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Technical Review Report
Histon and Impington
Cambridgeshire
October 2018

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Quality Management

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1. Executive Summary

1.1.1 Capita SKANSKA were commissioned by Cambridgeshire County Council to undertake a review of the existing Surface Water Management Plan (SWMP) for Histon and Impington.

1.1.2 The existing SWMP included an assessment of the flood risk within Histon and Impington before going on to assess a selection of combined options for the area as part of a Pre-Project Appraisal Report (PAR) assessment.

1.1.3 Further to the SWMP, Cambridgeshire County Council now have a requirement to better understand the potential for the individual options proposed at two specific locations within Histon and Impington; Villa Road and Park Lane. There is a requirement to gain a high-level understanding of the potential benefits provided by each of these options individually and to consider the economic benefits.

1.1.4 A high-level review of the existing SWMP and associated modelling was undertaken to determine whether the existing information could provide the required level of understanding for these two specific location options. The review also included a technical review of the model to determine if it was suitable to undertake further assessment of the specific options for a high-level understanding of the benefits provided if required.

1.1.5 The review concluded that it was not possible to gain the understanding of benefits required based on the existing information. A second phase was commissioned to use the existing model to assess the individual options and prepare a high-level economic appraisal in line with the latest Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG).

1.1.6 The existing model was run with only minor changes for the Do Nothing and Do Minimum options. Three Do Something options were run; HI02, Villa Road; HI03, Park Lane and Combined HI02 and HI03. The economic assessment was undertaken for the HI02 Do Something option and the Combined Do Something option.

1.1.7 For the Villa Road option, the results indicate that, whilst small, there are potential benefits from the scheme. However, the current schematisation indicates a potential increase in flood risk upstream of the scheme. As such further work would be required to optimise the scheme to provide the most benefit downstream without increasing risk upstream.

1.1.8 For the Park Lane Culvert option, the model results show improved conveyance through the channels that helps to reduce flood risk upstream through the centre of Histon. This is based on a replacement of the existing culvert and regrading of the channel bed upstream rather than a re-sizing of the culvert.

2. Introduction

2.1 Background

2.1.1 Cambridgeshire County Council have a requirement to better understand the potential for individual options proposed at two specific locations within Histon and Impington that had previously been part of the wider Surface Water Management Plan (SWMP) and the secondary Pre-Project Appraisal Report (PAR) assessments. The location of these are at Villa Road and Park Lane within Histon.

2.1.2 The requirement at Villa Road has come about due to a proposed residential development in this location. As there was an option for flood risk reduction proposed at Villa Road through the SWMP Pre-PAR, the council would like to understand if there is the potential for the developer to incorporate the options in their development to help provide betterment to the area.

2.1.3 The requirement at Park Lane has come about due to the ongoing improvement works on the A14. Partnership working between Cambridgeshire County Council, highways and the A14 project has generated the funding to replace the currently collapsed access culvert on Park Lane. As part of the works there is a need to understand the benefits that replacement of the culvert will provide. The option was originally included as part of the Pre-PAR assessment.

2.1.4 Capita SKANSKA were initially commissioned by Cambridgeshire County Council to undertake a review of the existing SWMP for Histon and Impington. This included a high level review of the existing SWMP and associated modelling to determine whether the existing information could provide the required level of understanding for the two specific locations. The review also included a technical review of the model to determine if it was suitable to undertaken further assessment of the specific options for a high level understanding of the benefits provided if required.

2.1.5 Based on the outcome of the review, the second stage of the commission was to undertake hydraulic modelling, utilising the existing SWMP model, to assess the individual options and prepare a high level economic appraisal in line with the latest Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG)

2.1.6 This document outlines the background to the project before detailing the outcomes of the review and high-level options appraisal conducted for the specified locations within Histon and Impington.

2.2 Aim

2.2.1 This study aims to identify the high-level benefits of two individual options within Histon and Impington, using existing data and proposals.

2.2.2 The conclusions of this report aim to direct future approaches for work in the study area.

2.3 Location

2.3.1 The communities of Histon and Impington are located within Cambridgeshire, approximately 3 miles to the north of Cambridge as shown in Figure 2-1.

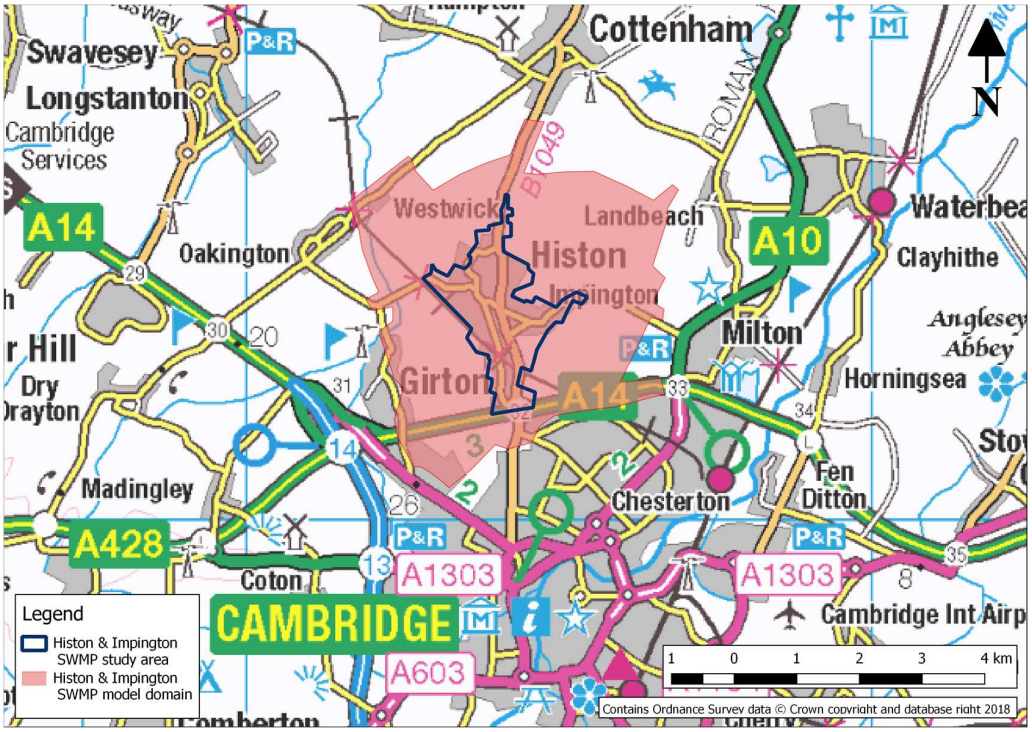

Figure 2-1. Location plan

2.3.2 The river network in the area consists of several Award Drains (ordinary watercourses), with the two key ones in Histon and Impington being Award Drains 165 and 164. The catchment for Award Drain 165 covers the eastern side of Histon and Impington, flowing into the town around Merrington Place. The catchment for Award Drain 164 accounts for the southern area of Histon and Impington, flowing in from the south of the town around the Villa Road area. The two drains confluence at the pond in the centre of town, from where the watercourse flows in a westerly direction, ultimately joining with Beck Brook. The location of the Award Drains are shown in Figure 2-1.

2.3.3 There are two specific locations within the overall study area that are the focus of this study; these are Villa Road to the South of Histon and Park Lane access road to the West of Histon. Both these locations are highlighted in Figure 2-1.

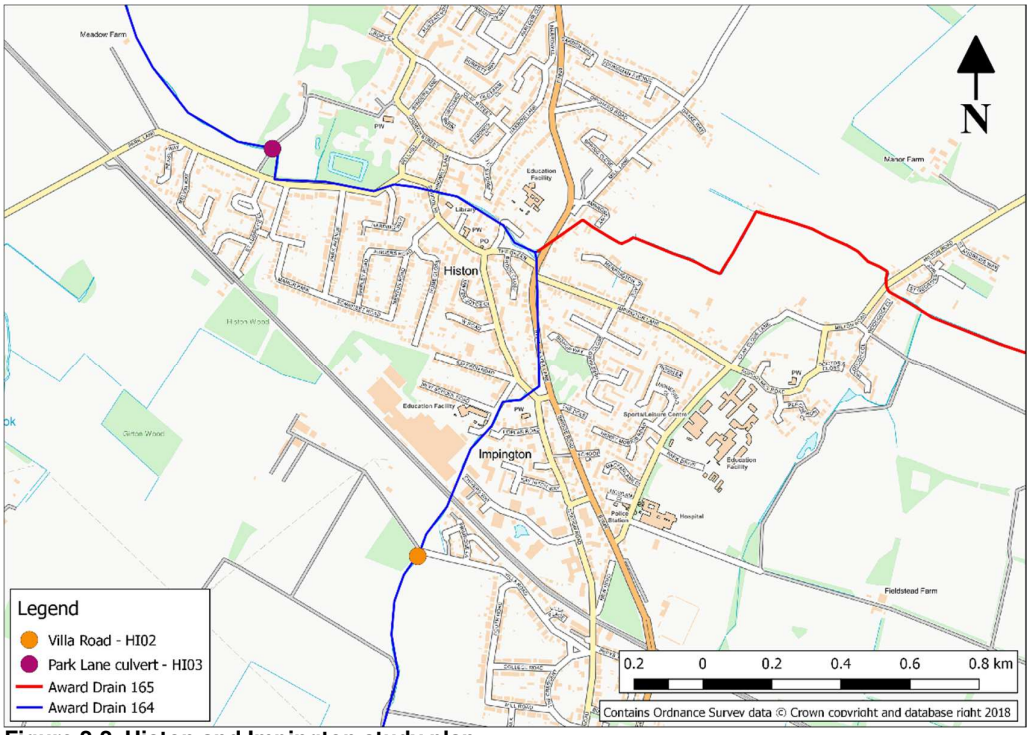

Figure 2-2. Histon and Impington study plan

3. Methodology

3.1 Review

3.1.1 The aim of the review was to assess the available information to determine the likely outcomes (benefits and costings) of the Villa Road and Park Lane options that were previously accounted for as part of the overall SWMP Pre-PAR assessment for Histon and Impington. This included a review of the SWMP reports and the existing modelling that was used to undertake the assessments. The review of the modelling included identifying how the assessment had been undertaken previously. It also determined if the model was suitable for further modelling of the options, if required.

3.1.2 The information detailed in Table 3-1 was made available for review, supplied by Cambridgeshire County Council.

Table 3-1. Data available for review

Data	Source	Comment
SWMP scoping study report	Cambridgeshire County Council	Histon and Impington Surface Water Management Plan, Scoping Study, Draft report, April 2014, undertaken by Hyder Consulting. This project aimed to undertake an initial review of surface water and fluvial flood risk information and determine a scope for further modelling and assessment as part of a detailed SWMP. Three key wetspots were identified across Histon and Impington. These were recommended as the focus for future options considerations.
SWMP Pre-PAR report	Cambridgeshire County Council	Surface Water Management Plan, Histon and Impington Pre-PAR Final report, October 2014, undertaken by Hyder Consulting. Further to the scoping study, the Pre-PAR included the assessment of potential options within the previously identified 3 key wetspots. This was achieved via the development of the Histon and Impington model.
SWMP Pre-PAR model	Cambridgeshire County Council	Histon and Impington Infoworks ICM model, version 5.0.4 Full details of the model provided are available in the Histon and Impington Model Audit report. In summary, the model available included a Do Nothing version, Do Minimum version and a series of Do Something versions to account for options testing.
SWMP Pre-PAR model build checklist	Cambridgeshire County Council	The aim of the document is to confirm the approach and detail of the model build. However, there was significant information missing within the document.
Survey	Cambridgeshire County Council	The survey undertaken in 2014 for the original model build was provided. The survey mainly covers the Award Drains within the study area, but also includes survey data for the outfalls.

3.1.3 The SWMP undertaken by Hyder in 2014 identified the key areas at risk across Histon and Impington. These resulted from a combination of both fluvial risk from overtopping of the Award drains and surface water flood risk. The surface water risk is exacerbated by the pipe network, flat nature of the catchment and depression storage.

3.1.4 Having identified the key risks, the SWMP Pre-PAR aimed to assess the potential for mitigation within the area. The assessment followed the standard approach of considering the Do Nothing and Do Minimum scenarios, followed by a series of Do Something scenarios. The Do Nothing scenario accounted for no maintenance, clearance or other intervention (to represent this the sewer network was removed from the model). The Do Minimum scenario accounted for maintaining the existing storm sewers, watercourses and highways drainage. The Do Something scenario represented intervention methods to mitigate risk in a series of combinations.

3.1.5 For the Do Something scenarios, a long list of options was produced which was narrowed down to a list of seven individual options across Histon and Impington (listed in Table 3-2 below). These individual options were then grouped into batches to form the Do Something scenario options that were assessed. Table 3-3 shows the grouped Do Something options that were tested.

Table 3-2. SWMP Pre-PAR short list of options (Source: Histon and Impington SWMP Pre-PAR report, Hyder, 2014)

Measure	Measure Name	Description
HI01	Improved maintenance	Increased cleaning of channel beds and banks, desilting of culverts and pipes, clearing of gullies
HI02	Upstream channel widening and flow attenuation	Widening the cross-section of Award Drain 164 reaches upstream of the urban area to store flood flows and provision of a flow control structure to maximise upstream flood storage and reduce pass forward flow downstream
HI03	Downstream channel desilting/reprofiling and culvert realignment	Channel desilting and reprofiling of a short stretch of Award Drain 164 immediately downstream of the main urban area. This also includes relaying of an existing access culvert with steep negative gradient.
HI04	Off Merrington Place detention area	Interception and attenuation of flood flows from Award Drain 165 before entering the culverted section along Glebe Way into an offline detention area off Merrington Place.
HI05	Homefield Park Detention Basin and Geocellular Units	Lowering of ground levels at an open area of Homefield Park to provide additional flood storage. It also includes provision of underground cellular units to maximise storage.
HI06	Glebe Way Rain Gardens	Provide rain gardens to store flows locally and allowed to infiltrate at the junction of Narrow Close and Glebe Way.
HI07	Premier Food's Factory disconnection	Reduce flows from a large existing factory unit to the storm system/river.

Table 3-3. Do Something options tested during the SWMP Pre-PAR

Measure	Option 3	Option 4A	Option 4B	Option 4C
HI01	X			X
HI02		X	X	X
HI03		X	X	X
HI04		X	X	X
HI05			X	X
HI06			X	X
HI07			X	X

3.1.6 The focus of this project is to understand the benefits provided by two individual options from the overall short list of seven. These include HI02, Villa Road and HI03, Park Lane. An assessment of the groups, a review of the model set up and a review of the mechanisms of flood risk using the model results for each group was undertaken. This review determined that the options were too interlinked to be able to distinguish the benefits from these individual options.

3.1.7 The conclusion from the initial review was that it was not possible to distinguish the individual benefits from options HI02 and HI03 from the currently available information.

3.1.8 The next stage of the study was therefore to undertake a review of the model to determine whether it was suitable to undertake model runs to test the individual options. Full details of the model review are available within the Histon and Impington Model Audit Report in Appendix A. The aim of this study was to get a high level picture of the benefits to advise further work and there was a limited budget available. The outcome of the model review concluded that, whilst updates would be recommended to provide a fully updated best practice model, for the scale of this study and the high-level nature of the requirements, the model was suitable subject to only minor updates. This also allows direct comparisons to be made back to the original SWMP work.

3.1.9 The next section of the report outlines the hydraulic modelling undertaken within this study.

3.2 Hydraulic Modelling

3.2.1 The baseline model used for the hydraulic modelling was the Hyder Histon and Impington Pre-Par 2014 Infoworks ICM model. As per the recommendations from the review, only minor updates were required as follows:

- The model was transferred to a newer version of the software, version 6.5
- The building representation was updated. The buildings were originally represented with raised mesh zones for the building footprint i.e this effectively raises the building and prevents water entering the footprint of the building. For this study the ground level modifications applied to the mesh zones were removed. The roughness value applied to buildings was updated following the current best practice. The original manning's n value of 0.1 applied was reviewed and raised to 0.7. This represents the potential for a limited amount of flow to pass through buildings. These updates allow for an improved process for the economic analysis.

3.2.2 These updates were applied to the Do Nothing, Do Minimum and Do Something versions of the model. All other aspects of the model were retained from the inherited Pre-PAR model.

3.2.3 The schematisation of the options was assessed to determine whether the original schematisation was suitable or if updates were required. The outcome of the review of both the Villa Road and Park Lane options are outlined below.

3.2.4 Option HI02, Villa Road, schematisation

3.2.4.1 A residential development has been proposed in the location upstream of Villa Road. The development is required to ensure that it does not result in an increase to flood risk. However, Cambridgeshire County Council aims to achieve betterment to flood risk as part of developments wherever feasible. Due to the scheme's position around the Villa Road option, the potential for this scheme to be incorporated as part of the development proposals is being considered.

3.2.4.2 The schematisation of the pre-PAR option proposed at Villa Road was considered for its suitability. The scheme includes widening of the channel by 5m on both its left and right banks over a reach of approximately 325m. A 2m wide summer channel was retained to aid flows during low flow conditions. This is combined with the inclusion of a flow control structure just upstream of Villa Road consisting of a 500mm diameter culvert through a flow control weir. The invert of the weir was set 1m above the soffit of the culvert. Figure 3-1 shows the reach of channel updates for HI02.

3.2.4.3 Following review of the schematisation and in discussion with Cambridgeshire County Council, it was determined that the schematisation used for the Pre-PAR assessment was suitable for this study. Further modifications could be assessed following analysis of the results.

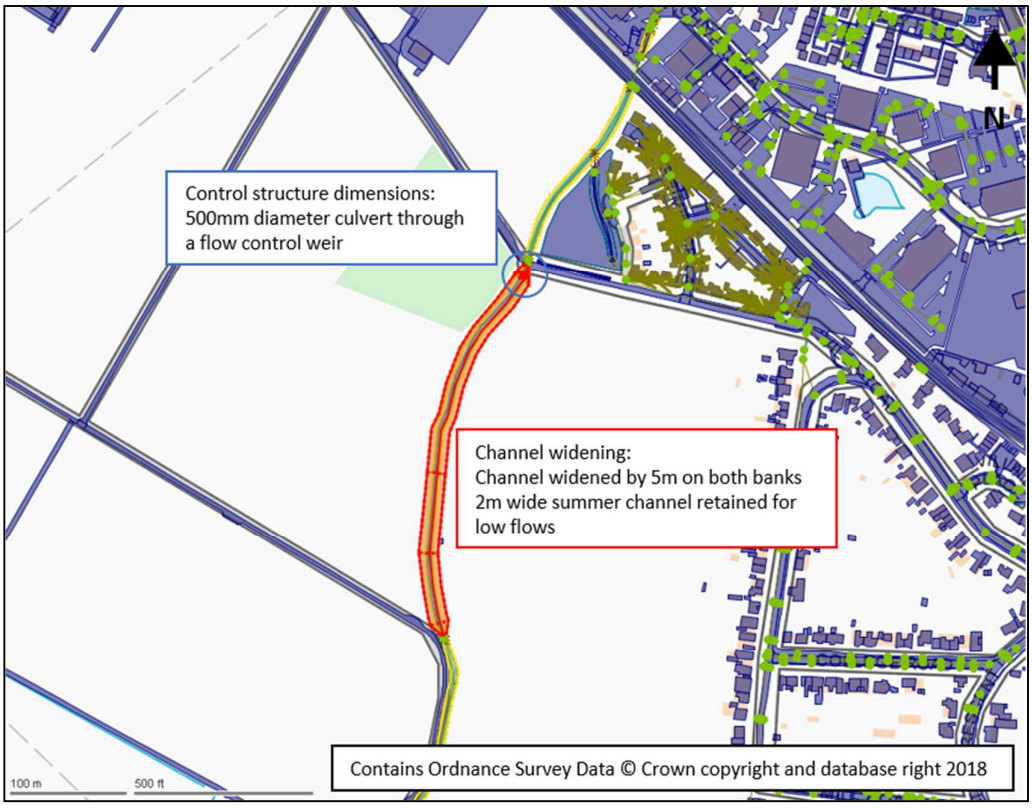

Figure 3-1. River reach schematised for the HI02 option (screenshot from the model)

3.2.5 Option HI03, Park Lane, schematisation

3.2.5.1 The Pre-PAR assessment identified that an access culvert off Park Lane was acting as a constriction to flow. Additionally, upstream of the culvert, the profile of the channel bed was uneven with large reaches of negative gradients.

3.2.5.2 A partnership between Cambridgeshire County Council Highways and the A14 project has resulted in funding being available to re-lay the access culvert. This option is being considered to understand the flood risk benefits provided from undertaking this scheme in isolation to the others proposed within the overall Pre-PAR option.

3.2.5.3 The schematisation of the Pre-PAR option proposed at Park Lane was considered for its suitability. The scheme included reprofiling a 420m reach of river upstream of the Park Lane access culvert. The culvert was effectively relayed by retaining the original culvert dimensions but adjusting the invert levels at both the upstream and downstream end to tie in with an improved overall gradient of the channel. The original culvert in the model consisted of a 5.5m long arch culvert that was 1.55m wide and 1.5m high. Figure 3-2 shows the location of updates for HI03.

3.2.5.4 At the stage of undertaking this study, the details of potential changes to the sizing or type of culvert was not available. Therefore, in agreement with Cambridgeshire County Council, it was determined that the schematisation used for the Pre-PAR assessment was suitable for this study to gain a high-level assessment of benefits. Further testing could be undertaken on the sizing of the culvert if required when moving towards detailed design.

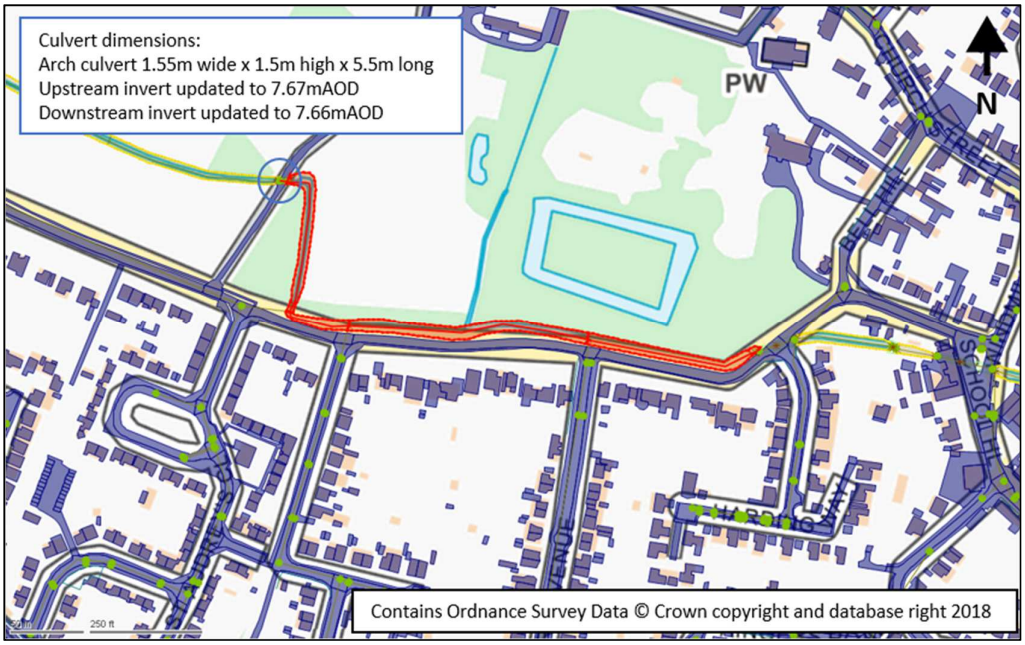

Figure 3-2. River reach schematised for the HI03 option - red lines show the reach of channel regraded (screenshot from the model).

3.2.6 Having determined the Pre-PAR schematisation of options to be suitable, the relevant model versions were created for this study. The updated version of the Do Something Option 4a model (refer to Table 3-2Table 3-3) was used as a baseline for the development of retained options scenarios. For the Villa Road (HI02) individual option, the HI03 and HI04 options were removed from the model and the baseline schematisation from the Do Minimum model was reinstated in these locations. For the Park Lane (HI03) individual option, the HI02 and HI04 options were removed from the model and the baseline schematisation from the Do Minimum model was reinstated for these locations. A final version of the model was developed to consider a combined option incorporating HI02 and HI03. The full list of the model scenarios undertaken was as follows:

- Do Nothing;
- Do Minimum;
- Villa Road individual option – HI02;
- Park Lane individual option – HI03; and
- Combined option – HI02 and HI03 combined.

3.2.7 Each scenario was run for the following design AEPs: 5%, 3.33%, 2%, 1.33%, 1% and 0.5%.

3.2.8 A series of storm durations were available from the Pre-PAR model. This project focused on the 60-minute storm duration as the worst case scenario.

3.3 Economic appraisal

3.3.1 The economic assessment has been based upon the Environment Agency's FCERM – AG specification to establish the Benefit Cost Ratio and determine how effective options would be, if implemented.

3.3.2 The original scope for this project was to only consider the economic assessment for the Villa Road, HI02 option. Following a review of the model results, Cambridgeshire County Council requested that the economic analysis was also undertaken for the combined HI02 and HI03 option.

3.3.3 Maximum flood extents have been processed for the Do Minimum and Do Something scenarios for a 5%, 3.33%, 2%, 1.33%, 1% and 0.5% AEP events. A 100 year asset life time has been used for the economic appraisal of the Do Something scenario, for a 100 year appraisal period.

3.3.4 A maximum flood depth has been output from the hydraulic model for both the Do Minimum and Do Something scenarios and assigned at each property in the study area using the National Receptor Database (NRD) data.

3.3.5 In the absence of property threshold survey across Histon and Impington, default values of 0.15 and 2.5 m have been applied for Ground Floor and Upper Floor levels respectively. A 0.05m cut off threshold has been applied to model results under which no damages to property is to be counted. This accounts for the direct rainfall approach that results in immediate flooding across the 2D zone, although at limited depths. 0.05m has been chosen as the depth above which water starts to accumulate enough in the model to cause flooding.

3.3.6 As part of the economic analysis the onset of flooding is accounted for within the calculations. In this case the smallest event available was the 5% AEP event. There is no historic information available and following discussions with Cambridgeshire County Council it was determined that there is no further evidence to support an earlier onset to flooding. Therefore, the 5% AEP event was used within the economic calculations.

3.3.7 The costs provided by Cambridgeshire County Council included the construction costs only. For Villa Road (HI02), the costs provided were high level costs estimated as part of the Pre-PAR analysis. It should be noted that the cost estimate is now 4 years old (as of 2018), although these are based on the design as schematised within the model. For Park Road (HI03), the costs provided were based on an estimate by SKANSKA in 2018. This accounted for the replacement of the Park Lane access culvert. However, the total cost does not appear to account for the full reach of bed reprofiling from the original schematisation.

3.3.8 The costs provided did not account for any maintenance costs; these were estimated based on the Environment Agency Guidance 'cost estimation for culverts – summary of evidence' 2014.

3.3.9 Damages to residential properties have been capped to the average market values shown in Table 3-4 for each property type.

Table 3-4. Average property value in Histon and Impington (Source: home.co.uk website, 2018)

Property Type	Average price (£)
Flat	£221,429
Terraced	£280,000
Semi-detached	£395,993
Detached	£805,556

3.3.10 Non-Residential properties are capped based on the rateable value for the property type and the floor area for the property as noted within the NRD data set.

4. Outcomes

4.1 General

4.1.1 For the direct rainfall approach to modelling, immediate flooding across the whole 2D domain is observed. A minimum depth is therefore set to eliminate the areas of very shallow water. In this case a value of 0.05m has been identified as the depth above which water starts to accumulate enough in the model to cause flooding. Therefore, the results and mapped outputs are based on a minimum threshold of 0.05m. It should be noted that the previous SWMP Pre-PAR outputs appear to be based on a 0.15m threshold and therefore there is a slight variation in the extent of flooding observed.

4.1.2 The original raw model results were not available for comparison against the latest model results, instead two comparisons have been undertaken to verify the model performance against the original modelling.

4.1.3 The model was initially run with no changes to test the model worked and to gain a baseline set of results. These were compared to the updated version of the model that included the amended building representation. The comparison showed there was very little difference in the results. Minor variations in extent were observed around the buildings where the flow path could now enter the footprint of the buildings but there was no significant change observed to the overall extent and depth of flooding in the model.

4.1.4 A further comparison was undertaken between the flood depths and extents from the updated model to the processed mapped outputs from the SWMP Pre-PAR study. The results are broadly very similar. There are variations around individual model mesh triangles at the edges of depth bands within the flood extent. However, overall these result in only minor variations of the extent. These are attributed to a combination of minor variations in the positioning of the model mesh following transfer of the model to a newer version and the difference in minimum depth threshold between the two studies.

4.1.5 A key location is the electricity substation to the north west of Villa Road. The depth mapping from this study shows water within the footprint of the electricity substation. The SWMP depth mapping showed the electricity substation to be clear of flood risk, with the extent only encroaching the field to the south east. This is due to the difference in the minimum threshold depth applied between the studies and the minor differences in extent as explained. The water shown within the footprint of the electricity substation in this study results from water ponding from the direct rainfall. However, at the higher order events, the drainage of this water to the south east may be restricted due to the presence of flood water that has overtopped the Award Drain.

4.1.6 When analysing the benefits of the scheme, the comparisons have been made between the Do Minimum (as the current situation) and the Do Something options unless otherwise stated.

4.2 Do Nothing

4.2.1 The results for the Do Nothing scenario are comparable to the original SWMP Pre-PAR modelling. Figure 4-1 shows the 1% AEP depth outputs. The depth maps for the Do Nothing scenario for all AEP's are included within Appendix B.

Figure 4-1. 1% AEP depth results for the Do Nothing scenario

4.2.2 The total number of properties at risk of flooding in a Do Nothing scenario are listed below in Table 4-1.

Table 4-1. Number of properties flooding in the Do Nothing model

AEP event (%)	Residential Properties	Non-residential properties
5	90	99
3.33	105	125
2	136	148
1.33	166	162
1	229	193
0.5	292	221

4.2.3 The Annual Average Damage (AAD) in a Do Nothing scenario for Histon and Impington is £565,446 with £351,077 damages for residential properties. Total Present Value (PV) Damages for a 100-year appraisal period is £16,857,399.

4.3 Do Minimum

4.3.1 The results for the Do Minimum scenario are comparable to the original SWMP Pre-PAR modelling. Figure 4-2 shows the 1% AEP depth outputs. The depth maps for the Do Minimum scenario for all AEP's are included within Appendix C.

Figure 4-2. 1% AEP depth results for the Do Minimum scenario

4.3.2 The total number of properties at risk of flooding in a Do Minimum scenario are listed below in Table 4-2.

Table 4-2. Number of properties flooding in the Do Minimum model

AEP event (%)	Residential Properties	Non-residential properties
5	82	98
3.33	97	124
2	121	148
1.33	152	161
1	186	180
0.5	276	220

4.3.3 The Annual Average Damage (AAD) in a Do Minimum scenario for Histon and Impington is £542,532 with £336,298 damages for residential properties. Total Present Value (PV) Damages for a 100-year appraisal period is £16,174,263.

4.4 Villa Road, HI02

4.4.1 The option at Villa Road included the implementation of a flow control structure just upstream of Villa Road and widening of the channel upstream of the structure to provide storage capacity.

4.4.2 The results of the modelling show that the mechanism of the scheme is working as proposed, with water being held back by the control structure and storing in the area upstream of Villa Road. Figure 4-3 shows the 1% AEP results for the Do Something HI02 Villa Road option. The depth maps for the Do Something HI02 scenario for all AEP's are included within Appendix D.

Figure 4-3. 1% AEP depth results for the Do Something, HI02 Villa Road scenario

4.4.3 Overall, downstream of the scheme, there is a slight reduction in the peak of the hydrograph immediately downstream of the proposed control structure. The greatest drop is seen during the 0.5% AEP event where the peak of the hydrograph reduces by 1.8m^3 down to a peak of 1.7m^3. Whilst there is a reduction in the peak of the hydrograph, the control of flow results in a prolonged falling limb, meaning that levels do not drop as quickly after the peak in the option as opposed to the Do Minimum scenario.

4.4.4 Whilst there is a reduction in the peak of the hydrograph downstream of the scheme, this does not result in significant reduction in the overall flood extent observed. The greatest reduction in extents and depths downstream of the scheme are observed between Villa Road and the guided busway.

4.4.5 On the right bank between Villa Road and the guided busway this is mainly resulting in a reduction in depth, although at the 1% AEP there is a slight reduction in extent immediately adjacent to the bank.

4.4.6 The area on the left bank between Villa Road and the guided busway is where the greatest changes in extent are observed. The reduction in extent is mainly within the open space on the left bank. However, for the 1% AEP a benefit is observed at the electricity substation, where the flood extent is largely removed from within the boundary of the site as shown in Figure 4-4 below.

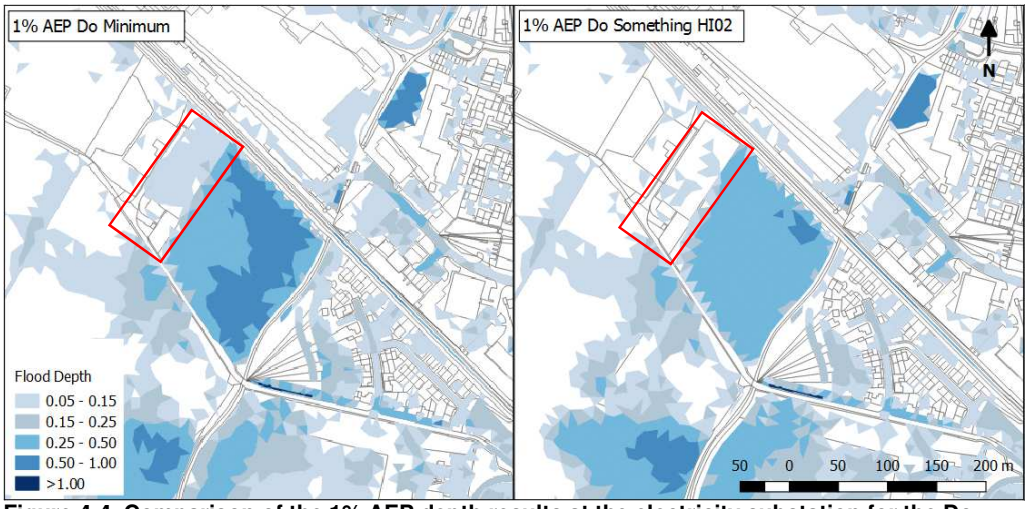

Figure 4-4. Comparison of the 1% AEP depth results at the electricity substation for the Do Minimum and Do Something HI02 option

4.4.7 Downstream of the guided busway, the benefits observed are mainly very marginal decreases in depth rather than a reduction in the overall extent. However, these marginal differences are sufficient in places to drop the depth at properties through central Histon from just above to just below the 0.15m depth threshold at properties.

4.4.8 The downstream extent of any observable reduction in flood extent from the scheme is around the junction between Water Lane and Station Road in the centre of Histon. For the 1% AEP event there are no discernible differences in the overall extent downstream of the guided busway.

4.4.9 There are two factors that are influencing the extent of benefit observed downstream of the guided busway. Firstly, the proposed option focuses on controlling the flows within the Award Drain. However, the predominant mechanism of flood risk in Histon appears to relate to surface water. This is due to the rate of input from rainfall exceeding the pipe capacity of the surface water sewer network and resulting in water backing up. The Award Drains do exacerbate this as the outfalls from the surface water network are unable to discharge to the Award Drains when the levels are high. However, the pipe network itself appears to reach capacity irrespective of the capacity within the Award Drains.

4.4.10 The second key influence on the extent of benefits observed downstream is the culvert on Award Drain 164 under the guided busway. The culvert below the guided busway acts as a constriction to flow and results in water backing up in the open space upstream of the culvert. The control at Villa Road significantly reduces the amount of water observed backing up and coming out of bank at the guided busway culvert.

4.4.11 Upstream of the proposed scheme the model results indicate an increase in the flood extents. Whilst additional storage capacity is being created within the scheme, the control structure is resulting in a greater additional volume of water being held back than can be stored within the scheme. As a result, there is an increase in the flood extent and depths observed on both the right and left banks upstream of the proposed control structure. For the smaller events this is largely just impacting the open land either side of the watercourse. However, for the 1% AEP event, there is an increase in the flood risk observed within the property boundaries (as based on OS Mastermap boundaries) on South Road. In all AEP events, this increase in flood risk observed within the open area may influence the risk seen within the proposed development. Further work would therefore be required on the design of the scheme to ensure it can provide the downstream benefits without increasing the risk to properties upstream.

4.4.12 Analysis of the volumes of material has been undertaken to estimate the additional storage that would be required to eliminate the increase in flood risk upstream.

4.4.13 Based on the existing schematisation, it is estimated that approximately 5,200m^3 of material would need to be excavated. Based on the additional volume of water shown in the HI02 model for the 1% AEP, a further 3,600m^3 of material would need to be removed, with approximately 900m^3 on the left bank and 2,700m^3 on the right bank. Based on the additional volume of water shown in the HI02 model for the 5% AEP, a further 340m^3 of material would need to be removed.

4.4.14 Based on the analysis of volumes, to resolve the increase in flood risk upstream of the control structure, it would require almost double the amount of material than the current proposed schematisation. It may be more realistic and cost effective to consider options for incorporating bunds around the widened channel rather than extending the width of the channel further. More detail would be required on the ground levels through this area based on topographic survey and a greater understanding of the land ownership and development plans would be required to determine the most suitable options for further analysis.

4.4.15 The total number of properties at risk of flooding in the Do Something scenario for Villa Road are listed in Table 4-3Table 4-2.

Table 4-3. Number of properties flooding in the Do Something, Villa Road, HI02 model

AEP event (%)	Residential Properties	Non-residential properties
5	77	95
3.33	93	114
2	115	139
1.33	152	157
1	175	172
0.5	270	217

4.4.16 The Annual Average Damage (AAD) in a Do Something scenario for Villa Road is £520,401 with £329,853 damages for residential properties. Total Present Value (PV) Damages for a 100-year appraisal period is £15,514,482.

4.4.17 Table 4-4 shows the movement of properties between the risk bands. It should be noted that the property count for each risk band excludes the numbers of properties previously counted at a higher percentage AEP event. However, the exact properties may differ between the risk bands. i.e, there is a benefit to a total of 11 properties at the 1% AEP event but 6 of these have already been accounted for within the lower percentage AEPs.

4.4.18 The results show that, whilst marginal, there could be some benefits resulting from the proposed scheme at Villa Road. However, further work would be required to optimise the scheme and ensure that the currently observed increases in flood risk upstream were eliminated.

Table 4-4. Properties moving between risk bands between the Do Minimum and Do Something HI02 option

	Moderate risk band (1% AEP event)	Significant risk band (2% AEP event)	Very significant risk band (5% AEP event)
Before	65	39	82
After	60	38	77
Change due to scheme	-5	-1	-5

4.5 Park Lane, HI03

4.5.1 The option at Park Lane included the relaying of the existing culvert combined with reprofiling of a reach of watercourse upstream to provide a positive gradient.

4.5.2 The results of the modelling show that the conveyance of water through this reach is improved by the reprofiling and relaying of the culvert. The degree of benefit to flood risk is determined by which AEP is observed. Figure 4-5 shows the 1% AEP results for the Do Something HI03 Park Lane option. The depth maps for the Do Something HI03 scenario for all AEP's are included within Appendix E.

Figure 4-5. 1% AEP depth results for the Do Something, HI03 Park Lane scenario

4.5.3 The model outputs show that conveyance of water through this reach and the culvert is improved by the upgrades, resulting in less water backing up following the proposed works. The benefits of this are significantly greater for the lower order events. For the 5% and 3.33% AEP events, the proposed option results in a reduction in the flood extent and depths observed through the vicinity of The Green and High Street, with the reduction in depth being the main observed difference. Continuing upstream from The Green and High Street, a slight reduction in depth is also observed up to the junction of Bridge Road, Water Lane and Station Road. However, this change in depth is not significant enough to result in a change in the overall flood extent.

4.5.4 By the time the scale of event has increased to the 1% AEP, there is negligible difference in the flood extent and only a very minor reduction in the depth observed. The overall impact of the proposed option for the 1% AEP is minimal.

4.5.5 The scope of the project did not include an economic assessment of HI03 option, therefore a comparison of property numbers and the economic assessment has not been undertaken for HI03 on its own.

4.5.6 The results show that at the higher percentage AEP events there is a benefit to properties from the replacement of the culverts and reprofiling of the channel. However, these benefits are reduced at the lower percentage AEP events.

4.6 Combined options

4.6.1 Following an initial review of the individual options for HI02 and HI03 with Cambridgeshire County Council, the scope was expanded to undertake a combined model run for the two options, along with the economic assessment.

4.6.2 The results of the combined model run are very similar to those shown when each option was modelled individually. This is due to the downstream and upstream limits to the benefits observed for HI02 and HI03 respectively, with only a very marginal overlap in the benefits observed between each option. Figure 4-6 shows the 1% AEP results for the Do Something combined HI02 and HI03 option. The depth maps for the Do Something combined scenario for all AEP's are included within Appendix F.

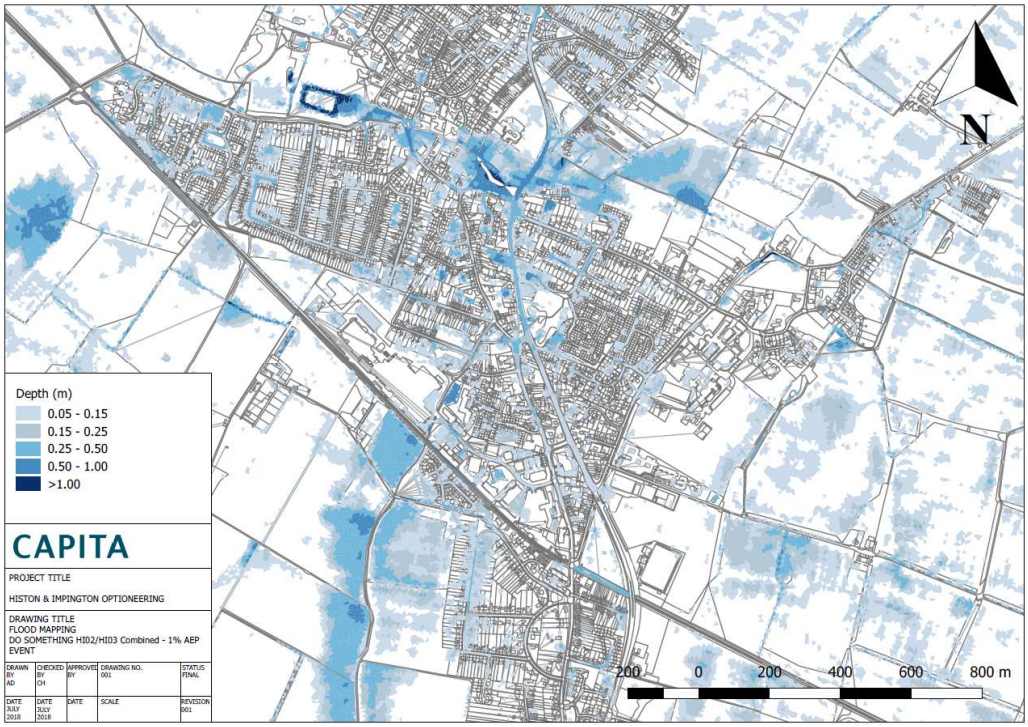

Figure 4-6. 1% AEP depth results for the Do Something, combined HI02 and HI03 scenario

4.6.3 The total number of properties at risk of flooding in the Do Something combined scenario are listed below in Table 4-5.

Table 4-5. Number of properties flooding in the Do Something combined model

AEP event (%)	Residential Properties	Non-residential properties
5	63	83
3.33	83	106
2	108	133
1.33	158	158
1	173	171
0.5	276	218

4.6.4 The Annual Average Damage (AAD) in a Do Something combined scenario is £501,011 with £314,727 damages for residential properties. Total Present Value (PV) Damages for a 100-year appraisal period is £14,936,405.

4.6.5

4.6.6 Table 4-6 shows the movement of properties between the risk bands. It should be noted that the property count for each risk band excludes the numbers of properties previously counted at a higher percentage AEP event. However, the exact properties may differ between the risk bands. i.e, there is a benefit to a total of 13 properties at the 2% AEP, however, as this is less than the 19 where a benefit was observed at the 5% AEP, this is shown as an increase of 6 properties.

Table 4-6. Properties moving between risk bands between the Do Minimum and Do Something combined option

	Moderate risk band (1% AEP event)	Significant risk band (2% AEP event)	Very significant risk band (5% AEP event)
Before	65	39	82
After	65	45	63
Change due to the scheme	0	+6	-19

4.6.7 The results show that the main benefits from the combined option is at the higher percentage AEP events. The downstream benefits from HI02 do not significantly overlap with the upstream benefits observed from HI03.

5. Summary

5.1.1 Two scenarios have been tested individually to assess their benefits and to provide recommendations for further work. The outcomes and recommendations of these are provided below.

5.1.2 Table 5-1 summarises the number of residential properties at risk in each AEP for each scenario whilst Table 5-2 provides a summary of the Annual Average Damages across each scenario.

Table 5-1. Summary of residential properties at risk across the AEPs for each scenario

AEP event (%)	5	3.33	50	1.33	1	0.5
Do Nothing	90	105	136	166	229	292
Do minimum	82	97	121	152	186	276
HI02	77	93	115	152	175	270
Combined	63	83	108	158	172	276

Table 5-2. Summary of the Annual Average Damages across each scenario

Scenario	Annual Average Damage	Damages for residential properties
Do Nothing	565,446	351,077
Do Minimum	542,532	336,298
HI02	520,401	329,853
Combined	501,011	314,727

5.1.3 Figure 5-1 shows the general location of the properties benefiting from the schemes. It should be noted that this should be used as a guide to the locations where benefits are observed. Further detailed modelling and options design would be required to confirm individual property benefits.

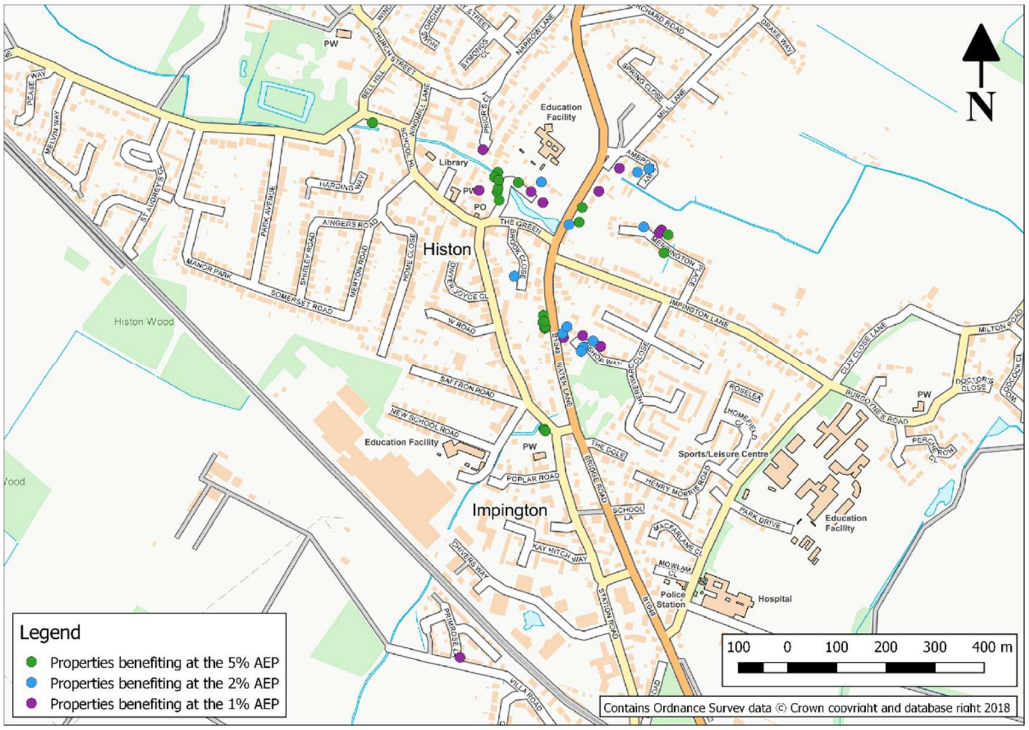

Figure 5-1. Map showing the locations where properties are benefiting in the combined option

5.2 Villa Road, HI02, scheme recommendations

5.2.1 Whilst the scheme does not show significant benefits in terms of number of properties protected, there are still some benefit. The benefits may be more visible in the future if further options are implemented through Histon and Impington. The small reduction in flows from the upstream area of the catchment may be sufficient when combined with improvements within Histon to provide the combined benefit.

5.2.2 Further work is required to optimise the scheme and ensure that it provides a benefit whilst not increasing flood risk upstream. It is recommended that the existing scheme could be used as a base but further work undertaken to consider additional widening, the introduction of a flood bund or introducing a designated flood storage feature. Additional understanding of the availability of land and development proposals would be required to inform further design work.

5.2.3 It is also recommended that, for further detailed work on optimising the HI02 option, additional updates are made to the model including hydrology and updated survey information. The model currently shows some instabilities at the 0.5% event that would need to be resolved if further detailed understanding was required.

5.3 Park Lane access culvert, HI03, scheme recommendations

5.3.1 The main benefits for HI03 are observed at the more frequent flood events, with the greatest benefits observed at the 5% AEP event.

5.3.2 For the observed benefits to be achieved, the culvert would need be replaced as per the model schematisation. The culvert would need to be replaced with a 1.55m wide and 1.5m high arch culvert at a length of 5.5m and the channel upstream of the culvert re-graded.

5.3.3 Improved conveyance through this reach is also likely to provide a further combined benefit if additional options are implemented within central Histon in the future, such as those identified within the SWMP. The improved conveyance may also be a benefit to future maintenance costs as it could help reduce the build-up of silt through this reach.

6. Assumptions and Limitations

6.1 Key Assumptions

6.1.1 The aim of this project was a high level study of the potential benefits from two specific options identified within the Pre-PAR assessment. Certain assumptions were made where there was limited information.

6.1.2 There was limited information about some of the data and analysis undertaken as part of the original model development; therefore a number of assumptions were made taking into account the high level nature of the project requirements. The following assumptions were made regarding the modelling:

6.1.2.1 The hydrology remains suitable for use whilst the aim of the project is to understand overall potential benefits from the options. For future work and if detailed design is to be undertaken it would be recommended that the hydrology should be updated to account for the latest techniques.

6.1.2.2 The channel survey was undertaken in 2014 and there have not been any significant changes to the channel since that time. Therefore, the survey was considered suitable.

6.1.2.3 There was insufficient information available to verify the highways network and surface water sewer network. It was therefore assumed that these were represented appropriately within the model.

6.1.3 For the economic analysis, only high level estimated costs were available for the proposed options and no maintenance costs were available. Estimates for the maintenance were based on the EA Guidance on cost estimation for culverts[1] and channel maintenance[2].

6.1.4 When undertaking economic analysis, the onset of flooding is identified and set within the calculations. In this instance the smallest event available within the modelling was the 5% AEP. With no further data to suggest an earlier onset, this was assumed as the onset of flooding for the economic calculations in agreement with Cambridgeshire County Council.

6.1.5 The access culvert for the HI03 option is represented in the Do Minimum as a clear culvert with no blockage. Therefore, the benefits may be greater based on the fact the culvert is currently in poor condition.

6.2 Limitations

6.2.1 The Premier Food's Factory adjacent to the guided busway is considered to play a key role within the surface water mechanisms in this area of Histon. It is noted within the Pre-PAR documentation that there was insufficient information to fully determine the existing drainage situation to incorporate within the model. This is therefore acting as a limitation to the model representation in this location.

[1] http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SC080039_cost_culverts.sflb.ashx
[2] http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/SC080039_cost_channel_mgmt.sflb.ashx

6.2.2 The construction costs for HI02 were based on the original Pre-PAR estimation and updated estimates were not available. Updated costs were provided for the HI03 Park Lane option but it should be noted that the updated costs focus on the upgrading of the culvert and immediate regrading of the channel. It is not clear if the full reach of regrading schematised within the model was incorporated within the updated cost estimate.

6.2.3 The property count is based on the specific point of the NRD property point location within the model mesh triangles. There is the potential for some discrepancy in the locations between the property points, mesh triangles and building footprints.

6.2.4 The results are sufficient to get a gauge of benefits and the general location of benefits. It should be noted that, due to assumptions and limitations with the model and data processing, the results should not be used for specific assessment of individual properties. If further detail is required, updates to the model would be required and detailed scheme design should be used for the options.

Appendix A

ICM model audit – Histon and Impington

Appendix B

Do Nothing depth maps

Appendix C

Do Minimum depth maps

Appendix D

HI02 – Villa Road depth maps

Appendix E

Park Lane – HI03 depth maps

Appendix F

Combined run – HI02 and HI03 depth maps