Office of Public Works

Ballinasloe Flood Relief Scheme

Hydraulics Report
Appendix C
Hydraulic Model QA Information

Issue 1 | 17 February 2022

Job number 271741-00

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Contents

1 Introduction

This model QA file has been prepared to provide further information about the model build process; it includes information on the data used and modelling processes, details on the hydraulic structures included in the model and highlights modelling decisions and assumptions made. This document should be read in conjunction with the Ballinasloe Flood Relief Scheme Hydraulics Report.

The following staff were responsible for the delivery of the model:

Table 1: Responsible Staff

Arup Project Manager	Alan Leen
Senior Modeller	Kevin Barry
Other modellers	Marco Maiozzi, Cian Buckley
Hydrologist	Anthony Cawley, Hydro Environmental Ltd

2 List of input data

Table 1 below summarises the input data used in the hydraulic model. Further discussion is provided in Section 2 of the main Hydraulics Report.

Table 2: List of Input Data Used in the Hydraulic Model

Data	Details / Source	Comment
Lidar Digital Terrain Model	Captured in 2011-2012 as part of the Shannon CFRAM project. Horizontal Resolution: 2m. Vertical resolution: ± 0.2m.	Used to define the 2D domain for the model.
CFRAM channel and structure survey	Undertaken in 2012 by Murphy Surveys.	Used for most of the watercourses' cross-sections in the 1D model.
Ballinasloe FRS Infill and Validation Survey	Undertaken in 2020 by McDonald Surveys.	Used to add additional cross-sections in the 1D model in key areas (esp. in the vicinity of the Town Centre). A Flood Defence Survey was part of this contract and was used to check, improve the representation of Derrymullen's defences This survey also included a banktop survey to improve the definition of the 1D-2D links

Data	Details / Source	Comment
East Bridge Survey	Undertaken in 2011 by FCG Surveys. Data provided by GCC	Used to infill missing bed levels data in the CFRAM Survey downstream section of the East Bridge. Please refer to Section 4.4.5 of the hydraulics report for detail.
Culvert Survey	Undertaken in 2021 by Enva Ltd.	Used to inform the modelling of the Townparks culvert, Pollboy culvert. (See Appendix C).
Calibration data	As described in Section 2.5 of the main Hydraulics report	Used for in-channel calibration and out of bank calibration within the town
Design flows and hydrographs	Ballinasloe FRS Hydrology Report (2021)	The main hydraulics report details choices made in terms of integrating the hydrology and hydraulics (ref section 3.6)

3 Modelling Processes

This section provides information on the model construction including basic model construction details. Further detail about hydraulic structures is also included along with the relevant modelling decisions.

3.1 Model Construction

Table 3: Model Construction

Model Construction	
Model Type	Linked 1D-2D (FloodModeller-Tuflow)
Key purpose of the model	Evaluation of baseline fluvial flood risk in Ballinasloe town and to facilitate modelling of potential flood relief scheme options
TUFLOW version used	V2018
Flood Modeller Pro version used	v4.6
Model directory	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\
Types of Inflow Sources	Lumped fluvial inflow from each watercourse as described in section 3.6 of the main hydraulics report
River Reaches	Parts of the River Suck, Bunowen, Deerpark, Ballyhugh, all as described in Section 4.3 of the main hydraulics report. The lengths of the reaches were chosen to ensure that no boundary effects would influence predicted water levels within the "scheme area" files provided by OPW

Model Construction	
Adopted approach	The model was progressively developed through the following main steps: - Creating an initial 1D main channel model without hydraulic structures - Progressively adding key 1D hydraulic structures to the model e.g. the East Bridge - Adding the west channel in the town centre - Adding other minor tributaries - Addition of 2D domain - Addition of hydraulic structures within the 2D domain including culverts, existing flood defences
Available data	Refer to Section 2 above, and Section 2 of the main hydraulics report
General Schematisation	As described in Section 4 of the main hydraulics report which provides a detailed description of the model development, treatment of blockage risk, etc.
Key limitations of the model	Model is deemed to be accurate and robust given the very good calibration achieved between the model and recorded data (refer to hydraulics report for details). Model limitations are the standard limitations that apply to all 1D/2D models (i.e. cross sectional averaged approach for the 1D model, representation of the floodplain in finite difference grid etc.)

3.2 Hydraulic Structures

Refer to Appendix C2 of the hydraulics report which contains sheets describing each hydraulic structure and the relevant modelling decisions for each structure.

3.3 Model Development Log

See overleaf

Filename [?]	Preceding file [?]	File location [?]	Comments / changes since preceding file
26SUCK_Combined	-	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	First full-length model of the Suck, with no structures.
26SUCK_Combined_cut	26SUCK_Combined	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Removed all the sections downstream of the M6 bridge. (Note: these sections were later added back in to account for the backwatering effect from the River Shannon)
26SUCK_Combined_cut_v2	26SUCK_Combined_cut	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added details to section 16335.
26SUCK_Combined_cut_v3	26SUCK_Combined_cut_v2	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Isolated sections 16372, 14304, 13234bis, 13188, which were causing numerical instabilities in the model.
26SUCK_Combined_cut_v4	26SUCK_Combined_cut_v3	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added East Bridge to the model (key hydraulic structure).
26SUCK_Combined_cut_v5	26SUCK_Combined_cut_v4	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Error associated with the CFRAM set up of the East bridge corrected. This was related to an error in the surveyed ds cross section of the bridge from the CFRAM survey. Please refer to Section 4.4.5 of the hydraulics report for detail.
26SUCK_Combined_cut_v6	26SUCK_Combined_cut_v5	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added railway and motorway bridge to the model

26SUCK_Combined_cut_v7	26SUCK_Combined_cut_v6	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added Suck C cross sections to the model. These were taken from the original CFRAM survey
26SUCK_Combined_cut_v8	26SUCK_Combined_cut_v7	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added Ballinasloe West Channel to the model (critical channel of the model)
26SUCK_Combined_cut_v9	26SUCK_Combined_cut_v8	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added Ballinasloe Infill survey data. This data was added to a number of different channels
26SUCK_Combined_cut_v10	26SUCK_Combined_cut_v9	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added Deerpark channel to the overall model
26SUCK_Combined_cut_v11	26SUCK_Combined_cut_v10	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	The names of a number of cross section weere edited in order to ensure the whole model complies with the CFRAM model convention
26SUCK_Combined_cut_v12	26SUCK_Combined_cut_v11	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	The changing of the cross section names intorduced a number of connectivity errors in the DAT file. These were fixed with this version of the model.
26SUCK_Combined_cut_v13	26SUCK_Combined_cut_v12	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	**1D model fully coupled to the 2D model (First 1D - 2D model)**

26SUCK_Combined_cut_v14	26SUCK_Combined_cut_v13	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added additional cross sections at the location of the M6 road bridge in order to better represent the hydraulics through this reach
26SUCK_Combined_cut_v15_2009	26SUCK_Combined_cut_v14	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	A number of changes were made to replicate the 2009 calibration sceanario: Modified Upstream boundary inflows, Adjusted the alignment of the hxe boundaries, Removed Derrymullen defences (for the 2009 event only)
26SUCK_Combined_cut_v16	26SUCK_Combined_cut_v15_2009	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	East Bridge openings were modified in order to represent 2009 conditions at the bridge (i.e. with sluice gates in the dropped down position).
26SUCK_Combined_cut_v17	26SUCK_Combined_cut_v16	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added the Bunowen watercourse to the model.
26SUCK_Combined_cut_v18	26SUCK_Combined_cut_v17	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Modified the width of the Deerpark Railway Culvert
26SUCK_Combined_cut_v19	26SUCK_Combined_cut_v18	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Inlcuded the additional channel downstream of the railway bridge in the model. Note: this is referred to as Suck B in the model.
26SUCK_Combined_cut_v20	26SUCK_Combined_cut_v19	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	The twin circular culverts immediatley upstream of the West Bridge were inlcuded in the model.

26SUCK_Combined_cut_v20_S1	26SUCK_Combined_cut_v20	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Various Sensitivity Runs on the Manning's n-values in the town centre were undertaken as part of the calibration. Results from model were compared with recorded data from the event. (Note: Section 5.4 of the hydraulics report provides a detailed description of the model calibration)
26SUCK_Combined_cut_v20_S2	26SUCK_Combined_cut_v20_S1	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	
26SUCK_Combined_cut_v20_S3	26SUCK_Combined_cut_v20_S2	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	
26SUCK_Combined_cut_v20_S4	26SUCK_Combined_cut_v20_S3	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	
26SUCK_Combined_cut_v21	26SUCK_Combined_cut_v20	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Further modification of the Manning's values for the entire 2D model. Took out secondary drainage channel running parallel to the main deerpark channel up to the Deerpark link and also amended the Deerpark Link 1D-2D elements. The left bank at the western channel was also adjusted.
26SUCK_Combined_cut_v22	26SUCK_Combined_cut_v21	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Modified the Z-points at the atlas stream in order to accommodate the alignment of the channel and the hydraulic structures
26SUCK_Combined_cut_v23	26SUCK_Combined_cut_v22	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added WL lines to the model to allow flood depths in the 1D channel to be output to the flood maps. The Railway culvert configuration and a number of the HXI lines were also ammended. Amended junction between Deerpark Link and the Suck. Added additional

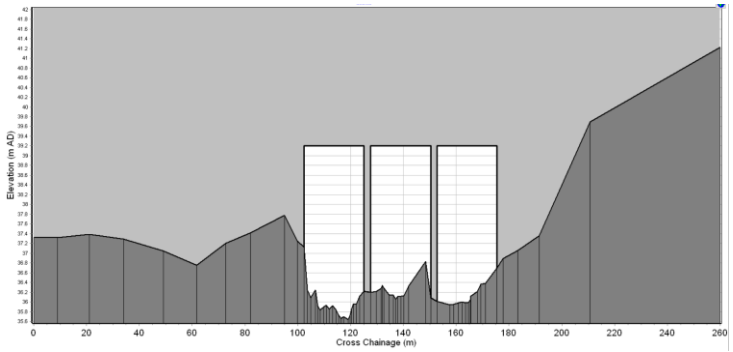
			cross sections in order to inlclude the River Suck as far as its confluence with the River Shannon.
26SUCK_Combined_cut_v23	26SUCK_Combined_cut_v23	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Model was set up to replicate the 2009 event
26SUCK_Combined_cut_v24	26SUCK_Combined_cut_v23	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Amended twin culverts at the railway in the model as this could not be done with an IED file
26SUCK_Combined_cut_v24_2009	26SUCK_Combined_cut_v24	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Adjustment to the 1D componment of the 2009 model. Results from model compared with recorded data from the event
26SUCK_Combined_cut_v24_2009_07	26SUCK_Combined_cut_v24_2009	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Made the calibration coefficient in the East Bridge 0.7 (from 1.0). Results from model compared with recorded data from the event
26SUCK_Combined_cut_v25	26SUCK_Combined_cut_v24	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added the structures in the Tuflow domain along the Atlas Stream. Results from model compared with recorded data from the event
26SUCK_Combined_cut_v26	26SUCK_Combined_cut_v25	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Integrated the Ballyhugh model with the larger River Suck model.
26SUCK_Combined_cut_v27	26SUCK_Combined_cut_v26	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03	Identical to v26 - error with the .gxy file was however fixed

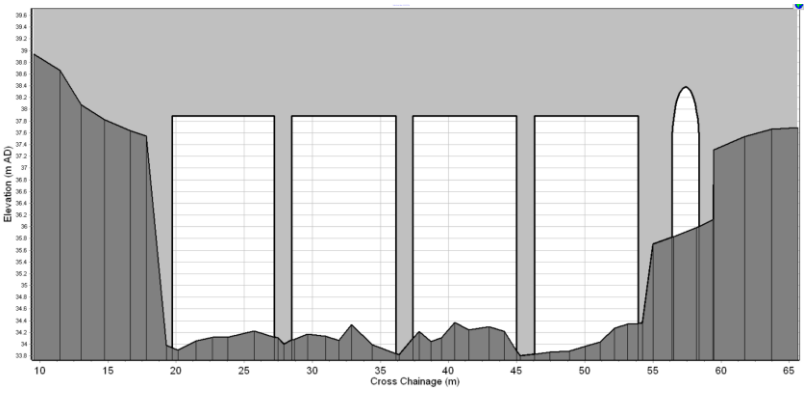
		Infrastructure\06. Hydraulic Modelling\Model\Model	
26SUCK_Combined_cut_v25_shift	26SUCK_Combined_cut_v25	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	As v25, but with a downstream WL peak shifted in time by 7 days as part of the sensitivity testing of the downstream boundary. Results from model also compared with recorded data from the event
26SUCK_Combined_cut_v25_NDBDY	26SUCK_Combined_cut_v25_shift	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	As v25, but with a NDBDY at the downstream boundary of the Suck. Results from model also compared with recorded data from the event
26SUCK_Combined_cut_v28	26SUCK_Combined_cut_v27	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Modified the d/s boundary to have the peak occur at the same time as the peak in the town centre (5hrs after the peak at Bellagill, to allow for the peak to travel down the River)
26SUCK_Combined_cut_v29	26SUCK_Combined_cut_v28	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Added the Deerpark Trib1 (inlcuded due to the findings of the small tribs memo)
26SUCK_Combined_cut_v30	26SUCK_Combined_cut_v29	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Created just to fix a bug in the .gxy file. This is the baseline version of the model. Used in the optioneering for Option 1, Option 3, Option 5, Option 8, and all variations of the same unless otherwise stated elsewhere (ex. Option 1b)
26SUCK_Combined_cut_v30b	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Changed a SPILL unit at 01BLN00407su in order to address an instability in the CC Q1000 runs which entailed using very high flows
26SUCK_Combined_cut_v30_EB_HL2	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03	Sensitivity model: East Bridge headloss coefficient adjusted to 2 (refer to Section 7 of the hydraulics report for description of all the sensitivity runs)

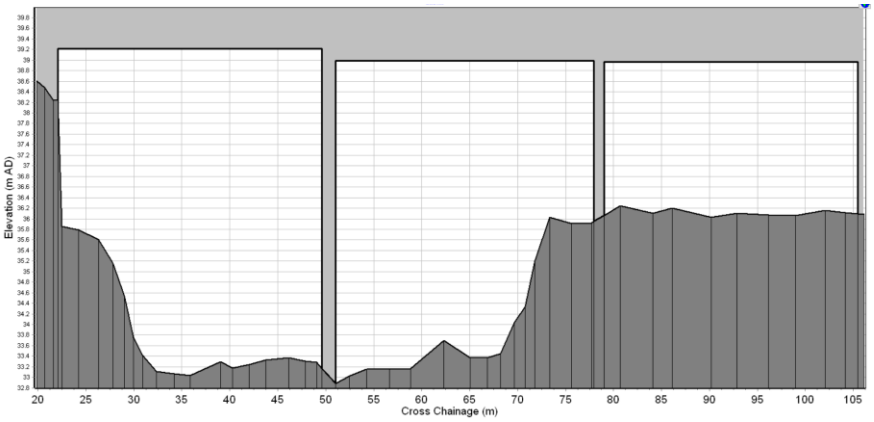
		Infrastructure\06. Hydraulic Modelling\Model\Model	
26SUCK_Combined_cut_v30_RB_HL2	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Sensitivity model: Railway Bridge headloss coefficient adjusted to 2
26SUCK_Combined_cut_v30_EB_USBPR	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Sensitivity model: East Bridge changed from Arch to USBPR
26SUCK_Combined_cut_v30_Manning_20pc	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Sensitivity model: Manning's values multiplied by 1.2
26SUCK_Combined_cut_v30_Manning_-20pc	26SUCK_Combined_cut_v30	\\global\europe\Cork\Jobs\271000\271741-00\4. Internal\4-03 Design\4-03-03 Infrastructure\06. Hydraulic Modelling\Model\Model	Sensitivity model: Manning's values multiplied by 0.8

C1 Structures Datasheet – Bridges

C1.1 Bridges on the Main River Suck

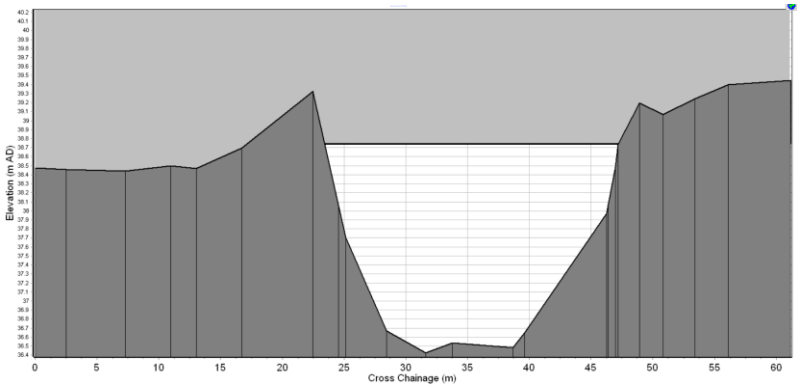
Name/model node label	**05SUC02200bu (Railway Bridge)**	
River Reach	River Suck	
Type of structure	Railway Bridge	
Description	Masonry and Steel Bridge with three openings	
Survey Reference	26SUCK01892	
Irish Grid Reference	184469.5,231964.2	
Included in model	Yes	
Photograph	 Note: two of the three bridge openings shown in the photo	
Model section		
Dimensions & levels	*Invert Level*	35.94 mOD
	Soffit level	39.20 mOD
	Springing level	39.20 mOD
Manning's n	Bed n of structure section = 0.06.	
Modelled as	USBPR Bridge unit	
Model assumptions and limitations	No spill unit was added to the bridge as it is not at risk of being overtopped due to its elevation.	

Name/model node label	**04SUC01917bu (East Bridge)**	
River Reach	River Suck	
Type of structure	Road Bridge	
Description	Masonry Bridge with 4 openings and 1 flood relief opening on the right bank	
Survey Reference	26SUCK01634D	
Irish Grid Reference(s)	185747.99, 231073.95	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	33.82 mOD
	Soffit level	37.89 mOD
	Springing level	37.89 mOD
Manning's n	Bed n of structure section = 0.06.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Refer to Section 4.4.5 of the main Hydraulics Report for a detailed description of the set-up of the bridge in the model.	

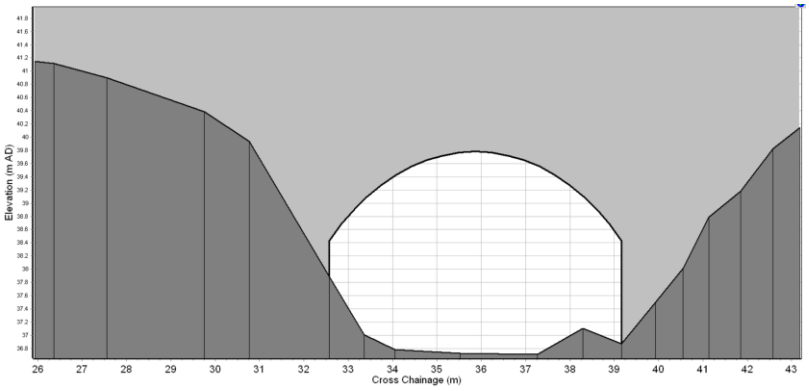
Name/model node label	**03SUC00581bu (M6 Bridge)**	
River Reach	River Suck	
Type of structure	Road Bridge	
Description	Concrete Bridge with 4 openings (3no modelled with main channel and 1no modelled separately with navigation channel, see overleaf	
Survey Reference	26SUCK01323D	
Irish Grid Reference(s)	187341.73, 229161.16	
Included in model	Yes	
Photograph	 Photo looking upstream	
Model section	 Navigation channel present to the right of this section (not shown here, see overleaf)	
Dimensions & levels	*Invert Level*	32.88 mOD
	Soffit level	38.99 mOD
	Springing level	38.99 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	USBPR Bridge unit	
Model assumptions and limitations	Road deck is not at risk of being overtopped due to its high elevation. Pollboy lock and navigation channel has been modelled separately.	

Name/model node label	**Pollboy Lock (navigation channel) and eastern opening of M6 bridge**	
River Reach	River Suck	
Type of structure	Concrete Road Bridge and navigation lock	
Description	Eastern opening of M6 bridge over the navigation channel, plus the lock gates immediately upstream	
Survey Reference	26POOL00031_DN	
Irish Grid Reference(s)	187264.99,229150.28	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	30.47 mOD
	Bridge Soffit level	36.26 mOD
	Bridge Springing level	36.26 mOD
	Crest of lock gates	36.26mOD
	Width of lock gates	9.3m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	TUFLOW 2D elements only	
Model assumptions and limitations	It is assumed that the gates of the lock are fully closed in the model. The bridge opening downstream of the lock gates has also been modelled in 2D only. Road deck is not at risk of being overtopped due to its high elevation.	

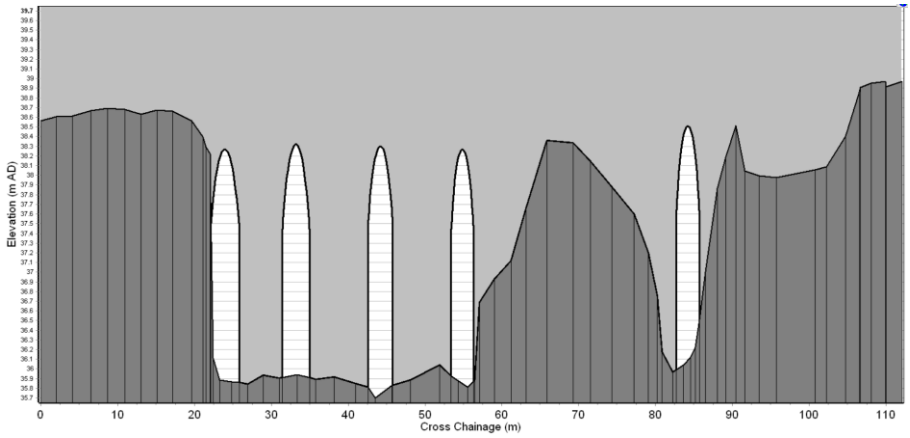
C1.2 Bridges on the Bunowen

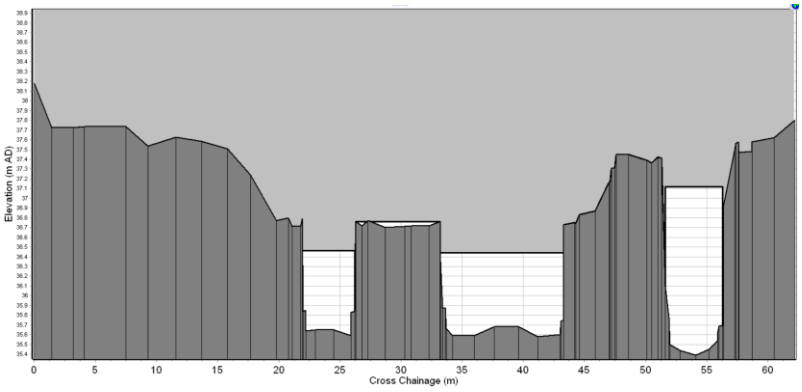
Name/model node label	**26BUN00082BU (R358 Bridge)**	
River Reach	River Bunowen	
Type of structure	Road Bridge	
Description	Concrete Bridge	
Survey Reference	26BUN00082BU	
Irish Grid Reference(s)	183160.2,233359.6	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	36.43 mOD
	Soffit level	38.74 mOD
	Springing level	38.74 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to the bridge in order to simulate the spill over the bridge	

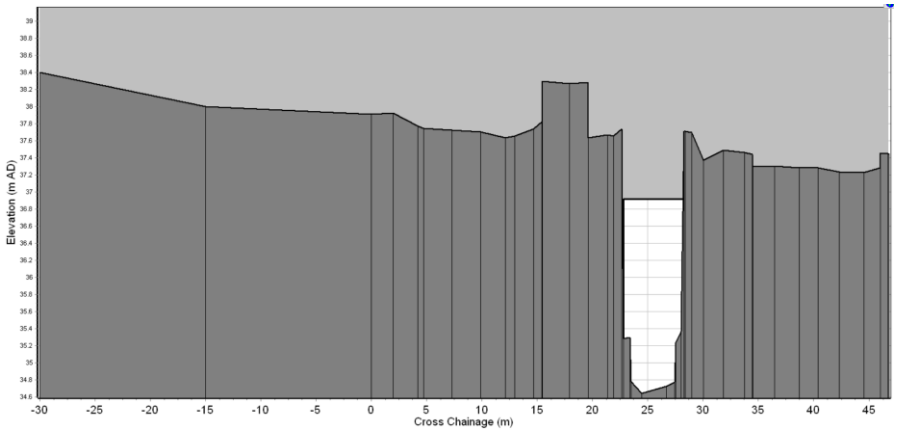
C1.3 Bridges on the Deerpark

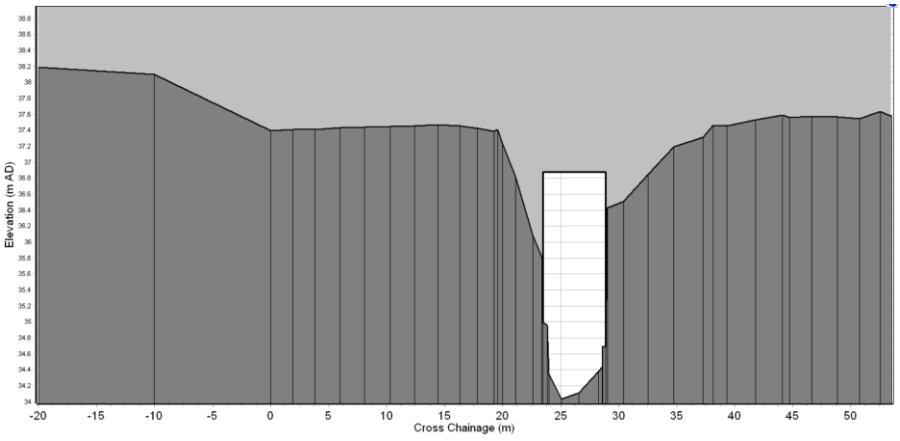
Name/model node label	**01DEE00476bu (Kilclooney Bridge)**	
River Reach	River Deerpark	
Type of structure	Road Bridge	
Description	Masonry Bridge	
Survey Reference	26DEER00057D	
Irish Grid Reference(s)	183965.9,231791.9	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	36.71 mOD
	Soffit level	38.43 mOD
	Springing level	39.78 mOD
Manning's n	Bed n of structure section = 0.035.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Pipe underneath bridge is not explicitly included in the model. It will however be considered as part of the blockage analysis. The surveyed dimensions of the bridge were modified to take account of the skew angle with regards to the direction of flow. A spill unit was added to simulate overtopping of the bridge deck.with regards to the direction of flow. A spill unit was added to simulate overtopping of the bridge deck.	

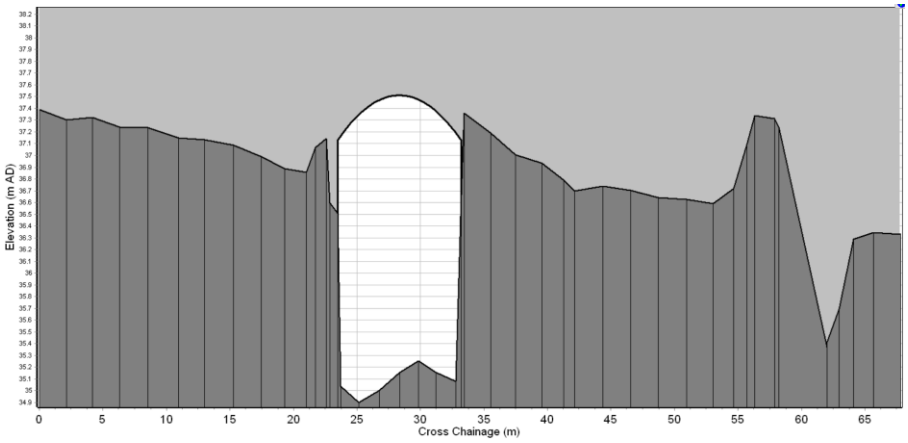
C1.4 Bridges on the West Channel

Name/model node label	**01BLN00576bu (R446 Bridge)**	
River Reach	West Channel / Old Channel	
Type of structure	Road Bridge	
Description	Masonry Bridge with 5 openings	
Survey Reference	26SLOE00064D	
Irish Grid Reference(s)	185518.7,231150.7	
Included in model	Yes	
Photograph	 Photograph taken looking upstream and shows the third and fourth openings of the bridge, which are similar to the other openings	
Model section		
Dimensions & levels	*Invert Level*	35.70 mOD
	Soffit level	38.30 mOD
	Springing level	37.50 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to simulate the overtopping of the bridge.	

Name/model node label	**01BLN00535bu**	
River Reach	West Channel / Old Channel	
Type of structure	Pedestrian Bridge	
Description	Concrete Bridge with 3 openings	
Survey Reference	26SLOE00060	
Irish Grid Reference(s)	185498.49,231127.51	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	35.59 mOD
	Soffit level	36.44 mOD
	Springing level	36.44 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to simulate overtopping of the bridge deck. The reader is also referred to section 5.3.2 of the hydraulics report where the set-up of the bridge is considered in detail as part of the model calibration discussion.	

Name/model node label	**01BLN00407bu**	
River Reach	West Channel / Old Channel	
Type of structure	Road Bridge	
Description	Concrete Bridge	
Survey Reference	26SLOE00047D	
Irish Grid Reference(s)	185410.9,231019.6	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	34.64 mOD
	Soffit level	36.92 mOD
	Springing level	36.92 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to simulate the spill over the bridge.	

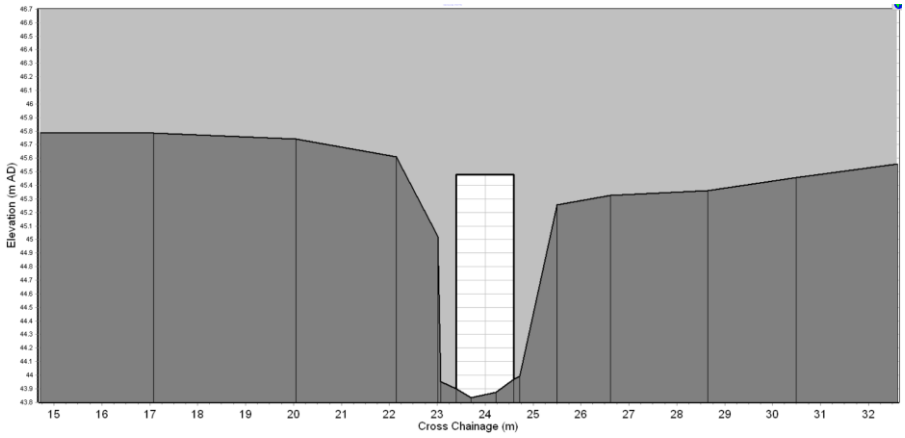
Name/model node label	**01BLN00360bu**	
River Reach	West Channel / Old Channel	
Type of structure	Pedestrian Bridge	
Description	Concrete Bridge	
Survey Reference	26SLOE00042D	
Irish Grid Reference(s)	185405.40,230970.72	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	34.035 mOD
	Soffit level	36.88 mOD
	Springing level	36.88 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to simulate the spill over the bridge.	

Name/model node label	**01BLN00238bu (Marina Footbridge)**	
River Reach	West Channel / Old Channel	
Type of structure	Pedestrian Bridge	
Description	Steel Bridge	
Survey Reference	26SLOE00030D	
Irish Grid Reference(s)	185503.0,230913.3	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	34.9 mOD
	Soffit level	37.51 mOD
	Springing level	37.13 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	Spill unit added to simulate the spill over the bridge.	

C1.5 Bridges on the Atlas Channels

Name/model node label	**02SUX00024bu**	
River Reach	Atlas Channel (Southern Branch)	
Type of structure	Pedestrian Bridge	
Description	Concrete Bridge	
Survey Reference	26BCMA00008D	
Irish Grid Reference(s)	185503.0,230913.3	
Included in model	No	
Photograph		
Dimensions & levels	*Invert Level*	34.62 mOD
	Soffit level	36.00 mOD
	Springing level	36.00 mOD
Manning's n	Bed n of structure section = 0.04.	
Modelled as	ARCH Bridge unit	
Model assumptions and limitations	This bridge was not included in the model as its influence on the hydraulics was deemed to be minor. A pipe crosses the channel upstream of the bridge which may introduce a blockage risk and will therefore be considered as part of the blockage analysis.	

C1.6 Bridges on the Ballyhugh

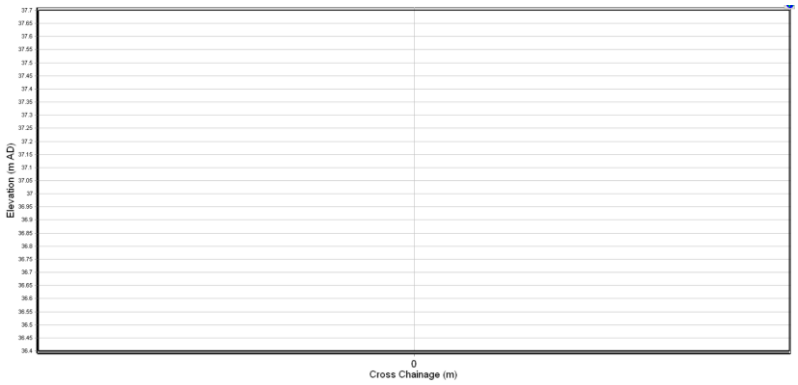
Name/model node label	**01BAL01177u**	
River Reach	Ballyhugh	
Type of structure	Footbridge	
Description	Concrete bridge	
Survey Reference	26HUGH00127E	
Irish Grid Reference(s)	187835.36,230276.14	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	43.83 mOD
	Soffit level	45.48 mOD
	Springing level	45.48 mOD
Modelled as	Arch Bridge unit	
Model assumptions and limitations	Spill unit added to simulate the spill over the bridge.	

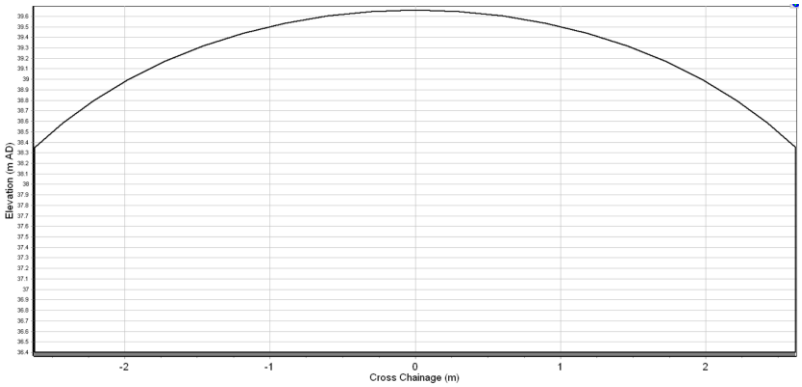
C2 Structures Datasheet – Culverts

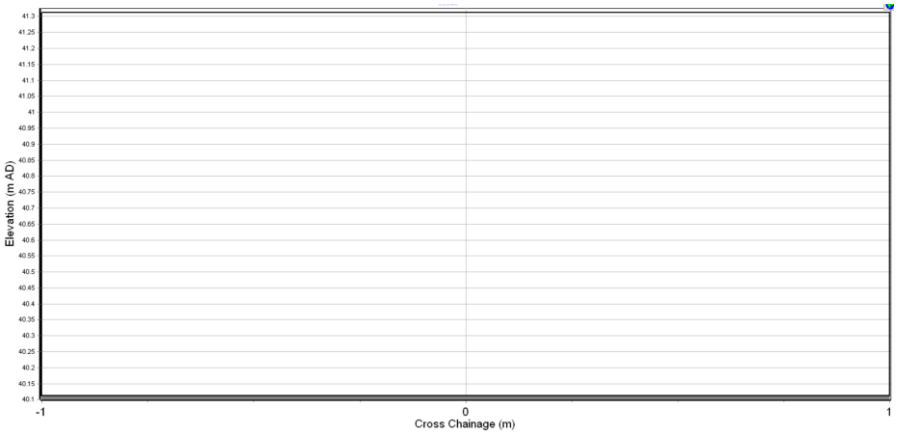
C2.1 Culverts on the Main River Suck

Name/model node label	**01RAILT10004**	
River Reach	Suck (floodplain)	
Type of structure	Railway Bridge	
Description	Masonry Culvert	
Survey Reference	01RAILT10004	
Irish Grid Reference(s)	184692.2,232087.0	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	34.38 mOD
	Height	2.78 m
	Width	6.86 m
Manning's n	Bed n of structure section = 0.04.	
Modelled as	Rectangular Culvert unit (TUFLOW 2D element only)	
Model assumptions and limitations	A spill over the structure (i.e. across the railway line) was not included as it is elevated above the design flood level.	

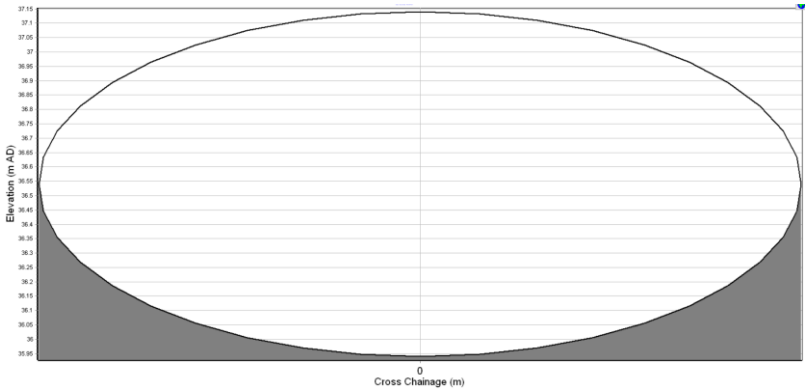
C2.2 Culverts on the Deerpark

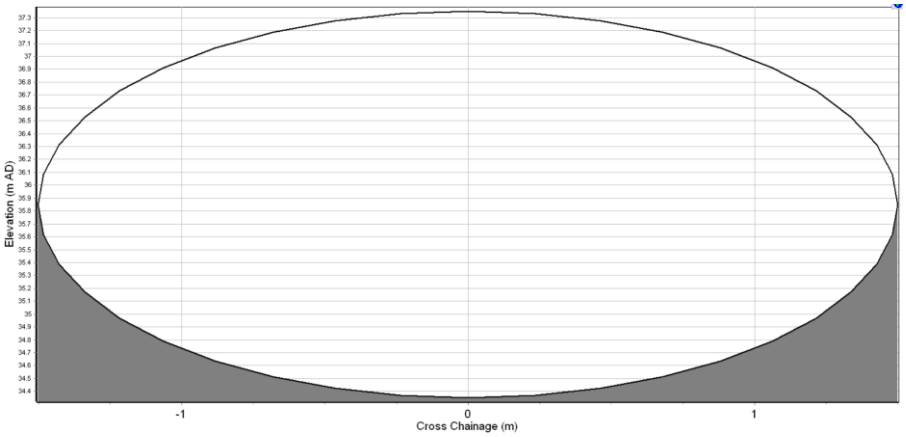
Name/model node label	**26DERL00039 (Railway Road Culvert)**	
River Reach	Deerpark Link	
Type of structure	Road Bridge	
Description	Twin concrete culverts	
Survey Reference	26DERL00039	
Irish Grid Reference(s)	184081.54,231831.19	
Included in model	Yes	
Photograph		
Model section	 Note: this graphic only presents one of the culvert openings	
Dimensions & levels	*Invert Level*	36.4 mOD
	Height	1.8 m each
	Width	1.3 m each
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Rectangular Conduit unit * 2	
Model assumptions and limitations	Spill unit added to simulate the spill over the culvert.	

Name/model node label	**01DEE00628c (Railway Culvert)**	
River Reach	Deerpark	
Type of structure	Railway Culvert	
Description	Masonry Sprung Culvert	
Survey Reference	26DEER00062	
Irish Grid Reference(s)	183965.51,231792.32	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	36.43 mOD
	Height	1.31 m (crown) 1.95 m (springing)
	Width	5.24 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Sprung Conduit Culvert unit	
Model assumptions and limitations	The surveyed cross section has been modified to take account the skew angle of the bridge with regards to the direction of flow. Spill unit added to simulate the spill over the structure.	

Name/model node label	**26DEERT116cu**	
River Reach	Deerpark Trib1	
Type of structure	Concrete Rectangular Culvert	
Description	Culvert	
Survey Reference	26DEERT100016	
Irish Grid Reference(s)	182928.9,231848.8	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	40.11 mOD
	Height	1.20 m
	Width	2.00 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Rectangular Conduit unit	
Model assumptions and limitations	Spill unit added to simulate the spill over the culvert.	

C2.3 Culverts on the West Channel

Name/model node label	**02BLN00170 (Millrace)**	
River Reach	West Channel / Old Channel	
Type of structure	Concrete Circular Culvert	
Description	Twin culvert	
Survey Reference	26MILL00023I	
Irish Grid Reference(s)	185540.0,231143.0	
Included in model	Yes	
Photograph		
Model section	 Note: this graphic only presents one of the culvert openings	
Dimensions & levels	*Invert Level*	35.94 mOD
	Diameter	1.2 m each
Manning's n	Bed n of structure section = 0.018.	
Modelled as	Circular Conduit unit*2	
Model assumptions and limitations	Spilling over the headwall of the culverts is accounted for in the 2D model	

Name/model node label	**01BLN00281c (R446 Bridge)**	
River Reach	West Channel/Old Channel	
Type of structure	Road Bridge	
Description	Twin corrugated steel pipe culverts	
Survey Reference	26SLOE00034I	
Irish Grid Reference(s)	185471.7,230920.1	
Included in model	Yes	
Photograph		
Model section	 Note: only one of the sections is shown	
Dimensions & levels	*Invert Level*	34.38 mOD
	Diameter	3 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Circular Conduit units	
Model assumptions and limitations	Spill unit added to simulate the spill over the culverts.	

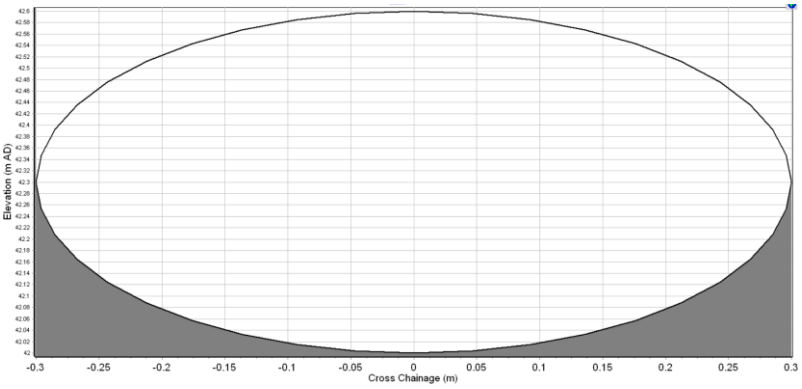
C2.4 Culverts on the Atlas Channels

Name/model node label	**02SUX00228bu (Atlas Channel Bridge)**	
River Reach	Atlas Channel (Western Branch)	
Type of structure	Road Bridge with 3 openings. Upstream inlets are rectangular cross sections, and downstream outlets are arch cross sections	
Description	Concrete Bridge/masonry bridge	
Survey Reference	26BCMA00027D	
Irish Grid Reference(s)	185855.4,231059.2	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	36.20 mOD
	Height	2.00 m
	Width	3.20 m (each)
Manning's n	Bed n of structure section = 0.03.	
Modelled as	1x Rectangular Conduit unit (TUFLOW 2D element only), with a cross sectional area equalling the sum of the 3no culvert cross sectional areas.	
Model assumptions and limitations	The pipe crossing immediately downstream of the arches is not explicitly included in the model. The risk of blockage associated with the pipe will be assessed as part of the blockage analysis.	

Name/model node label	**03SUX00020ou (Atlas Channel culvert)**	
River Reach	Atlas Channel (Eastern branch)	
Type of structure	Road Bridge	
Description	Concrete/masonry culvert	
Survey Reference	26BCMB00007D	
Irish Grid Reference(s)	185916.4,231060.1	
Included in model	Yes	
Photograph	 Photo looking upstream	
Dimensions & levels	*Invert Level*	36.18 mOD
	Height	2.00 m
	Width	3.50 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Rectangular Conduit unit (TUFLOW 2D element only)	
Model assumptions and limitations	The pipe crossing is not explicitly included in the model. The risk of blockage associated with the pipe will be assessed as part of the blockage analysis.	

Name/model node label	**03SUX00056ou (Castle access bridge)**	
River Reach	Atlas Channel (Eastern branch)	
Type of structure	Access Bridge	
Description	Masonry bridge	
Survey Reference	26BCMB00011D	
Irish Grid Reference(s)	185913.9,231097.3	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	36.36 mOD
	Height	1.40 m
	Width	1.80 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Rectangular Conduit unit (TUFLOW 2D element only)	
Model assumptions and limitations	One of the openings is completely blocked. Only one opening has therefore been included in the model.	

C2.5 Culverts on the Ballyhugh

Name/model node label	**01BAL00713c (Portnick Drive culvert)**	
River Reach	Ballyhugh	
Type of structure	Concrete Circular Culvert	
Description	Culvert	
Survey Reference	26HUGH00077I	
Irish Grid Reference(s)	187373.54,230333.61	
Included in model	Yes	
Photograph		
Model section		
Dimensions & levels	*Invert Level*	42.00 mOD
	Diameter	0.6 m
Manning's n	Bed n of structure section = 0.025.	
Modelled as	Circular Conduit unit	
Model assumptions and limitations	Culvert consists of a double pipe but transitions into a single pipe along its length. The culvert was modelled as single pipe in the model due to the absence of any data on the transition of the two pipes into one pipe. Spill over the culvert entrance headway was accounted for in the 2D domain.	

Name/model node label	**26HUGH00013I**	
River Reach	Ballyhugh	
Type of structure	Concrete Circular Culvert	
Description	Culvert	
Survey Reference	26HUGH00077I	
Irish Grid Reference(s)	186877.15,230152.20	
Included in model	No	
Photograph		
Dimensions & levels	*Invert Level*	36.19 mOD
	Diameter	0.68 m
Manning's n	Bed n of structure section = 0.025.	
Modelled as	Circular Conduit unit	
Model assumptions and limitations	This long culvert is surcharged by the River Suck which causes water to flow up through the culvert from the downstream end. When building the model it was found that this mechanism caused the model to become unstable due a limitation in FMP in modelling small diameter culverts being surcharged by a downstream boundary. This culvert was therefore omitted in order to ensure model stability. The accuracy of the model is not compromised by the exclusion of the culvert as flood risk at this location is dominated by water levels in the River Suck.	

C2.6 Culvert on the Townparks Stream

Name/model node label	**26TPAR00052J**	
River Reach	Townparks	
Type of structure	Plastic Circular Culvert	
Description	Culvert	
Survey Reference	26TPAR00052J	
Irish Grid Reference(s)	185568.76,230602.27	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	36.81 mOD
	Diameter	1.00 m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Circular Culvert unit (TUFLOW 2D element only)	
Model assumptions and limitations	Spilling over the culvert entrance headwall is accounted for in the 2D grid	

C2.7 Culverts on the River Mackney

Name/model node label	**26LOUGH00001**	
River Reach	Mackney	
Type of structure	Rectangular Concrete Culvert	
Description	Culvert	
Survey Reference	26LOUGH00001	
Irish Grid Reference(s)	186730.8,229179.9	
Included in model	Yes	
Photograph		
Dimensions & levels	*Invert Level*	33.30 mOD
	Width	3 m
	Height	2.6m
Manning's n	Bed n of structure section = 0.03.	
Modelled as	Rectangular Culvert unit (TUFLOW 2D element only)	
Model assumptions and limitations	Spilling over the culvert is not accounted for as it was not deemed to be a significant flood mechanism	

C3 Structures Datasheet – Weirs

Name/model node label	**01BLN00659wu**	
River Reach	West Channel / Old Channel	
Type of structure	Weir	
Description	Concrete weir	
Survey Reference	26SLOE00072W	
Irish Grid Reference(s)	185560.15,231219.30	
Included in model	Yes	
Photograph		
Dimensions & levels	*Elevation of crest*	36.12 mOD
	Breadth of Crest	9.5 m
	Length	0.3 m
Modelled as	Broad Crested Weir Unit plus spill unit to model bypass on both banks and overtopping of centre raised element	
Model assumptions and limitations	Dummy flow added to the model at this point to prevent west channel drying out	