Cambridge Waste Water Treatment Plant Relocation Project
Anglian Water Services Limited

Appendix 20.5 Fluvial Model Report

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1. Introduction

1.1 Background

The Cambridge Wastewater Treatment Plant (WWTP) Relocation project, also known as CWWTPRP, includes the relocation of the existing WWTP. The project scope also includes an extension of the existing Riverside Sewer Tunnel to convey flows to the proposed new WWTP location and a new outfall to discharge effluent from the WWTP into the River Cam.

This report describes the river modelling to assess the impact of outfall discharges on fluvial flood levels in the River Cam.

1.2 Flood Risk Assessment

The project falls into the category of being 1 hectare or greater in Flood Zone 1 or a proposal located in Flood Zones 2 and 3 and therefore must be accompanied by a Flood Risk Assessment (FRA). The CWWTPRP is now at the stage where the FRA is required. The FRA will:

- Identify and assess the risks of all sources of flooding to and from the project.
- Demonstrate how these flood risks will be managed.
- Take climate change into account.
- Help develop the design of the new outfall.

For the FRA it is proposed that three stages of modelling are carried out to understand the impact of the new WWTP and associated outfall on the local fluvial and land environment:

- Stage 1: river modelling of the River Cam using an existing one-dimensional (1D) – two-dimensional (2D) hydraulic model of the River Cam. This is to assess fluvial flood levels throughout the River Cam and the relative impact of the new outfall compared to existing conditions.
- Stage 2: river and outfall modelling using a new local hydrodynamic model of the River Cam in the vicinity of the new outfall (in 2D or 3D). This is to assess velocities and mixing of the effluent as it enters the River Cam.
- Stage 3: outfall modelling using Computational Fluid Dynamics (CFD). This is to inform the design of the outfall, for example to prevent scour of the river bed and opposite bank.

There is also potential for a further consideration of fluvial-geomorphology modelling. Detailed design of the relevant parts of the project will link into and be informed by the modelling results.

This report only covers the Stage 1 modelling.

2. Scope

The scope provided for this work in the Project Brief is:

> *"Carry out hydraulic modelling of the River Cam to determine the baseline flows and water levels along the river. Modelling is also required across a range of return periods to determine the impact on water levels, flows, etc. and determine the likely impacts from flooding along the watercourse.*
>
> *It is understood that, based on the location of the outfall and the surrounding area, the design flood standard should be 1 in 100 years (typical design standard for "Built-up Areas") in Table 10.1/pg133 of CIRIA 786 (Culvert, Screen and Outfall Manual, 2019).*
>
> *The model should include appropriate allowances for the potential effects of climate change.*
>
> *The model of the River Cam is required (based on the EA ISIS data and Lidar sets) to assist with the design development of the proposed outfall for the new Cambridge Waste Water Treatment Plant at the location shown on Drawing No. 00000-100006-CAMEST-FED-GAR-C-3110. The modelling is to assess the impact of discharging Final Effluent and Storm Flows from the proposed outfall. The current flows are as follows although these are to be confirmed by CWRP Ltd/@One prior to commencement of the modelling:*
>
> *Max FE outfall flow = 2.2m^3/s; Max outfall storm flow = 5m^3/s (tbc); Total max outfall flow (FE and storm) = 7.2m^3/s (tbc)."*

3. Implementation

3.1 Model version

We have been provided with the "Cam Phase 2 – Cam Urban" existing Environment Agency (EA) ISIS – Tuflow model of the River Cam through Cambridge. We have a copy of the Product 7 model files (but no model results or documentation), downloaded from the Anglian Water data storage system. From the version of Tuflow used, and the run file names, the model appears to date from 2011.

It is noted by Chris Swain of the Environment Agency in his email from the 21st June 2021 that:

> *"The EA are updating the Cam model (through Jacobs) in the 2021 financial year and likely including the existing outfall, may be able to use this model as it nears completion"*

We understand that the updated Cam model has not yet been finalised so that the 2011 model remains the most up-to-date model available. As such, we have used the 2011 model version for this study.

3.2 Modifications to the model

No changes have been made to the hydraulic model except:

- A very minor change to the model (renaming one model node) that was required to get the model to run. This could be related to software changes in the last 10 years. We have used up-to-date versions of Flood Modeller Pro (FMP, version 5.0, formerly ISIS) and Tuflow (build 2020-10-AA) for these runs.

- Adding inflow locations for the existing and new WWTP outfall discharges, which were not represented explicitly in the model provided.

    - Existing WWTP outfall – immediately upstream of the A14 bridge, left bank.

    - New WWTP outfall – immediately downstream of the A14 bridge right bank.

Note that the 'existing WWTP outfall' refers only to the existing outfall at Milton. There is also:

- An outfall at Waterbeach (around 4km downstream of the site), which currently discharges but will cease when the new WWTP is in place. This has not been added to the model.

- The Riverside CSO (combined sewer overflow), upstream within Cambridge itself. We were informed by the project team that this CSO "never flows". Again, this has not been added to the model.

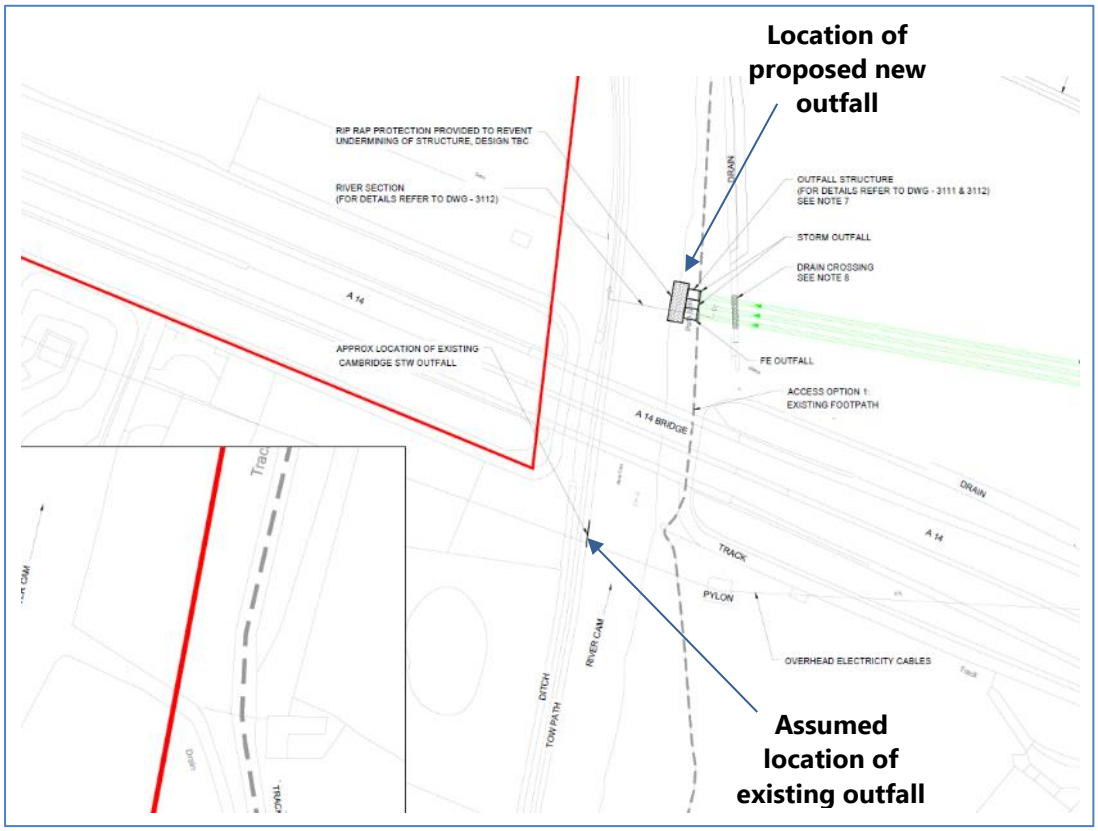


Figure 3.1. Locations of existing and new outfall (drawing 00000-100006-CAMEST-FED-GAR-C-3110)

3.3 Fluvial flood inflows

Design floods are implemented in the River Cam model as 14 inflows representing a 61 hour storm over the whole 791km^2 River Cam catchment. Details of these fluvial inflows are provided in Table 3.2 for the 1 in 100 year plus climate change (20% uplift) flood and their locations are shown in Figure 3.2.

Inflow files were provided for the 1 in 5, 10, 20, 25, 50, 75, 100, 200 and 1000 year floods, along with the 1 in 100 year flood plus climate change. However, it was straightforward to modify the inflows to create the other flood magnitudes required. These peak inflows are shown in Table 3.2.

Note that the hydrological approach used in the model is not up-to-date in terms of methodology (FEH rainfall-runoff model) so will likely be superseded in the new modelling being undertaken for the EA. However, it is not within the scope of our study to review or update the model inflows.

Alternative peak inflows for the 1 in 100 year plus climate change flood were calculated as part of this study (by adjusting the storm duration in the model input files) and are shown in Table 3.2 for a 4 hour design storm. This is a sensitivity test to match the design storm duration used in the WWTP outfall flow modelling.

Table 3.1. Information on fluvial flood inflows within river model (1 in 100 year plus climate change)

Model inflow name	Description	Catchment area (km^2)	1 in 100 year plus CC peak flow (m^3/s)	
			61 hour catchment storm	4 hour WWTP storm
C1	River Granta (at Stapleford)	115.1	18.5	12.1
C2	River Cam (at Dernford)	201.8	18.9	9.3
C3	River Rhee (at Burnt Mill)	305.6	26.3	14.4
C4	Bourn Brook	87.5	33.1	26.1
C5	Bin Brook	16.8	8.9	10.5
C6	Hobson's Brook	14.1	2.1	2.1
C7	Cherry Hinton Brook	10.8	1.8	3.5
C8	Lateral to Byron's Pool	16.5	5.6	5.8
C9	Lateral to Jesus Green	9.9	5.4	14.5
C10	Lateral to Baits Bite	12.9	6.5	17.7
C11	Lateral to River Great Ouse	24.8	4.7	3.7
Bottisham PS	Pumped inflow from Bottisham Lode	-	3.4	3.4
Swaffham PS	Pumped inflow from Swaffham Lode	-	2.3	2.3
Upware PS	Pumped inflow from Reach Lode	-	2.5	2.5

Table 3.2. Information on fluvial flood inflows within river model (other flood magnitudes)

Model inflow name	Peak flow (m^3/s)								
	1 in 2	1 in 10	1 in 20	1 in 30	1 in 50	1 in 75	1 in 100	1 in 200	1 in 1000
C1	3.3	8.0	10.1	11.2	13.0	14.4	15.5	18.4	28.6
C2	3.5	8.0	10.0	11.3	13.2	14.5	15.7	18.9	30.1
C3	4.8	11.6	14.5	16.1	18.6	20.5	22.0	26.1	39.8
C4	7.9	16.2	19.4	21.3	24.0	26.0	27.6	31.8	45.6
C5	2.2	4.4	5.3	5.8	6.5	7.0	7.4	8.6	12.2
C6	0.2	0.8	1.0	1.2	1.4	1.6	1.7	2.1	3.5
C7	0.2	0.6	0.8	0.9	1.0	1.2	1.3	1.7	2.9
C8	1.2	2.6	3.2	3.5	4.0	4.3	4.6	5.4	7.9
C9	1.3	2.3	2.8	3.1	3.5	3.9	4.2	4.9	7.4
C10	1.6	2.8	3.3	3.7	4.2	4.6	4.9	5.9	8.8
C11	0.8	2.0	2.6	2.9	3.3	3.7	3.9	4.7	7.2
Bottisham PS	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Swaffham PS	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Upware PS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Figure 3.2. Location of inflow nodes from the model

3.4 Climate change

The scope requires that the model should include appropriate allowances for the potential effects of climate change. In the existing river model, the 100-year plus climate change flood is represented by a 20% uplift in flow rate. The EA released new climate change allowances in July 2021[1], with the values in Table 3.3 showing their values for the River Cam catchment. The model allowance of 20% for climate change uplift is similar to the values identified by the EA for 2050s Upper (22%) and 2080s Higher (19%). Therefore, we have retained the 20% uplift for climate change in the model simulations.

[1] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Table 3.3. Climate change allowances for Cam and Ely Ouse Management Catchment

Epoch	Central	Higher	Upper
2020s	2%	7%	21%
2050s	-2%	5%	22%
2080s	9%	19%	45%

3.5 Model inflows – outfall discharge

For the existing outfall:

- Outfall discharges were provided by the Binnies Network Modelling team from their sewer model of Cambridge, used in the WWTP design.
- Initially only flows for the 1 in 100 year (1% annual exceedance probability) flood including climate change allowance were available. This was for a 4 hour (239 minute) design storm.
- This is the combined discharge from the existing lagoon and flow to full treatment (FFT) from the existing WWTP.
- Discharge was applied as a hydrograph input to the model, as shown in Figure 3.3.
- Was only included for the existing WWTP scenarios (zero inflow is applied for the future WWTP scenarios).
- Has a peak flow of 3.8m^3/s, occurring 5 hours after the start of the rainfall event.

For the new outfall:

- Outfall discharges were provided by the Binnies Network Modelling team from their sewer model of Cambridge, used in the WWTP design.
- This is the combined discharge from the ten pumps (pumps 1-9 and pump A). The 14,000m^3 storm storage tank within the new WWTP has been accounted for in the calculation.
- Was applied as a hydrograph input to the model, as shown in Figure 3.4.
- Was only included for the future WWTP scenarios (zero inflow is applied for the existing WWTP scenarios).
- Has a peak flow of 7.0m^3/s, occurring 3.5 hours after the start of the rainfall event.

After the draft version of this report was issued, the project team requested the analysis was extended to cover other flood magnitudes. The same process was repeated to cover the 1 in 2, 10, 20, 30, 50, 75, 100, 200 and 1000 year floods.

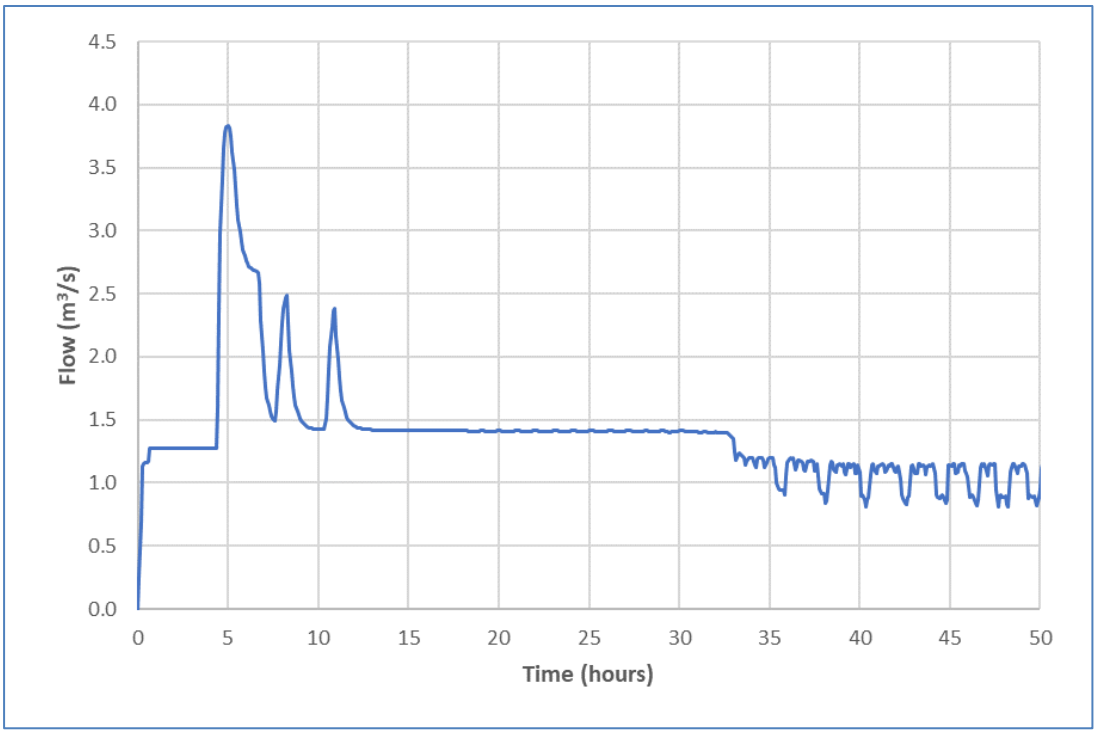


Figure 3.3. Existing outfall discharge (1 in 100 year flood plus climate change)

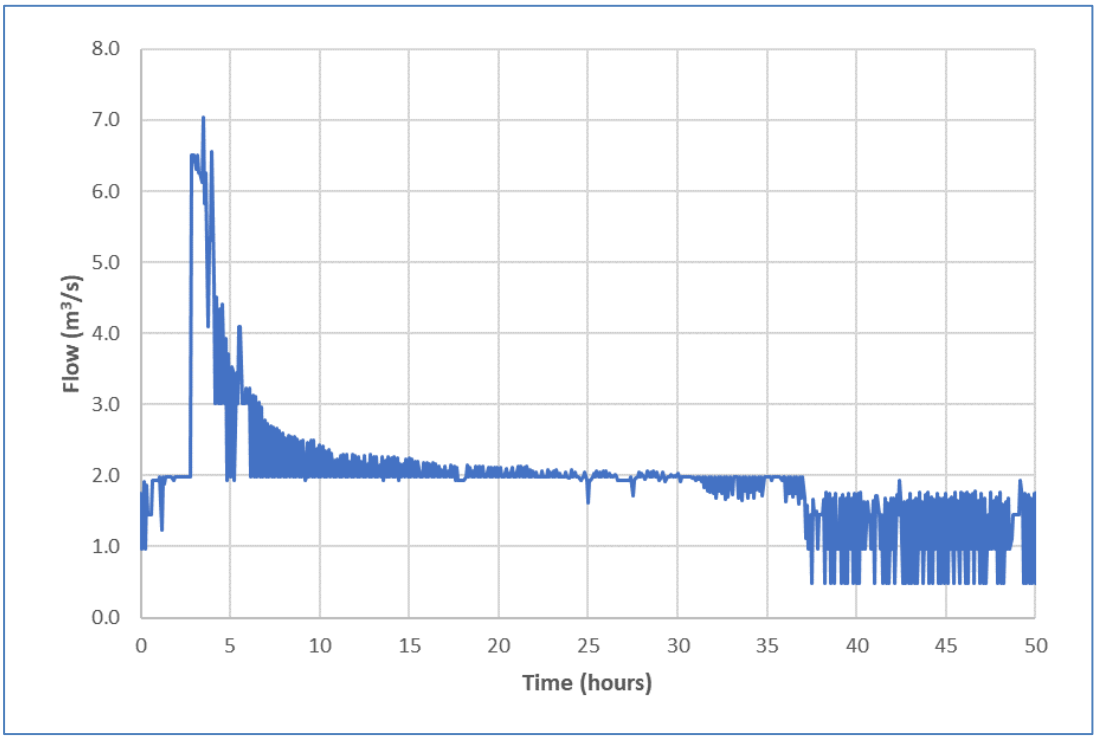


Figure 3.4. New outfall discharge (1 in 100 year flood plus climate change)

As noted in Section 3.3, the River Cam model uses a storm duration of 61 hours, compared to the 4 hour duration used in the WWTP model to derive the outfall discharges. This reflects the different runoff mechanisms between an urban drainage/sewer system and a large river catchment. To address this disparity, we took the following approach:

1. Base case assumption that the outfall discharge begins at the centroid of the rainfall in the fluvial river model. That is, the outfall discharges shown in Figure 3.3 and Figure 3.4 are offset by 30 hours. This is a conservative simplification given the different storm durations used for river and WWTP flows.

2. Sensitivity test with the outfall discharge occurring 15 hours earlier than in the base case (outfall discharge offset by 15 hours from the fluvial flows).

3. Sensitivity test with the outfall discharge occurring 15 hours later than in the base case (outfall discharge offset by 45 hours from the fluvial flows).

4. Sensitivity test using a 4 hour design storm for the whole River Cam catchment. Therefore, no offset was required for the outfall discharge.

3.6 Scenarios to run

The scenarios that were simulated are listed in Table 3.4. As noted above, initially for the draft version of this report only the 1 in 100 year plus climate change case was tested (runs 1 to 8). However, at the project team's request, this was then expanded to include a range of other flood magnitudes (runs 9 to 26).

Table 3.4. Modelling scenarios to be carried out

Run no.	Type	Flood magnitude (fluvial and outfall flow)	Storm duration (hours)	Existing outfall flow	New outfall flows	Outfall flow offset
1	Base	1 in 100 plus climate change	61	✓	×	30 hours
2	Base	1 in 100 plus climate change	61	×	✓	30 hours
3	Sensitivity test 1	1 in 100 plus climate change	61	✓	×	15 hours
4	Sensitivity test 1	1 in 100 plus climate change	61	×	✓	15 hours
5	Sensitivity test 2	1 in 100 plus climate change	61	✓	×	45 hours
6	Sensitivity test 2	1 in 100 plus climate change	61	×	✓	45 hours
7	Sensitivity test 3	1 in 100 plus climate change	4	✓	×	0 hours

Run no.	Type	Flood magnitude (fluvial and outfall flow)	Storm duration (hours)	Existing outfall flow	New outfall flows	Outfall flow offset
8	Sensitivity test 3	1 in 100 plus climate change	4	×	✓	0 hours
9	Base	1 in 2	61	✓	×	30 hours
10	Base	1 in 2	61	×	✓	30 hours
11	Base	1 in 10	61	✓	×	30 hours
12	Base	1 in 10	61	×	✓	30 hours
13	Base	1 in 20	61	✓	×	30 hours
14	Base	1 in 20	61	×	✓	30 hours
15	Base	1 in 30	61	✓	×	30 hours
16	Base	1 in 30	61	×	✓	30 hours
17	Base	1 in 50	61	✓	×	30 hours
18	Base	1 in 50	61	×	✓	30 hours
19	Base	1 in 75	61	✓	×	30 hours
20	Base	1 in 75	61	×	✓	30 hours
21	Base	1 in 100	61	✓	×	30 hours
22	Base	1 in 100	61	×	✓	30 hours
23	Base	1 in 200	61	✓	×	30 hours
24	Base	1 in 200	61	×	✓	30 hours
25	Base	1 in 1000	61	✓	×	30 hours
26	Base	1 in 1000	61	×	✓	30 hours

4. Model results

4.1 General

The river modelling results are presented as:

- Tables of peak water levels and flows (Table 4.1 to Table 4.4 for the 1 in 100 year plus climate change flood; Appendix A for other flood magnitudes) in the River Cam. Note that the flows are based on the FMP results only so do not include bypassing alongside the river in the floodplain. The node locations for these comparison points are shown in Figure 4.2.

- Simple flood extent maps (Figure 4.1, and Figure 4.3 to Figure 4.5 for the 1 in 100 year plus climate change flood; Appendix B for other flood magnitudes).

4.2 Base case – 1 in 100 year plus climate change

The base case comparison of results for the 1 in 100 year plus climate change flood is shown in Table 4.1 and Figure 4.1. These results indicate that:

- There is almost no change in peak water levels, flows or flood extents with the new WWTP outfall compared to the existing WWTP.

- The maximum predicted increase in peak water level is 0.007m (7mm) at Baits Bite Lock.

- Elsewhere the predicted increase in peak water levels is even smaller:

    - Either 1mm or zero increase upstream of the A14 through Cambridge.

    - A 3mm increase between the A14 and Baits Bite Lock and downstream of Shrubbs Marina.

    - A 3-6mm increase between Horningsea and Bottisham Lock.

- The changes in peak flow are 0.3m^3/s or smaller (which is a very small proportion of the total flow in the River Cam, which is around 90m^3/s). This is because the peak WWTP discharge occurs well before the river peak flow.

- There is no perceptible change in flood extent (Figure 4.1), which is unsurprising given how small the water level changes are.

Note that, with changes this small, to some extent they may be due to minor differences in the iterative numerical solution produced by FMP-Tuflow rather than genuine physically based differences. For example: (1) there is not a logical explanation for the 0.1m^3/s change in flow at the M11 crossing with no other difference predicted upstream of the A14; and (2) the water level convergence tolerance for each model iteration is 0.01m. Normally we would only present water level results to two decimal places (to the nearest centimetre), reflecting the accuracy possible with a hydraulic model of this type. But in this case, as the differences are so small, we have shown three decimal places to avoid misleading rounding effects. This could create a misleading impression of the accuracy of the model predictions.

Table 4.1. Base case – 1 in 100 year plus climate change, 61 hour storm, 30 hour outfall flow offset

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		**Level (m)**
M11	CA27350	9.507	9.507	0.000
A1134 Fen Causeway	CA22770	7.644	7.644	0.000
Silver Street	CA22230us	7.426	7.426	0.000
Trinity Bridge	CA21670	7.132	7.132	0.000
Bridge Street	CA21250	6.557	6.557	0.000
Victoria Avenue	CA20440	5.941	5.942	0.001
A1134 Elizabeth Way	CA19600us	5.699	5.700	0.001
Railway	CA17720	5.314	5.314	0.000
A14	CA15730	4.671	4.674	0.003
Baits Bite Lock US	CA15170J	4.587	4.590	0.003
Baits Bite Lock DS	CA15140	4.372	4.379	0.007
Horningsea	CA14200	4.214	4.220	0.006
Waterbeach	CA12080J	4.006	4.011	0.005
Bottisham Lock US	CA10600J	3.835	3.838	0.003
Bottisham Lock DS	CA10560	3.738	3.742	0.004
Shrubbs Marina	Cam8647	3.603	3.606	0.003
Upware	Cam4930	3.504	3.507	0.003
A1123	Cam2651u	3.452	3.455	0.003
Great Ouse confluence	Cam0000	3.396	3.399	0.003
		Peak flow (m^3/s)		**Flow (m^3/s)**
M11	CA27350	63.1	63.2	0.1
A1134 Fen Causeway	CA22770	42.0	42.0	0.0
Silver Street	CA22230us	4.7	4.7	0.0
Trinity Bridge	CA21670	91.6	91.6	0.0
Bridge Street	CA21250	94.3	94.3	0.0
Victoria Avenue	CA20440	93.2	93.2	0.0
A1134 Elizabeth Way	CA19600us	92.0	92.0	0.0
Railway	CA17720	85.7	85.7	0.0
A14	CA15730	93.4	93.5	0.1
Baits Bite Lock US	CA15170J	56.1	56.2	0.1
Baits Bite Lock DS	CA15140	56.1	56.2	0.1
Horningsea	CA14200	46.0	45.8	-0.2
Waterbeach	CA12080J	58.0	57.9	0.0
Bottisham Lock US	CA10600J	74.5	74.6	0.1
Bottisham Lock DS	CA10560	74.5	74.6	0.1
Shrubbs Marina	Cam8647	76.8	76.9	0.1
Upware	Cam4930	74.2	74.5	0.3
A1123	Cam2651u	73.9	74.1	0.2
Great Ouse confluence	Cam0000	60.3	60.3	0.1

Figure 4.1. Base case – 1 in 100 year plus climate change, 61 hour storm, 30 hour outfall flow offset

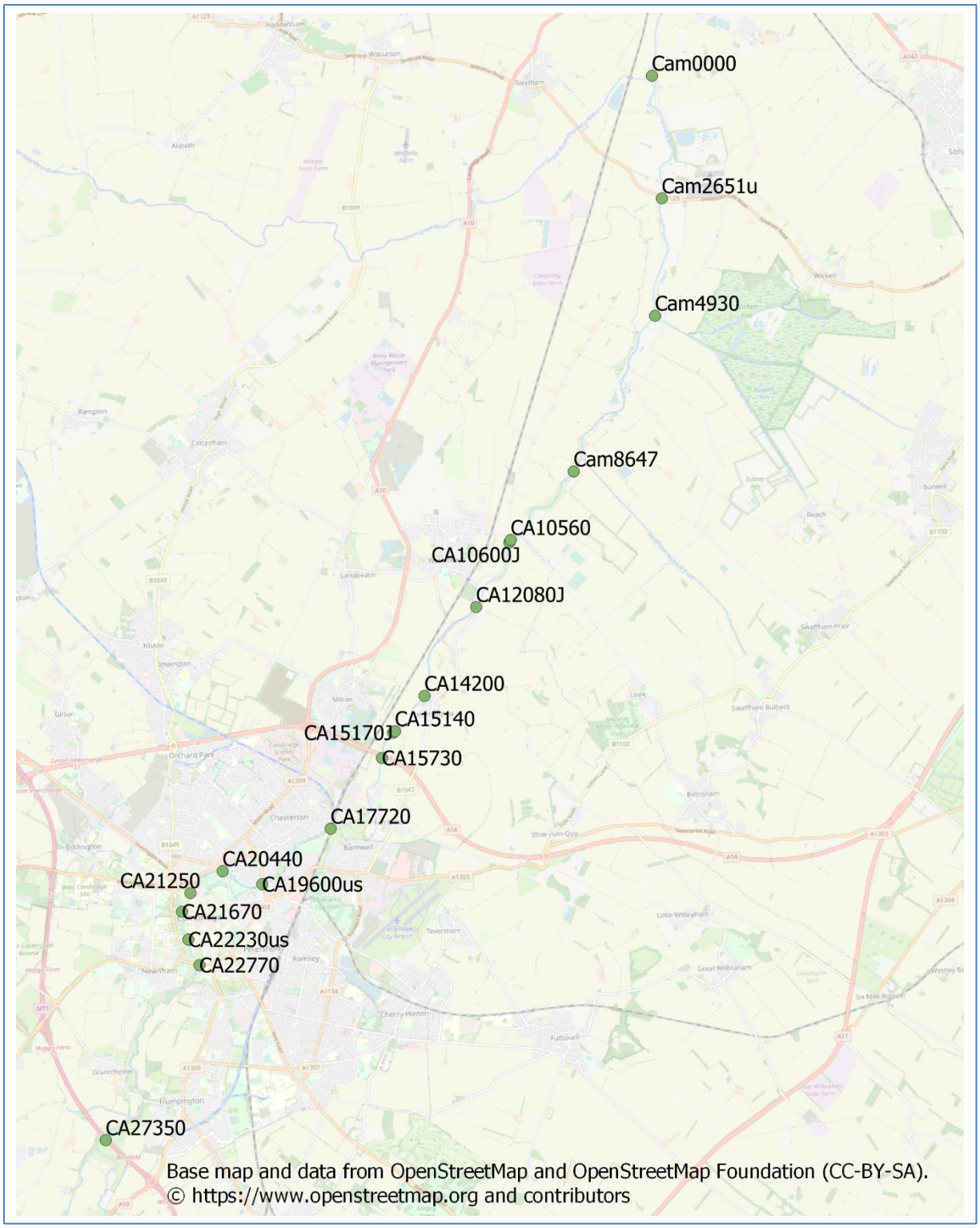


Figure 4.2. Comparison node locations

4.3 Sensitivity testing – 1 in 100 year plus climate change

The sensitivity testing results in Table 4.2 to Table 4.4 and Figure 4.3 to Figure 4.5 indicate that:

- The predicted increases in peak water levels are even smaller with the alternative offsets for the 61 hour storm duration:
    - Table 4.2 shows a maximum increase of only 2mm in any location, with a shorter offset for the outfall discharge (sensitivity test 1).
    - Table 4.3 shows a maximum increase of only 4mm, with a longer offset for the outfall discharge (sensitivity test 2).
    - This suggests the 30 hour offset for the outfall discharge is a conservative assumption for the 61 hour catchment storm.
    - Again, there is no perceptible difference in the flood extents for either sensitivity test, or compared to the base case.
- For the 4 hour catchment storm duration (sensitivity test 3):
    - The relative impact of the new WWTP outfall discharge is larger (up to 15mm) but still very small.
    - There is almost no impact upstream of the A14 (2mm or less) whereas the impact increases moving downstream along the River Cam (6 to 15mm).
    - Peak water levels in the River Cam are much lower (0.3 to 1.1m) than for the 61 hour storm duration. This illustrates that the critical storm duration for the WWTP is very different to the river catchment.
    - There is still no perceptible difference in flood extent between the existing and new WWTP outfall discharges.
    - The flood extent is much smaller than for the 61 hour storm.

Table 4.2. Sensitivity test 1 – 1 in 100 year plus climate change, 61 hour storm, 15 hour outfall flow offset

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		**Level (m)**
M11	CA27350	9.506	9.507	0.001
A1134 Fen Causeway	CA22770	7.644	7.644	0.000
Silver Street	CA22230us	7.426	7.426	0.000
Trinity Bridge	CA21670	7.132	7.131	-0.001
Bridge Street	CA21250	6.557	6.557	0.000
Victoria Avenue	CA20440	5.941	5.941	0.000
A1134 Elizabeth Way	CA19600us	5.699	5.699	0.000
Railway	CA17720	5.313	5.313	0.000
A14	CA15730	4.671	4.673	0.002
Baits Bite Lock US	CA15170J	4.586	4.588	0.002
Baits Bite Lock DS	CA15140	4.371	4.372	0.001
Horningsea	CA14200	4.210	4.211	0.001
Waterbeach	CA12080J	4.002	4.004	0.002
Bottisham Lock US	CA10600J	3.831	3.833	0.002
Bottisham Lock DS	CA10560	3.735	3.737	0.002
Shrubbs Marina	Cam8647	3.600	3.601	0.001
Upware	Cam4930	3.502	3.503	0.001
A1123	Cam2651u	3.450	3.452	0.002
Great Ouse confluence	Cam0000	3.394	3.395	0.001
		Peak flow (m^3/s)		**Flow (m^3/s)**
M11	CA27350	63.1	63.1	0.0
A1134 Fen Causeway	CA22770	42.0	42.0	0.0
Silver Street	CA22230us	4.7	4.7	0.0
Trinity Bridge	CA21670	91.6	91.5	0.0
Bridge Street	CA21250	94.3	94.3	0.0
Victoria Avenue	CA20440	93.2	93.2	0.0
A1134 Elizabeth Way	CA19600us	92.0	92.0	0.0
Railway	CA17720	85.6	85.6	0.0
A14	CA15730	93.3	93.5	0.1
Baits Bite Lock US	CA15170J	56.0	56.1	0.1
Baits Bite Lock DS	CA15140	56.0	56.1	0.1
Horningsea	CA14200	46.1	45.9	-0.2
Waterbeach	CA12080J	57.9	57.8	-0.1
Bottisham Lock US	CA10600J	74.3	74.2	0.0
Bottisham Lock DS	CA10560	74.3	74.2	0.0
Shrubbs Marina	Cam8647	76.7	76.6	0.0
Upware	Cam4930	74.0	74.1	0.1
A1123	Cam2651u	73.7	73.8	0.1
Great Ouse confluence	Cam0000	60.2	60.2	0.0

Table 4.3. Sensitivity test 2 – 1 in 100 year plus climate change, 61 hour storm, 45 hour outfall flow offset

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		**Level (m)**
M11	CA27350	9.506	9.506	0.000
A1134 Fen Causeway	CA22770	7.644	7.644	0.000
Silver Street	CA22230us	7.426	7.426	0.000
Trinity Bridge	CA21670	7.132	7.132	0.000
Bridge Street	CA21250	6.557	6.557	0.000
Victoria Avenue	CA20440	5.941	5.942	0.001
A1134 Elizabeth Way	CA19600us	5.699	5.699	0.000
Railway	CA17720	5.314	5.314	0.000
A14	CA15730	4.672	4.675	0.003
Baits Bite Lock US	CA15170J	4.588	4.590	0.002
Baits Bite Lock DS	CA15140	4.375	4.379	0.004
Horningsea	CA14200	4.216	4.220	0.004
Waterbeach	CA12080J	4.007	4.011	0.004
Bottisham Lock US	CA10600J	3.835	3.838	0.003
Bottisham Lock DS	CA10560	3.738	3.742	0.004
Shrubbs Marina	Cam8647	3.602	3.605	0.003
Upware	Cam4930	3.504	3.507	0.003
A1123	Cam2651u	3.452	3.455	0.003
Great Ouse confluence	Cam0000	3.396	3.399	0.003
		Peak flow (m^3/s)		**Flow (m^3/s)**
M11	CA27350	63.1	63.1	0.0
A1134 Fen Causeway	CA22770	42.0	42.0	0.0
Silver Street	CA22230us	4.7	4.7	0.0
Trinity Bridge	CA21670	91.6	91.5	0.0
Bridge Street	CA21250	94.3	94.3	0.0
Victoria Avenue	CA20440	93.2	93.2	0.0
A1134 Elizabeth Way	CA19600us	92.0	92.0	0.0
Railway	CA17720	85.6	85.6	0.0
A14	CA15730	93.4	93.5	0.2
Baits Bite Lock US	CA15170J	56.1	56.2	0.1
Baits Bite Lock DS	CA15140	56.1	56.2	0.1
Horningsea	CA14200	46.4	46.5	0.1
Waterbeach	CA12080J	58.1	58.1	0.0
Bottisham Lock US	CA10600J	74.6	74.8	0.2
Bottisham Lock DS	CA10560	74.6	74.8	0.2
Shrubbs Marina	Cam8647	77.0	77.2	0.2
Upware	Cam4930	74.3	74.5	0.2
A1123	Cam2651u	73.9	74.1	0.2
Great Ouse confluence	Cam0000	60.3	60.3	0.1

Table 4.4. Sensitivity test 3 – 1 in 100 year plus climate change, 4 hour storm, 0 hour outfall flow offset

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		**Level (m)**
M11	CA27350	9.073	9.073	0.000
A1134 Fen Causeway	CA22770	7.241	7.241	0.000
Silver Street	CA22230us	6.299	6.299	0.000
Trinity Bridge	CA21670	6.072	6.072	0.000
Bridge Street	CA21250	5.806	5.806	0.000
Victoria Avenue	CA20440	5.244	5.244	0.000
A1134 Elizabeth Way	CA19600us	5.082	5.083	0.001
Railway	CA17720	4.767	4.769	0.002
A14	CA15730	4.384	4.390	0.006
Baits Bite Lock US	CA15170J	4.244	4.250	0.006
Baits Bite Lock DS	CA15140	3.995	4.000	0.005
Horningsea	CA14200	3.742	3.747	0.005
Waterbeach	CA12080J	3.228	3.237	0.009
Bottisham Lock US	CA10600J	3.094	3.104	0.010
Bottisham Lock DS	CA10560	2.980	2.992	0.012
Shrubbs Marina	Cam8647	2.873	2.886	0.013
Upware	Cam4930	2.783	2.797	0.014
A1123	Cam2651u	2.731	2.745	0.014
Great Ouse confluence	Cam0000	2.654	2.669	0.015
		Peak flow (m^3/s)		**Flow (m^3/s)**
M11	CA27350	27.3	27.3	0.0
A1134 Fen Causeway	CA22770	33.2	33.2	0.0
Silver Street	CA22230us	1.8	1.8	0.0
Trinity Bridge	CA21670	45.2	45.2	0.0
Bridge Street	CA21250	45.4	45.4	0.0
Victoria Avenue	CA20440	45.4	45.4	0.0
A1134 Elizabeth Way	CA19600us	45.2	45.2	0.0
Railway	CA17720	44.3	44.3	0.0
A14	CA15730	44.1	44.1	0.0
Baits Bite Lock US	CA15170J	43.2	43.4	0.3
Baits Bite Lock DS	CA15140	43.2	43.4	0.3
Horningsea	CA14200	42.5	42.7	0.2
Waterbeach	CA12080J	40.8	41.3	0.5
Bottisham Lock US	CA10600J	40.4	40.7	0.2
Bottisham Lock DS	CA10560	40.4	40.7	0.2
Shrubbs Marina	Cam8647	43.7	44.0	0.3
Upware	Cam4930	45.6	45.9	0.3
A1123	Cam2651u	47.8	48.1	0.3
Great Ouse confluence	Cam0000	42.6	42.9	0.3

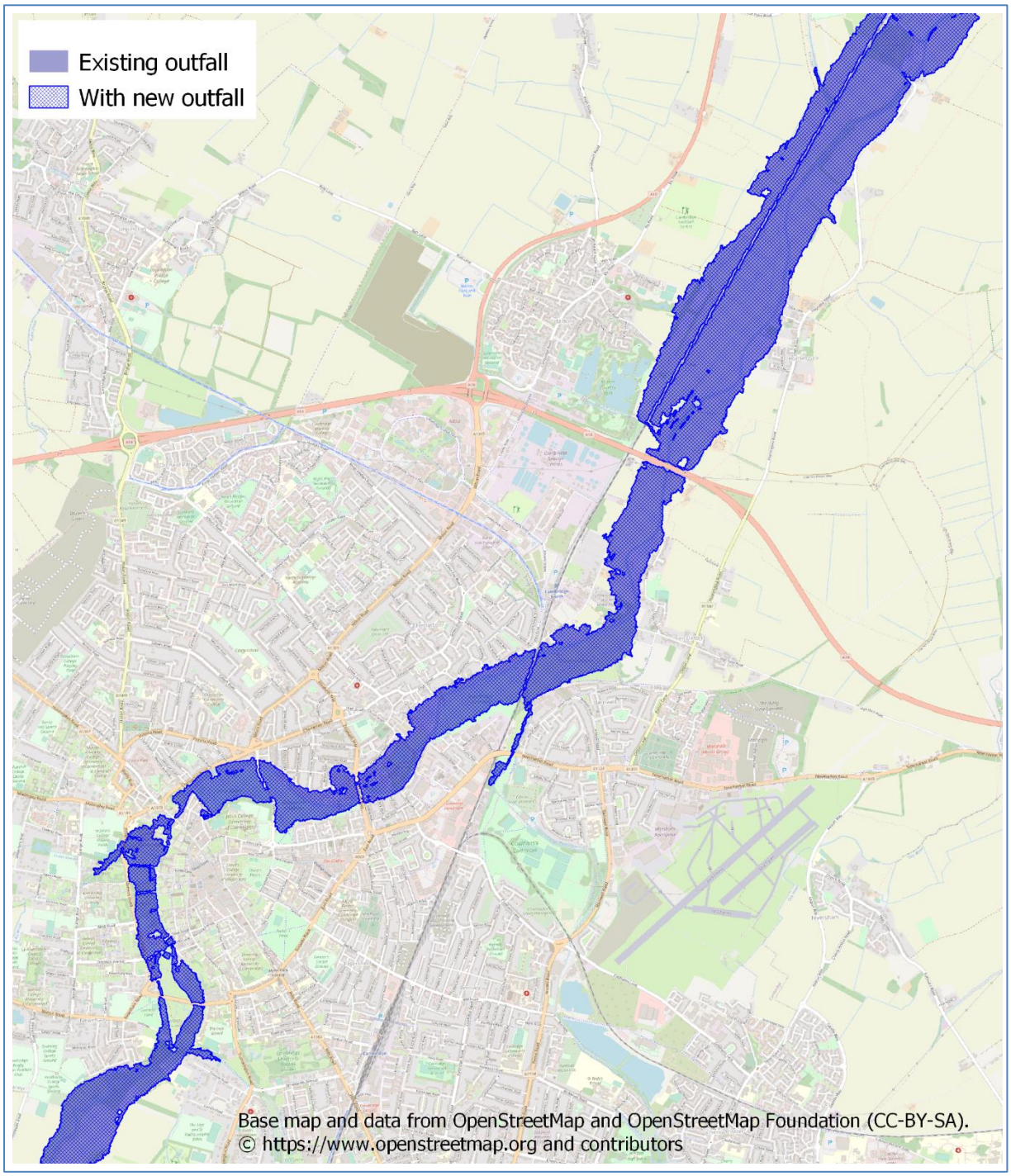


Figure 4.3. Sensitivity test – 1 in 100 year plus climate change, 61 hour storm, 15 hour outfall flow offset

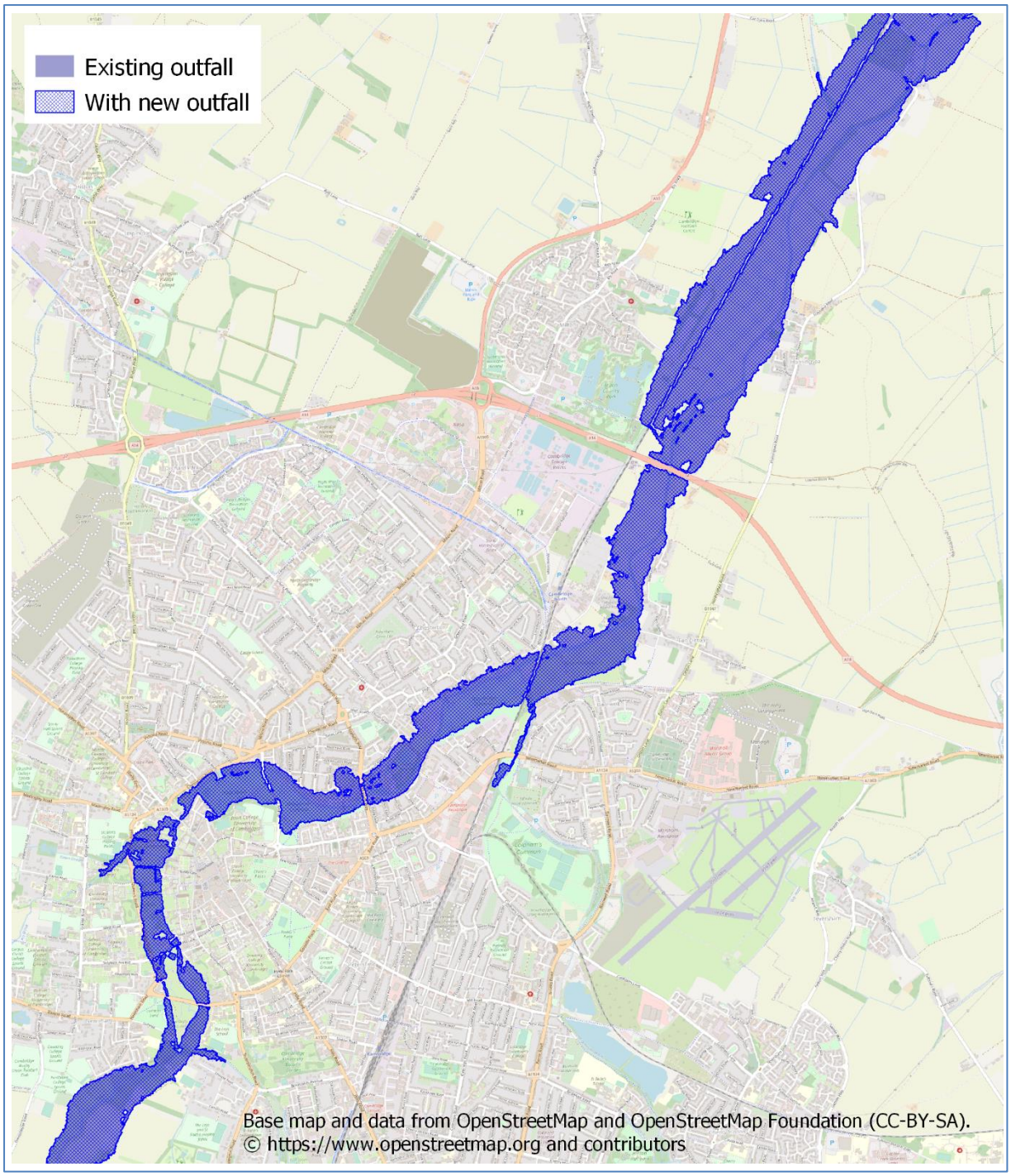


Figure 4.4. Sensitivity test – 1 in 100 year plus climate change, 61 hour storm, 45 hour outfall flow offset

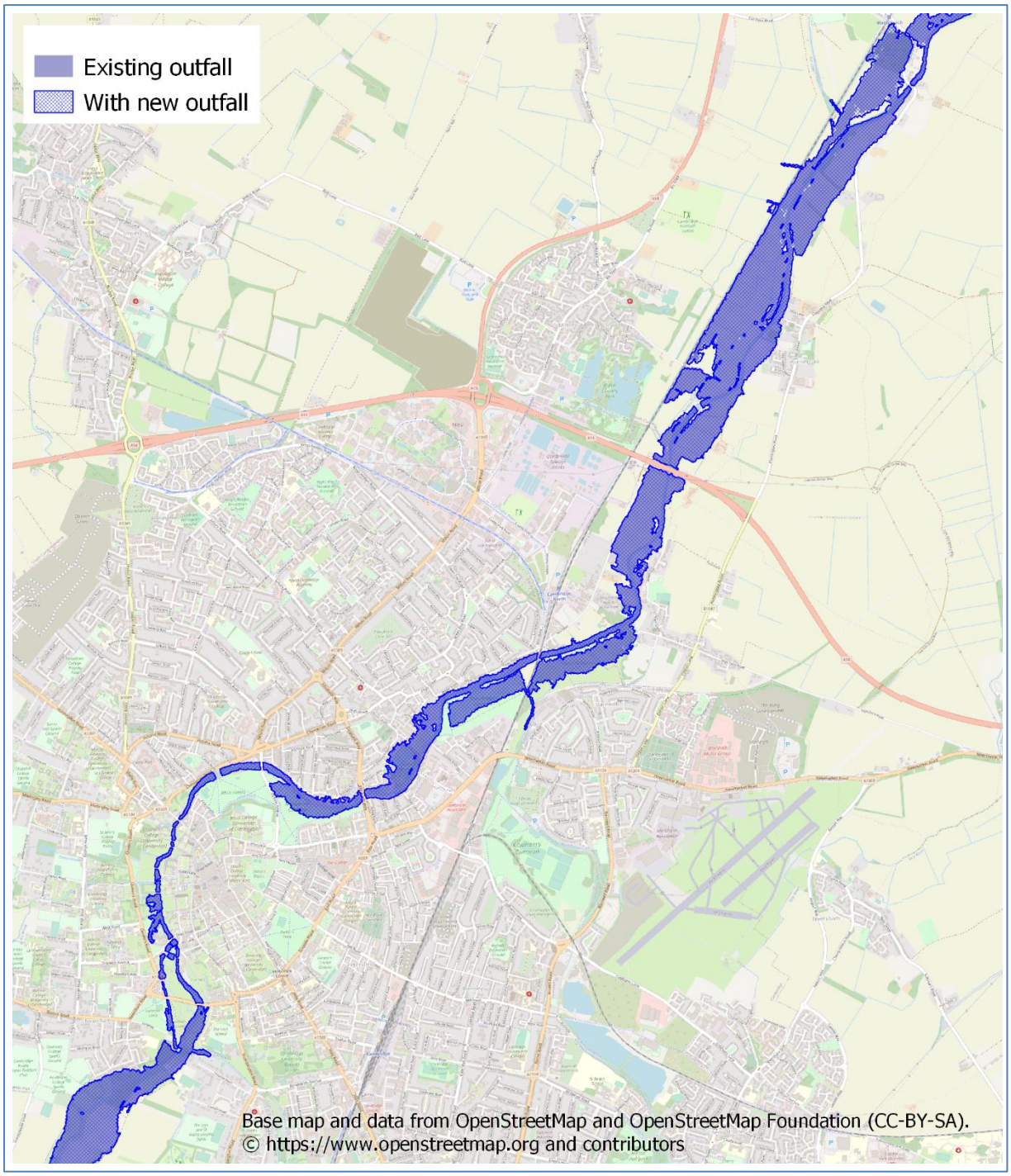


Figure 4.5. Sensitivity test – 1 in 100 year plus climate change, 4 hour storm, 0 hour outfall flow offset

4.4 Base case – other flood magnitudes

The results for other flood magnitudes are shown in Appendix A and B. These results indicate that:

- There is no genuine impact on peak water levels, peak flows or flood extent upstream of the A14. The maximum predicted increase in water level is 0.002m, with no discernable change in flood extent.

- Small increases in water level (up to 0.02m) and flow (up to $1m^3/s$) are predicted downstream of the A14. The impact is larger for the lower return periods because the WWTP discharge makes up a larger proportion of the total River Cam flow.

- There are some minor differences in the flood extent for the 1 in 10 to 1 in 50 year flood extents downstream of the A14. There are no properties within the affected area.

Note that the downstream impact is likely to be overstated by the modelling since the existing Waterbeach outfall is not represented in the model. There will be flow through the Waterbeach outfall in existing conditions but not with the new WWTP.

4.5 Non-flood conditions

In non-flood conditions (normal and low flows), river levels at the outfall location are controlled by the operation of Baits Bite Lock. Water levels upstream of Baits Bite Lock are maintained at around 3.85mAOD (normally within 3.80 to 3.90mAOD), as shown by both:

- The operating logic within the hydraulic model for the Bates Bite sluice gates (node CA15170Sus).

- Recorded water levels for Bates Bite gauge. For example as shown on the River Levels website[2].

Figure 4.6 contains:

- The hydraulic model results for the model node immediately downstream of the A14 bridge (the new WWTP outfall site), comparing flow and water levels. Results are presented for both the whole rising limb of the 1 in 2 year flood and the flood peaks for all the design floods considered.

- The nominal 3.85mAOD retention level.

- Flow exceedance statistics for the closest river flow gauging station – the River Cam at Bottisham, a short distance downstream.

These results confirm that even at the peak of the 1 in 2 year flood, water levels at the A14 are only 0.1m above the normal 3.85mAOD retention level at Baits Bite Lock. In normal flows and low flows, we would expect water levels at the outfall to be at, or very close to, 3.85mAOD.

[2] https://riverlevels.uk/river-cam-fen-ditton-cambridge-baits-bite#.YlgtFcjMKUk

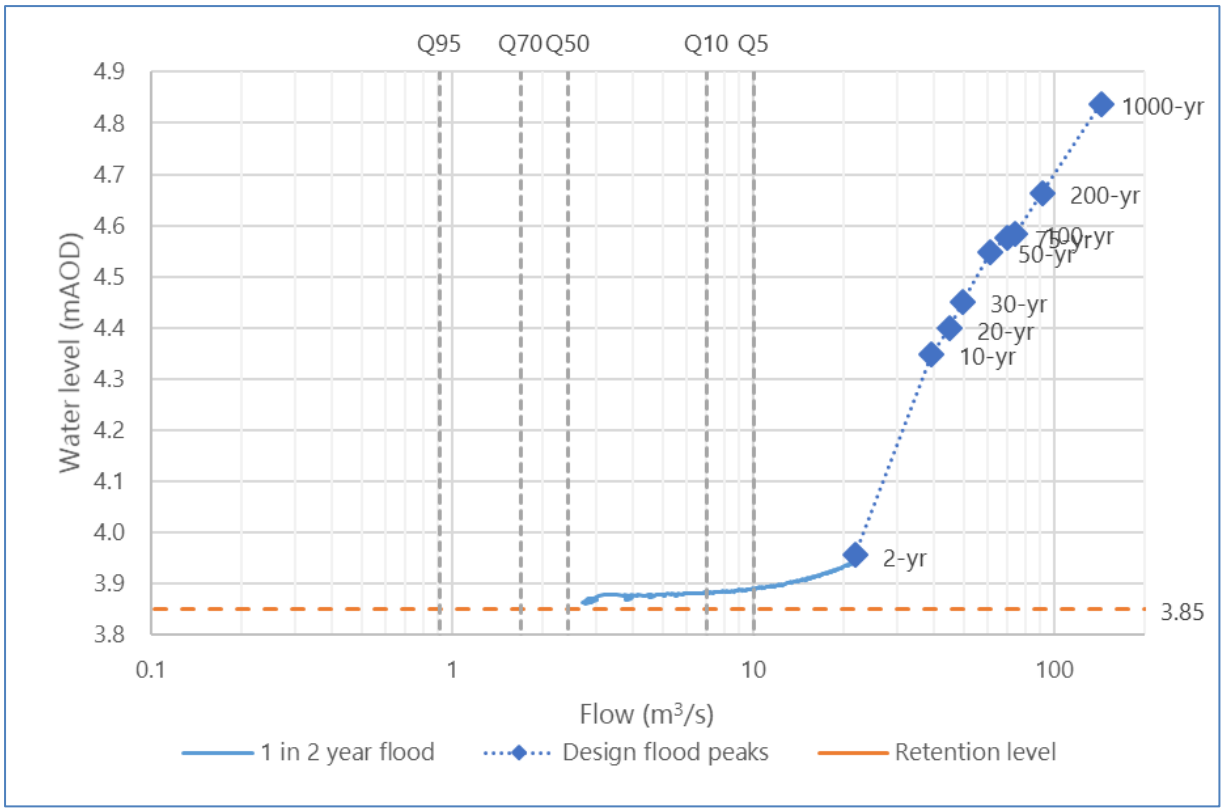


Figure 4.6. Water level – flow relationship at the new outfall (from hydraulic model results)

5. Conclusions

This report describes river modelling undertaken to assess the impact of the Cambridge WWTP Relocation project new outfall on fluvial flood risk in the River Cam.

The modelling was undertaken using information readily available to the project team. The Environment Agency's 2011 River Cam hydraulic model was used with only minor modifications (to enable the model to run using up-to-date software versions and to explicitly include the existing and new WWTP outfall discharge).

The 1 in 100 year flood including climate change allowance was used as the primary design case and for sensitivity testing. A range of other fluvial flood magnitudes were also simulated.

There is a mismatch in the storm durations used in the modelling – the river model uses a 61 hour storm as the critical case for the whole River Cam fluvial catchment; whereas the critical case for the WWTP outfall discharge is a 4 hour storm. We have explored this issue using sensitivity testing to offset the timing of the WWTP discharge and also test a 4 hour river catchment storm.

The river model results indicate that:

- Only a very minor impact on peak flood levels in the River Cam is predicted for the 1 in 100 year plus climate change flood. There is a maximum increase of only 7mm, and generally less, for the base assumptions (61 hour duration storm).
- There is no perceptible increase in flood extent due to the new WWTP outfall discharge for any of the 1 in 100 year plus climate change cases considered (base or sensitivity tests).
- Sensitivity testing indicates we have taken a conservative assumption for the timing of the WWTP discharge relative to the river flood. With alternative offset timings, the predicted relative impact of the new WWTP is smaller.
- With a much shorter river catchment storm, the relative impact of the new WWTP on peak water levels is larger but still small (up to 15mm increase). However, river levels are much lower and flood extents are much smaller, as this is not the critical duration for river flooding.
- For smaller magnitude floods (1 in 10 to 1 in 50 year), the predicted impact is greater because the WWTP discharge makes up a larger proportion of the total River Cam flow. The impact, however, remains very small with no change at all through Cambridge and a maximum increase in downstream peak water levels of only 0.02m and only very minor changes to the predicted downstream flood extent. The downstream impact is likely to be overstated because the model does not include the Waterbeach outfall flow, which is currently present but will cease with the new WWTP.
- In non-flood conditions, water levels at the outfall will be controlled by the operation of Baits Bite Lock, which has a normal retention level of around 3.85mAOD.

In summary, based on these modelling results, we expect no impact on flood risk from the new WWTP outfall.

Appendix A: Results tables for other flood magnitudes

A.1 1 in 2 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	8.455	8.455	0.000
A1134 Fen Causeway	CA22770	7.046	7.046	0.000
Silver Street	CA22230us	5.559	5.560	0.001
Trinity Bridge	CA21670	5.447	5.447	0.000
Bridge Street	CA21250	5.342	5.342	0.000
Victoria Avenue	CA20440	4.490	4.492	0.002
A1134 Elizabeth Way	CA19600us	4.395	4.396	0.001
Railway	CA17720	4.181	4.183	0.002
A14	CA15730	3.949	3.955	0.006
Baits Bite Lock US	CA15170J	3.877	3.894	0.017
Baits Bite Lock DS	CA15140	3.288	3.310	0.022
Horningsea	CA14200	3.097	3.114	0.017
Waterbeach	CA12080J	2.723	2.727	0.004
Bottisham Lock US	CA10600J	2.637	2.641	0.004
Bottisham Lock DS	CA10560	2.314	2.333	0.019
Shrubbs Marina	Cam8647	2.219	2.238	0.019
Upware	Cam4930	2.096	2.117	0.021
A1123	Cam2651u	2.014	2.035	0.021
Great Ouse confluence	Cam0000	1.910	1.932	0.022
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	11.9	11.9	0.0
A1134 Fen Causeway	CA22770	18.4	18.4	0.0
Silver Street	CA22230us	1.8	1.8	0.0
Trinity Bridge	CA21670	19.8	19.8	0.0
Bridge Street	CA21250	21.2	21.2	0.0
Victoria Avenue	CA20440	21.2	21.2	0.0
A1134 Elizabeth Way	CA19600us	21.3	21.3	0.0
Railway	CA17720	21.4	21.4	0.0
A14	CA15730	21.6	21.8	0.1
Baits Bite Lock US	CA15170J	23.0	23.7	0.7
Baits Bite Lock DS	CA15140	23.0	23.7	0.7
Horningsea	CA14200	22.9	23.5	0.6
Waterbeach	CA12080J	23.1	23.7	0.6
Bottisham Lock US	CA10600J	23.3	23.8	0.5
Bottisham Lock DS	CA10560	23.3	23.8	0.5
Shrubbs Marina	Cam8647	26.5	27.0	0.6
Upware	Cam4930	26.9	27.3	0.4
A1123	Cam2651u	28.7	29.0	0.4
Great Ouse confluence	Cam0000	28.4	28.8	0.4

A.2 1 in 10 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	8.978	8.978	0.000
A1134 Fen Causeway	CA22770	7.207	7.206	-0.001
Silver Street	CA22230us	6.089	6.089	0.000
Trinity Bridge	CA21670	5.892	5.891	-0.001
Bridge Street	CA21250	5.668	5.668	0.000
Victoria Avenue	CA20440	5.112	5.112	0.000
A1134 Elizabeth Way	CA19600us	4.972	4.972	0.000
Railway	CA17720	4.687	4.688	0.001
A14	CA15730	4.345	4.349	0.004
Baits Bite Lock US	CA15170J	4.226	4.227	0.001
Baits Bite Lock DS	CA15140	3.914	3.931	0.017
Horningsea	CA14200	3.671	3.685	0.014
Waterbeach	CA12080J	3.169	3.176	0.007
Bottisham Lock US	CA10600J	3.039	3.045	0.006
Bottisham Lock DS	CA10560	2.916	2.922	0.006
Shrubbs Marina	Cam8647	2.798	2.803	0.005
Upware	Cam4930	2.697	2.712	0.015
A1123	Cam2651u	2.643	2.658	0.015
Great Ouse confluence	Cam0000	2.562	2.579	0.017
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	24.9	24.9	0.0
A1134 Fen Causeway	CA22770	29.9	29.9	0.0
Silver Street	CA22230us	1.8	1.8	0.0
Trinity Bridge	CA21670	37.5	37.5	0.0
Bridge Street	CA21250	38.8	38.8	0.0
Victoria Avenue	CA20440	38.8	38.8	0.0
A1134 Elizabeth Way	CA19600us	38.8	38.8	0.0
Railway	CA17720	38.8	38.8	0.0
A14	CA15730	39.1	39.2	0.1
Baits Bite Lock US	CA15170J	39.3	39.8	0.5
Baits Bite Lock DS	CA15140	39.3	39.8	0.5
Horningsea	CA14200	38.9	39.5	0.7
Waterbeach	CA12080J	38.1	38.5	0.4
Bottisham Lock US	CA10600J	38.1	38.5	0.4
Bottisham Lock DS	CA10560	38.1	38.5	0.4
Shrubbs Marina	Cam8647	41.4	41.8	0.4
Upware	Cam4930	43.1	43.5	0.3
A1123	Cam2651u	45.5	45.9	0.3
Great Ouse confluence	Cam0000	40.6	40.9	0.3

A.3 1 in 20 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.115	9.115	0.000
A1134 Fen Causeway	CA22770	7.237	7.237	0.000
Silver Street	CA22230us	6.292	6.293	0.001
Trinity Bridge	CA21670	6.076	6.076	0.000
Bridge Street	CA21250	5.820	5.820	0.000
Victoria Avenue	CA20440	5.261	5.261	0.000
A1134 Elizabeth Way	CA19600us	5.096	5.097	0.001
Railway	CA17720	4.779	4.780	0.001
A14	CA15730	4.392	4.398	0.006
Baits Bite Lock US	CA15170J	4.252	4.258	0.006
Baits Bite Lock DS	CA15140	4.002	4.006	0.004
Horningsea	CA14200	3.764	3.772	0.008
Waterbeach	CA12080J	3.283	3.289	0.006
Bottisham Lock US	CA10600J	3.158	3.165	0.007
Bottisham Lock DS	CA10560	3.057	3.066	0.009
Shrubbs Marina	Cam8647	2.956	2.966	0.010
Upware	Cam4930	2.874	2.884	0.010
A1123	Cam2651u	2.825	2.836	0.011
Great Ouse confluence	Cam0000	2.752	2.763	0.011
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	30.7	30.7	0.0
A1134 Fen Causeway	CA22770	32.7	32.7	0.0
Silver Street	CA22230us	1.8	1.8	0.0
Trinity Bridge	CA21670	44.2	44.2	0.0
Bridge Street	CA21250	45.9	45.9	0.0
Victoria Avenue	CA20440	45.9	45.9	0.0
A1134 Elizabeth Way	CA19600us	46.1	46.0	0.0
Railway	CA17720	45.0	45.0	0.0
A14	CA15730	44.8	44.8	0.0
Baits Bite Lock US	CA15170J	43.5	43.8	0.3
Baits Bite Lock DS	CA15140	43.5	43.8	0.3
Horningsea	CA14200	42.6	42.8	0.2
Waterbeach	CA12080J	42.2	42.6	0.4
Bottisham Lock US	CA10600J	41.3	41.7	0.4
Bottisham Lock DS	CA10560	41.3	41.7	0.4
Shrubbs Marina	Cam8647	44.5	44.8	0.3
Upware	Cam4930	46.4	46.6	0.2
A1123	Cam2651u	48.5	48.7	0.2
Great Ouse confluence	Cam0000	44.7	44.9	0.2

A.4 1 in 30 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.194	9.194	0.000
A1134 Fen Causeway	CA22770	7.254	7.254	0.000
Silver Street	CA22230us	6.396	6.396	0.000
Trinity Bridge	CA21670	6.168	6.169	0.001
Bridge Street	CA21250	5.892	5.893	0.001
Victoria Avenue	CA20440	5.338	5.340	0.002
A1134 Elizabeth Way	CA19600us	5.170	5.171	0.001
Railway	CA17720	4.853	4.855	0.002
A14	CA15730	4.444	4.450	0.006
Baits Bite Lock US	CA15170J	4.307	4.313	0.006
Baits Bite Lock DS	CA15140	4.052	4.056	0.004
Horningsea	CA14200	3.818	3.821	0.003
Waterbeach	CA12080J	3.391	3.410	0.019
Bottisham Lock US	CA10600J	3.266	3.285	0.019
Bottisham Lock DS	CA10560	3.168	3.185	0.017
Shrubbs Marina	Cam8647	3.066	3.083	0.017
Upware	Cam4930	2.987	3.004	0.017
A1123	Cam2651u	2.942	2.959	0.017
Great Ouse confluence	Cam0000	2.872	2.890	0.018
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	36.3	36.3	0.0
A1134 Fen Causeway	CA22770	34.2	34.2	0.0
Silver Street	CA22230us	1.8	1.8	0.0
Trinity Bridge	CA21670	48.0	48.0	0.0
Bridge Street	CA21250	49.6	49.6	0.0
Victoria Avenue	CA20440	49.6	49.5	0.0
A1134 Elizabeth Way	CA19600us	49.6	49.6	0.0
Railway	CA17720	48.5	48.4	0.0
A14	CA15730	49.6	49.7	0.0
Baits Bite Lock US	CA15170J	45.6	45.8	0.2
Baits Bite Lock DS	CA15140	45.6	45.8	0.2
Horningsea	CA14200	43.4	43.5	0.1
Waterbeach	CA12080J	44.7	45.7	1.0
Bottisham Lock US	CA10600J	43.9	44.7	0.8
Bottisham Lock DS	CA10560	43.9	44.7	0.8
Shrubbs Marina	Cam8647	47.0	47.8	0.7
Upware	Cam4930	47.7	48.0	0.3
A1123	Cam2651u	49.6	49.8	0.2
Great Ouse confluence	Cam0000	47.4	47.8	0.4

A.5 1 in 50 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.294	9.294	0.000
A1134 Fen Causeway	CA22770	7.334	7.333	-0.001
Silver Street	CA22230us	6.725	6.722	-0.003
Trinity Bridge	CA21670	6.463	6.461	-0.002
Bridge Street	CA21250	6.114	6.113	-0.001
Victoria Avenue	CA20440	5.546	5.545	-0.001
A1134 Elizabeth Way	CA19600us	5.353	5.352	-0.001
Railway	CA17720	5.009	5.009	0.000
A14	CA15730	4.545	4.549	0.004
Baits Bite Lock US	CA15170J	4.411	4.415	0.004
Baits Bite Lock DS	CA15140	4.139	4.144	0.005
Horningsea	CA14200	3.920	3.927	0.007
Waterbeach	CA12080J	3.643	3.659	0.016
Bottisham Lock US	CA10600J	3.502	3.516	0.014
Bottisham Lock DS	CA10560	3.402	3.417	0.015
Shrubbs Marina	Cam8647	3.294	3.308	0.014
Upware	Cam4930	3.216	3.230	0.014
A1123	Cam2651u	3.173	3.187	0.014
Great Ouse confluence	Cam0000	3.110	3.124	0.014
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	43.6	43.7	0.1
A1134 Fen Causeway	CA22770	37.6	37.6	0.0
Silver Street	CA22230us	2.9	2.9	0.0
Trinity Bridge	CA21670	60.7	60.6	-0.1
Bridge Street	CA21250	62.1	62.0	-0.1
Victoria Avenue	CA20440	62.1	62.0	-0.1
A1134 Elizabeth Way	CA19600us	61.8	61.7	-0.1
Railway	CA17720	58.6	58.5	-0.1
A14	CA15730	61.5	61.4	-0.1
Baits Bite Lock US	CA15170J	50.4	50.7	0.2
Baits Bite Lock DS	CA15140	50.4	50.7	0.2
Horningsea	CA14200	44.3	44.2	-0.1
Waterbeach	CA12080J	53.9	54.1	0.2
Bottisham Lock US	CA10600J	55.8	56.5	0.7
Bottisham Lock DS	CA10560	55.8	56.5	0.7
Shrubbs Marina	Cam8647	58.5	59.2	0.6
Upware	Cam4930	56.2	56.7	0.6
A1123	Cam2651u	56.3	57.0	0.7
Great Ouse confluence	Cam0000	53.0	53.4	0.3

A.6 1 in 75 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.352	9.353	0.001
A1134 Fen Causeway	CA22770	7.376	7.377	0.001
Silver Street	CA22230us	6.914	6.915	0.001
Trinity Bridge	CA21670	6.635	6.636	0.001
Bridge Street	CA21250	6.242	6.243	0.001
Victoria Avenue	CA20440	5.656	5.657	0.001
A1134 Elizabeth Way	CA19600us	5.452	5.453	0.001
Railway	CA17720	5.089	5.090	0.001
A14	CA15730	4.576	4.576	0.000
Baits Bite Lock US	CA15170J	4.448	4.453	0.005
Baits Bite Lock DS	CA15140	4.201	4.206	0.005
Horningsea	CA14200	4.003	4.011	0.008
Waterbeach	CA12080J	3.779	3.790	0.011
Bottisham Lock US	CA10600J	3.624	3.635	0.011
Bottisham Lock DS	CA10560	3.527	3.538	0.011
Shrubbs Marina	Cam8647	3.411	3.421	0.010
Upware	Cam4930	3.328	3.338	0.010
A1123	Cam2651u	3.283	3.293	0.010
Great Ouse confluence	Cam0000	3.223	3.233	0.010
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	48.9	49.0	0.1
A1134 Fen Causeway	CA22770	39.6	39.6	0.0
Silver Street	CA22230us	4.0	4.0	0.0
Trinity Bridge	CA21670	68.6	68.7	0.1
Bridge Street	CA21250	70.0	70.1	0.1
Victoria Avenue	CA20440	70.0	70.1	0.1
A1134 Elizabeth Way	CA19600us	69.4	69.5	0.1
Railway	CA17720	65.7	65.8	0.0
A14	CA15730	69.8	69.8	0.0
Baits Bite Lock US	CA15170J	52.3	52.3	0.0
Baits Bite Lock DS	CA15140	52.3	52.3	0.0
Horningsea	CA14200	44.8	44.5	-0.3
Waterbeach	CA12080J	56.2	56.3	0.1
Bottisham Lock US	CA10600J	62.7	63.1	0.5
Bottisham Lock DS	CA10560	62.7	63.1	0.5
Shrubbs Marina	Cam8647	65.2	65.6	0.5
Upware	Cam4930	61.9	62.4	0.5
A1123	Cam2651u	62.2	62.7	0.5
Great Ouse confluence	Cam0000	55.8	56.1	0.2

A.7 1 in 100 year flood

Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.394	9.393	-0.001
A1134 Fen Causeway	CA22770	7.405	7.405	0.000
Silver Street	CA22230us	7.046	7.045	-0.001
Trinity Bridge	CA21670	6.761	6.760	-0.001
Bridge Street	CA21250	6.328	6.327	-0.001
Victoria Avenue	CA20440	5.719	5.719	0.000
A1134 Elizabeth Way	CA19600us	5.507	5.507	0.000
Railway	CA17720	5.137	5.137	0.000
A14	CA15730	4.582	4.584	0.002
Baits Bite Lock US	CA15170J	4.478	4.482	0.004
Baits Bite Lock DS	CA15140	4.245	4.249	0.004
Horningsea	CA14200	4.059	4.065	0.006
Waterbeach	CA12080J	3.852	3.860	0.008
Bottisham Lock US	CA10600J	3.692	3.700	0.008
Bottisham Lock DS	CA10560	3.595	3.603	0.008
Shrubbs Marina	Cam8647	3.474	3.482	0.008
Upware	Cam4930	3.387	3.394	0.007
A1123	Cam2651u	3.340	3.347	0.007
Great Ouse confluence	Cam0000	3.282	3.289	0.007
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	52.5	52.4	-0.1
A1134 Fen Causeway	CA22770	41.2	41.2	0.0
Silver Street	CA22230us	4.6	4.6	0.0
Trinity Bridge	CA21670	74.9	74.9	0.0
Bridge Street	CA21250	76.0	75.9	-0.1
Victoria Avenue	CA20440	74.6	74.6	0.0
A1134 Elizabeth Way	CA19600us	73.9	73.8	0.0
Railway	CA17720	70.0	70.0	0.0
A14	CA15730	74.5	74.5	-0.1
Baits Bite Lock US	CA15170J	52.4	52.4	0.0
Baits Bite Lock DS	CA15140	52.4	52.4	0.0
Horningsea	CA14200	45.2	44.8	-0.4
Waterbeach	CA12080J	57.0	57.0	0.0
Bottisham Lock US	CA10600J	66.0	66.3	0.3
Bottisham Lock DS	CA10560	66.0	66.3	0.3
Shrubbs Marina	Cam8647	68.5	68.8	0.3
Upware	Cam4930	65.5	65.9	0.4
A1123	Cam2651u	65.8	66.2	0.3
Great Ouse confluence	Cam0000	57.3	57.4	0.2

A.8 1 in 200 year flood

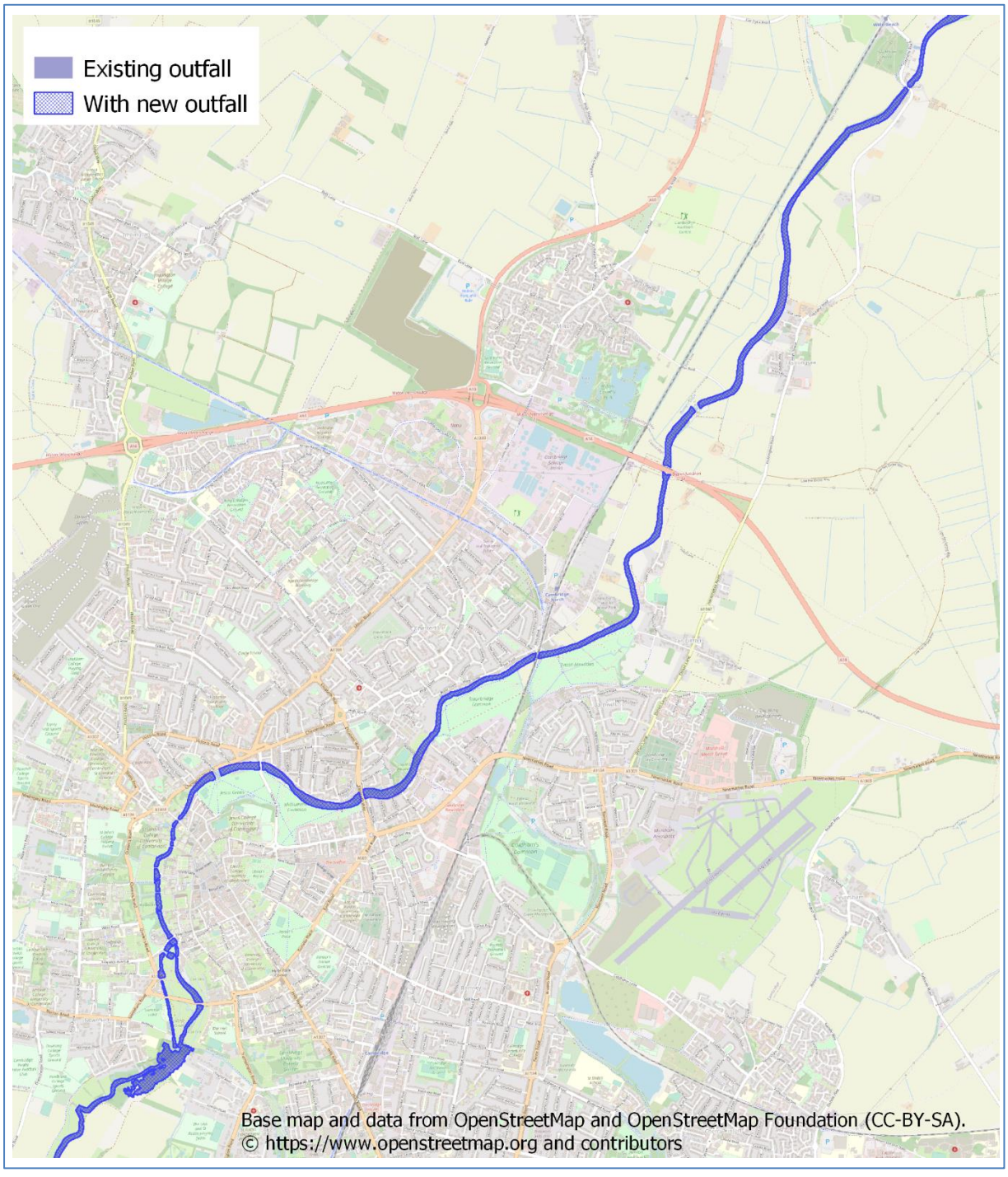
Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.500	9.500	0.000
A1134 Fen Causeway	CA22770	7.620	7.620	0.000
Silver Street	CA22230us	7.386	7.386	0.000
Trinity Bridge	CA21670	7.093	7.093	0.000
Bridge Street	CA21250	6.537	6.536	-0.001
Victoria Avenue	CA20440	5.918	5.918	0.000
A1134 Elizabeth Way	CA19600us	5.678	5.678	0.000
Railway	CA17720	5.295	5.295	0.000
A14	CA15730	4.662	4.664	0.002
Baits Bite Lock US	CA15170J	4.575	4.579	0.004
Baits Bite Lock DS	CA15140	4.358	4.362	0.004
Horningsea	CA14200	4.198	4.202	0.004
Waterbeach	CA12080J	3.991	3.995	0.004
Bottisham Lock US	CA10600J	3.822	3.826	0.004
Bottisham Lock DS	CA10560	3.726	3.730	0.004
Shrubbs Marina	Cam8647	3.591	3.595	0.004
Upware	Cam4930	3.494	3.498	0.004
A1123	Cam2651u	3.443	3.446	0.003
Great Ouse confluence	Cam0000	3.387	3.390	0.003
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	62.7	62.7	0.0
A1134 Fen Causeway	CA22770	42.0	42.0	0.0
Silver Street	CA22230us	4.7	4.7	0.0
Trinity Bridge	CA21670	89.7	89.7	0.0
Bridge Street	CA21250	92.2	92.2	0.0
Victoria Avenue	CA20440	91.5	91.5	0.0
A1134 Elizabeth Way	CA19600us	90.1	90.1	0.0
Railway	CA17720	83.9	83.9	0.0
A14	CA15730	91.2	91.2	0.1
Baits Bite Lock US	CA15170J	55.6	55.7	0.1
Baits Bite Lock DS	CA15140	55.6	55.7	0.1
Horningsea	CA14200	46.0	45.6	-0.4
Waterbeach	CA12080J	57.9	57.9	0.0
Bottisham Lock US	CA10600J	73.7	73.8	0.1
Bottisham Lock DS	CA10560	73.7	73.8	0.1
Shrubbs Marina	Cam8647	76.1	76.2	0.1
Upware	Cam4930	73.4	73.6	0.2
A1123	Cam2651u	73.2	73.4	0.2
Great Ouse confluence	Cam0000	60.0	60.1	0.1

A.9 1 in 1000 year flood

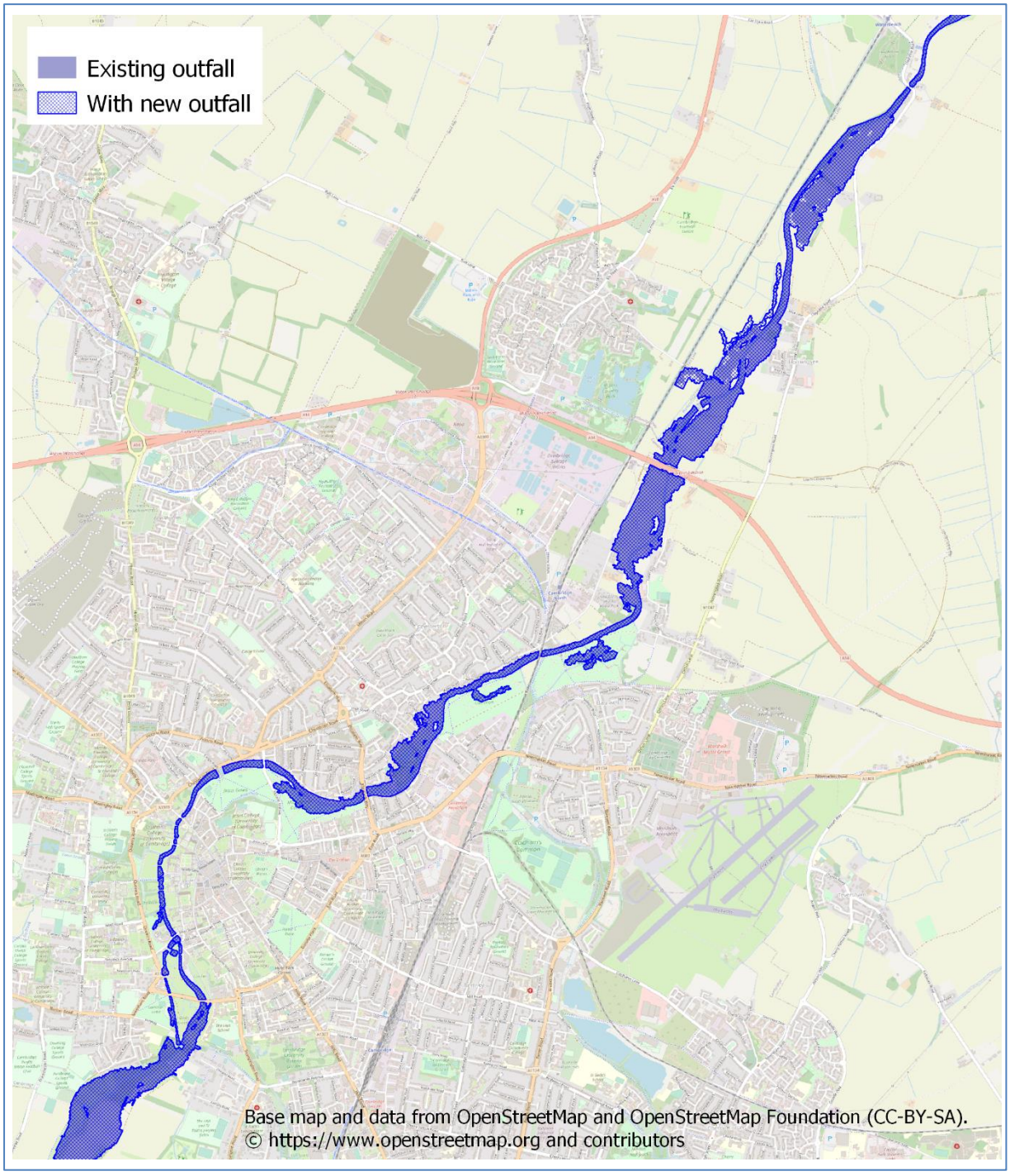
Location	Node	Existing outfall	New outfall	Increase
		Peak water level (mAOD)		Level (m)
M11	CA27350	9.822	9.822	0.000
A1134 Fen Causeway	CA22770	8.189	8.188	-0.001
Silver Street	CA22230us	8.128	8.128	0.000
Trinity Bridge	CA21670	7.855	7.855	0.000
Bridge Street	CA21250	6.905	6.905	0.000
Victoria Avenue	CA20440	6.380	6.380	0.000
A1134 Elizabeth Way	CA19600us	6.085	6.085	0.000
Railway	CA17720	5.674	5.674	0.000
A14	CA15730	4.836	4.838	0.002
Baits Bite Lock US	CA15170J	4.769	4.771	0.002
Baits Bite Lock DS	CA15140	4.617	4.619	0.002
Horningsea	CA14200	4.460	4.462	0.002
Waterbeach	CA12080J	4.161	4.162	0.001
Bottisham Lock US	CA10600J	3.977	3.978	0.001
Bottisham Lock DS	CA10560	3.877	3.879	0.002
Shrubbs Marina	Cam8647	3.717	3.718	0.001
Upware	Cam4930	3.601	3.602	0.001
A1123	Cam2651u	3.543	3.544	0.001
Great Ouse confluence	Cam0000	3.487	3.488	0.001
		Peak flow (m^3/s)		Flow (m^3/s)
M11	CA27350	98.3	98.1	-0.1
A1134 Fen Causeway	CA22770	42.0	42.0	0.0
Silver Street	CA22230us	4.6	4.6	0.0
Trinity Bridge	CA21670	102.2	102.2	0.0
Bridge Street	CA21250	130.9	130.8	0.0
Victoria Avenue	CA20440	105.4	105.4	0.0
A1134 Elizabeth Way	CA19600us	137.3	137.3	0.0
Railway	CA17720	127.3	127.3	0.0
A14	CA15730	143.2	143.3	0.0
Baits Bite Lock US	CA15170J	63.9	64.0	0.1
Baits Bite Lock DS	CA15140	63.9	64.0	0.1
Horningsea	CA14200	53.4	53.6	0.1
Waterbeach	CA12080J	58.9	58.9	0.1
Bottisham Lock US	CA10600J	83.8	83.7	-0.1
Bottisham Lock DS	CA10560	83.8	83.7	-0.1
Shrubbs Marina	Cam8647	85.9	85.8	-0.1
Upware	Cam4930	83.6	83.7	0.1
A1123	Cam2651u	82.2	82.3	0.1
Great Ouse confluence	Cam0000	62.7	62.7	0.0

Appendix B: Flood outlines for other flood magnitudes

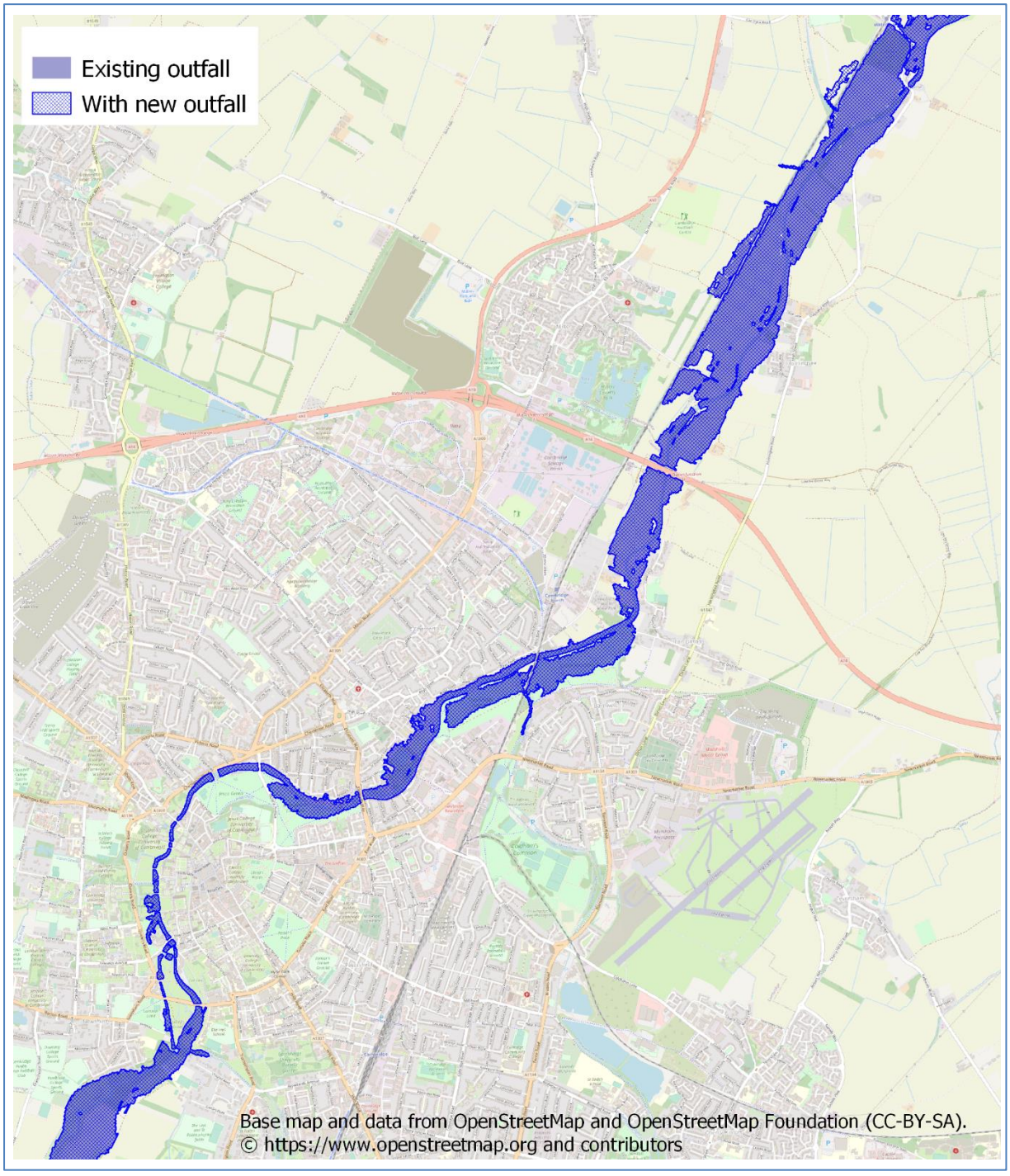
B.1 1 in 2 year flood



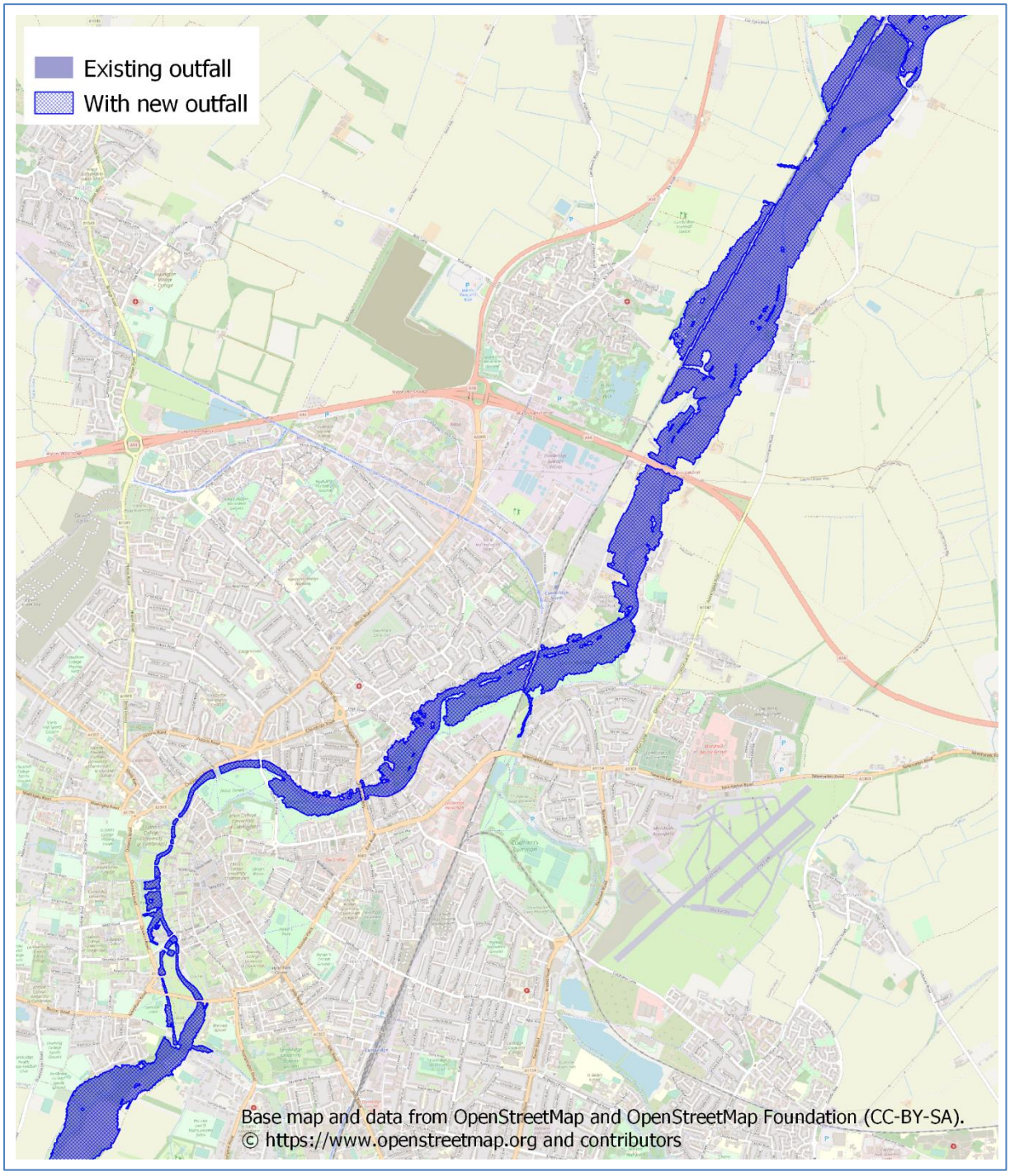
B.2 1 in 10 year flood



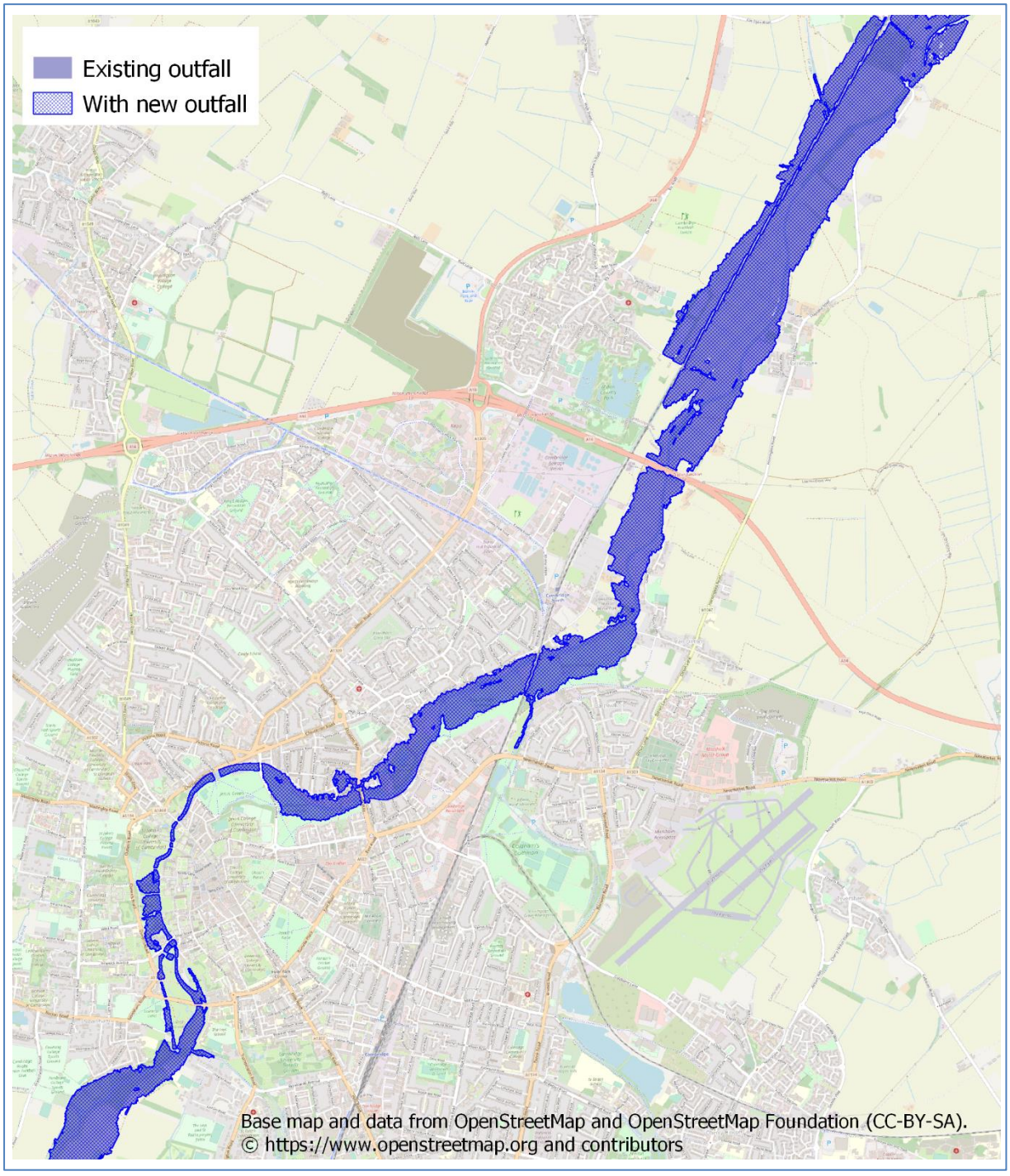
B.3 1 in 20 year flood



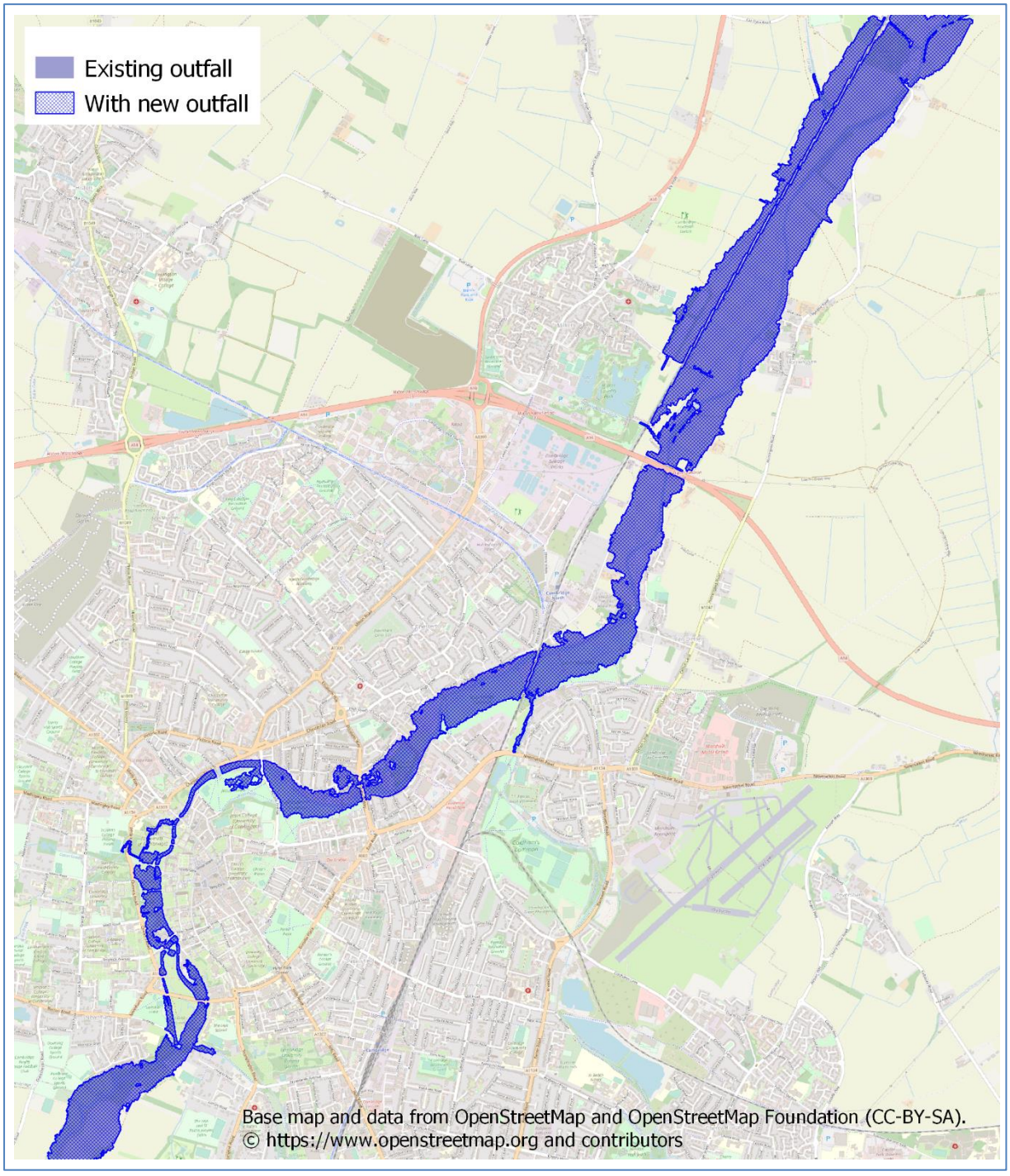
B.4 1 in 30 year flood



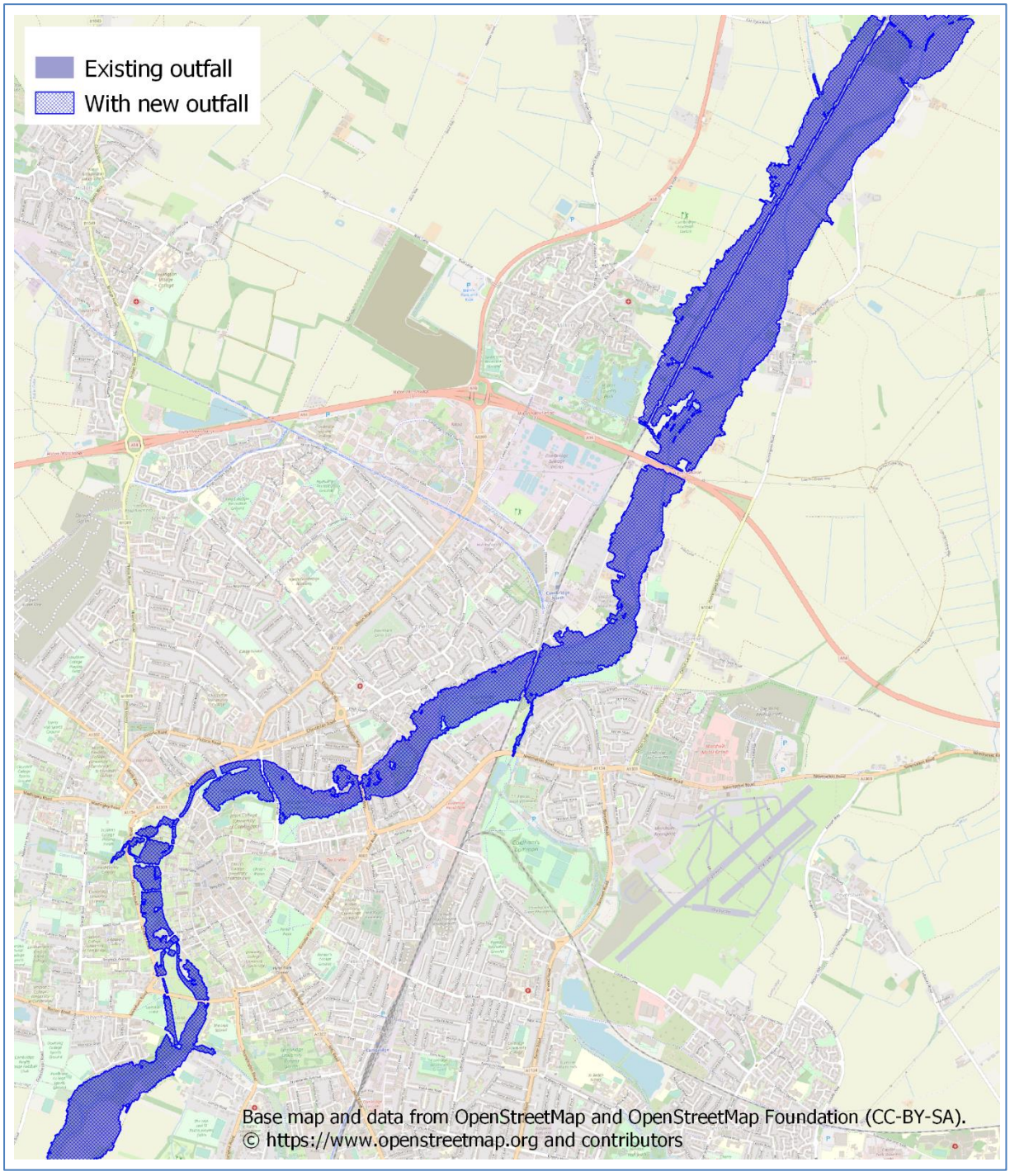
B.5 1 in 50 year flood



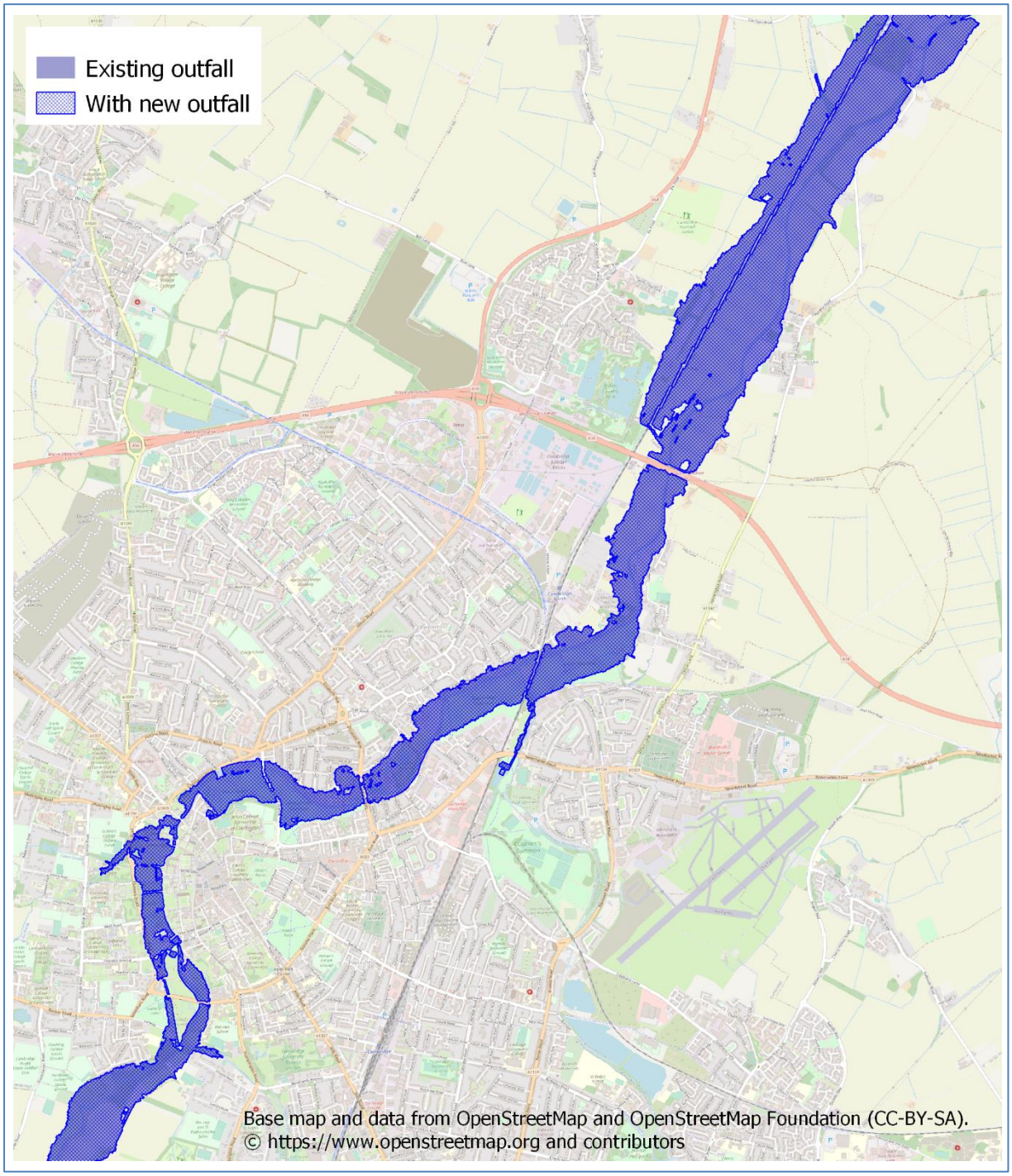
B.6 1 in 75 year flood



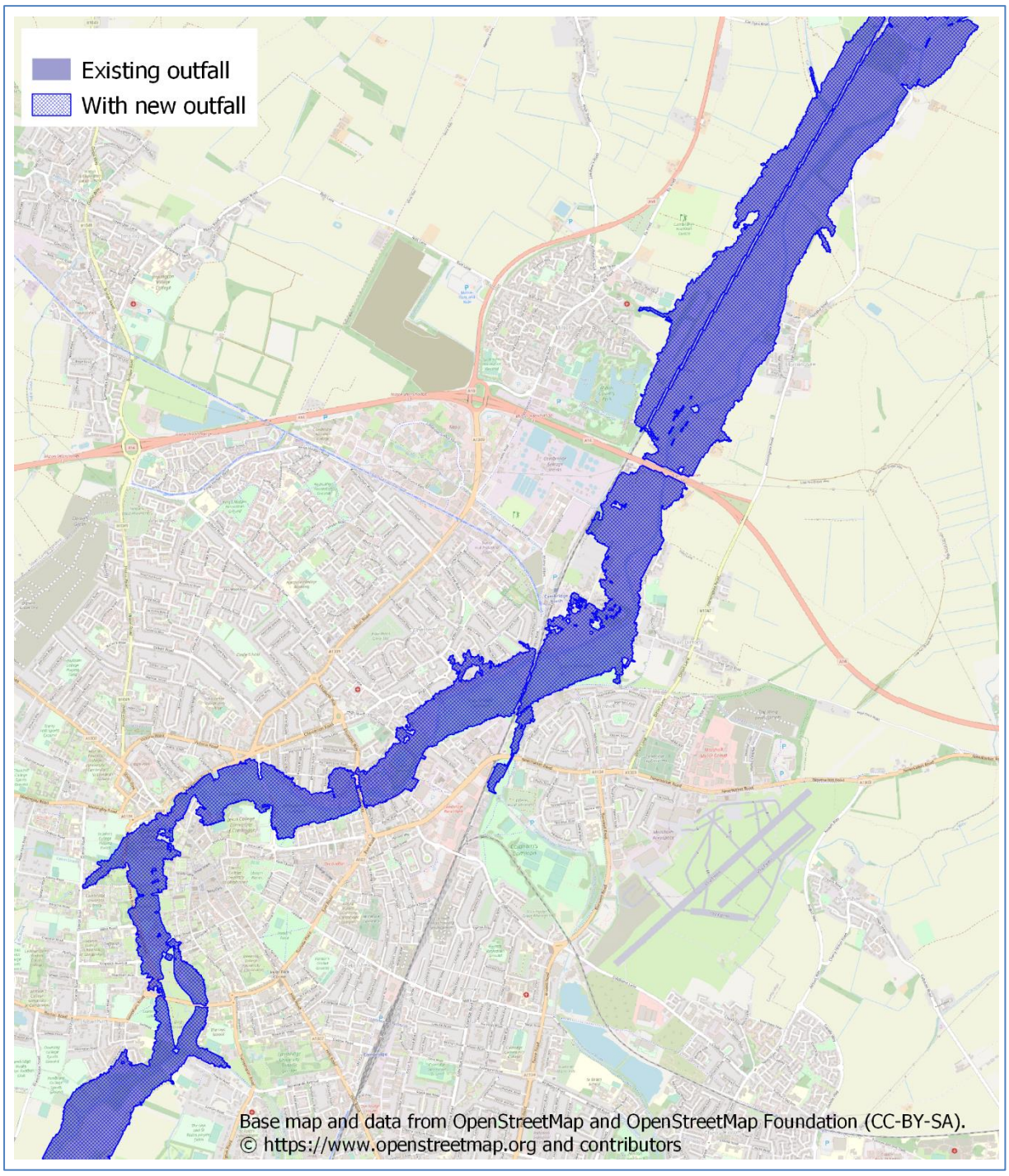
B.7 1 in 100 year flood



B.8 1 in 200 year flood



B.9 1 in 1000 year flood



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You can view all our DCO application documents and updates on the application on The Planning Inspectorate website:

https://infrastructure.planninginspectorate.gov.uk/projects/eastern/cambridge-waste-water-treatment-plant-relocation/