.65	29.64	0.00	29.96	29.96	0.00	30.08	30.08	0.00	30.36	30.36	0.00	31.05	31.05	0.00
Aspin Lane D/S	IRKR01_0685E	28.48	28.48	0.00	28.93	28.93	0.00	29.23	29.22	0.00	29.35	29.36	0.00	29.71	29.71	0.01	30.62	30.62	0.01
	IRKR01_0627B	28.19	28.19	0.00	28.63	28.63	0.00	28.87	28.87	0.00	28.97	28.97	0.00	29.27	29.28	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	28.67	28.67	0.00	28.76	28.76	0.00	29.01	29.01	0.00	29.94	29.94	0.00
Scotland Weir D/S	IRKR01_0579G	25.54	25.54	0.00	26.39	26.39	0.00	26.70	26.69	0.00	26.86	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	26.66	26.66	0.00	26.83	26.83	0.00	27.23	27.23	0.00	29.41	29.41	0.00
Irk Culvert D/S Face	IR_COND0033	25.22	25.22	0.00	26.08	26.08	0.00	26.35	26.35	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]

Technical Note



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	52.4	52.4	0.0	60.2	60.1	0.0	68.7	68.5	-0.2	81.3	81.1	-0.2	100.1	100.1	0.0
Smedley Rd D/S	IRKR01_2464E	44.9	44.9	0.0	65.2	65.2	0.0	75.7	75.7	0.0	81.7	81.8	0.0	96.3	96.2	-0.1	118.4	118.2	-0.2
HMG Paints Weir U/S	IRK_1.19u	44.8	44.8	0.0	57.8	57.9	0.1	58.4	58.5	0.1	58.8	58.9	0.1	59.9	60.0	0.1	60.4	60.9	0.5
HMG Paints Weir D/S	IRK_1.18d1	44.8	44.8	0.0	57.8	57.9	0.1	58.4	58.5	0.1	58.8	58.9	0.1	59.9	60.0	0.1	60.4	60.9	0.5
P&P Bridge U/S	IRK_1.16u	58.7	58.7	0.0	76.6	76.7	0.1	86.8	86.3	-0.5	89.7	90.5	0.8	96.8	98.0	1.3	121.8	120.1	-1.7
Collyhurst Weir U/S	IRK_1.13u	58.7	58.7	0.0	77.8	78.2	0.4	90.5	89.1	-1.3	94.3	94.8	0.5	108.7	109.4	0.7	148.9	147.7	-1.2
Collyhurst Weir D/S	IRK_1.11	58.7	58.7	0.0	77.8	78.2	0.4	90.5	89.1	-1.3	94.3	94.8	0.5	108.7	109.4	0.7	148.9	147.7	-1.2
Location of Planit Cross-section A-A	IRKR01_1449	51.9	53.5	1.6	66.7	70.2	3.5	77.1	80.0	2.9	79.9	85.3	5.4	91.7	98.7	7.0	127.0	132.7	5.7
	IRK_1.10	51.6	50.8	-0.8	66.3	71.5	5.1	78.6	82.5	3.9	86.3	89.4	3.1	107.1	107.7	0.7	134.4	138.0	3.6
Location of Planit Cross-section B-B	IRKR01_1293	59.4	59.4	0.0	78.9	78.9	0.0	89.2	89.2	0.0	93.0	94.3	1.3	102.9	104.7	1.8	121.8	123.4	1.6
	IRK_1.07	59.4	59.0	-0.4	79.1	77.0	-2.1	89.9	86.6	-3.3	94.0	91.2	-2.7	104.5	100.6	-3.9	124.8	117.6	-7.2
	IRK_1.06	59.4	59.4	0.0	79.2	78.5	-0.7	90.6	88.7	-1.9	95.5	93.8	-1.7	108.2	106.4	-1.8	130.3	125.8	-4.5
Location of Planit Cross-section C-C	XS_C-C		58.8			78.3			88.9			93.9		107.1			128.3		
	IRKR01_1042	59.4	59.4	0.0	79.2	77.8	-1.5	91.2	88.5	-2.7	96.6	93.5	-3.1	110.8	107.0	-3.8	130.1	130.0	-0.1
Location of Planit Cross-section D-D	IRK_1.05	59.4	59.4	0.0	79.2	76.3	-3.0	91.1	82.6	-8.5	96.6	86.2	-10.3	110.8	97.0	-13.8	138.3	107.7	-30.6
Location of Planit Cross-section F-F	XS_F-F		61.0			94.2			106.4			112.1		124.6			137.1		
Union Bridge U/S	IRK_1.04u	52.1	52.1	0.0	52.4	52.4	0.0	52.5	52.6	0.1	52.6	52.6	0.1	52.7	52.8	0.1	47.0	47.0	0.0
Union Bridge D/S	IRK_1.03d	52.1	52.1	0.0	52.4	52.4	0.0	52.5	52.6	0.1	52.6	52.6	0.1	52.7	52.8	0.1	47.0	47.0	0.0

Technical Note

281943

2 March 2022

	IRKR01_0835	59.2	59.1	-0.1	77.2	77.2	0.0	83.3	83.1	-0.2	84.9	84.9	0.0	86.9	86.8	-0.1	85.1	84.9	-0.3
Aspin Lane U/S	IRKR01_0685D	59.2	59.1	-0.1	75.9	75.9	0.0	77.5	77.4	-0.1	77.9	77.9	-0.1	79.1	79.0	0.0	72.1	71.9	-0.2
Aspin Lane D/S	IRKR01_0685E	59.2	59.1	-0.1	75.9	75.9	0.0	77.5	77.4	-0.1	77.9	77.9	-0.1	79.1	79.0	0.0	72.1	71.9	-0.2
	IRKR01_0627B	59.2	59.1	-0.1	78.2	78.2	0.0	88.6	88.4	-0.2	92.7	92.7	0.0	103.3	103.5	0.2	115.5	115.5	0.0
Scotland Weir U/S	IRKR01_0579F	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.8	-0.2	93.6	93.6	0.0	106.8	107.0	0.3	133.4	133.7	0.3
Scotland Weir D/S	IRKR01_0579G	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.8	-0.2	93.6	93.6	0.0	106.8	107.0	0.3	133.4	133.7	0.3
Irk Culvert U/S Face	IR_COND0564u	59.2	59.1	-0.1	78.2	78.2	0.0	88.9	88.8	-0.1	93.6	93.6	0.0	106.8	107.0	0.3	133.5	133.7	0.3
Irk Culvert D/S Face	IR_COND0033	59.2	59.1	-0.1	78.1	78.1	0.0	88.9	88.7	-0.1	93.5	93.5	0.0	106.7	106.9	0.2	133.2	133.7	0.4
Irk/Irwell Confluence	IRKR01_0027	59.2	59.1	-0.1	78.1	78.1	0.0	88.9	88.7	-0.1	93.5	93.5	0.0	106.7	106.9	0.2	133.2	133.7	0.4

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]

Figure 8 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.

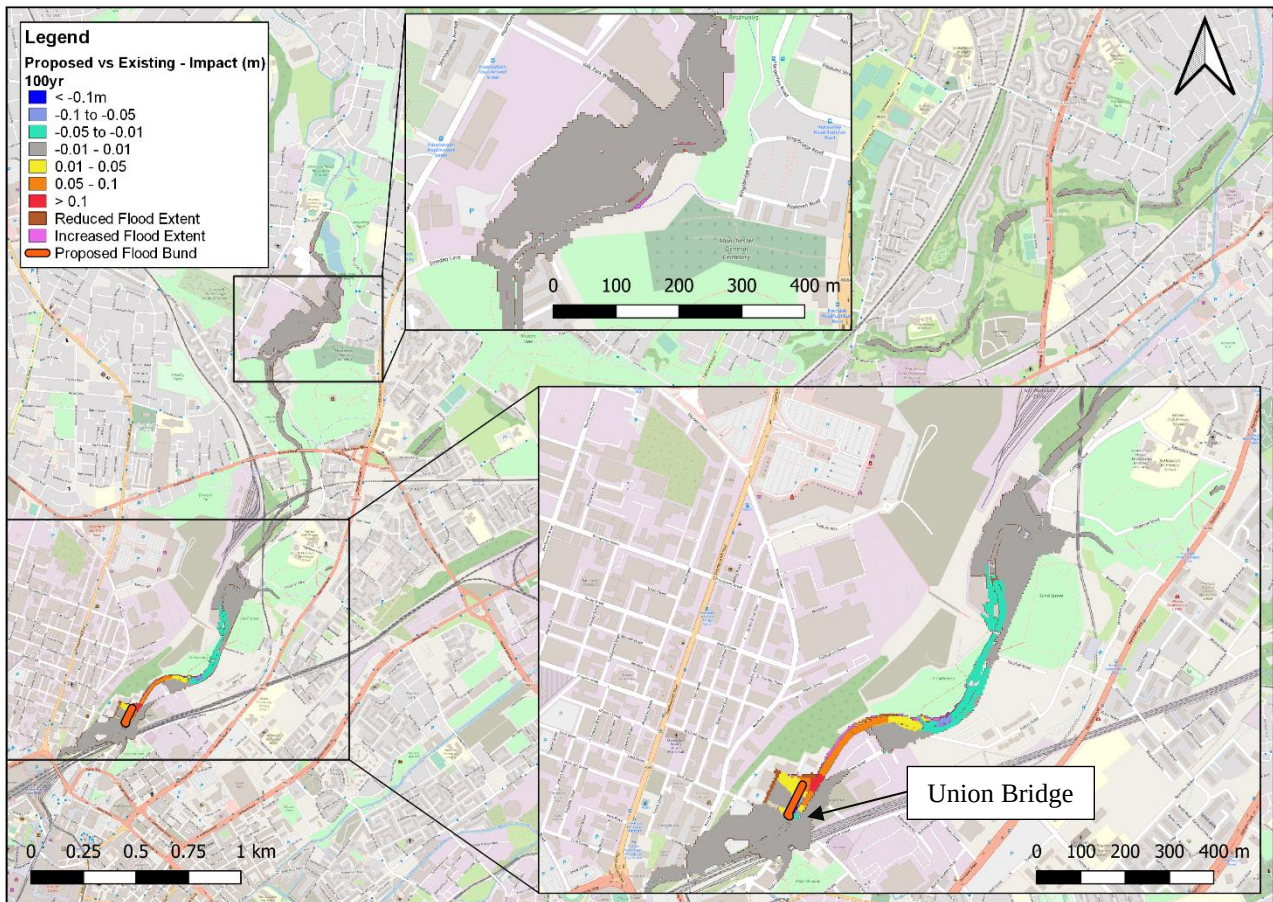


Figure 8: 100 year event HIF with flood bund vs Existing

Technical Note

281943

2 March 2022

Figure 9 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.

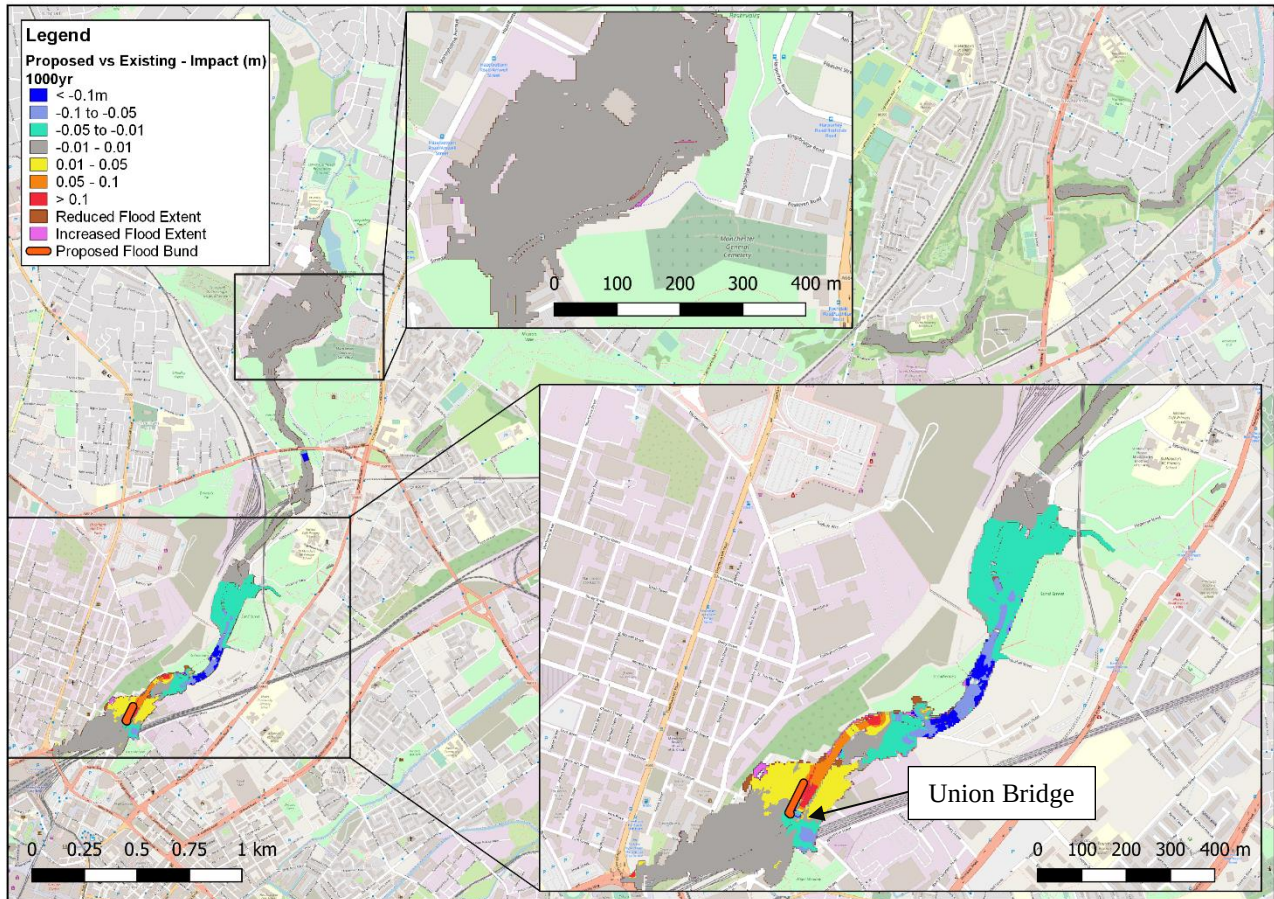


Figure 9: 1000 year event HIF with flood bund vs Existing

Technical Note

281943

2 March 2022

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 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 $0.3\text{m}^3/\text{s}$ 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 0.04m in channel and in the floodplain (reducing from a floodplain depth of 0.77m to 0.73m) 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 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 14**, 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

Technical Note

281943

2 March 2022

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 10** 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.

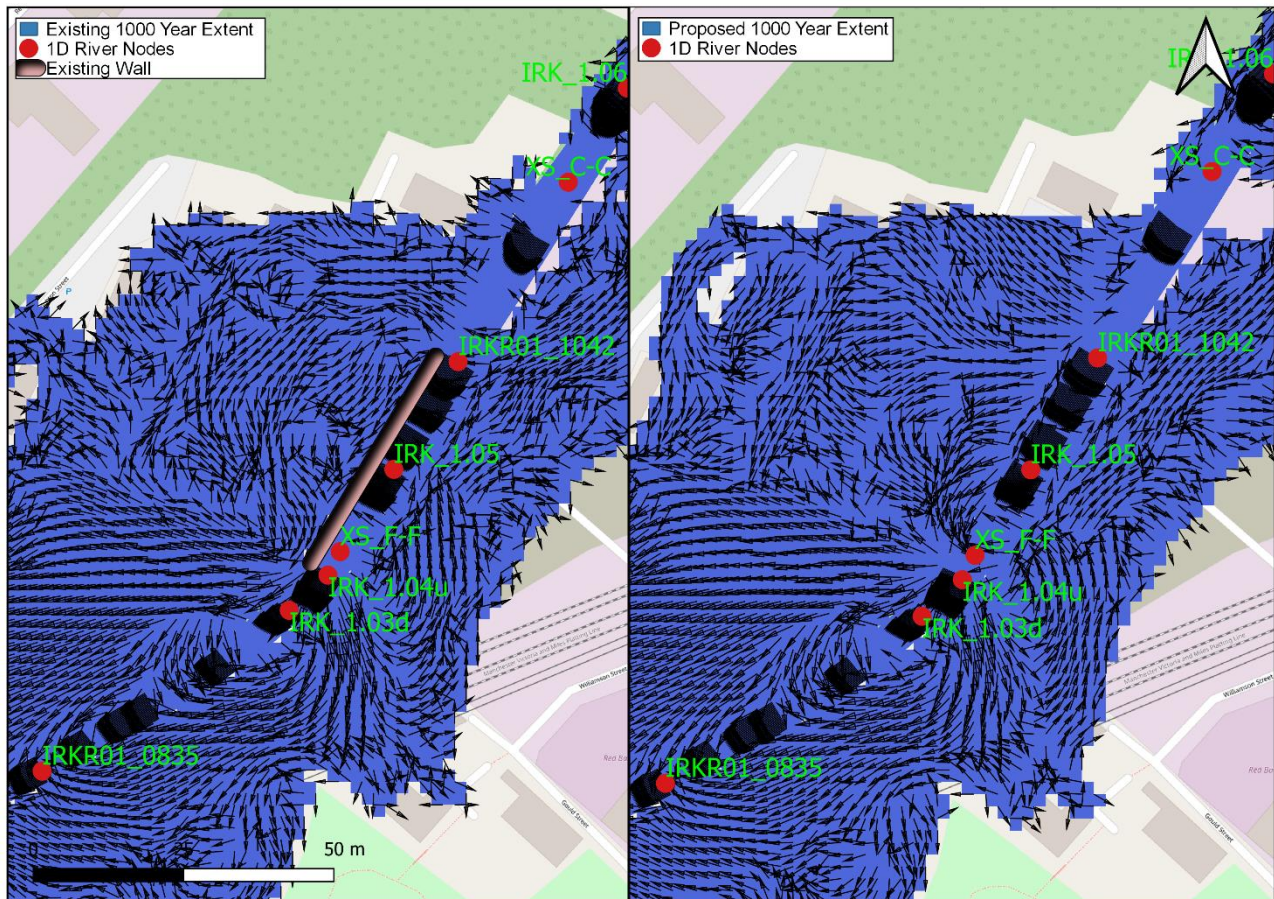


Figure 10: Direction of flow (1000 year event) Existing vs Proposed

Increases in flood heights in the floodplain on the right (north) bank, immediately west of Union Bridge on Roger Street up to a maximum of +0.06m (from existing condition depth of 0.74m) for the 100 year and up to a maximum of +0.02m (from existing condition depth of 1.3m) 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 0.015-0.035m, (from existing depths of up to 0.67m) 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 0.02m 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

Technical Note

281943

2 March 2022

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 8, Figure 9 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 $0.4\text{m}^3/\text{s}$ for the 1000 year event (0.33% 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 11 illustrates a comparison of the 100 year impact without and with the mitigation bund in place, compared to existing.

Technical Note

281943

2 March 2022

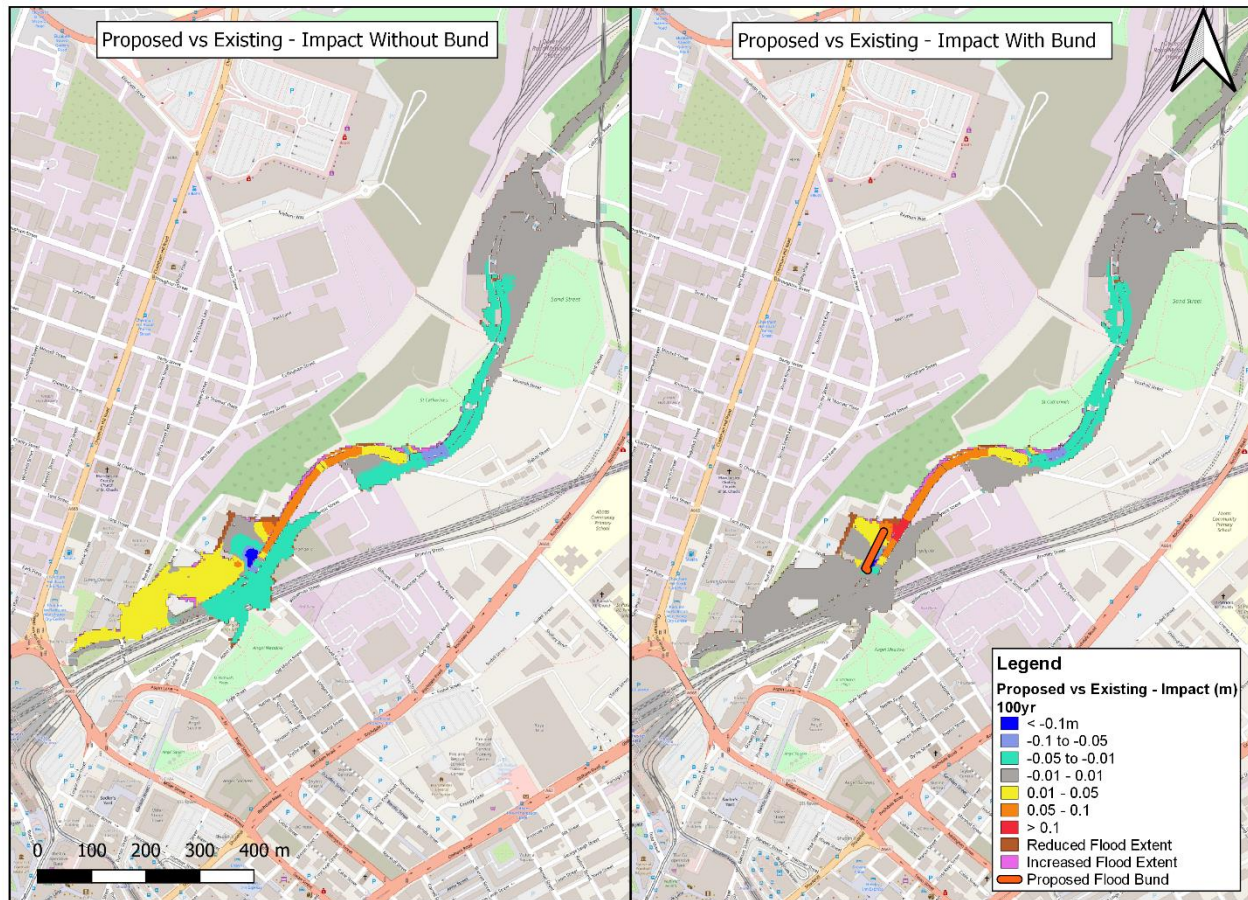


Figure 11: Impact comparison – with and without the flood bund – 100 year

Figure 11 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 Dantzig Street is negligible comparing the bundled 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 a increase in level along the bank, within the floodplain, at Travis Island of up to 0.035m (from an average depth of 0.650m to 0.685m), 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.

As shown in **Table 5**, there is a Negligible pass forward of flows for 100 year event and a small increase in pass forward flow of 0.2 to 0.4m³/s for the 100 year + CC 2080 and 1000 year events, which is less than 0.5% change.

Technical Note

281943

2 March 2022

The bund predominately mitigates the changes flood risk predicted for the proposed HIF Infra works, however **Figure 12** shows that the impact for the 1000 year event does still marginally propagate (up to 0.011m 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 Dantzie Street, with an increase in flood depth in the region of 0.015-0.030m (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 0.75m in existing situation) illustrated in yellow, although the majority of this area has negligible impact or a reduction of up to approximately 0.065m.

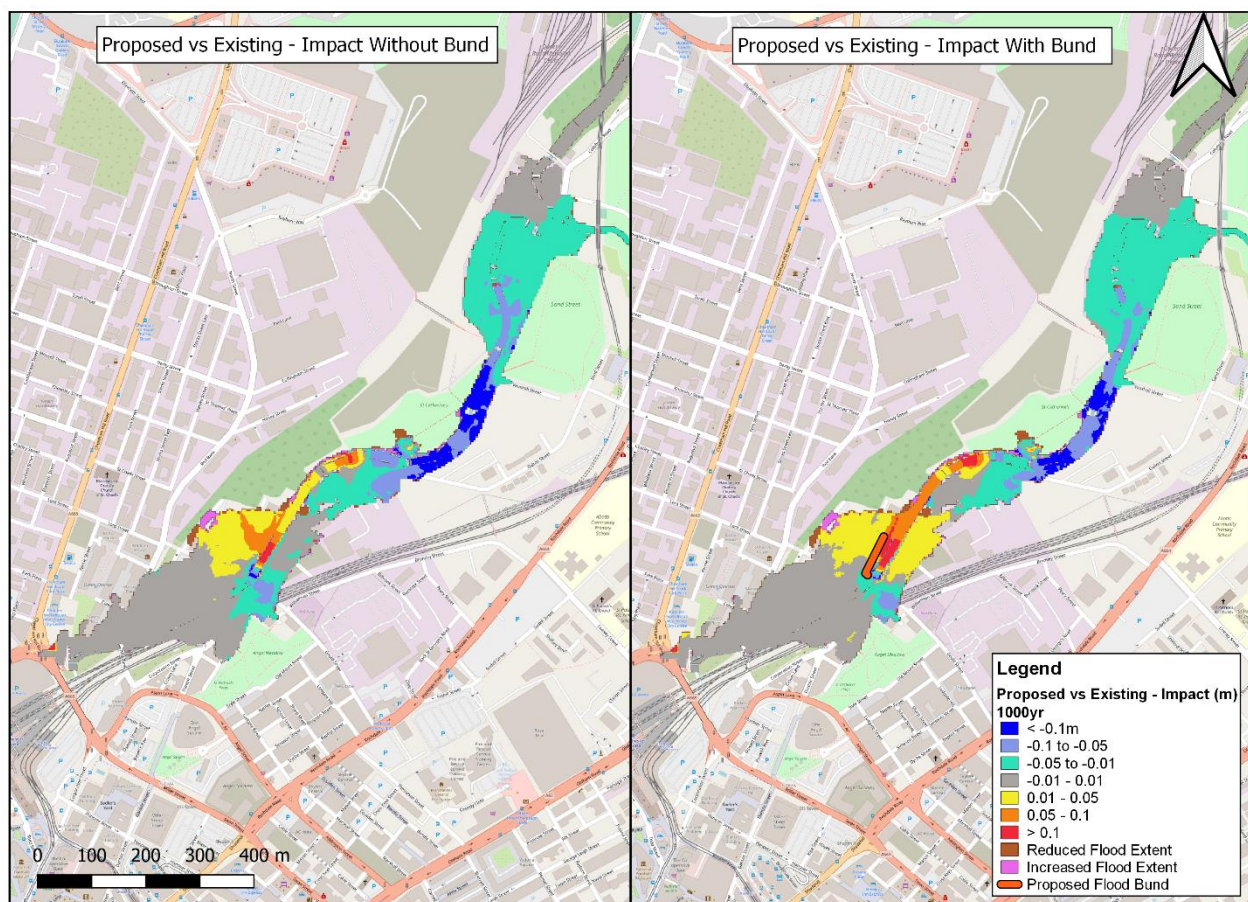


Figure 12: Impact comparison – with and without the flood bund – 1000 year

Technical Note

281943

2 March 2022

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 13: 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.

Technical Note

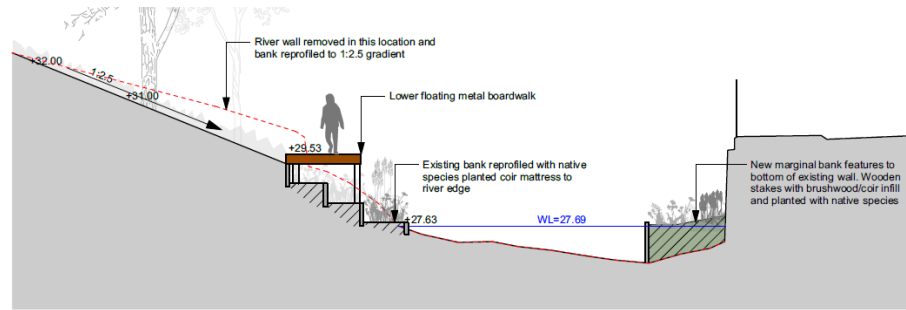
281943

2 March 2022

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



Figure 14: 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 NRFA², 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 tables³. 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 13, a new Mastermap layer was created to assign current roughness values.

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\INF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRA\PROPOSALS_ISSUE2A.DOCX

Arup | F0.15

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

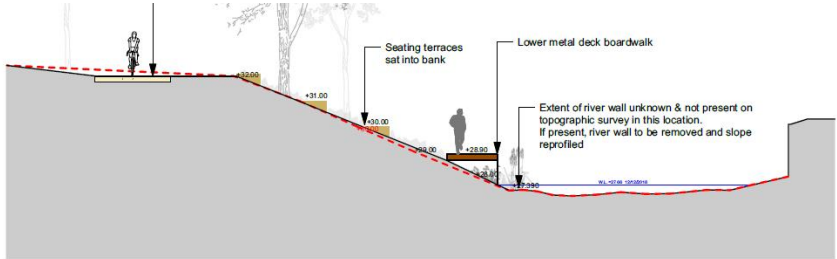
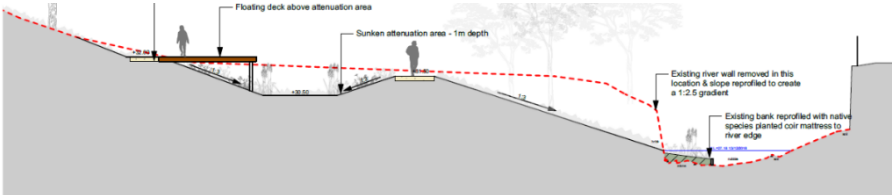
J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\INF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRA\PROPOSALS_ISSUE2A.DOCX

Arup | F0.15

Technical Note

281943

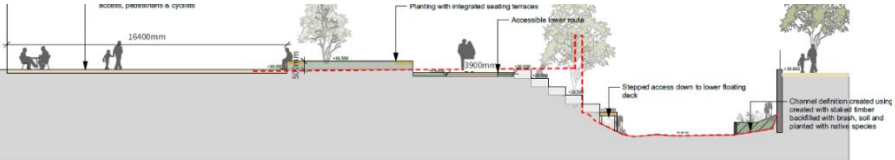
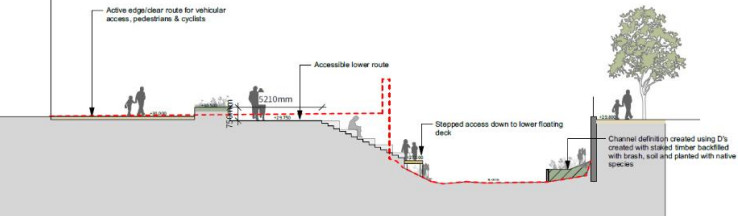
2 March 2022

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 13, 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 13, a new Mastermap layer was created to assign current roughness values.

Technical Note

281943

2 March 2022

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 brush 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 13, 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 brush 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

Technical Note

281943

2 March 2022

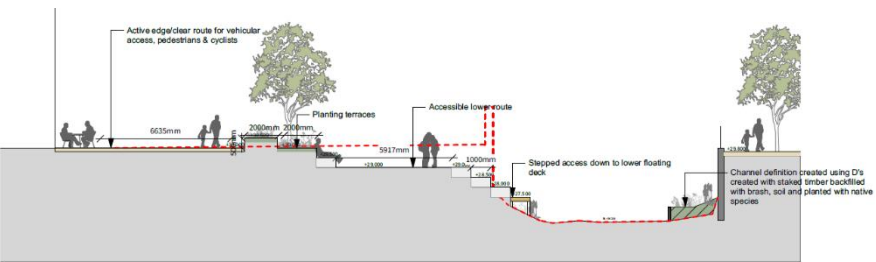
Proposed in-channel works	1D model cross-sections impacted	Proposed changes to cross-sections
F – F'  6 Section F-F' Scale: 1:150	IRK_1.05 and XS_F-F	with the 1D node levels. To account for the terrain changes shown in Figure 13, a new Mastermap layer was created to assign current roughness values. Channel 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, 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 13, a new Mastermap layer was created to assign current roughness values.

Table 6 - Summary of HIF Infrastructure Works modelled

Technical Note

281943

2 March 2022



Figure 15 - Plot Boundaries

Technical Note

281943

2 March 2022

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.	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

2 March 2022

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. There still seems to be an issue at MOST01_5400 with the right bank continuing down into the floodplain due to inappropriate 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?	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

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	Additionally, the drawings were compared to amended cross sections with the following issues noted: 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 between 1.18 and 1.17 from a spot check.	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 amended to account for this. Chainage in the model between sections 1.18 and 1.17 was compared to aerial imagery and

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	Action: Please check where new survey has been added that 1d chainage matches.	survey, and values were adjusted accordingly.
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. 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.	Completed – all addressed 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	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

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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.	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 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 values of vegetated areas outside of boardwalks in the proposed model have been dropped to 0.07, as per Chow item 1g (normal).
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	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	Downstream boundary taken from the Manchester Ship Canal 2018 model. As agreed with Nick Prebble on 15/12/2021:

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\INFRA-PP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRA\PROPOSALS_ISSUE2A.DOCX

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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.	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 Please also confirm the return period used from 2018 model for the downstream boundary in reporting.	•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 •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	Check and address comments for structures highlighted. If not changed, need full justification in reporting.	Completed: Weir in new survey amended

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULIC MODELLING OF INFRA\INFRA-PP-ZZ-RIV-RP-DF-0002_HYDRMODELLING OF INFRA PROPOSALS_ISSUE 2A.DOCX

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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: - 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	NB - no one issue causes the "red" RAG status, but lots of smaller issues together does.	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 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

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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.	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 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.	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.
Orifice flow on surcharging bridges: The following bridges surcharge with orifice flow not enabled:	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

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
IRKR01_2770A, IRKR01_2464A, IRKR01_2123D, IRKR01_2024D, IRKR01_1930D, IRK_1.09bu, IRK_1.04bu, IRKR01_0685D, MOST01_5892D, MOST01_4212D		
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 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.	Review spill coefficients and ensure consistent across study area. Justification for values used should be included in reporting. 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 at HMG paints reduced to 1.0 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

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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. It looks as if the polygons were cropped to the previous domain boundary, but have not been reinstated for a larger 2D domain.	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) 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?	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 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.	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).

Technical Note

281943

2 March 2022

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

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	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. 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. 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.	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 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.	Justify missing HX lines, and as far as possible, add HX lines to connect 1D and 2D domains at locations highlighted.	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.

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?																																																																				
Some 2D spills only have HX line on upstream/downstream, for example IRKR01_3311 doesn't have a spill on the upstream.	Justify representation of 2D overtopping using HX lines.	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><tr><td>MOST01_5850</td><td>- 12.26</td><td>- 10.95</td><td>- 1.31</td></tr><tr><td>MOST01_5300</td><td>- 09.02</td><td>- 10.16</td><td>- 1.14</td></tr><tr><td>MOST01_4950</td><td>- 57.20</td><td>- 08.80</td><td>- 48.4</td></tr><tr><td>MOST01_4500</td><td>- 12.02</td><td>- 10.48</td><td>- 1.54</td></tr><tr><td>MOST01_3830</td><td>- 21.45</td><td>- 22.11</td><td>- 0.66</td></tr><tr><td>MOST01_1400</td><td>- 39.16</td><td>- 41.65</td><td>- 2.49</td></tr><tr><td>MOST01_0645</td><td>- 25.00</td><td>- 11.25</td><td>- 13.75</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	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	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. 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	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, 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
	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																																																																			
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																																																																			

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
	2d grid size so please address where discrepancies remain, especially where the difference is more significant.	
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). Action: please include or explain absence.	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.
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.	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).	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

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULIC MODELLING OF INFRA\INFRA-PP-ZZ-RIV-RP-DF-0002_HYDRMODELLING OF INFRA\PROPOSALS_ISSUE2A.DOCX

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
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. 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.	W2229 - trash screen height set to 0 W2262 - backflow encountered at culvert outlet. (This is evident at most of the culvert units underneath 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.	
1D convergence:	1D stability could be better in terms of convergence. Investigate how much	Increase of boundary viscosity factor to 3 in the 1000yr event. Testing around the use of

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLINGOFINFRA\WIF-ARP-ZZ-RIV-RP-DF-0002_HYDRMODELLINGOFINFRA\PROPOSALS_ISSUE2A.DOCX

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
Some non-convergence related to culverts surcharging. See Q1000 bitmap below.	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 high given oscillating peak stage spikes and are therefore unreliable.	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).
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. Dvol appears to be more unstable compared to previous submission, see screenshot to the right. Please improve the oscillating nature of the signature.	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.
2D Comments and warnings: Warning's from Q1000 tlf. W0305 - Projection of .shp file is different to that specified by the SHP Projection == command.	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

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULICMODELLING\INFRA\NIF-ARP-ZZ-RV-RP-DF-0002_HYDRMODELLING\INFRA\PROPOSALS_ISSUE2A.DOCX

Technical Note

281943

2 March 2022

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

J:\280000\281943-004 INTERNAL PROJECT DATA\4-05 REPORTS\4-05-02 CIVIL\HYDRAULIC MODELLING\INFRA\INFRA-PP-ZZ-RIV-RP-DF-0002_HYDRMODELLING\INFRA\PROPOSALS_ISSUE2A.DOCX

Technical Note

281943

2 March 2022

EA Model Review Comments	EA Model Review Actions	Addressed in the HIF Infrastructure Assessment model?
In the absence of any previous flood event information, sensitivity test are more important to understand uncertainty of modelled outputs.		
Confidence limits: Not provided	Comment on model uncertainty limits in the reporting. Please ensure this is undertaken at any modelling stage.	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. 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 2022 and the Arup response in February 2022.

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			