Leiston Mitigation Scheme and Property Count Estimation

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Synopsis: This technical addendum accompanies the Leiston Surface Water Management Plan modelling update report. It details the proposed mitigation scheme for Leiston and shows the estimated number of properties impacted by predicted flooding in both the baseline and mitigated cases.

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Executive Summary

Suffolk County Council have commissioned BMT to assess an agreed flood mitigation scheme for Leiston, and perform property count estimations for both the predicted baseline and mitigated scenarios. This report follows on from the Leiston Surface Water Management Plan completed by BMT in December 2017, and uses the existing Integrated Urban Drainage (IUD) model developed for this study. In summary the work undertaken for this investigation included:

- Agreeing the preferred mitigation scheme for the modelled area. This was determined to consist of two runoff attenuation bunds and basins at The Gables and Leiston Primary School. These measures were selected in consultation with SCC based on an assessment of land-uses and overland flow routes;
- Concept designs for the mitigation options were built into the existing IUD model. These were run across the full range of agreed design rainfall events used within the baseline (existing) case;
- Property count estimations performed on the predicted baseline scenario confirmed a significant risk to property along several of the major overland flowpath routes; and

The mitigation analysis confirms that the two runoff attenuation structures are likely to reduce flood risk to a number of predicted flooded properties within the modelled area.

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1 Introduction

BMT have been commissioned by Suffolk County Council (SCC), as a part of their role as Lead Local Flood Authority, to model agreed flood mitigation measures and determine any benefit from these measures (via a property count estimation). This study follows on from the Leiston Surface Water Management Plan completed by BMT in December 2017, and uses the existing Integrated Urban Drainage (IUD) model.

The purpose of this study is to incorporate a mitigation scheme within existing baseline IUD model, and perform property count estimations for both the baseline and mitigated cases to assess any changes as a result of the inclusion of the scheme. The model results will provide SCC with a more comprehensive understanding of existing property risk in Leiston, and demonstrate the effectiveness of potential mitigation measures in reducing this risk for the full range of agreed design rainfall events. The results will be used to assist with the development of capital schemes and secure funding for future flood alleviation schemes.

2 Mitigation Option

This section details the proposed mitigation options in Leiston, along with a summary of the preferred strategy.

2.1 Options Appraisal

A range of flood risk management measures have been considered to assist in reducing the surface water flood risk to Leiston. These were initially identified in the Leiston Surface Water Management Plan (SWMP) update (Figure 2-1).

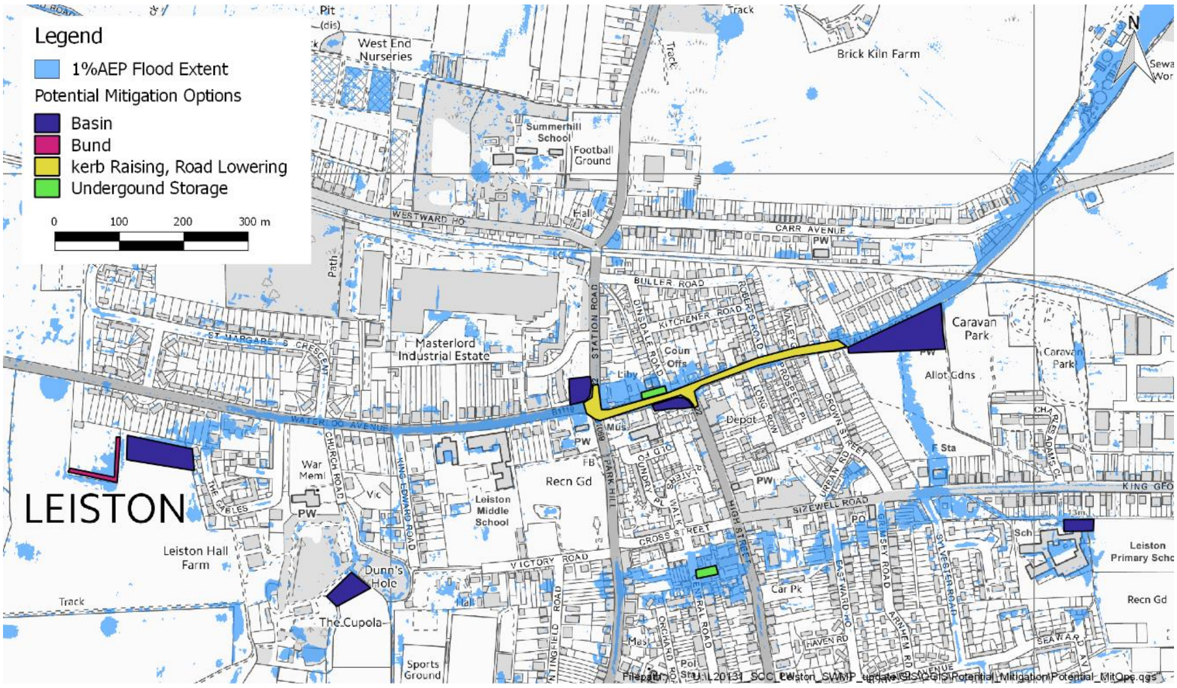
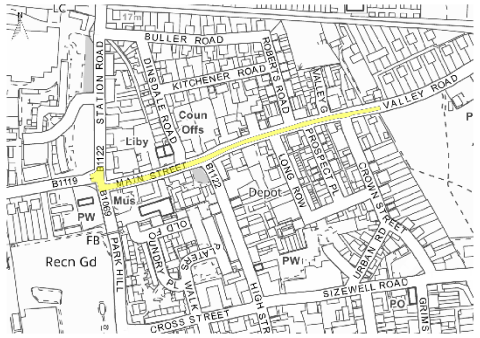


Figure 2-1 Leiston SWMP model update - Mitigation Options Proposed

Consultation was held with SCC to derive a short-list of potential options for the areas of interest, taking into consideration existing/ future land uses, land ownership, potential benefit (i.e. size and upstream inflows), perceived costs and any existing measures in place.

A total of eight mitigation measures from those proposed in the updated SWMP model were short-listed and assessed. High level concept designs for each option were then incorporated within the existing IUD model to gauge how each measure may perform. These measures are summarised in Table 2-1 below.

Mitigation Option

Mitigation Option	Option Description	Figure	Assessment	Preferred?
Road Lowering (Valley Road)	Lowering of Valley Road and Main Street by 0.3m. The scheme would aim to reduce risk to properties along the Valley Road flowpath by increasing the threshold at which properties become flooded.		Initial modelling and depth difference results indicate that road lowering on Main Street and Valley Road would increase the conveyance capacity of the Valley Road flowpath. Whilst minor benefits are predicted to the properties on Valley Road, there is a heightened risk predicted to properties further downstream. The scheme would be expensive, requiring substantial engineering work along the main road through Leiston. The presence of existing services may also present a significant constraint to this measure being constructed.	✗
Storage Basin (Central Road)	Storage basin of 0.5m depth between properties on Central Road. The scheme would aim to benefit surrounding properties and reduce flood risk along the Sizewell Road flowpath.		Initial modelling and depth difference results reveal minor benefits (<0.02m) to properties across all flood events. Given the lack of available space and location adjacent to residential and business areas, it was determined that there was limited scope for mitigation measures in this area.	✗
Storage Basin (High Street)	Storage basin on existing green space on the High Street. The basin would aim to divert overland flow off the Valley Road and reduce flood risk to properties downstream.		Initial modelling and depth difference results suggest the scheme would have only minor benefits to properties downstream along the Valley Road flowpath. Substantial re-profiling and engineering work would be required to divert flows effectively off the main road, given the area is up to 1m higher than the road level.	✗
Storage Basin (Station Road)	Storage basin on existing green space at the Waterloo Avenue and Station Road junction. The basin would aim to divert flow off the Valley Road flowpath and reduce flood risk to properties downstream.		Initial modelling and depth difference results suggest the scheme would have only minor benefits to properties downstream along the Valley Road flowpath. Substantial re-profiling and engineering work would be required to divert flows effectively off the main road, and given the area is up to 1.5m higher than the road level.	✗

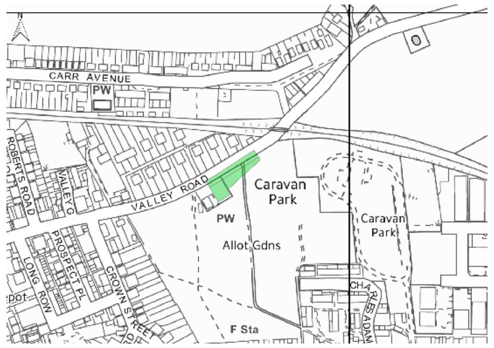
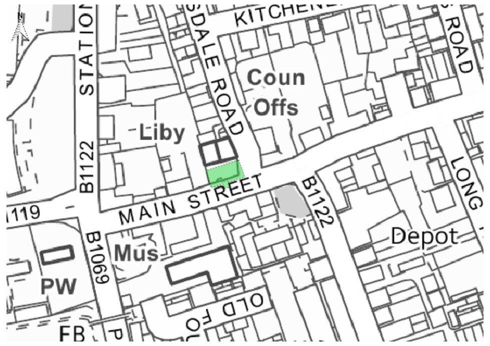
Mitigation Option	Option Description	Figure	Assessment	Preferred?
Storage Basin (Allotments)	Storage basin on the allotment gardens adjacent to Valley Road. The basin would aim to divert flows off the Valley Road flowpath, and capture flow from the flow route through the allotment gardens.		Initial modelling and depth difference results indicate minor benefits to the properties at Archway Cottages on the lower portion of the Valley Road flowpath. Optimal placement of the basin across the full width of the allotment garden flowpath is not possible due to the existing car park and building adjacent to Valley Road. Substantial re-profiling and engineering work would be required to divert flows effectively off the main road.	✗
Storage Basin (Main Street)	Underground storage basin of 0.3m depth located on existing car parking spaces at Leiston Library. The basin would aim to attenuate floodwater on the Valley Road flowpath and reduce flood risk to properties further downstream.		Initial modelling and depth difference results indicate negligible benefits to flood risk. There is limited scope for options in this location given that parking spaces and ammenity need to be retained. Substantial engineering works would further be required to develop an underground storage basin that would have any meaningful impact to flood risk.	✗
Runoff Attenuation Bund and Basin (The Gables)	Raised bund of 0.8m and accompanying storage basin of 0.5m depth on agricultural land at The Gables. The structure would aim to capture and attenuate run-off at the head of the Valley Road flowpath.		Initial modelling and depth difference results reveal substantial flood risk benefits to properties along the full length of the Valley Road flowpath. The feature attenuates run-off significantly, holding the water back at the head of the flowpath. The existing land-use is agricultural, and therefore there is far greater scope for potential mitigation.	✓
Runoff Attenuation Bund and Basin (Leiston Primary School)	Raised bund of 0.5m and shallow storage basin located on the Leiston Primary School playing fields. The feature would aim to attenuate run-off from the playing fields, benefitting the Sizewell Road flowpath and the downstream portion of Valley Road.		Initial modelling and depth difference results suggest positive impacts to properties along King George's Avenue and through the allotment gardens leading into Valley Road. The scheme would require relatively minor engineering works given the existing land-use. However, appropriate steps would be required to ensure the risk to Leiston Primary School are minimised.	✓

Table 2-1 Options Appraisal

2.2 Preferred Option

In discussion with SCC officers, the preferred option was to model an attenuation bund and basin on agricultural land at The Gables, and at Leiston Primary School playing fields. The selection was based on both land use, feasibility of implementation, and the significance of overland flow routes in these locations.

These structures act on the Valley Road and Sizewell Road flowpaths and can perform as standalone options, but also function well as a scheme targeting the downstream portion of Valley Road where the two flowpaths meet. Other options have been discarded with consideration of existing land-uses and ownership, potential costs of implementation and due to minimal beneficial impacts observed in initial modelling results – see Table 2-1.

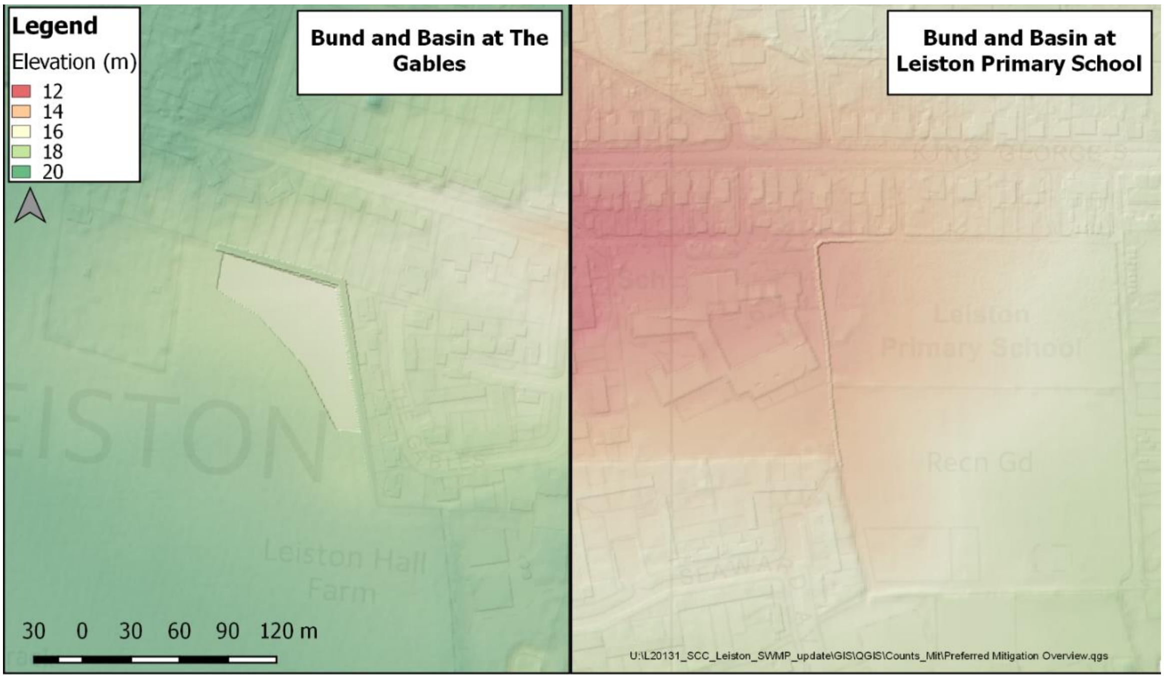


Figure 2-2 Preferred Options - proposed topography

Overland flow from the agricultural fields at Leiston Hall Farm, upstream of The Gables forms a significant contribution to surface flow along Waterloo Avenue, Main Street and Valley Road, particularly in events of 3.33% AEP and higher. Therefore, the installation of a bund and basin on agricultural land at The Gables would have the potential to hold water back at the head of the catchment and attenuate flows down this main flow route.

Similarly, the playing fields at Leiston Primary School were identified as a source of overland flow to the flow route along King George's Avenue and through the allotment gardens, eventually joining the Valley Road flow path. Attenuating overland flow on the playing fields would aim to benefit properties on King George's Avenue and the residential properties on lower Valley Road.

High level concept designs have been produced and represented within the hydraulic model to assess the impact on flood risk. The final design of the flood mitigation scheme will require further detailed development, including comprehensive survey on how locations are safely overtopped and discharged into the sewer system. It is recommended that the school basin should have a high flow weir to avoid floodwaters overtopping into the school.

The baseline IUD model was run with the preferred mitigation option to determine the impact on surface water flood risk. To visualise the change in flood risk, the predicted maximum flood depth results were subtracted from the baseline (existing without mitigation) results for each storm event. This process helped to determined where predicted flood depths have changed increased or decreased. Depth difference maps are presented within Figure 2-3 and Figure 2-4 – pink to red shades mean an increase in depths within the mitigation scenario, whilst greens reflecting a decrease in depth within the mitigated scenario.

A predicted reduction in flood depth can be seen along the Valley Road and Sizewell Road flowpaths across all modelled events. The combined effect of both mitigation measures is realised on Valley Road downstream of the allotment gardens where the two flowpaths meet, with depth reductions of 0.15 – 0.20m predicted at the confluence in the 1% AEP climate change upper event. The bund and basin at The Gables is predicted to positively impact flood depths along Valley Road for all flood magnitudes. However, it is noted that current configuration of the bund and basin at Leiston Primary School ceases to produce any notable reduction in flood depths in events greater than the 1% AEP magnitude.

In the 3.33% AEP event, depth differences of up to 0.08m are estimated on the Valley Road flowpath at the junction to High Street. Similarly on the Sizewell Road flowpath, depths are estimated to be reduced by up to 0.05m. The combined impact of both mitigation options is realised downstream of the confluence of the two flowpaths at the allotment gardens, with a predicted depth reduction of 0.04m at Archway Cottages, and increasing up to 0.07m at the Sewage Works.

The flood storage volumes for both structures can be seen in Table 2-1 for a range of event magnitudes.

Table 2-2 Basin predicited storage volumes

AEP	Storage Volume (m^3)	
	The Gables	Leiston Primary School
10%	1455	578
3.33%	3311	901
1%	5160	1048

Legend

Change in Peak Flood Depth (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- >0.5
- Model Boundary
- Mitigation Scheme

Title: **Leiston Mitigation Scheme: Depth Difference**		Drawing: 2-3	Rev: A
BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.	Drawn\Check: JP/REJ Date of issue: 29/06/2018	Scale: 0 50 100 150 200 250 m	BMT
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Change in Peak Flood Depth (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- >0.5

Title: **Leiston Mitigation Scheme: Depth Difference**		Drawing: 2-4	Rev: A
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3 Property Count Estimation

An estimation on the proposes at risk of flooding was then undertaken for the project. Property counts were estimated using the following datasets:

- The National Receptor Dataset (NRD);
- The Ordnance Survey Master Map (OSMM) building polygons; and
- The predicted flood depth results for the baseline and options scenarios.

The Environment Agency (EA) methodology uses the NRD property points and building footprints from the OSMM Topographic Area layer (Figure 3-1). The OSMM and the NRD typically have a degree of mismatch as they are updated at different times. The OSMM was last updated in Leiston in May 2017, whereas the NRD was updated in 2014. A comparison of the two datasets shows approximately 18% of buildings in the OSMM did not have appropriate corresponding NRD data. Where data is lacking, the building classification (residential, non-residential or critical services) has been manually filled. The manual assumption of classification has been based on satellite imagery, mapping and surrounding building class. Where no classification was clear, the building has been assumed to be residential. An example of the mismatch between the two datasets can be seen in in Figure 3-1 below on Poppy Way, Daisy Drive and Cornflower Close. Typically, this is related to new buildings which are not present within the NRD.

OSMM polygons representing garages and sheds can skew property count and damage estimation results. These have been filtered out using an area threshold of 20m^2. A threshold of 20m^2 was selected due to the identification of several small residential properties that should be included in the final dataset. Remaining garages and sheds of >20m^2 have been manually removed where easily identifiable.

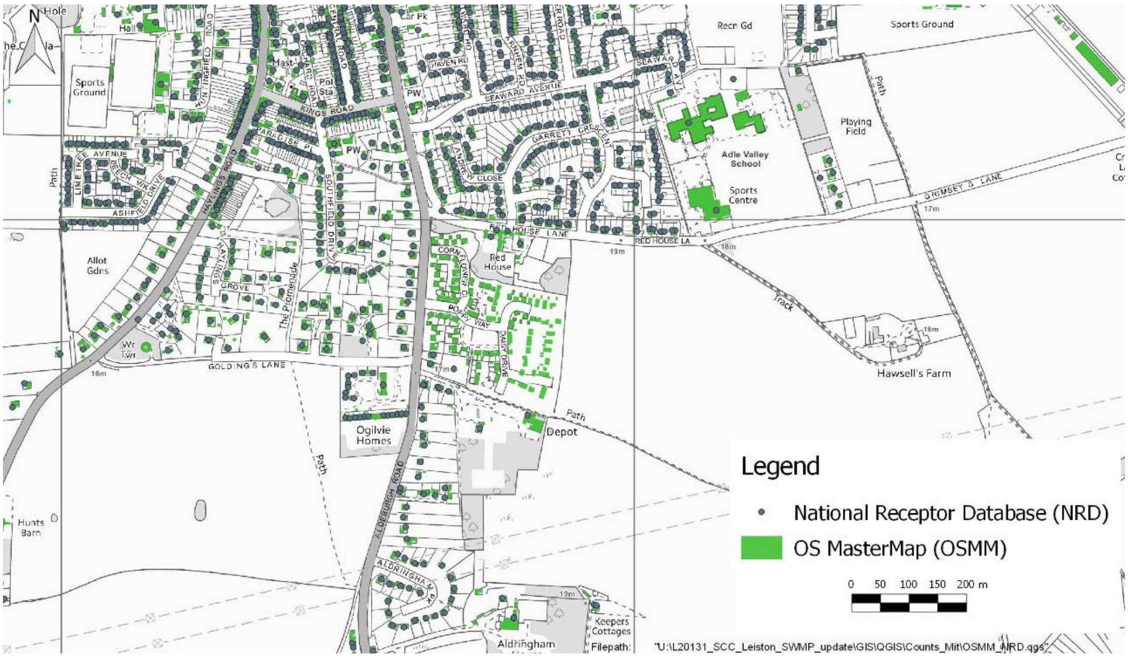


Figure 3-1 NRD and OSMM Dataset Comparison

The analysis has been carried out on the 10%, 3.33%, 1.33%, 1%, 0.5% AEP storm events and 1% AEP with Climate Change allowance; lower bound (20%) and upper bound (40%). The modelled results from the updated SWMP modelling have been used for the baseline flood risk estimation and mitigation option.

3.1 Methodology

The latest method developed by the EA for estimating the properties at risk from surface water flooding has been used in this analysis. A summary of the method developed by the EA is provided below. Further details can be found in the report accompanying the uFMfSW Property Points dataset[1].

The building footprints in the OSMM are buffered to reduce the gridded effect of the raised building footprint and flood extent. The recommendation for the buffer size is the modelled grid size, therefore, a 1m buffer has been applied. The analysis is then carried out on the buffered building boundary and is adjusted for internal building perimeters, for example when properties are terraced or semi-detached.

The proportion of the buffered boundary where the depth is greater than a specified threshold is calculated, as shown by the blue line in Figure 3-2.

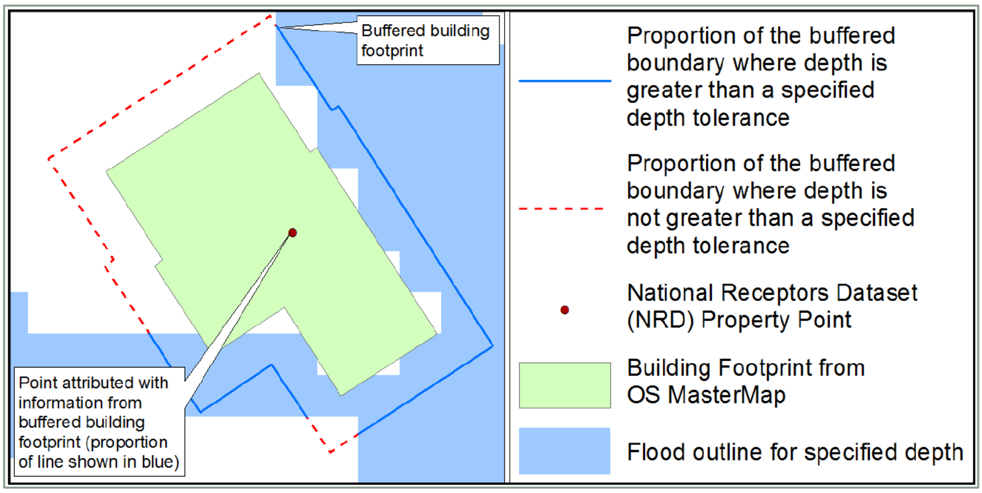


Figure 3-2 Property Count Methodology (EA, July 2014)

The final dataset is then filtered according to local judgement on the proportion of the buffered building boundary and depth threshold to produce locally applicable counts of properties that are at risk of surface water flooding.

The properties at risk of surface water flooding within Leiston have been selected using ≥ 50% wetted perimeter AND ≥ 0.1m depth threshold. The depth threshold, agreed in conjunction with SCC as part of the Leiston updated SWMP modelling, corresponds to the average height of building threshold or airbrick allowing floodwater to enter the property. This depth threshold is lower than the national standard of 0.2m as the properties in Leiston have typically lower threshold levels (refer to main SWMP model update report, section 3.3.2).

[1] The updated Flood Map for Surface Water (uFMfSW) Property Points dataset, Report version – 1.0, July 2014

Each building polygon that met the criteria is marked as 'flooded'. For multiple properties within one building (e.g. units within a multi-storey building) only basement and ground floor properties are counted. Property counts have been calculated separately for residential, non-residential and critical infrastructure.

For EA Flood Defence Grant in Aid (FDGiA) funding calculation, flooded properties are typically categorised by ward into deprivation indices for three classifications: 20% most deprived, 20% - 40% most deprived and 60% least deprived. As all wards in the Leiston catchment fall into the 60% least deprived category, this break down has not been presented.

3.2 Property Count Estimates

Table 3-1 and Table 3-2 below shows the number of properties at risk from surface water flooding in the baseline and mitigation scenarios for 0.2m and 0.1m thresholds. Property count results in Leiston have been provided for both the 0.2m and 0.1m thresholds to highlight the sensitivity to this parameter and provide future flexibility should counts at the national standard thresholds be required. Based on discussion with SCC officers and site visit inspections, the 0.1m threshold level has been adopted for this study.

Table 3-1 details the results using a 0.2m threshold, the national average; Table 3-2 details the results using a 0.1m threshold, which has been selected for Leiston based on local levels. Figure 3-3 shows the same count information graphically for the 0.1m threshold.

Figure 3-4 and Figure 3-5 shows the spatial distribution of inundated properties in Leiston in both the baseline and mitigated scenarios.

Table 3-1 Properties at Risk from Surface Water Flooding (0.2m Depth Threshold)

AEP	Baseline Scenario			Mitigated Scenario			Difference	
	Residential	Non-Residential	Critical Services	Residential	Non-Residential	Critical Services	Absolute	%
10%	15	1	0	12	1	0	**-3**	**19**
3.33%	46	8	1	40	6	0	**-9**	**16**
1.33%	72	18	1	71	13	1	**-6**	**7**
1%	82	23	1	80	20	1	**-5**	**5**
0.5%	112	27	3	106	25	1	**-10**	**7**
1% Lower Climate Change	106	27	2	99	24	1	**-11**	**8**
1% Upper Climate Change	140	35	5	129	31	2	**-18**	**10**

Table 3-2 Properties at Risk from Surface Water Flooding (0.1m Depth Threshold)

AEP	Baseline Scenario			Mitigated Scenario			Difference	
	Residential	Non-Residential	Critical Services	Residential	Non-Residential	Critical Services	Absolute	%
10%	42	5	3	40	5	1	**-4**	**8**
3.33%	101	26	5	98	23	2	**-9**	**7**
1.33%	165	37	5	156	33	3	**-15**	**7**
1%	188	46	6	180	44	4	**-12**	**5**
0.5%	253	65	8	245	63	8	**-13**	**4**
1% Lower Climate Change	243	62	7	231	60	7	**-8**	**2**
1% Upper Climate Change	293	71	9	287	70	8	**-19**	**3**

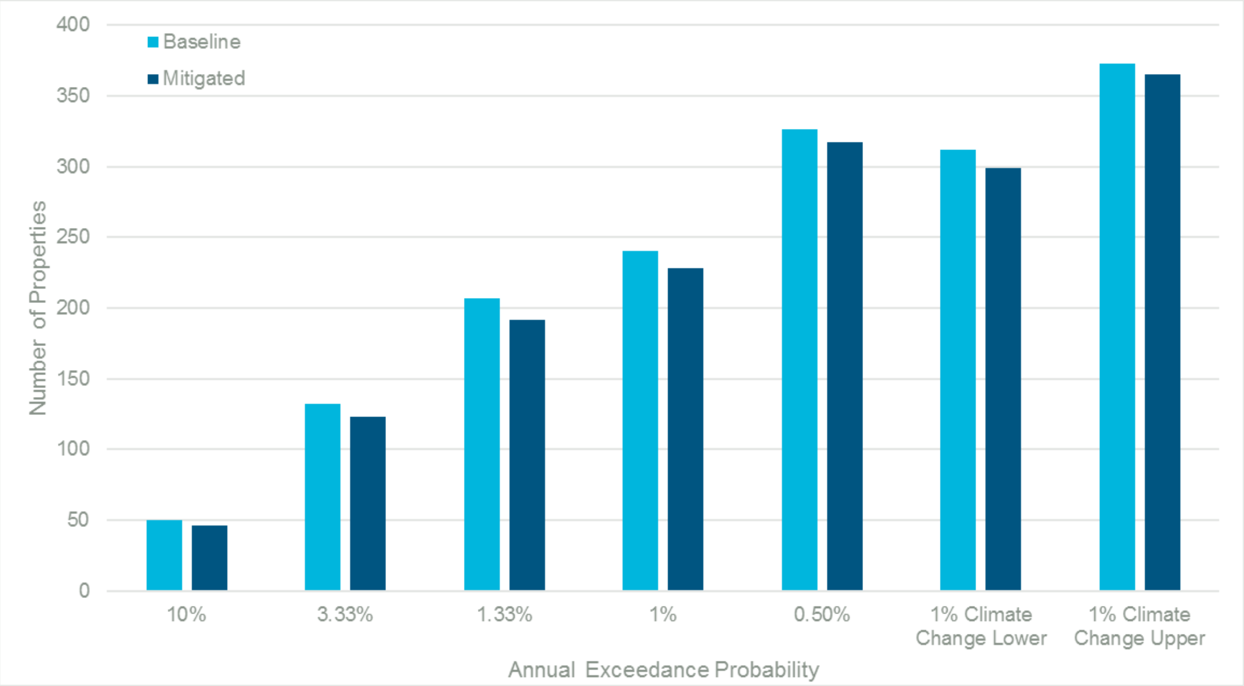
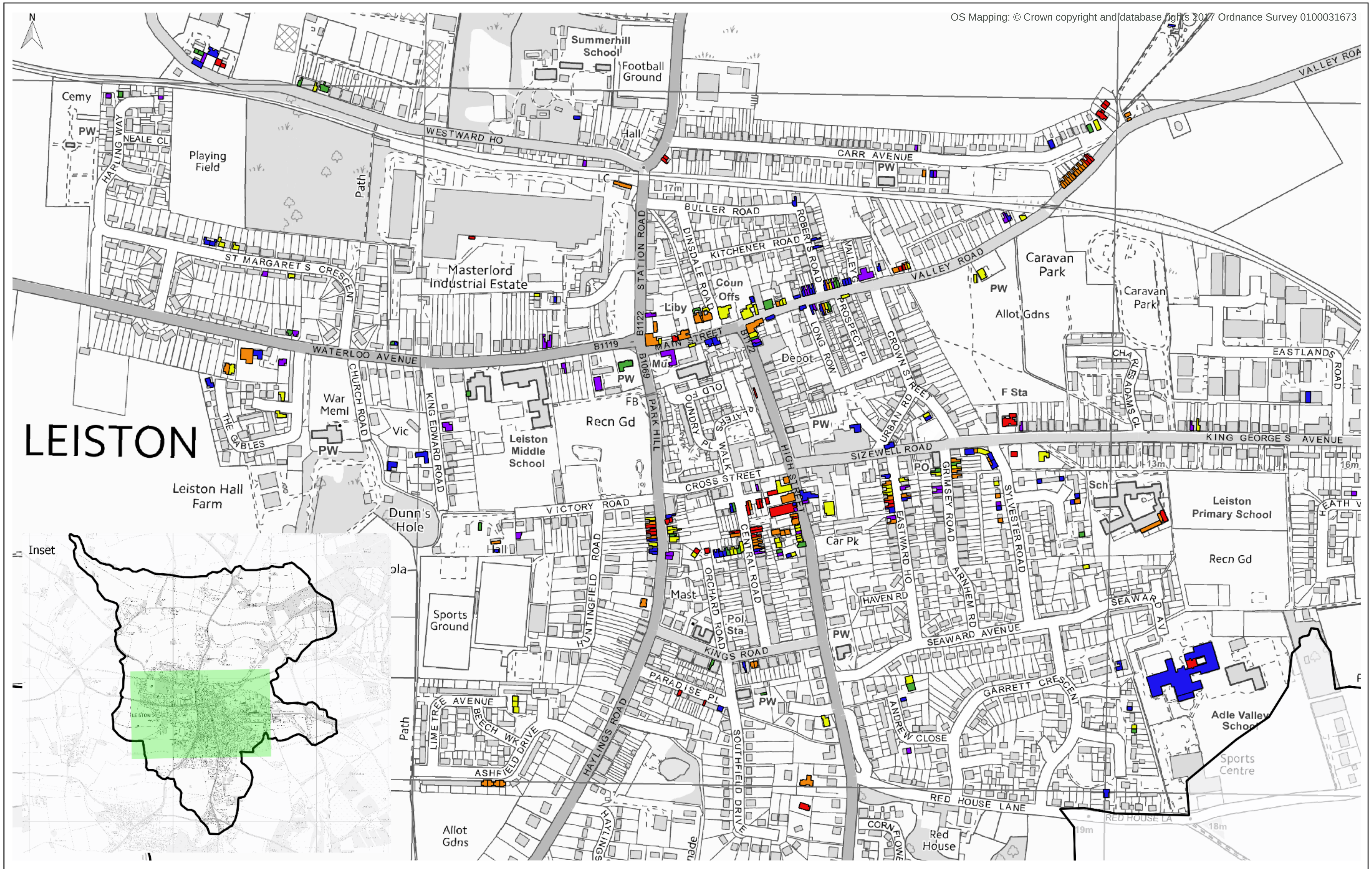


Figure 3-3 Properties at Risk from Surface Water Flooding (0.1m Depth Threshold)



Legend

Storm Event

- 10% AEP
- 3.33% AEP
- 1.33% AEP
- 1% AEP
- 0.5% AEP
- 1% AEP Climate Change Lower
- 1% AEP Climate Change Upper

Title: Storm event of initial property inundation -baseline scenario

Drawing: 3-4

Rev: A

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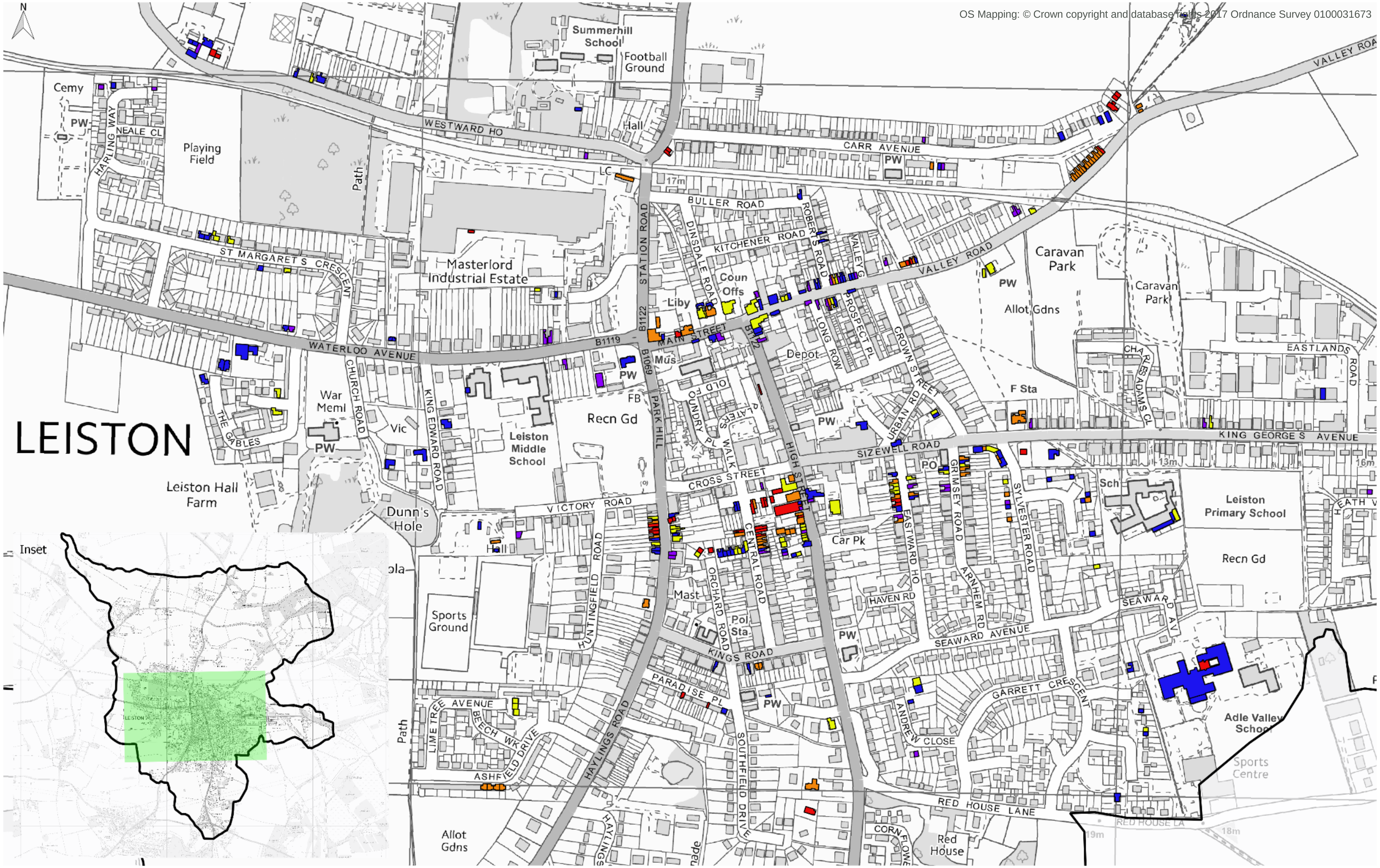

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Storm Event

- 10% AEP
- 3.33% AEP
- 1.33% AEP
- 1% AEP
- 0.5% AEP
- 1% AEP Climate Change Lower
- 1% AEP Climate Change Upper

Title: Storm event of initial property inundation - mitigated scenario			Drawing: 3-5	Rev: A
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3.3 Property Count Analysis

The following analysis has been carried out using the 0.1m depth threshold (to reflect the level at which water could enter the agreed ground floor level of properties in Leiston). However, consideration has also been paid to the results using a 0.2m threshold where significant.

Properties impacted are typically confined to the major surface water flow paths; with clusters identified along Main Street and the Eastern portion of Valley Road, Sizewell Road, and in the low-lying 'hollow' located between Central Road and High Street.

Notable increases in the number of impacted properties can be observed with the increase in flood risk from the 10% AEP to the 3.33% AEP event. The hydraulic model predicts several properties are inundated including The White Horse Hotel, The Engineers Arms and Leiston Library to a depth of 0.1m. All residential properties at Archway Cottages are shown to be flooded to a depth of about 0.1m in the 3.33% AEP event, and several are shown to be inundated to a depth of 0.2m. Notable increments are also identified in the low-lying 'hollow' adjacent to Central Road and High Street, in addition to the Fire Station on King George's Avenue that is shown to be inundated to a depth of 0.2m in the 3.33% AEP event.

A similar trend is seen in the 1.33% AEP event. There is a notable increase in the number of properties impacted to a depth of 0.2m on Main Street and Western Valley Road. All residential properties at Archway Cottages are identified as being inundated to 0.2m in the 1.33% AEP event. Further incremental impacts can be observed on Eastward Ho and Grimsey Road, as the surface water flow route between the residential gardens becomes significant for the higher magnitude events. This flow route tends to be shallow, as indicated by the far greater number of receptors impacted to a depth of 0.1m.

The incremental increase in impacted properties begins to slow with higher magnitude events above the 1.33% AEP event, as seen in Figures 3-1, 3-2 and 3-3. Additional impacts tend to be confined to properties along Main Street and Western Valley Road, and in the low lying 'hollow' adjacent to Central Road and High Street where surface water continues to pool.

The mitigated scenario proves most effective in the lower magnitude 10% AEP and 3.33% AEP events in terms of percentage reductions. Table 3-2 shows a reduction of four and nine properties respectively. Most notable benefits can be seen on Eastern Valley Road as several residential properties are shown to be benefitting in the 10% AEP event and up to six properties at Archway Cottages in the 3.33% AEP event. These are likely benefitting from the combined run-off attenuation of both mitigation structures, as floodwater is retained at the head of the flow paths.

A significant impact of the mitigation scenario can be seen in terms of the impact to the Fire Station on King George's Avenue. The property is no longer shown as impacted to a depth of 0.1m in the 10% AEP event, and is no longer impacted to a depth of 0.2m in the 3.33% AEP event.

There is a reduction in the efficacy of the mitigation above the 1.33% AEP event. However, notable benefits of the mitigation continue to be seen, as demonstrated by the absolute property reductions seen in Figures 3-2 and 3-3. Beneficial impacts to properties continue to be seen in higher magnitude storm events, generally confined to the flow path on Main Street and down Valley Road.

4 Conclusions and Limitations

A range of flood mitigation options were initially identified and assessed according to the overall objectives of the study and their technical, economic, social and environmental merits. The preferred mitigation option was determined in consultation with SCC staff. These measures include runoff attenuation bunds and basins at both The Gables and Leiston Primary School. High level concept designs have been developed and built into the IUD model. Further consideration would be required into the detailed drainage design and how each structure would overtop should the measures be taken forward.

The mitigation option is predicted to produce significant benefits in reducing flood risk on the Valley Road flowpath and along King George's Avenue. Greatest percentage reductions in impacted properties are typically seen in the lower magnitude 10% AEP and 3.33% AEP events. Corresponding reductions in property counts are noted at Archway Cottages on Western Valley Road, and the Fire Station on King George's Avenue. The percentage reduction in impacted properties is reduced for events of 1.33% AEP magnitude and greater, although absolute reductions in property counts remain significant. Reductions in property counts are typically realised on Main Street and Upper Valley Road, with several properties on Eastward Ho and Grimsey Road also benefitting. Greatest absolute reductions in property counts are seen in the 1% AEP climate change upper scenario (40% increase) for both depth thresholds of 0.1m and 0.2m, with a predicted reduction of 18 and 19 impacted properties respectively.

It must be noted that the number of properties at risk of surface water flooding is a function of the property count method used, the accuracy of the flood modelling undertaken, and the cut-off threshold level adopted. Counts at small spatial scales are extremely sensitive to local variation in terrain and building types, and counts for individual communities are best considered with the benefit of local knowledge.

Several assumptions are also made when finalising the OSMM and NRD datasets to perform property counts; most significant being that no genuine properties exist below the cut-off threshold, and that no redundant buildings remain in the final dataset that may skew count estimates.

The data should only be used as a first step in assessing the scale of the number of properties at surface water flood risk and indicating the potential benefit of mitigation measures. Further detailed cost benefit analysis is recommended to assess the lifetime costs and benefits of the scheme. The Environment Agency strongly recommend that it is used alongside other information and local knowledge where available (recorded flooding information, knowledge of the drainage system, and information about properties in areas at risk) when making decisions.

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