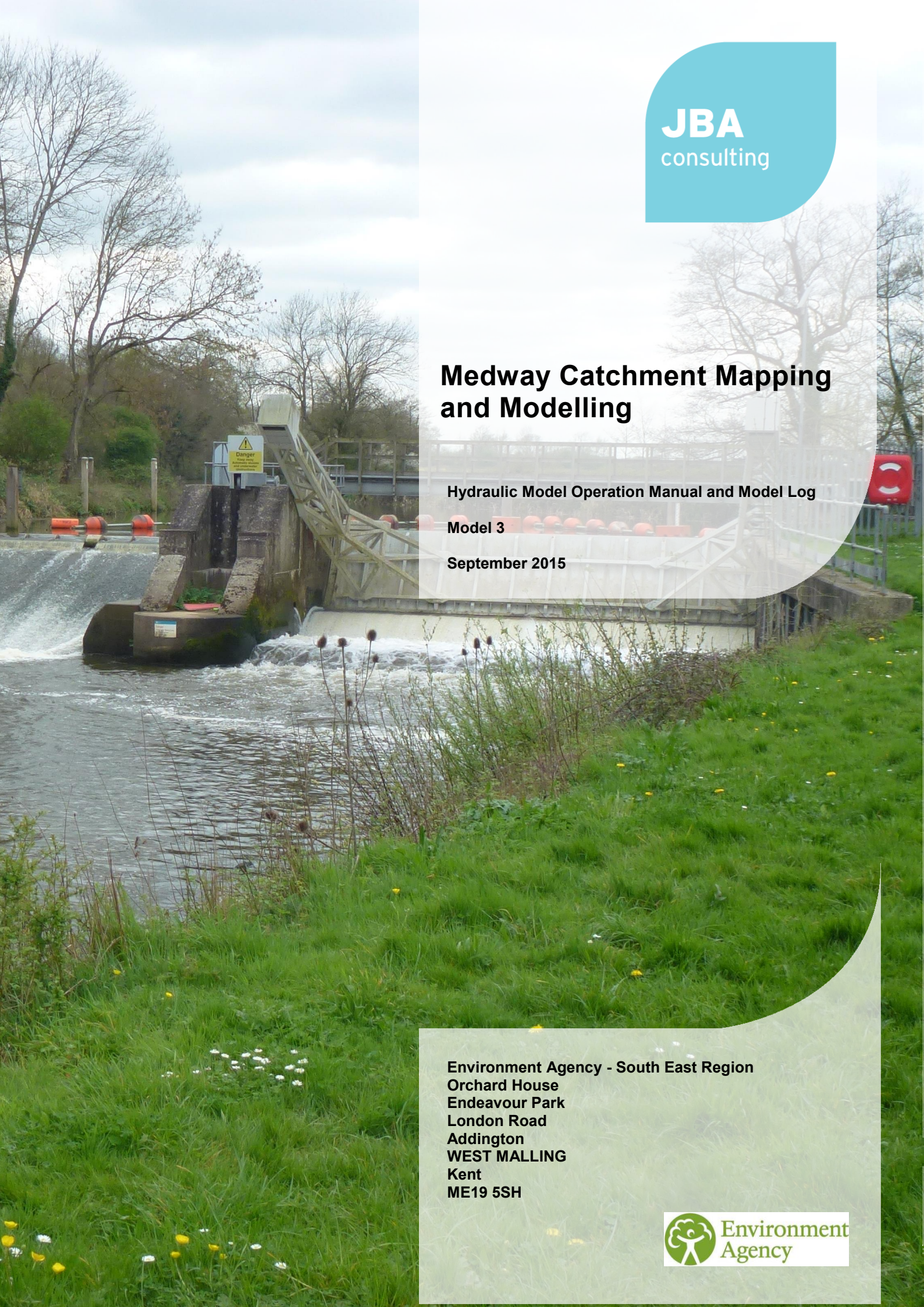

Medway Catchment Mapping and Modelling

Hydraulic Model Operation Manual and Model Log

Model 3

September 2015

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
Draft v0.3 November 2014 (Issued to assist with model review)	-	Emma Dauben and Neil Gunn (Environment Agency)
Draft Final v1.0 September 2015	Amendments following draft review of Model 3.	Emma Dauben and Neil Gunn (Environment Agency)

Contract

This report describes work commissioned by Emma Dauben, on behalf of Environment Agency South East Region, for the Medway Catchment Mapping and Modelling commission under the Environment Agency's Water and Environment (WEM) Framework. Environment Agency's representative for the contract was Emma Dauben.

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Purpose

This report provides a detailed record of information required to operate the hydraulic model of the River Medway, River Beult, River Teise, River Bourne and Coult Stream (Model 3) updated and developed under the Medway Catchment Modelling and Mapping project.

Acknowledgements

Thanks to Emma Dauben and Neil Gunn for the provision of information and assistance during the project.

Carbon Footprint

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JBA is aiming to reduce its per capita carbon emissions.

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Abbreviations

1D	One-dimensional
2D	Two-dimensional
AEP	Annual Exceedance Probability
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environment Agency
ESTRY	Proprietary 1D modelling software developed by WBM BMT
FEH	Flood Estimation Handbook
ISIS	Proprietary modelling software developed by Halcrow/CH2M Hill (all instances of ISIS in this report refer specifically to ISIS 1D)
LIDAR	Light Detection and Ranging
m AOD	Metres Above Ordnance Datum Newlyn
OS	Ordnance Survey
TCF	TUFLOW Control File
TUFLOW	Proprietary modelling software developed by WBM BMT (all instances of TUFLOW in this report refer to TUFLOW 'Classic' - a 2D modelling approach)

1 Introduction

The River Medway hydraulic Model 3 extends from Canon Lane in Tonbridge to East Farleigh on the River Medway. The River Beult, River Teise, Lesser Teise, River Bourne and Coult Stream are also modelled downstream of Smarden, Stone Bridge (River Teise and Lesser Teise), Victoria Road (Golden Green) and 500m upstream of Bullen Farm, respectively.

Modelling involves a linked 1D-2D ISIS-TUFLOW approach throughout. There are four domains, two domains at 6m grid resolution at East Peckham and Yalding. Upstream of East Peckham and for the majority of the River Beult and River Teise the grid size is 20m. The total length of watercourse modelled is 81km. A simulation implementing a finer grid size has been completed for the River Teise and River Beult to provide outputs to update the Flood Map for Planning.

The hydraulic modelling of the River Medway has been developed principally from the existing River Medway Modelling and Flood Mapping Updates (2008) ISIS model. The River Teise, River Beult and Lesser Teise have been informed from the 1D ISIS modelling of the area (Upper Beult 1D modelling, 2007 and ISIS model developed for calibration of the ESTRY component of the 1D-2D Teise and Beult model, 2007).

Modelling of the River Bourne has been derived from the ISIS model of the Bourne developed under the Beult, Bourne and Teise 1D mapping study (2007). The section of the Coult Stream modelled has been derived from the East Peckham HEC-RAS model (2004).

Data implemented from previous models has undergone a detailed review as part of this study. More recent LIDAR and survey information (e.g. channel, structure, gauging station and bank survey) has also been implemented.

Noted within this Model Operation Manual are the more major changes made during the model update process as well as new files and model setup.

This Model Operation Manual has been put together to enable future users of the model to use the model with ease. Section 2 provides a brief technical overview of the model; further details about the model build and results can be found in the Main Report and in the Modelling Approach and Overview section (Appendix A of this document). Section 3 describes the files and folder structure in which the model has been supplied, with Section 4 providing the information required to run the model. The document also contains information as to how the model has been developed throughout the course of the study.

2 Technical Summary

What software & reason for choice	ISIS-TUFLOW: ISIS v 3.7.1 (64-bit), single precision TUFLOW builds 2013-12-AD-iSP-w64 / 2013-12-AE-iSP-w64 ISIS was used for the 1D component of the model due to the existing River Medway Modelling and Flood Mapping Updates (2008) ISIS model being developed in this. ISIS version 3.7.1 was used as this was the latest release of the ISIS software at project commencement. TUFLOW Build 2013-12-AD-iSP-w64 was selected as this was the latest release on undertaking design runs. Some simulations were upgraded to 2013-12-AE-iSP-w64 to overcome a licensing drop-out issue. No changes to the computation engine of TUFLOW changed between builds 'AD' and 'AE' so model results should not be affected. Double precision versions of both software were used as these can be advantageous when models contain reservoir units. It was also found that double precision TUFLOW improved the mass balance across the 2D-2D links between domains.
General Schematisation	The model is 1D-2D linked throughout. The channel is represented by the ISIS 1D model and the floodplain represented by the TUFLOW 2D domain. Connections between the 1D and 2D domains are implemented as HX lines. There are four 2D domains. A finer 6m grid cell size is used within East Peckham (domain 2) and Yalding (domain 4). Elsewhere (domain 1 covers the River Medway upstream of East Peckham and domain 3 covers the majority of the River Beult and River Teise) a coarser 20m grid cell size is used. For the 1% and 0.1% AEP undefended events focused on the River Teise and River Beult, a 10m grid cell size is used for domain 3. Sections of the River Beult, River Teise, Lesser Teise, River Bourne and Coult Stream have been connected to the River Medway within the hydraulic model.
Design Events	The model was built to simulate defended design events for the following events: 20%, 10% (+20% flows to represent climate change), 5%, 3.33%, 2%, 1.33%, 1%, 1% (+20% flows to represent climate change), 0.4% and 0.1% Annual Exceedance Probability (AEP). The model was also simulated for the following undefended events: 5%, 1%, 1% (+20% flows to represent climate change) and 0.1% AEP.
Structures	Structures can be found listed in sections B.1 to B.6 of the Appendix.
Calibration Coefficients	Structure coefficients and spill weir coefficients are detailed in sections B.1 to B.6 of the Appendix.
Model Proving	**Calibration and verification** Please see main project report, Appendix C. **Sensitivity testing** Sensitivity testing of the following parameters were tested as part of the study. The outputs of this testing are summarised within the main study report. - A global change of +20% and -20% in the channel roughness (Manning's 'n') - A global change of +20% and -20% in the total inflows
Strengths, Weaknesses and Future development	**Strengths** The model is considered the best representation of the River Medway, its multiple channels and tributaries given the available survey and LIDAR data, and the agreed methodology for modelling this large area. A grid size of 6m was implemented in and around East Peckham and Yalding where risk receptors are greater. A larger grid size of 20m was implemented upstream and downstream of East Peckham, including the Rivers Teise and

Beult (Domains 1 and 3) where there are fewer flood risk receptors. Modelling of these areas was required to meet the objectives of the study and a compromise between model detail (e.g. ground level representation and 1D-2D linking) was reached in these areas.
A simulation implementing a finer grid size has been completed for the River Teise and River Beult to provide outputs to update the Flood Map for Planning.

The most up to date information available for the study has been implemented within the model. This includes new survey information collected at structures and channel, structure and bank top survey within East Peckham. Survey information collected at Stile Bridge and Stone Bridge gauging stations has also been implemented, improving the representation of these key gauging sites.

Weaknesses
Low flows
The model has been built for the purpose of flood risk mapping; therefore it will be optimised for high flows and would need adapting before it was suitable to be used for more low flows.
This is likely to include representing bed levels in more detail, reducing the distance between sections and representing minor channel features not currently represented e.g. informal weirs and bed level variations.

River Bourne
The River Bourne modelling was informed from the ISIS model developed under the Beult, Bourne and Teise 1D modelling and mapping study completed in 2007. The original model was constructed from the Medway Strategy Survey collected by Cartographical Surveys Ltd in 2002. However, the CAD survey cross-section information for this channel was not available for use in this study. Therefore, the ISIS model was implemented as per the previous study (with updates made for 1D-2D linking) and confidence in predictions is therefore reliant upon this being an accurate representation of the watercourse and structures.

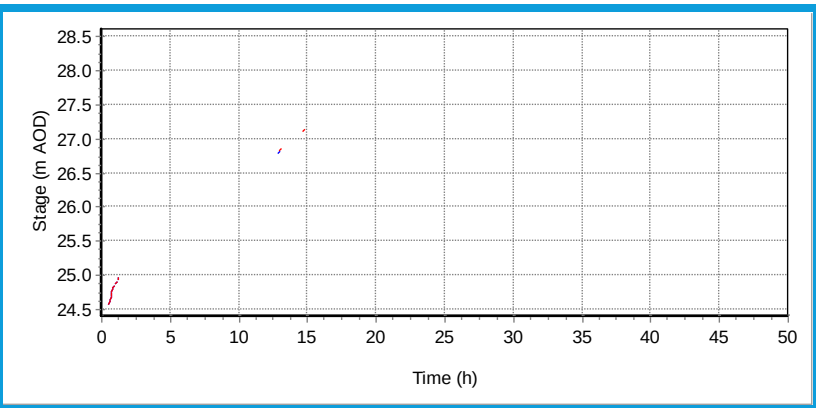
Coult Stream
The Coult Stream channel and structure data was taken from the East Peckham HEC-RAS model developed in 2004. The original survey data used to inform this model was not available. Therefore, on conversion of the HEC-RAS model to ISIS, the ISIS model was schematised (e.g. structures etc) according to the original HEC-RAS model and confidence in the predictions here is therefore reliant upon this being an accurate representation of the watercourse and structures.

Future development
Observed flood events
Should future flood events occur in the modelled area it is recommend that the hydrological and hydraulic model is re-visited and verification of observed vs. model predictions be made to assess the performance of the model.

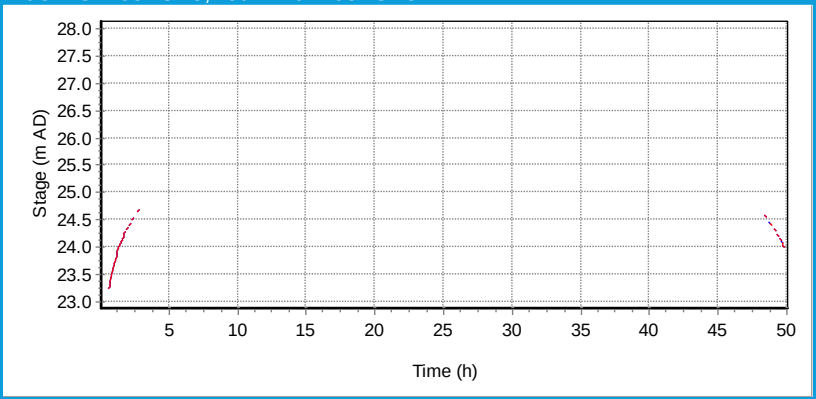
Lock/radial gate operation rules
The EA provided information relating to the operation rules at locks and sluices. The rules governing gate operation within the radial gates are thought to be the best representation of how these structures operate in a flood event. Should the operation rules change in the future it is recommended the operation rules are updated accordingly.

FRM options testing
The model has been developed with the intention of enabling flood risk management options to be tested in the areas which they are currently proposed (East Peckham, River Beult). Should future testing require more detailed representation of particularly areas (e.g. testing of a scheme within Domains 1 and 3 which have larger cell sizes), it may be necessary to reduce the grid size of the models to achieve the outcomes of the study. The model setup has been developed to enable this to be completed with ease.
Furthermore, should it be advantageous to reduce the overall extent of the

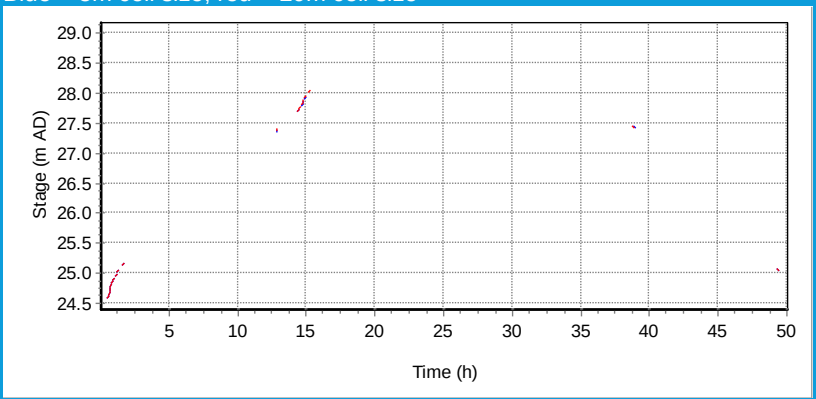
	model, the placement of the domain boundaries should enable this to be completed efficiently.
Further comments	**1D-2D link line widths** In general HX lines have been digitised to match the widths of ISIS cross sections at cross section locations. Between surveyed sections HX lines have been digitised to follow the bank top as evidenced by LIDAR or bank level survey, rather than digitising rigidly to a fixed width. This means that HX widths vary between sections resulting in some differences in section area, however the overall impact on floodplain volume is expected to be small. HX lines following the bank top provides consistent bank heights between sections improving stability by not picking up unrealistic low spots where a channel widens. **1D-2D link line FLC values** At a number of locations instabilities were observed as a result of a large volumes of water entering the 1D channel via the HX lines. This tended to be where the channel changes direction, meaning large volumes of water pass into the channel via one of the banks. These instabilities were evidenced in the model as oscillations in flow and level within the 1D ISIS channels. At the locations below a value of 5 has been applied to the 'A' parameter (form loss coefficient) of the HX lines, which reduces the oscillations. It has been shown in other studies that this has a minimal impact on water levels other than improving confidence in them by reducing the oscillations in flow. Additionally, a value of 1 was implemented to the 1D-2D links in the areas modelled for Stile Bridge and Stone Bridge gauging stations for rating review purposes. Domain 2: Coult Stream between Hale Street and Boyle Way Domain 3: Coult Stream downstream of Boyle Way Right bank upstream of Wateringbury (nodes CS162 to CS164) Downstream of Teston Gauging site Domain 4: Eastern, secondary channel at Yalding **1D-2D link line cell widths** Left and right bank lines (HX lines) have been implemented within all domains. Within the 20m grid size domains (domains 1 and 3), the channel is often smaller than the width of two grid cells (40m). Where this is the case, the elevation of the bank level (implemented by Z-Lines) will be applied to up to two cells (unless both HX/Z-Lines intersect one cell) potentially reducing the available storage in these areas. However, given the expansive nature of the floodplain, influences on model predictions are thought to be small. To test this assumption, the hydraulic model of Stone Bridge gauging station that was developed to derive a rating review was simulated at a cell size of 20m, and the results compared within the original cell size of 5m. This model was selected as it is a key gauging site, but also the location of the model at the upstream of the River Teise in Model 3 meant a wider model area did not need to be simulated which would impact model predictions. The model indicates that the choice of grid size has little impact on model predictions, with the stage at Stone Bridge gauging remaining very similar for the full range of flows tested (differences of 1-2cm). The same is true at river sections upstream and downstream of the gauging site and within peak floodplain levels. Stone Bridge gauging weir (STON_0117wu) Blue = 5m cell size, red = 20m cell size



Downstream of weir (STON01_0000)
Blue = 5m cell size, red = 20m cell size



Upstream of weir (STON01_0339)
Blue = 5m cell size, red = 20m cell size



Consideration was given to representing the 1D-2D links in domains 1 and 3 with a single HX line thereby selecting a single set of cells for the 1D-2D link. Under this approach the bank elevations would be specified via the use of a Z-Shape.
However, the dual HX Line approach was retained given the limited difference presented above and because the hydraulic model for the River Teise, River Beult and Lesser Teise will be re-simulated at a finer grid size to provide mapped outputs to inform the Flood Map for Planning which are of commensurate resolution to those from the previous 1D-2D modelling of the area. Consequently, it was considered the retaining the dual HX line approach would be favourable so that model inputs would remain the same between simulations, and only the grid size would require adjustment.

Stability patch (high roughness)
A 'stability patch' implementing a roughness of n=0.3 is implemented on the right bank downstream of Hampstead Lock and also along parts of the lower Teise channel where oscillations in water levels arose. The former represents the inlet to Yalding Marina which is modelled in the 2D domain.

	This elevated roughness value was implemented to reduce instabilities in flows and levels at this locations at peak flows which occurred due to large volumes of water spilling across this length of 1D-2D link cells which have a lower elevation than the surrounding area. The area of banks assigned a high roughness are relatively small and it is therefore not considered that this approach will notably alter model predictions. **2D-2D links** A warning message occurs along both 2D-2D links at regular intervals. "WARNING 2400 - Hidden node not allocated as a primary node to a 2D2D link cell in 2D Domain Model3_Domai. Review 2D2D link line shape and check vertex spacing is not too close." The 2D-2D link has been checked and it is considered that 2D-2D link is working correctly and this warning message does not identify any errors in the computation of the model. **Additional undefended simulation commentary** In addition to implementing a finer grid size (10m) for domain 3 1% and 0.1% undefended events focused on the River Teise and River Beult, further updates were made to improve model stability. Instabilities arose due to the very large volumes of water flowing across the floodplain and into channels during the large events. To help stabilise the models, sections on the lower parts of the River Teise (downstream of Collier Street) and River Beult (downstream of Stilebridge) were widened, along with parts of the River Medway downstream of Anchor Sluice and the canal channel at Hampstead Lane. This notably improved predicted water levels by reducing oscillations. Adjustments to channel widths completed remained within the tolerances for 1D channel width / 2D HX width relationships and is not expected to notably impact predictions beyond improving stability.

3 Data Structure and File Names

The final design model files and results supplied contain a series of folders as displayed in Figure 3-1.

Table 3-1 shows the folder structure and notes the files stored within these.

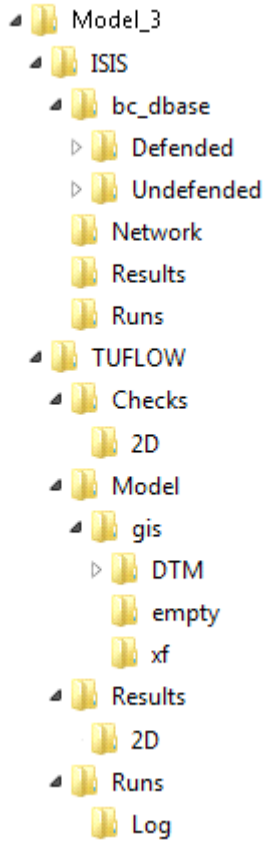
Table 3-1: Folder Structure and contents of Final Design Model

Folder	SF1	SF2	SF3	SF4	SF5	Contents
ISIS	bc_bdase					Folder containing model boundary conditions in IED files (inflows)
	Network					ISIS Data File (DAT) and GIS Visualiser File (GXY)
	Results					ISIS Results Files
	Runs					ISIS Event Files (IEF)
TUFLOW	bc_dbase					Boundary conditions for the TUFLOW component of the hydraulic model
	Checks	1D				1D ESTRY check files Medway_Model3_024_**###**_###_####_DDMMM########
		2D				2D TUFLOW check files Medway_Model3_024_**###**_###_####_DDMMM########
	Model					TUFLOW files: TUFLOW Materials File (.tmf) TUFLOW Boundary Conditions (.tbc) TUFLOW Geometry Control (.tgc)
		gis				Standard TUFLOW Model Files
			DTM			Ascii DTM used to define Zpts within the model
				xf		Binary dumps of selected input files, created by TUFLOW to speed up the start-up process next time a simulation is carried out
			empty			Empty geometry file templates
			Materials			TUFLOW materials model files
			Output_zones			Output zone GIS files
			xf			Binary dumps of selected input files, created by TUFLOW to speed up the start-up process next time a simulation is carried out
	Results	1D				1D ESTRY results files Medway_Model3_024_**###**_###_####_DDMMM########
		2D				2D TUFLOW results files Medway_Model3_024_**###**_###_####_DDMMM########
	Runs					TUFLOW Control Files (.tcf) and ESTRY Control Files (.ecf) Medway_Model3_024_**###**_###_~e~.tcf Medway_Model3_004.ecf
		log				Standard TUFLOW Log files (.csv and .shp) Medway_Model3_024_**###**_###_####_DDMMM########

Note: **###** denotes output zone. ### denotes **Defended** or **Undefended** case. #### denotes return period. DDMMM######## denotes event.

Note: 1%+CC, 0.4% and 0.1% AEP defended events begin **Medway_Model3_024_###b** and 1% and 0.1% AEP undefended events for output zones 3, 4, 5 and 6 end **_007**

Figure 3-1: File Directory of Final Design Model



4 Model Operation

Run reference	Design runs
Run purpose	Flood Risk Mapping
Operation and model running instructions	Prior to running the hydraulic model, the most straight forward approach is to save all the folders supplied (as listed in Section 3) onto the user's C drive. All the supplied files will then need to be uncompressed with care taken to preserve the supplied folder structure. The 'Default File Path' within each ISIS event file (.ief) should be amended to reflect the revised 'Runs' folder location. To run the model, open the ISIS .ief file in ISIS v3.7.1 (64-bit) and then click run simulation. It is important that both ISIS and TUFLOW are installed on the machine as the ISIS component will not provide accurate results if run independently. Four domains are used within the model, meaning that a multi-domain TUFLOW license and four TUFLOW network threads will be required. An ISIS run file (.ief) has been supplied with each of the models so the model should run without any alteration (provided the 'Default File Path' has been updated).
Explanation of file types	**ISIS** .dat = ISIS Data File .ied = ISIS Event Data File .zzn = ISIS Unsteady Results File .iic = ISIS Initial Conditions Files (used as initial conditions for model runs) .zzl = ISIS labels for unsteady results .ief = ISIS Run Settings (Event File) **TUFLOW** .tcf = TUFLOW Control File .tgc = TUFLOW Geometry Control File .tbc = TUFLOW Boundary Condition Control File .ecf = ESTRY Control File

4.1 ISIS

DAT	Medway_Model3_023b.DAT - for all 20% to 1% AEP defended events (all output zones) Medway_Model3_023c.DAT - for 1%+CC, 0.4% and 0.1% AEP defended events (output zones 1, 3, 4, 5, 6) and 5% AEP undefended events (all output zones) [Coult Stream channel removed and relevant inflows assigned directly to River Medway channel at the confluence of the two watercourses] Medway_Model3_023c_002.DAT - for 1%+CC, 0.4% and 0.1% AEP defended events (output zone 2) and 1%, 1%+CC and 0.1% AEP undefended events (output zones 1 and 2) and 1%+CC AEP undefended events (output zones 3, 4, 5, 6) [Modular limit of spill units T12SU and T6SU reduced from 0.9 to 0.3 to reduce instability when bypassing occurs via these spills] Medway_Model3_023c_006.DAT - for 1% and 0.1% AEP undefended events (output zones 3, 4, 6) and 1% AEP undefended event (output zone 5) [Widened the ISIS 1D section width of numerous sections along the River Teise downstream fo Colleir Street, River Beult downstream of Stilebridge GS and River Medway downstream of Anchor Sluice, including the canal at Hampstead Lane. Replaced ARCH bridge units at Yalding within orifice units to prevent these structures becoming unstable and failing]. Medway_Model3_023c_006ext.DAT - 0.1% AEP undefended event (output zone 5) [The QHBDY downstream boundary was extended to higher stage/flow as the last data point was exceeded leading to model failure].

IED

The IED for each output zone and return period are displayed in the tables below.

Defended

	Return period		
Output zone	**5**	**10CC**	**20**
1	06Dec55712300	12Feb57890900	01Jan42451000
2	05Jan27311100	07Apr46251000	26Dec42251600
3	24Mar47370500	08Dec19012300	16Oct23562100
4	17Jan50740100	17Jan42180300	31Jan65802200
5	20Dec67250500	28Jan39930100	14Jan34412200
6	17Dec48280500	10Jan32251200	16Jan46292100

	Return period		
Output zone	**30**	**50**	**75**
1	11Jan57360700	23Feb22572300	09Jan28672100
2	15Nov19231000	28Nov26221500	18Nov40812200
3	04Jan37481000	31Jan65802200	12Jan64631900
4	07Jan28820600	01Dec44462100	03Dec32970800
5	30Nov41320000	29Dec37922000	20Nov56061800
6	07Dec49980200	28Nov38710900	29Dec68331400

	Return period		
Output zone	**100 and 100CC**	**250**	**1000**
1	25Feb51991100	11Jan50280900	01Jan31620200
2	18Feb61962000	16Dec56880300	01Jan31620200
3	10Jan19241100	20Nov23882100	23Jan37940800
4	09Jan28672100	08Oct27000200	10Sep30800600
5	25Dec24260900	24Oct54680400	23Jan37940800
6	18Feb61962000	24Dec27621700	16Dec54850800

Undefended

	Return period		
Output zone	**20**	**100 and 100CC**	**1000**
1	03Oct40610200	01Feb32591900	02Jan32620000
2	16Dec48832000	18Feb54602100	31Jan40160100
3	15Dec54661400	09Jan50401500	05Dec26370200
4	31Jan65802200	09Jan28672100	10Sep30800600
5	14Jan34412200	25Dec24260900	23Jan37940800
6	16Jan46292100	18Feb61962000	16Dec54850800

IEF

Medway_Model3_024_**###**_###_####_DDMMM########.ief

Note: **###** denotes output zone. ### denotes **Defended** or **Undefended** case. #### denotes return period. DDMMM######## denotes event.
Note: 1%+CC, 0.4% and 0.1% AEP defended events begin **Medway_Model3_024_###b**
Note: 1% and 0.1% AEP undefended events (output zones 3, 4, 5, 6) end **_007.ief**

Model run parameters (as specified in .ief event files)

ISIS 1D timestep = 1.50s (except for events listed below)
ISIS 1D timestep = 0.75s (for 1%+CC, 0.4% and 0.1% AEP defended events (output zone 2) and 1%, 1%+CC and 0.1% AEP undefended events (output zones 1 and 2) and 1%+CC AEP undefended events (output zones 3, 4, 5, 6))

Save interval = 300s

The parameters listed below were adjusted from defaults. An explanation for each is provided.

Maximum iterations = 13 (default is 6).
[Increases the number of iterations at each timestep]
This has been increased and is considered acceptable to allow greater iterations for the model to converge where otherwise non-convergence would be recorded. The value specified remains within sensible limits.

dflood (m) = 5 (default is 3) (for all 20% to 1% AEP events)
dflood (m) = 8 (for 1%+CC, 0.4% and 0.1% AEP events (all output zones)
Height (m) of vertical walls added to the highest point on each river cross section to

	allow for flooding. It is not considered that the values of 5 and 8 should be impacting predictions from the hydraulic model.

4.2 TUFLOW

2D Control files (.tcf)	ECF: Medway_Model3_004.ecf TCF: *Defended* Medway_Model3_024_**###**_~e~.tcf - 20% to 1% AEP events Medway_Model3_024_**###**b_~e~.tcf **-** 1%+CC, 0.4% and 0.1% AEP events *Undefended* Medway_Model3_024_**###**_Und_~e~.tcf Medway_Model3_024_**###**_Und_0100_~e~_007.tcf - 1% AEP events (output zones 3, 4, 5, 6) Medway_Model3_024_**###**_Und_1000_~e~_007.tcf - 0.1% AEP events (output zones 3, 4, 5, 6) Note: **###** denotes output zone. ~e~ is replaced by the return period and event as specified in the 'Run Option' within the .ief.
2D Boundary condition control file (.tbc)	**Domain 1** Medway_Model3_Domain1_004 - All events **Domain 2** Medway_Model3_Domain2_010b - Defended 20% to 1% AEP events Medway_Model3_Domain2_010c - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events **Domain 3** Medway_Model3_Domain3_010b - Defended 20% to 1% AEP events Medway_Model3_Domain3_010c - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain3_010c_undefended - Undefended 0.1% and 1% AEP events (output zones 3-6) **Domain 4** Medway_Model3_Domain4_009b - Defended 20% to 1% AEP events and defended 1%+CC, 0.4% and 0.1% events (output zones 1 and 2) Medway_Model3_Domain4_009b_ext - Defended 1%+CC, 0.4% and 0.1% AEP events (output zones 3-6) and undefended events except 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain4_009b_undefended - Undefended 0.1% and 1% AEP events (output zones 3-6)
2D Geometry Control file (.tgc)	**Domain 1** Medway_Model3_Domain1_004 - Defended 20% to 1% AEP events Medway_Model3_Domain1_004_ext - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events **Domain 2** Medway_Model3_Domain2_007b - Defended 20% to 1% AEP events (output zones 1 and 3-6) Medway_Model3_Domain2_007c_ext - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain2_007c_undefended - Undefended 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain2_007d - Defended 20% to 1% AEP events (output zone 2) **Domain 3** Medway_Model3_Domain3_007b - Defended 20% to 1% AEP events (output zones 1 and 3-6) Medway_Model3_Domain3_007c_ext - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP

	events (output zones 3-6) Medway_Model3_Domain3_007c_undefended - Undefended 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain3_007d - Defended 20% to 1% AEP events (output zone 2) **Domain 4** Medway_Model3_Domain4_007 - Defended 20% to 1% AEP events Medway_Model3_Domain4_007_ext - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) Medway_Model3_Domain4_007_undefended - Undefended 0.1% and 1% AEP events (output zones 3-6)
1D/2D link files	1d_nd_ISIS_Model3_007b_P.shp - Defended 20% to 1% AEP events 1d_nd_ISIS_Model3_007c_P.shp - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events **Domain 1** 2d_bc_hxi_Model3_Domain1_004_L.shp / 2d_bc_hxi_Model3_Domain1_001_P.shp **Domain 2** 2d_bc_hxi_Model3_Domain2_007b_L.shp - Defended 20% to 1% AEP events 2d_bc_hxi_Model3_Domain2_007c_L.shp - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events **Domain 3** 2d_bc_hxi_Model3_Domain3_009b_L.shp - Defended 20% to 1% AEP events 2d_bc_hxi_Model3_Domain3_009c_L.shp- Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) 2d_bc_hxi_Model3_Domain3_009c_L_undefended.shp- Undefended 0.1% and 1% AEP events (output zones 3-6) **Domain 4** 2d_bc_hxi_Model3_Domain4_004b_L.shp - Defended 20% to 1% AEP events and defended 1%+CC, 0.4% and 0.1% events (output zones 1 and 2) 2d_bc_hxi_Model3_Domain4_004b_L_ext.shp - Defended 1%+CC, 0.4% and 0.1% AEP events (output zones 3-6) and undefended events except 0.1% and 1% AEP events (output zones 3-6) 2d_bc_hxi_Model3_Domain4_004b_L_undefended.shp - Undefended 0.1% and 1% AEP events (output zones 3-6)
2D/2D link files	2d_bc_2d_Model3_Domain1_Domain2_003_L.shp 2d_bc_2d_Model3_Domain1_Domain3_002_L.shp 2d_bc_2d_Model3_Domain2_Domain3_001_L.shp 2d_bc_2d_Model3_Domain3_Domain4_001_L.shp
ESTRY culvert link files	1d_nwke_2007study_floodplain_structures_003_L.shp 1d_nwke_MLS2014_floodplain_structures_001_L.shp 1d_nwke_CSL2013_floodplain_structures_001_L.shp 1d_nwke_MSS2002_floodplain_structures_001_L.shp 1d_nwke_Road_floodplain_structures_002_L.shp 1d_nwke_NetworkRail_floodplain_structures_001_L.shp 1d_nwke_KCC_Database_floodplain_structures_001_L.shp **Domain 2** 2d_bc_SX_floodplain_structures_Domain2_003_L.shp **Domain 3** 2d_bc_SX_floodplain_structures_Domain3_003_L.shp - All events except undefended 0.1% and 1% AEP events (output zones 3-6) 2d_bc_SX_floodplain_structures_Domain3_003_L_undefended_10m.shp - Undefended 0.1% and 1% AEP events (output zones 3-6) **Domain 4** 2d_bc_SX_floodplain_structures_Domain4_002_L.shp

Downstream boundary condition(s)	No 2D boundary conditions. 1D extended section included as last model section. Flared HX lines applied here to capture 2D floodplain flows.
2D grid files	**Grid location** 2d_loc_Model3_Domain1_002_L.shp 2d_loc_Model3_Domain2_001_L.shp 2d_loc_Model3_Domain3_001_L.shp 2d_loc_Model3_Domain4_001_L.shp **Grid dimensions in metres (X,Y)** 5000, 13000 (domain 1) 5000, 4000 (domain 2) 17000, 25000 (domain 3) 2500, 2000 (domain 4) **Cell size in metres** Defended: 20m (domains 1 and 3) 6m (domains 2 and 4) Undefended: 20m (domain 1) 10m (domain 3) 6m (domains 2 and 4) **Ascii grids** LIDAR_filtered_Medway_Model3_1m.asc LIDAR_filtered_Medway_Model3_50cm_A.asc LIDAR_filtered_Medway_Model3_50cm_B.asc LIDAR_filtered_Medway_Model3_50cm_C.asc LIDAR_filtered_Medway_Model3_25cm_A.asc LIDAR_filtered_Medway_Model3_25cm_B.asc **Active area file** 2d_code_activate_Model3_Domain1_002_R.shp - Defended 20% to 1% AEP events 2d_code_activate_Model3_Domain1_002b_R.shp - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events 2d_code_activate_Model3_Domain2_002_R.shp - Defended 20% to 1% AEP events 2d_code_activate_Model3_Domain2_002b_R.shp - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) 2d_code_activate_Model3_Domain2_002c_R.shp - Undefended 0.1% and 1% AEP events (output zones 3-6) 2d_code_activate_Model3_Domain3_003_R.shp - Defended 20% to 1% AEP events 2d_code_activate_Model3_Domain3_003b_R.shp - Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) 2d_code_activate_Model3_Domain3_003c_R.shp - Undefended 0.1% and 1% AEP events (output zones 3-6) 2d_code_activate_Model3_Domain4_001_R.shp - Defended 20% to 1% AEP events 2d_code_activate_Model3_Domain4_001b_R.shp- Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events except 0.1% and 1% AEP events (output zones 3-6) 2d_code_activate_Model3_Domain4_001c_R.shp - Undefended 0.1% and 1% AEP events (output zones 3-6) **Inactive area file** 2d_code_deactivate_Model3_Domain1_001_R.shp - All events 2d_code_deactivate_Model3_Domain2_003_R.shp - Defended 20% to 1% AEP events (output zones 1 and 3-6) 2d_code_deactivate_Model3_Domain2_003c_R.shp - Defended 1%+CC, 0.4% and 0.1%

	AEP events and all undefended events 2d_code_deactivate_Model3_Domain2_003d_R.shp - Defended 20% to 1% AEP events (output zone 2) 2d_code_deactivate_Model3_Domain3_004_R.shp - Defended 20% to 1% AEP events (output zones 1 and 3-6) 2d_code_deactivate_Model3_Domain3_004c_R.shp Defended 1%+CC, 0.4% and 0.1% AEP events and all undefended events 2d_code_deactivate_Model3_Domain3_004d_R.shp - Defended 20% to 1% AEP events (output zone 2) 2d_code_deactivate_Model3_Domain4_002_R.shp - All events
Materials file (.tmf)	Medway_Model3_005

4.2.1 Run settings

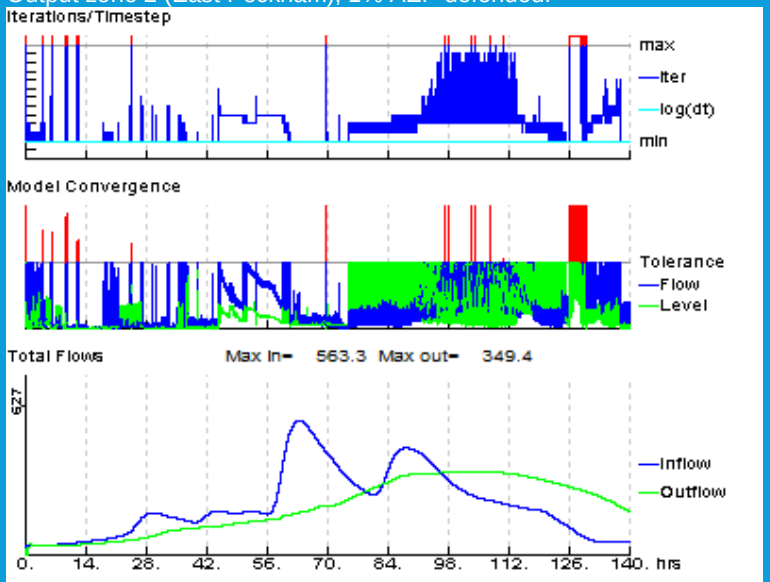
Model start time (hrs)	0	**Model end time (hrs)**	140
Map save interval (s)	18000	**Time series save interval (s)**	300
Map outputs (TUFLOW Flag) XMDF data format	d h q v MB1 MB2 ZUK0 Z0	**Time Step (s)**	3.00 (except for 1%+CC, 0.4% and 0.1% AEP defended events (output zone 2) and 1%, 1%+CC and 0.1% AEP undefended events (output zones 1 and 2) and 1%+CC AEP undefended events (output zones 3, 4, 5, 6) = 0.75s)

4.2.2 Model stability

Comments on results	Refer to plots of ISIS convergence, difference in volume in the 2D domain (dVol) and Cumulative Mass Error (Cum ME %) below for output zones 2 (East Peckham) and 3 (Yalding). **ISIS convergence plot** There are spikes of non-convergence however the model is generally stable. Model inflow and outflow plots are stable indicating stable model boundaries including 1D-2D links. **dVol** Difference in volume within each of the 2D domains generally shows a smooth transition between timesteps indicating the transfer of water into and out of the domains (via 1D-2D links or 2D-2D links) is stable. **Cum ME (%)** Overall model mass balance is good and within typical range for a healthy model (±1%) at the time of peak flooding. The mass balance is outside this range for the first 30-40 hours of the event. This is due to large mass error in domain 1 when the model first wets. However at this point flooding only covers a small fraction of the model cells which are wet at the peak of the flood event, meaning impacts are small. The mass error then returns to very close to 0.

ISIS convergence plots

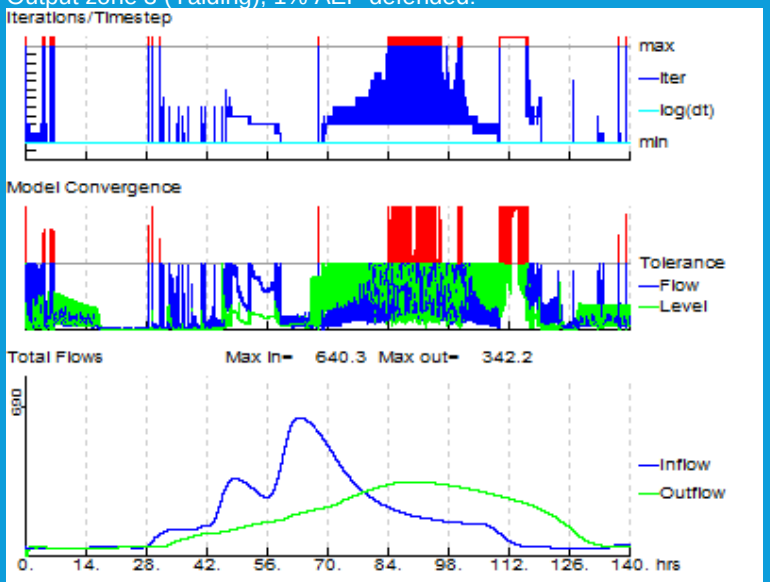
Output zone 2 (East Peckham), 1% AEP defended:



Datafile: ...\ISIS\RUNS\..\NETWORK\MEDWAY_MODEL3_023B.DAT
Results: ...WAY_MODEL3_024_002_DEF_0100_18FEB61962000.zzl
Ran at 16:53:08 on 07/08/2015
Ended at 04:13:21 on 09/08/2015
Start Time: 0.000 hrs
End Time: 140.000 hrs
Timestep: 1.5 secs

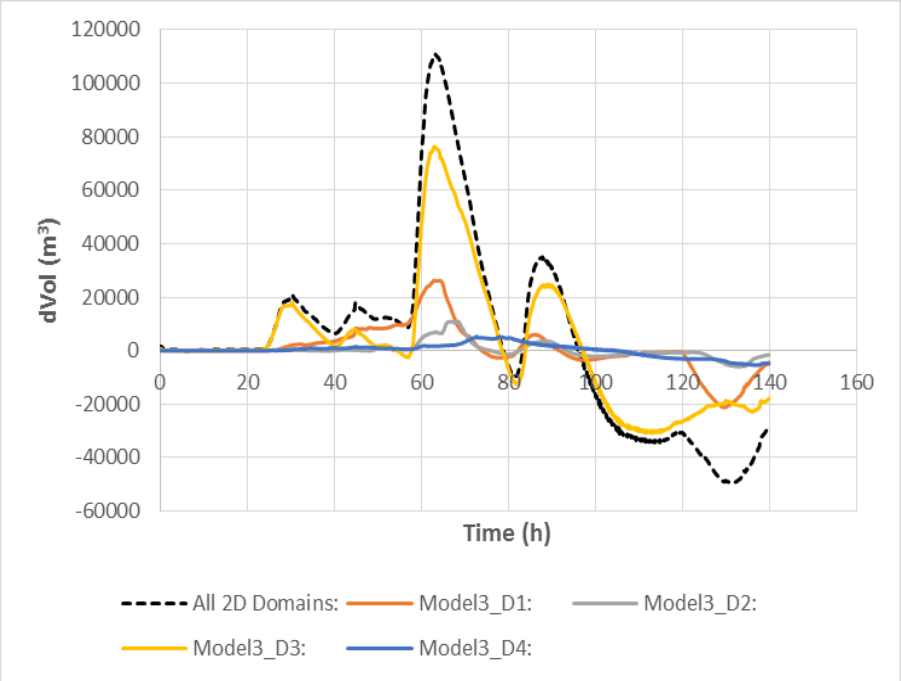
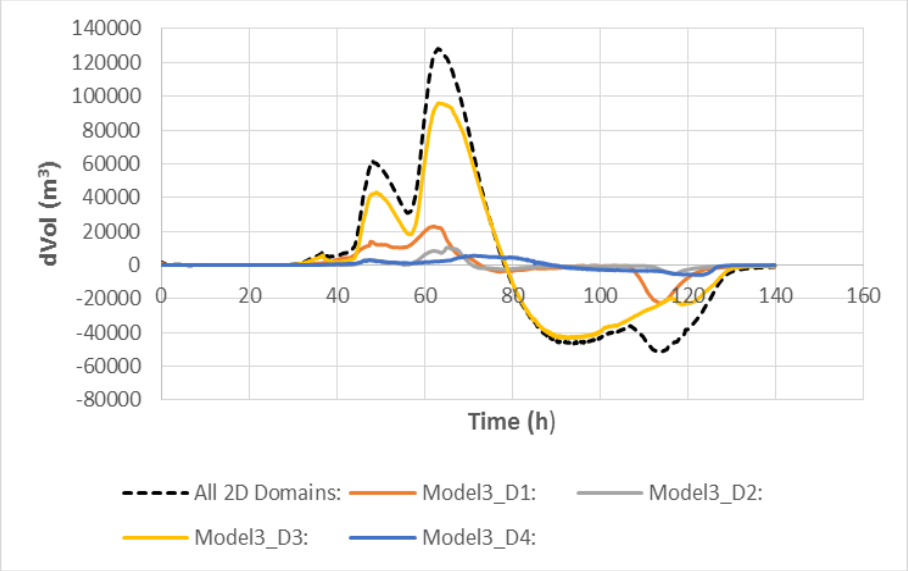
Current Model Time: 140.00 hrs
Percent Complete: 100 %

Output zone 3 (Yalding), 1% AEP defended:

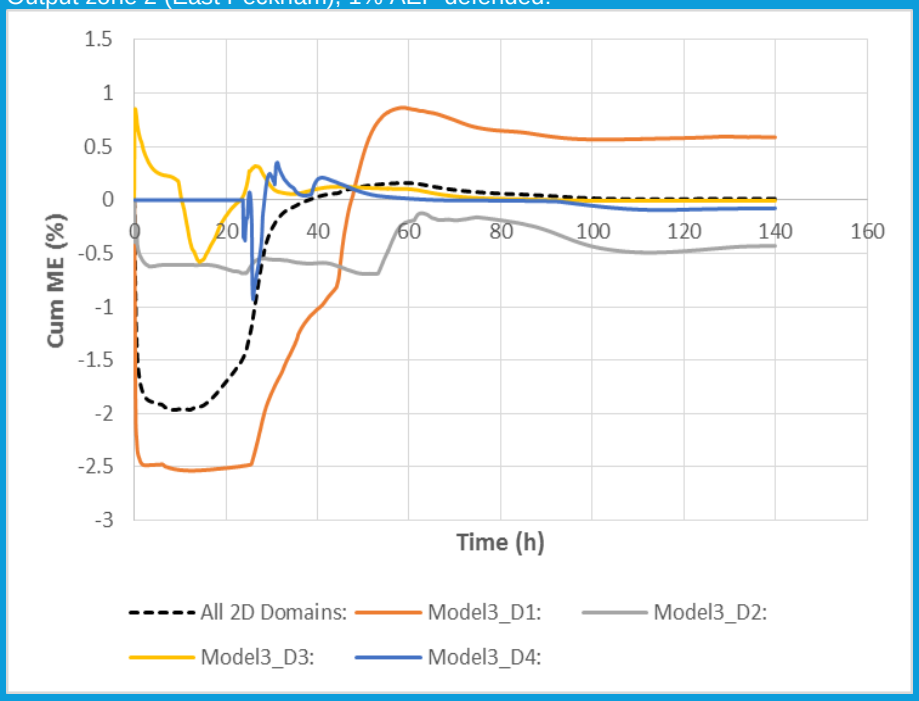


Datafile: ...\ISIS\RUNS\..\NETWORK\MEDWAY_MODEL3_023B.DAT
Results: ...WAY_MODEL3_024_003_DEF_0100_10JAN19241100.zzl
Ran at 12:52:57 on 08/08/2015
Ended at 23:06:06 on 09/08/2015
Start Time: 0.000 hrs
End Time: 140.000 hrs
Timestep: 1.5 secs

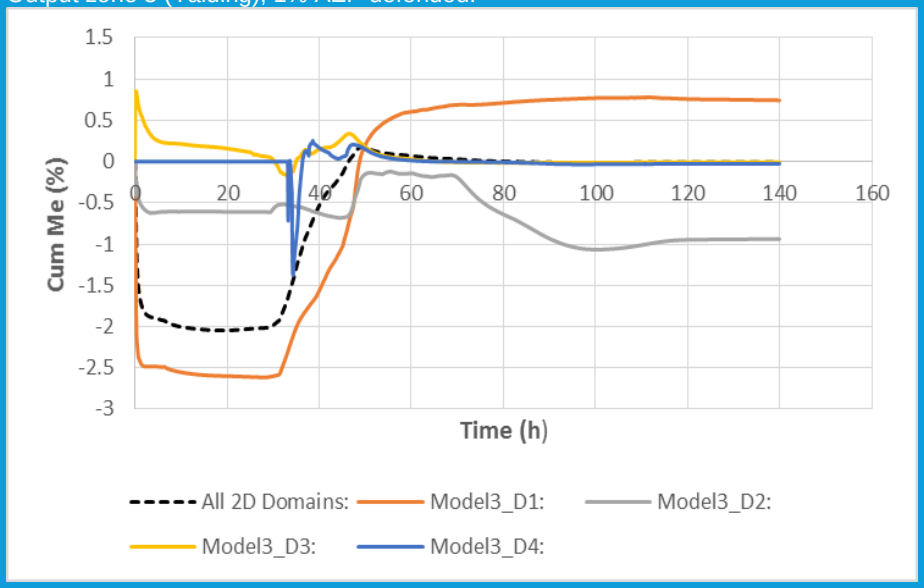
Current Model Time: 140.00 hrs
Percent Complete: 100 %

dVol (m^3)	Output zone 2 (East Peckham), 1% AEP defended:  Output zone 3 (Yalding), 1% AEP defended: 
Cum ME (%)	See next page.

Output zone 2 (East Peckham), 1% AEP defended:



Output zone 3 (Yalding), 1% AEP defended:



Appendices

A Modelling approach and overview

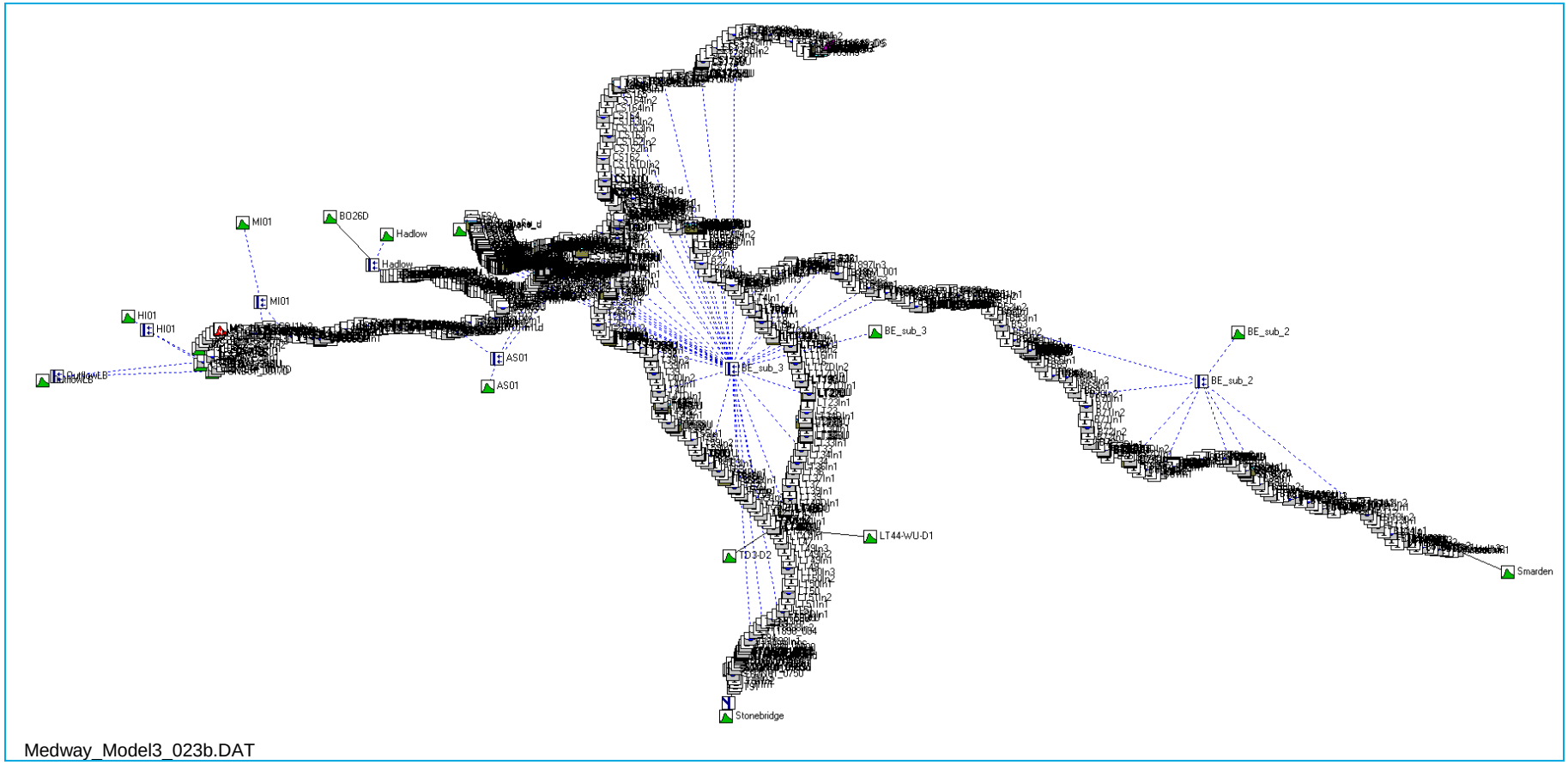
A.1 Modelling Approach

A.1.1 Available Data

Cross-section survey	The 2008 River Medway model, which makes up a large majority of the ISIS model along the River Medway, is constructed from survey data collected by Flynn & Rothwell in 1995. The River Beult, River Teise, Lesser Teise and River Bourne 1D models incorporated into the hydraulic model were originally constructed from the Medway Strategy Survey collected by Cartographical Surveys Ltd in 2002. The Coult Stream channel and structure data was taken from the East Peckham HEC-RAS model developed in 2004. The original survey data used to inform this model was not available. Therefore, on conversion of the HEC-RAS model to ISIS, the ISIS model was schematised (e.g. structures etc) according to the original HEC-RAS model and is therefore reliant upon this being an accurate representation of the watercourse and structures. Sections along the Gas Works Stream and Mill Stream in Tonbridge were taken from the Tonbridge Hazard Mapping Study (2010). The Tonbridge Hazard Mapping model was developed from a combination of the of the Cannon Lane 1D-2D model of Tonbridge (developed in 2008, which was developed from the original Section 105 Environment Agency study of the River Medway, which was updated in 2006 as part of Tonbridge and Malling's SFRA) and the Updated Flood Forecasting Model of the Upper Medway for Routing. The original survey data used to construct the model was not available. A number of other survey datasets were used within the model, including Longdin & Browning (2001) gauging station survey (at East Farleigh GS) and EDI Surveys Ltd (2013) gauging station survey (East Farleigh GS Stilebridge GS and Stone Bridge GS). Survey data was commissioned for this study for a number of structures, gauging stations and channel sections and was conducted by Maltby Land Surveys Ltd, 2014. In particular sections were collected in East Peckham, Stilebridge and Stonebridge. This information has been incorporated within the hydraulic model
Bank Top Survey	Bank level survey information was procured for this commission and was collected by Maltby Land Surveys Ltd in 2014. The data collected was implemented within the hydraulic mode, and updates bank levels at the following location: Stile Bridge gauging station Stone Bridge gauging station Left bank of the northern channel at East Peckham
LIDAR & other Topographic Data:	0.25cm filtered and unfiltered LIDAR data 0.50cm filtered and unfiltered LIDAR data 1m filtered and unfiltered LIDAR data
Map Data:	OS Open Data, OS 1:10,000, OS 1:25,000, OS 1:50,000 and OS MasterMap.

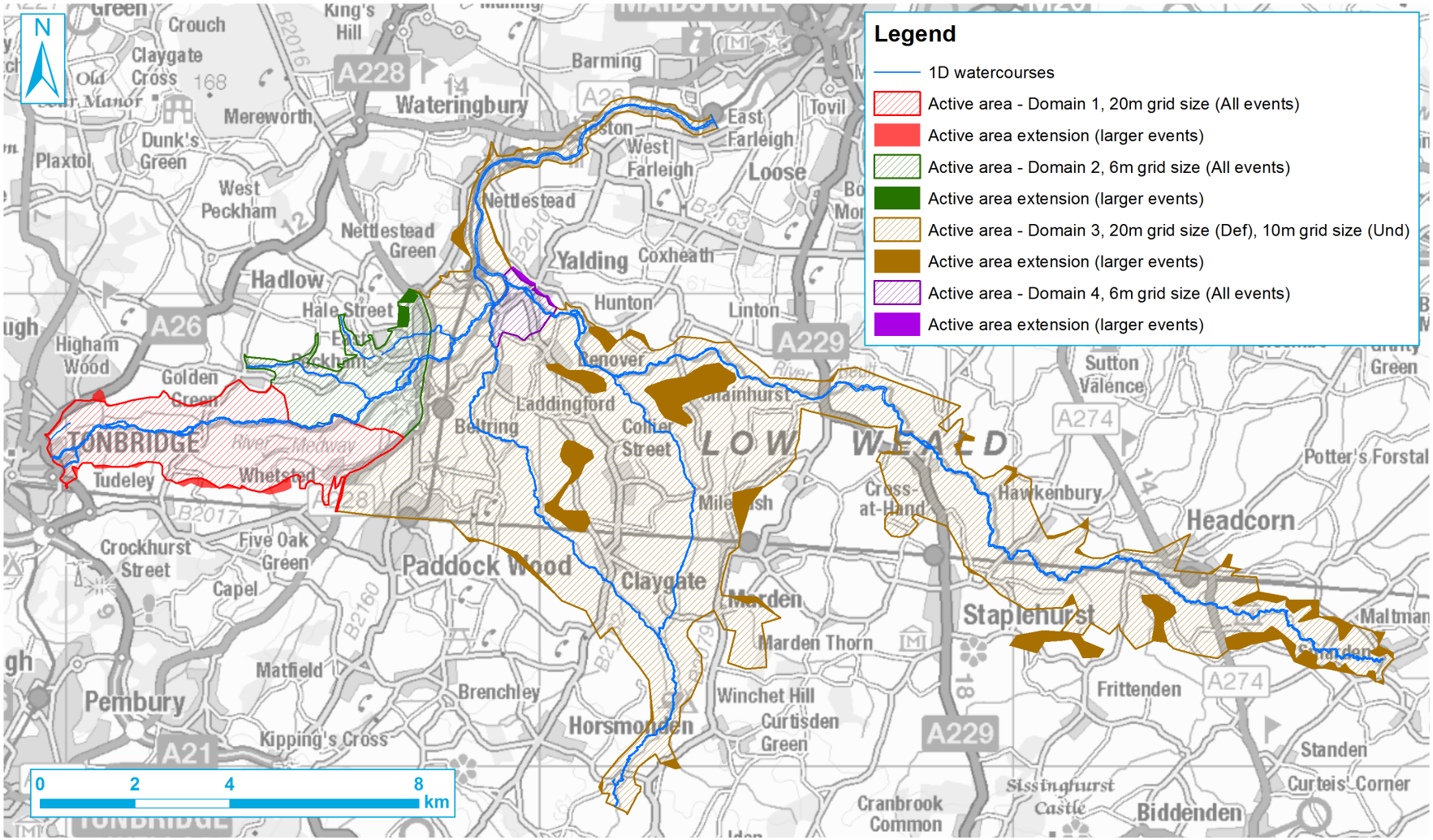
A.2 Model Overview

Figure A-1: ISIS Model Schematic (supplied with the model files as a .GXY file)



Medway_Model3_023b.DAT

Figure A-2: ISIS-TUFLOW model schematic



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A.2.2 Overview of 1D Model

Upstream Boundaries	River Medway: Canon Lane/Vale Road, Tonbridge River Beult: Smarden River Teise: 1km upstream of Stone Bridge GS River Bourne: Victoria Road, Golden Green Coult Stream: Downstream of East Peckham FSA
Lateral Catchment Weighting	Inflows were the flows from the routing (flood forecasting models) through which inflows are derived from PDM models. These inflows are based on watercourse locations and weighted according to upstream catchment areas using the FEH CD-ROM. Eighteen QTBDY inflows have been implemented. Fourteen correspond with actual inflows (although two of these are dummy inflows from the flood forecasting model), with six split into two or more lateral inflows. Four additional QTBDY inflows are implemented for connectivity (e.g. due ISIS needing a non-lateral inflow assigned at the upstream of a model reach). See Appendix C for details.
Downstream Boundary	**75m downstream of East Farleigh Lock at East Farleigh gauging station** A flow-head boundary (which is implemented as the downstream boundary in the Middle Medway flood forecasting model) is applied at the downstream boundary. The 1D-2D scheme is connected, via flared HX lines to an extended ISIS cross-section at the downstream model. This captures any floodplain flow so it is present in the last ISIS section connected to the flow-head boundary.
Total Number of nodes and structures	The Medway_Model3_023b.DAT ISIS model consists of 1388 nodes including: 537 River Sections 290 Interpolate units 114 Spill units (some represent inline weirs) 33 Round nosed broad crested weir units 30 Circular conduits 25 Arch Bridges 25 Vertical Sluice units 21 USBPR Bridges 18 Flow-Time (QTBDYs) 15 Culvert outlet units 14 Culvert inlet unit 8 Lateral units 5 Bernouilli Loss unit 4 Sharp crested weir 2 HTBDY 2 Orifice units 2 Flat-V weir 1 Flow-Head control 1 Flow-Head (QHBDY) 1 Reservoir unit 1 Radial Sluice unit
Labelling/ Numbering System Used	Labelling conventions of the model generally remains as per the existing River Medway Modelling and Flood Mapping Updates (2008) model, Tonbridge Hazard Mapping Study (2010), Upper Beult 1D model, Beult, Bourne and Teise 1D mapping study (2007) and East Peckham HEC-RAS model (2004) Where new survey has been implemented the labelling follows from the survey cross section labels. An overview of sections nomenclature is provided below, in addition to a description of whether this was retained from the previous modelling (indicated by a 'R'), or adjusted or implemented as part of the model updates ('indicated by a 'U'). CS## (R) River Medway (Flynn & Rothwell, 1995) CSJ## (R) River Medway bypass channel (Flynn & Rothwell, 1995) CST## (R) River Medway bypass channel (Flynn & Rothwell, 1995)

	GW_## (R)	Gas Works Stream (Tonbridge Hazard Mapping Study, 2010)
	MS_## (R)	Mill Stream (Tonbridge Hazard Mapping Study, 2010)
	B### (R)	River Beult (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	ST-### (R)	River Beult (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	BA# / BB# / BC# / BD# (R)	River Beult bypass channels (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	T## (R)	River Teise (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	LT## (R)	Lesser Teise (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	BO## (R)	River Bourne (Medway Strategy Survey, Cartographical Surveys Ltd, 2002)
	CO### (R)	Coult Stream (East Peckham HEC-RAS Model, 2004)
	S#.00# (U)	River Medway structures (Maltby Land Surveys Ltd, 2014)
	S# (U)	River Medway structures (Maltby Land Surveys Ltd, 2014)
	PECK0#_####	River Medway, East Peckham (Maltby Land Surveys Ltd, 2014)
	STIL0#_####	River Medway, Stile Bridge (Maltby Land Surveys Ltd, 2014)
	STON0#_####	River Medway, Stonebridge (Maltby Land Surveys Ltd, 2014)
	EF_XS-0# (U)	East Farleigh gauging station (Longdin & Browning, 2001)
	T11648 (U)	East Farleigh gauging station (EDI Surveys Ltd, 2013)
	T11897_00# (U)	Stile Bridge gauging station (EDI Surveys Ltd, 2013)
	T11898_00# (U)	Stonebridge gauging station (EDI Surveys Ltd, 2013)
Hydraulic roughness values used	Channel roughness values have been represented in the model by Manning's n. In order to determine the channel roughness, descriptions in Chow (1959)[1] were examined against photographic evidence, survey data and satellite imagery. Appendix E has more information relating to the roughness coefficients chosen for the new survey implemented. Sensitivity tests were undertaken to test the effect of increases and decreases in roughness. Please refer to the main study report for a summary of these tests.	

[1] Chow V.T. (1959) Open Channel Hydraulics McGraw Hill

A.2.3 Overview of 2D Model

Area of 2D domain	Domain 1: 10.5km^2 to 10.9km^2 (depending on event) Domain 2: 5.5km^2 to 5.7km^2 Domain 3: 67.6km^2 to 75.9km^2 Domain 4: 1.2km^2 to 1.3km^2	**DTM data source**	LIDAR. Supplied by Geomatics Group Ltd
Resolution of grid	Defended: Domains 1 and 3: 20m Domains 2 and 4: 6m Undefended: Domain 1: 20m Domain 3: 10m Domains 2 and 4: 6m	**DTM resolution**	25cm / 50cm / 1m
Orientation of grid	Domain 1: (WSW to ENE) Domain 2: (SW to NE) Domain 3: (SES to NWN) Domain 4: (SE to NW)		

Modifications to model topography (Domain 1)

File	Description
2d_zln_banks_Model2_003_L.shp | 2d_zln_banks_Model2_DTM_002_P.shp | 2d_zln_banks_Model2_DSM_001_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zsh_Mill_Stream_Model2_001_L.shp | 2d_zsh_Mill_Stream_Model2_001_P.shp	Z-shape cutting a channel into the 2D domain to account for Mill Stream. Levels based on filtered LIDAR data.
2d_zln_roads_railways_raised_Model3_Domain1_001_L.shp | 2d_zln_roads_railways_raised_Model3_Domain1_DTM_001_P.shp	Levels of roads, railways etc derived from 1m filtered LIDAR data
2d_zln_banks_Model3_Domain1_001_L.shp | 2d_zln_banks_Model3_Domain1_DTM_001_P.shp | 2d_zln_banks_Model3_Domain1_DSM_001_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate

Modifications to model topography (Domain 2)

File	Description
2d_zln_roads_railways_raised_Model3_Domain2_001_L.shp | 2d_zln_roads_railways_raised_Model3_Domain2_DTM_001_P.shp	Levels of roads, railways etc derived from 1m filtered LIDAR data
2d_zsh_gullies_ditches_roads_Model3_Domain2_001_L.shp |	Levels of roads, drains, gullies etc implemented as a Z-Shape to permit a continuous flow route

File	Description
2d_zsh_gullies_ditches_roads_Model3_ Domain2_001_P.shp	through the DEM
2d_zln_banks_Model3_Domain2_ 002_L.shp | 2d_zln_banks_Model3_Domain2_ DTM_002_P.shp | 2d_zln_banks_Model3_Domain2_ DSM_002_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zln_banks_Survey2014_ EastPeckham_001_L.shp | 2d_zln_banks_Survey2014_ EastPeckham_001_P.shp	Bank levels in East Peckham derived from bank level survey - Maltby Land Surveys Ltd 2014.
2d_zln_floodplain_culverts_Model3_ Domain2_001_L.shp	Lowers the cells to which SX connections for floodplain culverts are attached to 1cm below the structure invert. Input to reduce oscillations in flow.

Modifications to model topography (Domain 3)

File	Description
2d_zln_banks_DTM_Stilebridge_001_L.shp | 2d_zln_banks_DTM_Stilebridge_001_P.shp	Stile Bridge GS Bank levels derived from 1m filtered LIDAR data
2d_zln_banks_Survey2014_Stilebridge_ 001_L.shp | 2d_zln_banks_Survey2014_Stilebridge_ 001_P.shp	Stile Bridge GS Bank levels derived from bank level survey - Maltby Land Surveys Ltd 2014.
2d_zln_roads_Stilebridge_001_L.shp | 2d_zln_roads_Stilebridge_001_P.shp	Stile Bridge GS Level of roads derived from 1m filtered LIDAR data at 5m intervals
2d_zln_banks_DTM_Stonebridge_ 001_L.shp | 2d_zln_banks_DTM_Stonebridge_ 001_P.shp	Stone Bridge GS Bank levels derived from 1m filtered LIDAR data
2d_zln_banks_Survey2014_Stonebridge_ 001_L.shp | 2d_zln_banks_Survey2014_Stonebridge_ 001_P.shp	Stone Bridge GS Bank levels derived from bank level survey - Maltby Land Surveys Ltd 2014.
2d_zln_roads_Stonebridge_001_L.shp | 2d_zln_roads_Stonebridge_001_P.shp	Stone Bridge GS Level of roads derived from 1m filtered LIDAR data at 5m intervals
2d_zsh_ditch_Stonebridge_002_L.shp | 2d_zsh_ditch_Stonebridge_002_P.shp	Stone Bridge GS Implementing a continuous flow route for the floodplain ditch west of the main channel. Level derived from 1m filtered LIDAR data.
2d_zln_banks_Model4_005_L.shp | 2d_zln_banks_Model4_DTM_004_P.shp | 2d_zln_banks_Model4_DSM_001_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zln_roads_railways_raised_Model3_ Domain3_001_L.shp | 2d_zln_roads_railways_raised_Model3_ Domain3_DTM_001_P.shp | 2d_zln_roads_railways_raised_Model3_ Domain3_DSM_001_P.shp	Levels of roads, railways etc derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zln_banks_Model3_Domain3_ 003_L.shp | 2d_zln_banks_Model3_Domain3_ DTM_003_P.shp | 2d_zln_banks_Model3_Domain3_ DSM_003_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zln_floodplain_culverts_Model3_ Domain3_001_L.shp *Undefended only* 2d_zln_floodplain_culverts_Model3_ Domain3_001_L_undefended_10m.shp	Lowers the cells to which SX connections for floodplain culverts are attached to 1cm below the structure invert. Input to reduce oscillations in flow. As shapefile above but adjusted for 10m grid cell size for the undefended events.

File	Description
2d_zsh_gullies_ditches_roads_Model3_Domain3_001_L.shp | 2d_zsh_gullies_ditches_roads_Model3_Domain3_001_P.shp	Levels of roads, drains, gullies etc implemented as a Z-Shape to permit a continuous flow route through the DEM
Undefended only 2d_zsh_2d_channel_TB_F_016_domain3_001_L.shp | 2d_zsh_2d_channel_TB_F_016_domain3_001_P.shp	Levels of IDB watercourses from 2007 study

Modifications to model topography (Domain 4)

File	Description
2d_zln_roads_railways_raised_Model3_Domain4_002_L.shp | 2d_zln_roads_railways_raised_Model3_Domain4_DSM_002_P.shp	Levels of roads, railways etc derived from 1m unfiltered LIDAR data
2d_zln_banks_Model3_Domain4_003_L.shp | 2d_zln_banks_Model3_Domain4_DTM_003_P.shp | 2d_zln_banks_Model3_Domain4_DSM_002_P.shp	Bank levels derived from 1m filtered LIDAR data and unfiltered LIDAR data where filtering is inaccurate
2d_zln_floodplain_culverts_Model3_Domain4_002_L.shp	Lowers the cells to which SX connections for floodplain culverts are attached to 1cm below the structure invert. Input to reduce oscillations in flow.
2d_zsh_gullies_ditches_roads_Model3_Domain4_001_L.shp | 2d_zsh_gullies_ditches_roads_Model3_Domain4_001_P.shp	Levels of roads, drains, gullies etc implemented as a Z-Shape to permit a continuous flow route through the DEM
Undefended only 2d_zsh_2d_channel_TB_F_016_domain4_001_L.shp | 2d_zsh_2d_channel_TB_F_016_domain4_001_P.shp	Levels of IDB watercourses from 2007 study

Hydraulic roughness used within the 2D domain

Ordnance Survey MasterMap Topographic Area data was used to define the 2D floodplain roughness values for individual MasterMap feature classes. The Manning's *n* values used are tabulated below. These values have been informed from the roughness values applied to each of the four rating models developed for the current study at Colliers Land Bridge, Vexour Bridge, Stile Bridge and Stone Bridge. The values are typically greater than implemented on other studies previously, but given the evidence in the four models above that these values are required, these have been carried forward for the flood risk mapping models.

Table 4-1: Manning's n roughness values for the 2D domains, based on OS MasterMap land cover classes

Land cover	Manning's n
Building	0.300
General surface - multi surface	0.090
General surface - step	0.090
General surface	0.100
Glasshouse	0.200
Inland water	0.095
Landform	0.100
Boulders	0.105
Coniferous trees	0.160
Coniferous trees - scattered / Orchard	0.110
Coppice or osiers	0.130
Marsh reeds or saltmarsh	0.100
Non-coniferous trees	0.130
Non-coniferous trees - scattered	0.100
Rough grassland	0.100
Scrub	0.110

Land cover	Manning's n
Path	0.090
Rail	0.080
Road	0.080
Roadside	0.090
Structure	0.300
Structure - upper level of communication	0.300
Structure - pylon	0.100
Tidal water	0.095
Unclassified	0.100
Rock	0.110
Heath	0.130
Stability	0.100
Stability	0.300

A.2.4 1D-2D Linking

JBA have retained the standard approach to linking 1D ISIS and 2D TUFLOW models in each domain. Within the TUFLOW model HX boundaries are defined for the left and right banks and the channel area in between classified as 'inactive' in the 2D grid. The HX boundaries are linked to the respective ISIS nodes using CN connection lines and are discontinued at structures and confluences. Along these boundaries, water levels in the channel and floodplain interact dynamically and thus control floodplain wetting and drying.

B List of structures

The tables within the following sections outline the structures included within the hydraulic model. Listed are those included within the hydraulic model on the River Medway, River Beult, River Teise, Lesser Teise, River Bourne and Coult Stream channels.

Where the representation of the modelled structures differs from default (e.g. non-default parameters or coefficients) these are recorded. Links are also provided to structure photos where available.

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B.1 River Medway

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
Postern Lane bridge	Road bridge	Implemented	GW_24BU	GW_24BD	Tonbridge Hazard Mapping (2010) Estry data	Bridge (USBPR 1978)	Yes	1.20	0.90	No photo available
-	Weir	No change	CSJ1U	CSJ1	Flynn & Rothwell 1995	Broad crested round-nosed weir	N/a	-	-	No photo available
Eldridges Lock	Lock	Updated	CS56LU	CS56LD	108825-0900-0005-PB-Eldridges Lock.pdf and T4180_Eldridges Topo Survey (Halcrow)with updated points.dwg	Vertical Sluice unit	Yes*	1.00	0.50	No photo available
Radial gate at Eldridges Lock	Radial gate	Updated	CS56RU	CS56RD	WN-NELR-310 RA.pdf and 6359.01 Construction Drawings 24.01.2011.pdf	Radial Sluice unit	Yes*	1.00	0.50	No photo available
Fish and canoe pass at Eldridges Lock	Fish pass	Implemented	CS56FPU	CS56FPD	WN-NAVS-05C-053 Rev0.pdf	ISIS Spill unit	N/a	0.57	0.90	No photo available
Radial Gate at Porter's Lock	Radial gate	No change	CS68RU	CS68RD	Flynn & Rothwell 1995	Vertical Sluice unit	Yes*	1.50	0.90	No photo available
Fish and canoe pass at Porter's Lock	Fish pass	Implemented	CS68FPU	CS68FPD	PORTERS LOCK CFP AS BUILT DRAWINGS.pdf	ISIS Spill unit	N/a	0.57	0.90	No photo available
Porter's Lock	Lock	Updated	CS70LU	CS70LD	X- T4163_Porters.dwg and 108825-0900-0001-PA-Porters.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Hartlake Bridge	Road bridge	No change	CS76BU	CS76BD	Flynn & Rothwell 1995	Bernoulli Loss unit	No	-	-	Section **D.1**
Radial gate at East Lock	Radial gate	No change	CS83RU	CS83RD	Flynn & Rothwell 1995	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Fish and canoe pass at East Lock	Fish pass	Implemented	CS83FPU	CS83FPD	WN-NMFP-103 General Arrangement.pdf	ISIS Spill unit	N/a	0.57	0.90	No photo available
East Lock	Lock	Updated	CS83LU	CS83LD	T4180_East.dwg and 108825-0900-0004-PB-East.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Ford Green bridge	Road bridge	No change	CS88BU	CS90BD	Flynn & Rothwell 1995	Bernoulli Loss unit	No	-	-	No photo available
Oak Weir Lock	Lock	Updated	CS93LU	CS93LD	T4180_Oak.dwg and 108825-0900-0002-PA-Oak Weir.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Radial gate at Oak Weir	Radial gate	Updated	CS93RU	CS93RD	T4180_Oak.dwg	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Fish and canoe pass at Oak Weir	Fish pass	Implemented	CS93FPU	CS93FPD	Oak Lock fish and Canoe Pass.pdf	ISIS Spill unit	N/a	0.57	0.90	Section **D.1**
Lock at Sluice Weir	Lock	Updated	CS114LU	CS114LD	T4180_Sluice.dwg and 108825-0900-0003-PA-Sluice.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Vertical gates at Sluice Weir	Sluice gate	No change	CS114VU	CS114VD	Flynn & Rothwell 1995	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Radial gates at Sluice Weir	Radial gate	No change	CS114RU	CS114RD	Flynn & Rothwell 1995	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
South weir a Sluice Weir	Weir	No change	CS114SWU	CS114SWD	Flynn & Rothwell 1995	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
V-notch at Sluice Weir	Weir	No change	CS114VWU	CS114VWD	Flynn & Rothwell 1995	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
Fish pass at Sluice Weir	Fish pass	No change	CS114FU	CS114FD	Flynn & Rothwell 1995	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
Branbridges Road bridge	Road bridge	Implemented	PECK_0741 bu	PECK_0741bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.00	0.90	Section **D.1**
-	Access bridge	Implemented	PECK_0307 bu	PECK_0307bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.10	0.90	Section **D.1**
-	Weir	Implemented	PECK02_01 85	PECK02_0280	Maltby Land Surveys Ltd 2014	ISIS Spill unit	N/a	1.30	0.90	Section **D.1**
Branbridges Road bridge	Road bridge	Implemented	PECK_0132 bu	PECK_0132bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.00	0.90	Section **D.1**
Boyle Way bridge	Road bridge	Implemented	PECK_0461 bu	PECK_0461bd	Maltby Land Surveys Ltd 2014	Bridge (Arch)	Yes	1.30	0.90	Section **D.1**
-	Railtrack bridge	Implemented	PECK_0010 bu	PECK_0010bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.70	0.90	Section **D.1**
Vertical gates at Anchor Sluices	Sluice gate	Updated	CS147VU	CS147VD	Anchor Sluices location and site plan_108723-0100-0001.pdf and Anchor Sluices-existing details_108723-0100-0003.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Weir at Anchor Sluices	Weir	Updated	CS147UWU	CS147UWD	Anchor Sluices-existing details_108723-0100-0003.pdf	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
Weir at Anchor Sluices	Weir	Updated	CS147LWU	CS147LWD	Anchor Sluices-existing details_108723-0100-0003.pdf	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
Radial gates at Anchor Sluices	Radial gate	No change	CS147RU	CS147RD	Flynn & Rothwell 1995	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
-	Road bridge	Implemented	S4.001bu	S4.001bd	Maltby Land Surveys Ltd 2014	Bridge (Arch)	Yes	0.80	0.90	Section **D.1**
-	Access bridge	Implemented	S4.002bu	S4.002bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.30	0.90	Section **D.1**
-	Weir	No change	CST8WU	CST9WD	Flynn & Rothwell 1995	Sharp crested weir	No	-	-	No photo available
-	Lock	No change	CST8LU	CSTLD	Flynn & Rothwell 1995	Sharp crested weir	No	-	-	No photo available
Bow Bridge	Road bridge	Implemented	S6bu	S6bd	Maltby Land Surveys Ltd 2014	Bridge (Arch)	Yes	1.70	0.90	Section **D.1**
Lock at Teston	Lock	No change	CS172LU	CS172LD	T4180_Teston.dwg and T7406-TESTON LOCK PAGE 1.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**
Vertical gate at Teston	Sluice gate	Updated	CS172VU	CS172VD	J3047 Teston final hydrometric reporter vers 1 - compressed.doc; Teston Gauging Station- GA Details of sluice WR_3_7_16A.pdf and GCSWPP 710-AB.pdf	Vertical Sluice unit	Yes*	1.10	0.90	Section **D.1**

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
Weir at Teston	Weir	No change	CS172WU	CS172WD	J3047 Teston final hydrometric reporter vers 1 - compressed.doc	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.1**
Fish pass at Teston	Fish pass	Implemented	CS172FPU	CS172FPD	J3047 Teston final hydrometric report vers 1 - compressed.doc; GCSWPP 420 Rev C0.pdf and GCSWPP 421 Rev C0.pdf.	ISIS Spill unit	N/a	0.57	0.90	No photo available
Teston Lane bridge	Road bridge	No change	CS176BU	CS176BD	EA reference 11788	Bernoulli Loss unit	No	-	-	No photo available
Barming bridge	Footbridge	No change	CS182BU	CS184BD	EA reference 11788	Bernoulli Loss unit	Yes	1.20	0.90	No photo available
East Farleigh bridge	Road bridge	No change	CS186BU	CS188BD	EA reference 11788	Bernoulli Loss unit	Yes	0.90	0.90	No photo available
Lock at East Farleigh	Lock	Updated	CS188LU	CS188LD	T4180_East Farleigh.dwg and East Farleigh Lock, sluices and weir – general plan_L120.pdf	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Left vertical gate at East Farleigh	Sluice gate	Updated	CS188VU1	CS188VD1	Farleigh-proposed lifting sluice gates_223_10.pdf and Farleigh-proposed lifting sluice gates L121.pdf	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Right vertical gate at East Farleigh	Sluice gate	Updated	CS188VU2	CS188VD2	Farleigh-proposed lifting sluice gates_223_10.pdf and Farleigh-proposed lifting sluice gates L121.pdf	Vertical Sluice unit	Yes*	1.10	0.90	No photo available
Weir at East Farleigh	Weir	No change	CS188WU	CS188WD	East Farleigh Lock, sluices and weir – general plan_L120.pdf	Round nosed broad crested weir	Yes*	1.10	0.90	No photo available

*Spill used to represent bypassing flow

B.2 River Beult

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
Bell Lane road bridge	Road bridge	No change	B118BU	B118BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.20	0.90	Section **D.2**
-	Weir	Implemented	B115WB	B115BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Hadman's bridge	Access bridge	Updated	B115BU	B115WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.80	0.90	Section **D.2**
-	Drop in bed level/informal weir	Updated	B115WU	B115WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	0.80	0.90	Section **D.2**
-	Access bridge	Updated	B107BU	B107BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.80	0.90	Section **D.2**
New Bridge (A274)	Road bridge	Updated	B104BU	B104BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.70	0.90	Section **D.2**
-	Drop in bed level/informal weir	No change	B102WU1	B102WD1	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	No change	B102WU2	B102WD2	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	No change	B102WU3	B102WD3	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Railway Bridge	No change	B94BU	B94BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.20	0.90	Section **D.2**
-	Drop in bed level/informal weir	Implemented	B90WB	B90BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Stephen's Bridge (Water Lane)	Bridge	Updated	B90BU	B88WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.80	0.90	Section **D.2**
-	Drop in bed level/informal weir	Updated	B88WU	B88WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Railway Bridge	No change	B85BU	B85BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.20	0.90	Section **D.2**
-	Access bridge	Updated	B83BU	B83BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.90	0.90	Section **D.2**
-	Railway Bridge	Implemented	B79BU	B79BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.20	0.90	Section **D.2**
-	Drop in bed level/informal weir	Implemented	B75WB	B75BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Hawkenbury Bridge	Road bridge	Updated	B75BU	B75BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.00	0.90	Section **D.2**
-	Drop in bed level/informal weir	No change	B73WU1	B73WD1	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	No change	B73WU2	B73WD2	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	Implemented	B62WB	B62BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Herstfield Bridges (central)	Road bridge	Implemented	B62BU	B62WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.00	0.90	Section **D.2**
-	Weir	Implemented	B62WU	B61WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	Implemented	BD1WB	BD1BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Herstfield Bridges (left)	Road bridge	Implemented	BD1BU	BD1WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.2**
-	Weir	Implemented	BD1WU	BD1WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	Implemented	BC2WD	BC2BU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.85	0.90	Section **D.2**
Herstfield Bridges (right)	Road bridge	Updated	BC2BU	BC2WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.2**
-	Drop in bed level/informal weir	Updated	BC2WU	BC2WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	Section **D.2**
-	Drop in bed level/informal weir	Implemented	STIL_0252wb	STIL_0252bu	Maltby Land Surveys Ltd 2014	Sharp crested weir	N/a	-	-	Section **D.2**
Stile Bridge	Road bridge	Updated	STIL_0252bu	STIL_0252bd	Maltby Land Surveys Ltd 2014	Bridge (USBPR 1978)	Yes	1.30	0.90	Section **D.2**
Stile Bridge gauging weir	Weir	Implemented	STIL_0133wu	STIL_0133wd	Maltby Land Surveys Ltd 2014	Flat-V weir	Yes*	1.50	0.90	Section **D.2**
-	Road bridge	Updated	B34BU	B34BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.2**
Cheveney radial gate	Radial gate	Updated	B20RU	B20RD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.70	0.90	Section **D.2**

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
-	Weir	No change	B15WU	B15WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.00	0.90	Section **D.2**
-	Vertical gate	No change	BB18GU	BB14GD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.20	0.90	Section **D.2**
Yalding Bridge (B2010)	Road bridge	Updated	B6BU	B6BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.2**
-	Access bridge	Implemented	ST-049BU	ST-049GU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.60	0.90	Section **D.2**
-	Sluice gate	Implemented	ST-049GU	ST-049GD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	0.60	0.90	Section **D.2**
-	Drop in bed level/informal weir	Implemented	ST-054	ST-054D	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	ISIS Spill unit	N/a	1.60	0.90	Section **D.2**
B2010 Road bridge	Road bridge	Updated	BA3BU	BA3BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.2**

*Spill used to represent bypassing flow

B.3 River Teise

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
Goudhurst Road Bridge	Road bridge	Implemented	STON_0066bu	STON_0066bd	Maltby Land Surveys Ltd 2014	Orifice unit	No	-	-	Section **D.3**
Stone Bridge	Road bridge	Updated	STON_0206bu	STON_0206bd	Maltby Land Surveys Ltd 2014	Bridge (Arch)	Yes	1.10	0.90	Section **D.3**
Stone Bridge gauging weir	Weir	Updated	STON_0117wu	STON_0117wd	Maltby Land Surveys Ltd 2014	Flat-V weir	Yes*	1.50	0.90	Section **D.3**
-	Weir	No change	LT56WU	LT53WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.40	0.90	Section **D.3**
-	Weir	No change	LT46WU	LT44WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.10	0.90	Section **D.3**
Old Mill bridge	Road bridge	Updated	LT40BU	LT40BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.40	0.90	Section **D.3**
-	Railway bridge	Updated	LT32BU	LT32BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.3**
Chalkmead radial gate	Radial gate	Updated	LT27RU	LT24RD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.40	0.90	Section **D.3**
Spitz Bridge	Road bridge	Updated	LT21BU	LT21BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.40	0.90	Section **D.3**
-	Weir	No change	LT19WU	LT17WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.60	0.90	Section **D.3**
-	Weir	No change	LT15WU	LT13WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.40	0.90	Section **D.3**
-	Weir	No change	LT12WU	LT10WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.50	0.90	Section **D.3**
-	Weir	No change	LT7WU	LT5WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.50	0.90	Section **D.3**
-	Weir	No change	T73WU	T73WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	N/a	-	-	No photo available
Gafford's Bridge	Road bridge	Updated	T66BU	T66BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.3**
Bockingfold Sluice	Sluice gate	Updated	T60GU	T60GD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.50	0.90	Section **D.3**
-	Railway bridge	Updated	T52BU	T52BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.10	0.90	Section **D.3**
-	Weir	No change	T47WU	T47WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.60	0.90	Section **D.3**
Moors Farm radial gate	Radial gate	Updated	T43RU	T41RD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.60	0.90	Section **D.3**
Pikefish Lane	Road bridge	Implemented	T35BU	T35BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.30	0.90	Section **D.3**
Darman Bridge	Road bridge	Updated	T30BU	T30BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.20	0.90	Section **D.3**
Darman radial gate	Radial gate	No change	T29RU	T29RD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.50	0.90	Section **D.3**
Duddies radial gate	Radial gate	Updated	T24RU	T24RD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Vertical Sluice unit	Yes*	1.30	0.90	Section **D.3**
Laddingford bridge	Road bridge	Updated	T15BU	T15BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	1.20	0.90	Section **D.3**
-	Weir	No change	T12WU	T10WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.40	0.90	Section **D.3**
-	Weir	No change	T6WU	T4WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.30	0.90	Section **D.3**

*Spill used to represent bypassing flow

B.4 River Bourne

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
-	Weir	No change	BO21WU	BO19WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.00	0.90	Section **D.4**
Pierce Mill Lane	Road bridge	Implemented	BO16BU	BO16BD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (USBPR 1978)	Yes	1.40	0.90	Section **D.4**
-	Weir	No change	BO13WU1	BO9WD1	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.00	0.90	Section **D.4**
-	Weir	No change	BO13WU2	BO9WD2	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Sharp crested weir	Yes*	1.00	0.90	Section **D.4**
-	Siphon	No change	BO13SYU	BO9SYD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	1.00	0.90	Section **D.4**
Little Mill Bridge	Road bridge	Updated	BO9BU	BO9WU	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Bridge (Arch)	Yes	0.50	0.90	Section **D.4**
-	Drop in bed level/informal weir	Implemented	BO9WU	BO9WD	Medway Strategy Survey 2002 (Cartographical Surveys Ltd)	Round nosed broad crested weir	Yes*	0.50	0.90	Section **D.4**

*Spill used to represent bypassing flow

B.5 Coult Stream

Structure name	Structure type	Structure updated	Upstream node	Downstream node	Survey reference	Model representation	Spill unit attached	Spill Weir coefficient	Spill Modular limit	Structure photo
-	Flood storage area	Implemented	FSA	HydroBrake_u EP_Dam_Su	East Peckham FSA Study (JBA, 2014)	Reservoir	N/a	-	-	No photo available
-	Hydrobrake	Implemented	HydroBrake_u	HydroBrake_d	East Peckham FSA Study (JBA, 2014)	Flow - Head control	N/a	-	-	No photo available
-	Culvert	Implemented	HydroBrake_d	CO600co	East Peckham FSA Study (JBA, 2014)	Circular culvert	Yes	0.90	0.90	No photo available
-	Culvert	Implemented	CO545ci	CO545co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
-	Access bridge	Implemented	CO525bu	CO525bd	East Peckham HEC-RAS Model (2004)	Bridge (Arch)	Yes	1.20	0.90	No photo available
-	Drop in bed level/informal weir	Implemented	CO525bd	CO525wd	East Peckham HEC-RAS Model (2004)	ISIS Spill unit	N/a	1.70	0.90	No photo available
-	Access bridge	Implemented	CO515bu	CO515bd	East Peckham HEC-RAS Model (2004)	Bridge (USBPR 1978)	Yes	1.20	0.90	No photo available
-	Drop in bed level/informal weir	Implemented	CO515bd	CO515wd	East Peckham HEC-RAS Model (2004)	ISIS Spill unit	N/a	1.70	0.90	No photo available
-	Access bridge	Implemented	CO495bu	CO495bd	East Peckham HEC-RAS Model (2004)	Bridge (USBPR 1978)	Yes	1.20	0.90	No photo available
-	Drop in bed level/informal weir	Implemented	CO495bd	CO495wd	East Peckham HEC-RAS Model (2004)	ISIS Spill unit	N/a	1.70	0.90	No photo available
-	Culvert	Implemented	CO445ci	CO445co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Hatches Lane culvert	Culvert	Implemented	CO435ci	CO435co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Addlestead Road culvert	Culvert	Implemented	CO415ci	CO415co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Westwood Road culvert	Culvert	Implemented	CO395ci	CO395co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Fell Mead culvert	Culvert	Implemented	CO299ci	CO299co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Fell Mead culvert	Culvert	Implemented	CO291ci1 CO291ci2	CO291co1 CO291co2	East Peckham HEC-RAS Model (2004)	2 no. Circular culverts	Yes	1.20	0.90	No photo available
Builders Yard culvert	Culvert	Implemented	CO269ci	CO269co	East Peckham HEC-RAS Model (2004)	Circular culvert	Yes	1.20	0.90	No photo available
Builders Yard culvert	Culvert	Implemented	CO262ci1 CO262ci2	CO262co1 CO262co2	East Peckham HEC-RAS Model (2004)	2 no. Circular culverts	Yes	1.20	0.90	No photo available
-	Drop in bed level/informal weir	Implemented	CO135bd	CO135wd	East Peckham HEC-RAS Model (2004)	ISIS Spill unit	N/a	1.70	0.90	No photo available
Hale Street culvert	Culvert	Implemented	CO105cu1 CO105cu2 CO105cu3	CO105cd1 CO105cd2 CO105cd3	East Peckham HEC-RAS Model (2004)	3 no. Circular culverts	Yes	1.20	0.90	No photo available
-	Drop in bed level/informal weir	Implemented	CO017bd	CO017wd	East Peckham HEC-RAS Model (2004)	ISIS Spill unit	N/a	1.70	0.90	No photo available
-	Railway bridge	Implemented	S8.001bu	S8.001bd	Maltby Land Surveys 2014	Bridge (Arch)	Yes	1.10	0.90	Section **D.5**

B.6 Floodplain structures (ESTRY networks)

Structure name / location	Structure reference	Structure updated	Model name	Model domain	Source of data	Model representation	JBA Comment	Structure photo
Railway culvert. West of Pattenden Lane, Marden and east of Lesser Teise.	-	Implemented	Culvert_1	Domain 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert. West of Pattenden Lane, Marden and east of Lesser Teise.	-	Implemented	Culvert_2	Domain 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert. West of Pattenden Lane, Marden and east of Lesser Teise.	-	Implemented	Culvert_3	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. West of Pattenden Lane, Marden and east of Lesser Teise.	-	Implemented	Culvert_4	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. West of Pattenden Lane, Marden and east of Lesser Teise.	-	Implemented	Culvert_5	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. West of Lesser Teise and east of Collier Street, B2162.	-	Implemented	Culvert_6	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. West of Lesser Teise and east of Collier Street, B2162.	-	Implemented	Culvert_7	Domain 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert. West of Lesser Teise and east of Collier Street, B2162.	-	Implemented	Culvert_8	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. East of River Teise and west of Spenny Lane.	-	Implemented	Culvert_11	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert. West of River Teise and east of Willow Lane.	-	Implemented	Culvert_15	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Culvert under Boyle Way, A228. (South of B2015 roundabout).	-	Implemented	Culvert_20	Domain 2 and 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert south of Longend Road.	-	Implemented	Culvert_24	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Culvert under Maidstone Road, B2162. Claygate.	-	Implemented	Culvert_27	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Adjacent to Hunton Road. (South of Green Lane).	-	Implemented	Sluice_1	Domain 3	Beult and Teise 2D FRM study (2007) data	ESTRY weir		No photo available
Culvert under Hunton Road. (South of Green Lane).	-	Implemented	Culvert_28	Domain 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert west of Willow Lane and east of Queen Street.	-	Implemented	Culvert_29	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert east of Queen Street.	-	Implemented	Culvert_30	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert west of Queen Street.	-	Implemented	Culvert_31	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Railway culvert west of Queen Street.	-	Implemented	Culvert_32	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Culvert west of Spenny Lane.	-	Implemented	Culvert_35	Domain 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Culvert under Maidstone Road, B2162. South of River Teise.	-	Implemented	Culvert_38	Domain 3	Beult and Teise 2D FRM study (2007) data	Circular culvert (ESTRY)		No photo available
Culvert under Boyle Way, A228 (Tudeley Brook). North of Torbay Road.	-	Implemented	Culvert_23	Domain 2 and 3	Beult and Teise 2D FRM study (2007) data	Rectangular culvert (ESTRY)		No photo available
Railway culvert adjacent to Beltring Road, Beltring.	S2.001	Implemented	S2_001	Domain 3	Maltby Land Surveys (2014) data.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (4.5m^2)	Section **D.6**
Arch bridge under Boyle Way, A228. East Peckham.	S1.001	Implemented	S1.001	Domain 2 and 3	Maltby Land Surveys (2014) data.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (7.1m^2)	Section **D.6**
Railway bridge south of Yalding station	S5.001	Implemented	S5_002	Domain 3	Maltby Land Surveys (2014) data.	Rectangular culvert (ESTRY)	Railway Bridge (rectangular). Invert and soffit from survey. Width adjusted to match overall cross-section area of culvert as vegetation bank in middle of section (21.7m^2)	Section **D.6**
Arch bridge under Hampstead Lane, B2162. Yalding.	S4.001	Implemented	S4_001	Domain 4	Maltby Land Surveys (2014) data.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (6.28m^2)	Section **D.6**
Arch bridge under Branbridges Road (Tudeley Brook). East Peckham.	01.059	Implemented	01_059	Domain 2	Capital Surveys Ltd (2013) data. EA reference 11631.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall average cross-section area of culverts ((4.36m^2+3.96m^2)/2)	Section **D.6**
Circular culvert adjacent to Branbridges Road (Tudeley Brook). East Peckham.	01.058	Implemented	01_058	Domain 2	Capital Surveys Ltd (2013) data. EA reference 11631.	Circular culvert (ESTRY)	Circular culvert.	Section **D.6**
Arch bridge at end of Branbridges Road (Tudeley Brook). East Peckham.	01.056	Implemented	01_056	Domain 2	Capital Surveys Ltd (2013) data. EA reference 11631.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (1.31m^2)	Section **D.6**
Arch bridge under High Street, Yalding	ST-016	Implemented	ST016_B6U	Domain 4	Cartographical Surveys Ltd (2002) data - Medway Strategy Survey. EA reference 11790.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (4.82m^2)	Section **D.6**
Arch bridge under Chart Hill Road, Cross-at-Hand	ST-046	Implemented	ST046_BD1BU	Domain 3	Cartographical Surveys Ltd (2002) data - Medway Strategy Survey. EA reference 11790.	Rectangular culvert (ESTRY)	Arch Bridge approximated as a rectangular culvert. Invert and width from survey. Height adjusted to match overall cross-section area of culvert (3.97m^2)	No photo available

Structure name / location	Structure reference	Structure updated	Model name	Model domain	Source of data	Model representation	JBA Comment	Structure photo
Arch bridge under Headcorn Road (Hawkenbury Bridge).	ST-041	Implemented	ST041_B75U	Domain 3	Cartographical Surveys Ltd (2002) data - Medway Strategy Survey. EA reference 11790.	Rectangular culvert (ESTRY)	Arch Bridges approximated as rectangular culverts. Invert and width from survey (averaged the two openings). Height adjusted to match overall average cross-section area each culvert (2.45m^2)	Section **D.6**
Culvert under A229 Maidstone Road, just north of junction with Clapper Lane.	-	Implemented	A229_Maid	Domain 3	No survey exists for this structure.	Rectangular culvert (ESTRY)	Invert levels assumed from LIDAR and width taken from LIDAR and cross-checked against Google StreetView images.	No photo available
Culvert under B2079 W End Goudhurst Road, just north of junction with Roughlands Lane.	-	Implemented	B0279_Goud	Domain 3	No survey exists for this structure.	Rectangular culvert (ESTRY)	Invert levels assumed from LIDAR and width taken from LIDAR and cross-checked against Google StreetView images.	No photo available
Culvert under Smarden Road (River Sherway). Headcorn.	-	Implemented	Smard_Rd	Domain 3	No survey exists for this structure.	Rectangular culvert (ESTRY)	Invert levels assumed from LIDAR and width taken from LIDAR and cross-checked against Google StreetView images.	No photo available
Culvert under A229 Staplehurst Road. Cross-At-Hand.	-	Implemented	A229_Stap	Domain 3	No survey exists for this structure.	Circular culvert (ESTRY)	Invert levels assumed from LIDAR and width taken from LIDAR and cross-checked against Google StreetView images.	No photo available
Railway culvert east of Willow Lane, Paddock Wood.	ELR: XTD Struc ref: 295C:	Implemented	XTD_295BC	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level minus 400mm (where estimated water level is recorded within inspection sheet). High roughness reflects dense vegetation growth.	Section **D.6**
Railway culvert east of Willow Lane, Paddock Wood.	ELR: XTD Struc ref: 293	Implemented	XTD_293	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level minus half culvert height (where estimated water level is recorded within inspection sheet)	Section **D.6**
Railway culvert east of Willow Lane, Paddock Wood.	ELR: XTD Struc ref: 294	Implemented	XTD_294	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level minus 800mm (where estimated water level is recorded within inspection sheet)	Section **D.6**
Railway culvert east of Spenny Lane and west of Collier Street, B2126.	ELR: XTD Struc ref: 302	Implemented	XTD_302	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level minus 450mm (water depth recorded within inspection sheet)	Section **D.6**
Railway culvert adjacent to Longend Lane.	ELR: XTD Struc ref: 306	Implemented	XTD_306	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level. Limited water shown in inspection sheet.	Section **D.6**
Railway culvert east of Collier Street, B2126 and adjacent to Longend Lane.	ELR: XTD Struc ref: 305	Implemented	XTD_305	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level minus 500mm (where estimated water level is recorded within inspection sheet). Short culvert set to connect to distance further downstream as LIDAR indicates channel to here, but no further information available.	Section **D.6**
Railway culvert east of Water Lane. Hammer Stream.	ELR: XTD Struc ref: 343	Implemented	XTD_343	Domain 3	Network Rail inspection sheets.	Rectangular culvert (ESTRY)	Invert set as LIDAR level. Limited water shown in inspection sheet. Sprung arch implemented as a rectangular culvert (removed 100mm from height to account for this).	Section **D.6**
Railway culvert east of Headcorn Road (Hawkenbury Bridge)	ELR: XTD Struc ref: 338	Implemented	XTD_338	Domain 3	Network Rail inspection sheets.	Rectangular culvert (ESTRY)	Invert set as LIDAR level. Limited water shown in inspection sheet. Sprung arch implemented as a rectangular culvert (removed 100mm from height to account for this).	Section **D.6**
Railway culvert west of Water Lane.	ELR: XTD Struc ref: 342C, 342D, 342E	Implemented	XTD_342CDE	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Three assets grouped into one: XTS 342C,D,E. XTD 342C has two arch culverts approximated as circular. Invert set as LIDAR level. Limited water shown in inspection sheet.	Section **D.6**
Railway culvert east of Water Lane.	ELR: XTD Struc ref: 342F	Implemented	XTD_342F	Domain 3	Network Rail inspection sheets.	Circular culvert (ESTRY)	Invert set as LIDAR level. Limited water shown in inspection sheet.	Section **D.6**
Railway for River Sherway at Biddenden Lane, A274. Headcorn.	ELR: XTD Struc ref: 349	Implemented	XTD_349	Domain 3	Network Rail inspection sheets.	Rectangular culvert (ESTRY)	Invert set as LIDAR level. However, LIDAR thought to not represent channel base as height of culvert (3m) in inspection sheet would mean soffit is above railway line. Height reduced to 2m to account for this.	Section **D.6**
Railway culvert adjacent to Hampstead Lane, B2126. Yalding.	ELR: PWS1 Struc ref: 982A	Implemented	PWS1_982A	Domain 3	Network Rail inspection sheets.	Rectangular culvert (ESTRY)	Invert set as LIDAR level. Limited water shown in inspection sheet. Sprung arch implemented as a rectangular culvert (removed 500mm from height to account for this).	Section **D.6**
Culvert under Maidstone Road, B2160 (near to A228 roundabout). Beltring.	3152	Implemented	3152	Domain 3	Data provided by Kent County Council Highways via the Environment Agency.	Circular culvert (ESTRY)		Section **D.6**
Culvert under A228 (north of roundabout with B2160). Beltring.	3917	Implemented	3917	Domain 2 and 3	Data provided by Kent County Council Highways via the Environment Agency.	Rectangular culvert (ESTRY)		Section **D.6**
Culvert under A228 (north of roundabout with B2160). Beltring.	343	Implemented	343	Domain 2 and 3	Data provided by Kent County Council Highways via the Environment Agency.	Rectangular culvert (ESTRY)		Section **D.6**

C Model inflows and weightings

C.1 Introduction

The purpose of this section is to document the inflows into the Model 3 hydraulic model and explain how the weightings were derived.

Inflow areas from the Routing model (Flood Forecasting model adapted or extended for use in the Medway Catchment Mapping and Modelling Study) were retained for inflows to the hydraulic model. The catchment area assigned to each inflow (TOTAL area listed in the table below) were compared with those from the FEH CD-ROM v3.

In some instances the Routing/FF model inflows require weighting, to:

- Enable flows to be input upstream of this point location (e.g. where the flood mapping model extends further upstream than the flood forecasting model)
- Distribute flows from the Routing/FF model to a number of locations when the inflow is considered either
    - representing an 'intervening area' (where there is not a defined tributary, but rather a general increase in catchment area with distance downstream)
    - representing more than one tributary

The table below documents the model inflow (QTBDY), labels which connect the inflow to the corresponding model node, the location of the inflow/model node points, the area of the inflow assigned in the Routing/FF model and the corresponding area derived from the FEH CD-ROM v3. This is then used to apply a weighting for flows to each model node, based upon the ratio of the sub-area catchment derived from the FEH CD-ROM v3 and the total area derived from the FEH CD-ROM v3. Comments are made where applicable.

C.2 Model 1 inflows

Model inflows are listed in Table C-1, with the connecting model node indicated.

Table C-1: Inflows applied to relevant nodes

Inflow QTBDY	Lateral node label	Connected ISIS node	Easting (m)	Northing (m)	Area in Routing/FF model (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) SUB-AREA Area	Weighting	Comment
OutflowLB	OutflowLB_1	CS40	559621	146446	n/a	n/a	n/a	95%	Outflow from the Leigh FSA. Flow splits between River Medway (CS40) and Botany Stream (TONB01_0017D) are based on the peak flow weighting (ISIS and 2D out of bank flow) within the Model 2 hydraulic model.
	OutflowLB_2	TONB01_0017D	559947	146321			n/a	5%	
MI01	MI01_1	CSJ1In1	560995	147243	27.0	25.26*	7.30	30%	30% weighting to Pen Stream (CSJ1In1) inflow and 70% to the large drain (CS57In2) joining on the right bank (unnamed). Inflow weightings based on FEH catchment area weightings.
	MI01_2	CS57In2	561555	147121			17.43	70%	
HI01	HI01_1	CS40	559621	146446	53.0	n/a	n/a	95%	Hilden Brook and Hawden Stream inflows. Flow splits between River Medway (CS40) and Botany Stream (TONB01_0017D) are based on the peak flow weighting (ISIS and 2D out of bank flow) within the Model 2 hydraulic model.
	HI01_2	TONB01_0017D	559947	146321			n/a	5%	
AS01	AS01_1	CS114D	566995	147975	37.816	35.04	12.54	40%	40% weighting to Alder Stream (CS114D) and Tudeley Brook (CS126), and 20% weighting to Hammer Dyke (CS96). All join on the right bank. Inflow weightings based on FEH catchment area weightings.
	AS01_2	CS96	565397	147207			6.32	20%	
	AS01_3	CS126	567901	148574			13.34	40%	
Hadlow	hadlow_1	BO26D	563812	148456	51.0	53.34	53.34	100%	Upstream inflow on the River Bourne.
Smarden	n/a	Smarden	587811	142267	97.0	96.16	96.16	100%	Upstream inflow on the River Beult.
BE_sub_2	BE_sub_2_1	B112	585797	143084	182	171.43	5.18	3%	Inflow represents intervening areas along the River Beult (between Smarden and B53) as there are numerous small drains. River Sherway is included within B99 inflow and Hammer Stream within B91. The FEH catchment areas have been calculated from the difference in catchment area along the River Beult. The flow weightings are based on the catchment area weightings.
	BE_sub_2_2	B99	583633	143523			34.17	20%	
	BE_sub_2_3	B70In2	579356	145763			4.34	2.5%	
	BE_sub_2_4	B53	577606	147349			29.64	17%	
	BE_sub_2_5	B91In1	582712	144284			58.85	34.5%	
	BE_sub_2_6	B81	581148	144006			28.35	16.5%	
	BE_sub_2_7	B77D	580485	144293			10.94	6.5%	
BE_sub_3	BE_sub_3_A	FSA (reservoir)	565738	149683	190			1.6%	Intervening area of the River Beult. This was derived

Inflow QTBDY	Lateral node label	Connected ISIS node	Easting (m)	Northing (m)	Area in Routing/FF model (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) SUB-AREA Area	Weighting	Comment
	BE_sub_3_B1	CO500	565991	149025				0.35%	by assessing the relative contribution of the numerous ordinary watercourse and Main River channels which are located within this inflow area and weighting the inflows accordingly.
	BE_sub_3_B2	CO400	566206	148716				0.35%	
	BE_sub_3_B3	CO300	566506	148669				0.35%	
	BE_sub_3_B4	CO200	566923	148881				0.35%	
	BE_sub_3_B5	CO100	567282	149092				0.3%	
	BE_sub_3_C	S6d	569039	152734				7%	
	BE_sub_3_D	CS174	570854	153013				1.3%	
	BE_sub_3_E1	CS162	568659	151119				3.8%	
	BE_sub_3_E2	CS170	569991	152876				3.8%	
	BE_sub_3_E3	CS180	571612	153913				3.8%	
	BE_sub_3_F	CS142	568648	149442				6.4%	
	BE_sub_3_G	CS152	569191	149878				4.3%	
	BE_sub_3_H1	CS126	567901	148574				0.8%	
	BE_sub_3_H2	CS137d	568348	149086				0.8%	
	BE_sub_3_I1	B40	575089	148070				2.4%	
	BE_sub_3_I2	B39	574588	148201				2.4%	
	BE_sub_3_I3	B36	573708	148823				2.4%	
	BE_sub_3_I4	B35	5735270	148638				2.4%	
	BE_sub_3_I5	B30	572086	148307				2.4%	
	BE_sub_3_J1	B26	571264	148438				1.2%	
	BE_sub_3_J2	B22	570867	148756				1.2%	
	BE_sub_3_J3	B10	570401	149558				1.2%	
	BE_sub_3_J4	B9In1	569967	149769				1.2%	
	BE_sub_3_K1	T84	571968	140261				1.6%	
	BE_sub_3_K2	T83	572226	140582				1.6%	
	BE_sub_3_L	LT53DIn1	572591	140797				5.9%	
	BE_sub_3_M	T70In1	571676	143590				8.5%	
	BE_sub_3_N	T26In1	568537	147514				4.5%	
	BE_sub_3_O1	T72	572188	143091				2.2%	
	BE_sub_3_O2	T61	571003	144237				2.2%	
	BE_sub_3_O3	T40	569920	145859				2.2%	
	BE_sub_3_O4	T33	569183	146924				2.2%	
	BE_sub_3_O5	T18	568833	148309				2.2%	
	BE_sub_3_P	LT22D	573271	1445773				10%	

Inflow QTBDY	Lateral node label	Connected ISIS node	Easting (m)	Northing (m)	Area in Routing/FF model (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) TOTAL Area	Area in FEH CD-ROM v3 (km2) SUB-AREA Area	Weighting	Comment
	BE_sub_3_Q1	LT42	572751	143151				1.6%	
	BE_sub_3_Q2	LT33	573116	144523				1.6%	
	BE_sub_3_Q3	LT13D	572859	146885				1.6%	
Stonebridge	n/a	T91	571589	139155	134	133.27	133.27	100%	River Teise inflow (upstream of Stone Bridge gauging station).
Dummy inflows									
CS40	n/a	CS40	559621	146446	n/a	n/a	n/a	100%	Dummy inflow for connection purposes on River Medway (ISIS fails if a QTBDY is not connected directly at upstream of channel).
TONB01_0017D	n/a	TONB01_0017D	559947	146321	n/a	n/a	n/a	100%	Dummy inflow for connection purposes on Botany Stream (ISIS fails if a QTBDY is not connected directly at upstream of channel).
MS_08	n/a	MS_08	559661	146906	n/a	n/a	n/a	100%	Dummy inflow for connection purposes on Mill Stream (ISIS fails if a QTBDY is not connected directly at upstream of channel).
BO26D	n/a	BO26D	563812	148456	n/a	n/a	n/a	100%	Dummy inflow for connection purposes on the River Bourne (ISIS fails if a QTBDY is not connected directly at upstream of channel).
TD3-D2	n/a	T73D	572484	142782	n/a	n/a	n/a	100%	Dummy inflow to retain consistency with inflow schematisation of flood forecasting model used for continuous simulation hydrological modelling.
LT44-WU-D1	n/a	LT44D	572509	142784	n/a	n/a	n/a	100%	Dummy inflow to retain consistency with inflow schematisation of flood forecasting model used for continuous simulation hydrological modelling.
Sweet	Sweet_01	STON02_0163	571599	139612	n/a	n/a	n/a	100%	Dummy inflow for bypass channel on River Teise.
FSA	n/a	FSA (reservoir)	565738	149683	n/a	n/a	n/a	100%	Dummy inflow into Flood Storage Area (FSA) reservoir unit.
Dummy	n/a	CO600	565800	149502	n/a	n/a	n/a	100%	Dummy inflow into upstream of River Coult.

*FEH CD-ROM does not show Pen Stream catchment clearly. Total area equals catchment area downstream of small tributary (561650 147550) minus Mill Stream contributing area (560700 147450), plus catchment area of drain on right bank (MI01_2).

D Structure photos

D.1 River Medway

Return to section **B.1**.

CS70LU (looking downstream)

(upstream lock gates)

CS76BU

CS83LU (looking downstream)

(looking upstream)

CS93LU (upstream view)

CS93FPU

CS114RU (right hand side)

CS114FU (far left hand side)

PECK_0307bu

CS114LU

CS114SWU and CS114VWU (left hand side)

PECK_0741bu

PECK02_0185

PECK_0132bu

PECK_0461bu

PECK_0010bu

CS147VU

CS147UWU and CS147LWU

S4.001bu

S4.002bu

S6bu

CS172LU (Lock at back of photo)

CS172VU (right hand side)

CS172WU (left hand side)

D.2 River Beult

Return to section **B.2.**

B118BU

B115WB, B115BU and B115WU

B107BU

B104BU, B102WU1, B102WU2 and B102WU3

B94BU

B90WB

B90BU

B88WU

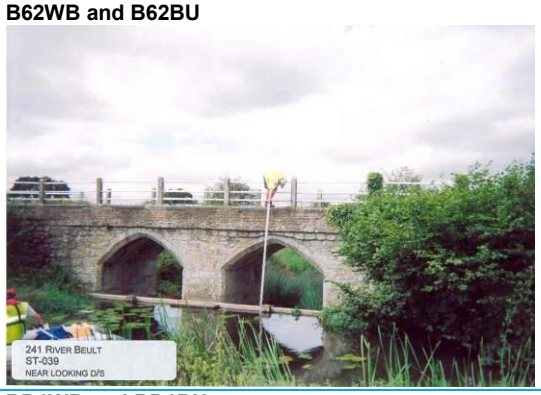
B85BU

B83BU

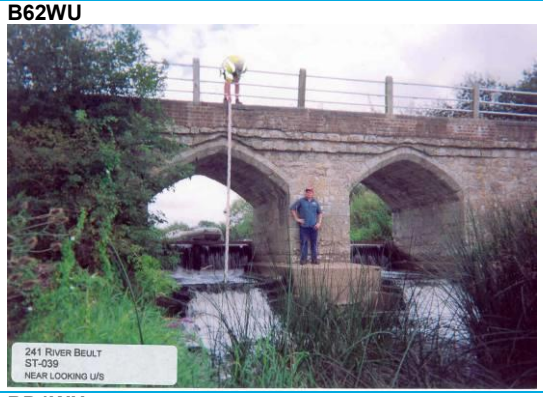
B79BU

B75WB, B75BU, B73WU1 and B73WU2

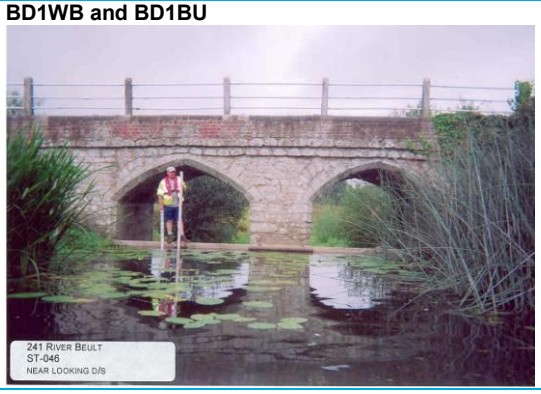
B62WB and B62BU



B62WU



BD1WB and BD1BU



BD1WU

BC2WD and BC2BU

BC2WU

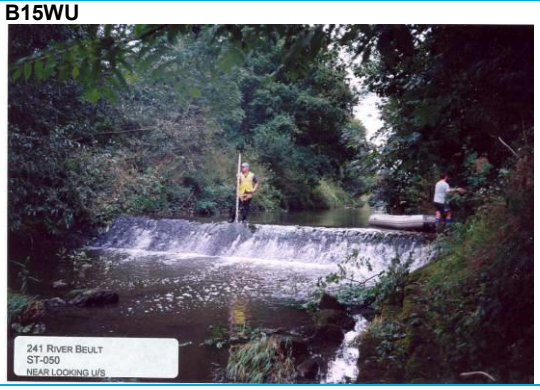
STIL_0252wb and STIL_0252bu

STIL_0133wu

B34BU

B20RU (back of photo)

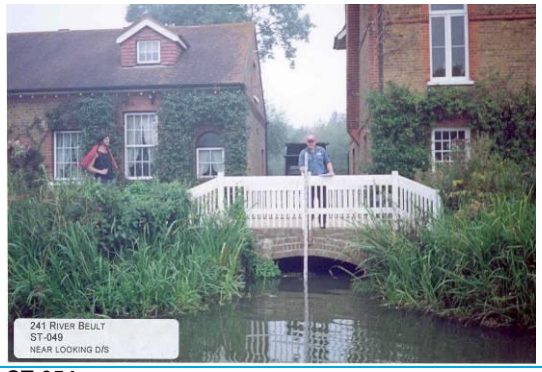
B15WU



BB18GU

B6BU

ST-049BU



ST-049GU

ST-054


241 River Beult
ST-048
NEAR LOOKING U/S


241 River Beult
ST-054
NEAR LOOKING D/S

BA3BU

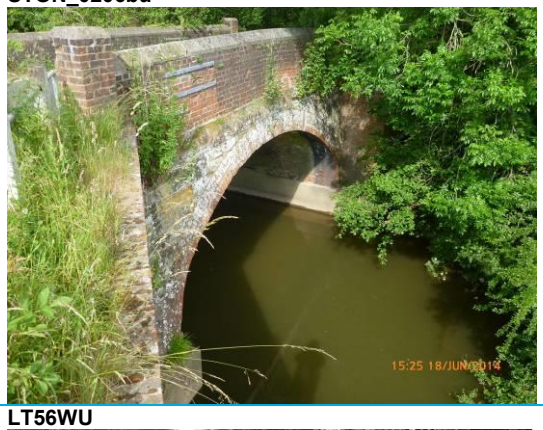

241 River Beult
ST-019
NEAR LOOKING U/S

D.3 River Teise

Return to section **B.3.**

STON_0066bu

STON_0206bu

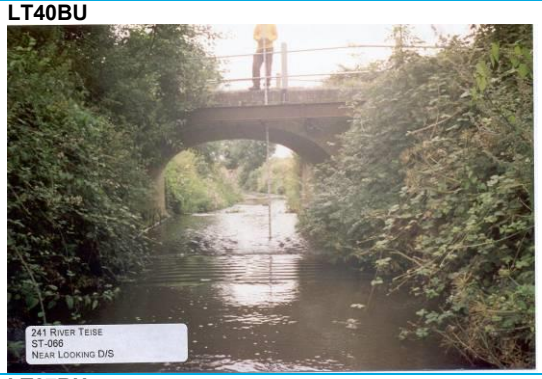


STON_0117wu

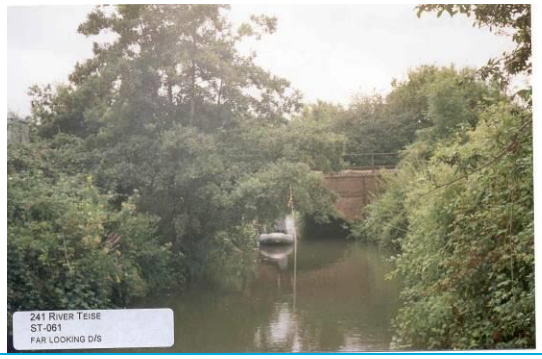
LT56WU

LT46WU

LT40BU



LT32BU



LT27RU

LT21BU

LT19WU

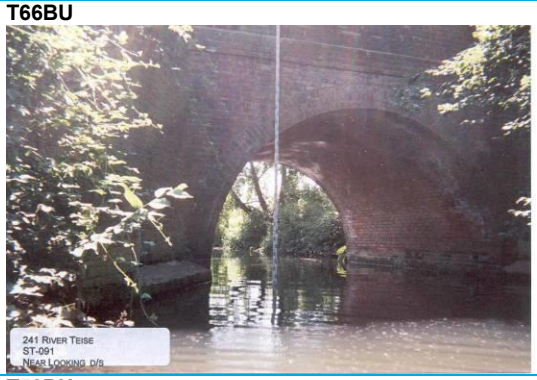
LT15WU

LT12WU

LT7WU

T66BU

T60GU



T52BU

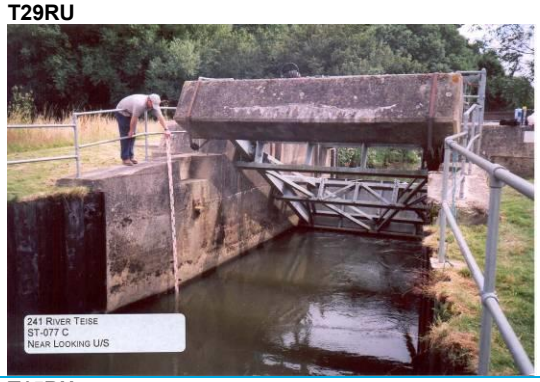
T47WU (submerged weir)

T43RU

T35BU

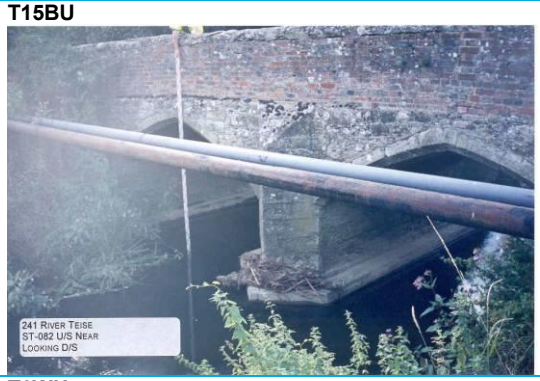
T30BU

T29RU

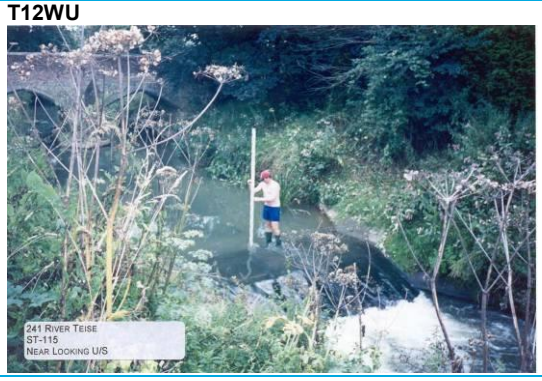


T24RU

T15BU



T12WU



T6WU

D.4 River Bourne

Return to section **B.4.**

BO21WU

BO16BU

BO13WU1and BO13WU2

BO13SYU

BO9BU

BO9WU

D.5 River Coult

Return to section **B.5.**

S8.001

D.6 Floodplain structures (ESTRY network)

Return to section **B.6**.

S2_001

S1.001

S5_002

S4_001

01.059

01_058

01.056

ST016_B6U

ST041_B75U (arch on left hand side - behind tripod)

XTD_295BC

XTD_293

XTD_294

XTD_302

XTD_306

XTD_305

XTD_343

XTD_338

XTD_342CDE:
342C

342D

342E

XTD_342F

XTD_349

PWS1_982A

3152

3917

343

E Roughness values used within the 1D hydraulic model

E.1 Introduction

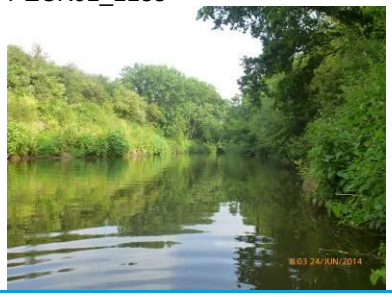
Model 3 consists of cross sections from a number of models and new survey. Roughness coefficients from the sections within the previous modelling studied have been reviewed and these roughness coefficients were not originally intended as adjusted. New channel survey data has also been included in the model, survey undertaken by Maltby Land Surveys Ltd in July 2014.

The purpose of this section is to outline the roughness values chosen for the new survey data on the River Medway. Where sections from the previous models are between sections from the 2014 survey data and the roughness coefficients chosen are reasonably different, the roughness coefficients of sections from the previous models was updated. There are a number of sources of reference for channel roughness values. Here, the main point of reference was Chow's (1959)[2] description of natural streams – minor streams.

In order to determine the roughness of the channel cross sections, photographic, survey data and satellite imagery was used in conjunction with Chow's (1959) Manning's *n* values.

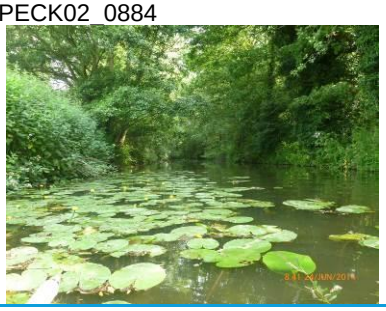
Unless otherwise stated the photographic evidence for the new channel survey is taken from the 2014 Maltby Land Survey Ltd survey undertaken in July. Given the photographs were taken in summer, it was kept in mind that assessing Manning's *n* values from these may result in conservative estimates of channel roughness (e.g. higher values compared with times of the year when vegetation growth may be less).

E.2 East Peckham (main channel)

Node label(s)	Manning's n	Photograph(s)
PECK01_1188 to PECK01_0621 and PECK01_0461 to PECK01_0010	Bed = 0.045 Banks = 0.055	PECK01_0010  PECK01_0461  PECK01_0621  PECK01_0741  PECK01_1188 

[2] Chow V.T. (1959) Open Channel Hydraulics McGraw Hill

E.3 East Peckham (secondary channel)

Node label(s)	Manning's n	Photograph(s)
PECK02_0046 to PECK02_0237	Bed = 0.050 Banks = 0.080	PECK02_0046  PECK02_0237  PECK02_0132 
PECK02_0280 to PECK02_0307	Bed = 0.050 Banks = 0.060	PECK02_0307 
PECK02_0454 to PECK02_0884	Bed = 0.050 Banks = 0.080	PECK02_0454  PECK02_0884 

E.4 Other sites

Node label(s)	Manning's n	Photograph(s)
S4.001	Bed = 0.045 Banks = 0.055	S4.001 (channel)  S4.001 (right bank) 
S4.002	Bed = 0.045 Banks = 0.055	S4.002 
S6u	Bed = 0.040 Banks = 0.055	S6.001 

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