Canterbury District Surface Water Management Plan Stage 1

Preliminary Risk Assessment

Final

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Contents

List of Figures

List of Tables

1 Introduction

1.1 Introduction to a Surface Water Management Plan

Surface water flooding can be caused by intense rainfall before it enters a watercourse or sewer, overland flow resulting from high groundwater levels, exceedance of the capacity of the sewer network and 'out of bank flow' from small watercourses which are not designated as Environment Agency Main River[1].

The purpose of a Surface Water Management Plan (SWMP) study is to identify sustainable responses to manage surface water flooding and to prepare an Action Plan. The Action Plan and supporting material provide an evidence base for future decisions and funding applications for putting the recommendations into practice.

Under the Flood & Water Management Act 2010[2], Kent County Council (KCC) are the Lead Local Flood Authority (LLFA) with responsibility for management of surface water flooding in the District of Canterbury. KCC commissioned Jacobs to undertake Stage 1 of a SWMP for Canterbury District to fulfil the objectives as listed in Table 1.1. The work in this report therefore represents only the first *Preparation* stage of a SWMP as defined by the Defra guidance.

Table 1.1 Objectives of the Stage 1 SWMP

Objective	Report Section
1. The establishment of a local partnership;	Section 1.3
2. The collation of a comprehensive flood history for all relevant local flood risk sources;	Section 3.8
3. The identification, collation and mapping of all available flood data and its availability for future use, including an assessment of the reliability of the data;	Section 2.1
4. The identification, where possible from the available data, of flood prone areas;	Section 3
5. The identification of areas where existing data may be missing or unreliable, as a consequence of inappropriate local assumptions, additional local features or any other reason, and options to improve our understanding;	Section 2.2
6. The identification of areas where the risks are from a combination of sources;	Section 3.9
7. Identification of any proposed or allocated development sites and any impacts they may have on local flood risks;	Section 2.4
8. The preparation of source pathway receptor models for all the risks and sources that are identified;	Section 3.9
9. The suitability of SUDS in the area and the techniques that are appropriate, identifying regional variations where necessary;	Section 2.3
10. The identification of any easy win opportunities that are apparent without further work, which may include planning policies or simple flood defence measures; and	Table 4.1
11. A clear plan for further work that may be necessary to manage or better understand the risks identified, including the owner of the actions, the timeframe for undertaking them and indicative costs.	Table 4.2

[1] There are no potable water reservoirs or canals in the District of Canterbury and therefore the risk of inundation to impounded water bodies from surface water runoff is not considered. However, it is noted that the District contains a number of balancing ponds which are designed to regulate flow, for example those connected with the A290 Thanet Way (up to 5,000m^2) and the Plenty Brook (up to 35,000m^3).

[2] http://www.legislation.gov.uk/ukpga/2010/29/contents

1.2 Links to Sea and Main River Flooding

The District of Canterbury covers an area of 310km^2, has 21km of coastline frontage and 15% of its land lies in Environment Agency Flood Zone 3a[3]. The District is at risk of flooding from the sea and a number of watercourses:

- Sea flooding has been experienced along the northern coast in 1953 and 1978 and led to substantial improvements in sea defences. Sea flooding is not discussed further in this report although tide-locking of watercourse outfalls is considered.

- Main River flooding has occurred in 1987, April 2000 and Winter 2000/1 from the Great Stour. Construction of storage reservoirs near Ashford has reduced the flood risk along the Great Stour. However, properties are still at risk from a sequence of storms which do not allow the reservoirs to drain. The Nailbourne and Little Stour are designated Main River and are groundwater fed, flowing on average every seven years (e.g. 2000/1, 2003 and 2010). A number of improvements have been made to the watercourses and management of flooding in the adjacent villages (e.g. Littlebourne, Bridge, Bishopsbourne) which has reduced the risk to an estimated 1% - 2% AEP.

Flooding from the sea and Main Rivers Great Stour, Little Stour and Nailbourne continues to be managed by the Environment Agency and is not considered further in this SWMP study. However, flooding from the following Main Rivers is considered in this study: Gorrell Stream, Swalecliffe Brook, Kite Farm Ditch, Westbrook and the Plenty Brook. This distinction is made for the following reasons:

- the watercourses were enmained recently (2006); and
- they can be viewed as open-channel and culverted watercourses which "receive a substantial proportion of peak flow from inside the urban area and, therefore, perform an urban drainage function"[4].

Flooding from non-main River watercourses is within the scope of this SWMP and, in Canterbury, these include the Sarre Penn and the Petham Bourne.

1.3 Local Flood Risk Management Partnership

Kent County Council (KCC) is the Lead Local Flood Authority for the District of Canterbury under the Flood & Water Management Act 2010. To coordinate the delivery of flood risk management responsibilities across the county, KCC has formed a members committee for flood risk management, the KCC Flood Risk Committee, and a pan-Kent group for officers from the Risk Management Authorities (Figure 1.1).

[3] Land assessed as having a 1 in 100 (1%) or greater annual probability of river flooding or 1 in 200 (0.5%) or greater annual probability of sea flooding in any one year
[4] Defra (2010) Surface Water Management Plan Technical Guidance. March 2010.

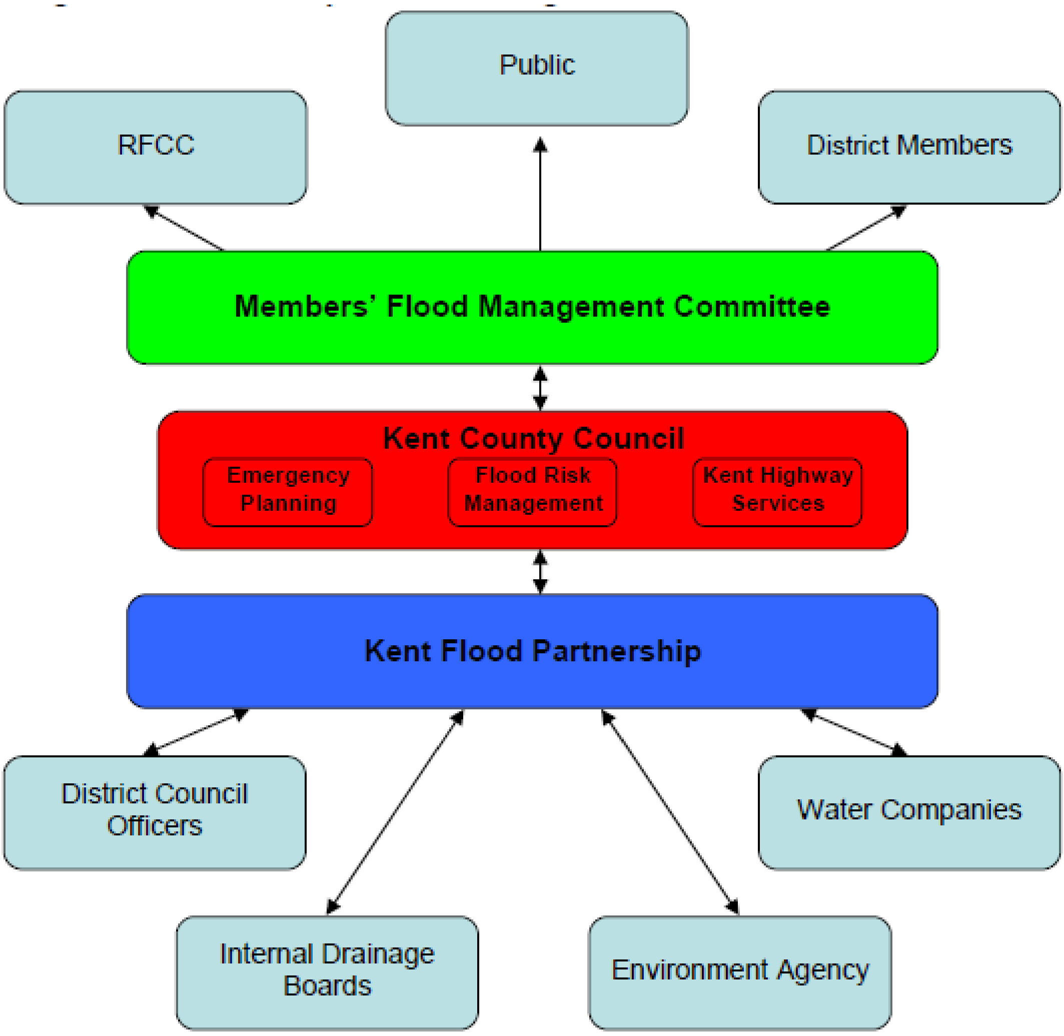

Figure 1.1 Relationship of Risk Management Authorities in Kent (taken from the KCC Preliminary Flood Risk Assessment)

The following Risk Management Authorities relevant to Canterbury have agreed to participate in a Partnership to manage local flood risk in the District:

- Kent County Council (lead Partner)
- Canterbury City Council
- The Environment Agency
- Southern Water
- The River Stour (Kent) Internal Drainage Board

An initial meeting to discuss local flood risk in the District was held with representatives from CCC on 24 November 2011 at the council offices. Telephone discussions were held with representatives from KCC, Southern Water and the Environment Agency. The findings of the draft of this report were discussed at a meeting involving representatives from KCC, CCC, EA and Southern Water on 2 February 2012 at the CCC offices in Canterbury.

2 Data for Local Flood Risk Management

2.1 Collation of Available Data

Data were requested from the SWMP Partners and the data received are catalogued in this section in Tables 1.2 to 1.3.

Table 2.1 Data provided by Kent County Council and Canterbury City Council

Data received	Details	Notes
Ordnance Survey Mapping	Mastermap and 1:10 000 scale raster tiles	
Canterbury City Council Strategic Flood Risk Assessment	Final Report August 2011	Includes Flooding Scrutiny Panel Action Plan – Update on Situation as at November 2007 as Appendix 8
Preliminary Flood Risk Assessment	Final Report August 2011	
Canterbury District Local Plan	GIS layers for included sites from plan adopted in 2006	
Herne Bay Area Action Plan	GIS layers for included sites from plan adopted 2010	

Table 2.2 Data provided by the Environment Agency

Data received	Details	Notes
River Stour Catchment Flood Management Plan	December 2009	
Historical flooding information	Historic Flood Map v1.19	No information contained for the study area
Topographic data	LiDAR data covering the study area	Composite of 1m 2008 data, 2m 2006 data and 2m 2004 data. Gaps in the data infilled with IfSAR data
River centrelines	Main River centreline – guidance v2.3 issued June 2011[5]	See below note about data in Whitstable.
Detailed River Network	Guidance 2010.	See below note about data in Whitstable.
Fluvial Flood Zones	National Flood Zones 2 and 3 v3.16	
Flood Map for Surface Water (FMfSW)	November 2010[6]	The PFRA identified the FMfSW as the best available information to represent surface water flooding in Canterbury District (Locally Agreed Surface Water Information)
Areas Susceptible to Groundwater Flooding (AStGWF)	2010[7]	
Whitstable Flood Report		

[5] Environment Agency (2011) Main Rivers. Guidance for Professional Partners. v2.3. June 2011

[6] Environment Agency (2010) What is the Flood Map for Surface Water. Guidance for Local Resilience Forums, Regional Resilience Teams, Local Planning Authorities and Lead Local Flood Authorities v1 November 2010

[7] Environment Agency (2010) Areas Susceptible to Groundwater Flooding. Guidance 2010

Data received	Details	Notes
– Flooding 21 August 2007		
Whitstable Flood Map – Technical Note on Hydrology, Halcrow	29 October 2007	

Table 2.3 Data provided by Southern Water

Data received	Details	Notes
Sewer Incident Report Forms	GIS data supplied December 2011	

In addition to the above, the following data have been used:

- Jacobs Groundwater Emergence Maps (taken from Jacobs (2004) Groundwater Flooding Scoping Study (LDS23). Final Report. May 2004.)

- BBC News website report of flooding in Whitstable on 26 August 2010: http://www.bbc.co.uk/news/uk-england-11094602; http://www.bbc.co.uk/news/uk-england-kent-11362862

It is also noted that the River Stour (Kent) IDB can provide a GIS layer showing the approximate boundary of the Board's district and IDB maintained watercourses if required.

2.2 Observations from Data Review

The collated data were reviewed to identify areas where the data may be missing or unreliable. The following observations are noted:

- **Main River / Detailed River Network:** In Whitstable, the EA supplied Main River centrelines and the Detailed River Network (DRN) data identify the old course of the Gorrell Stream between Belmont Road and the Gorrell Tank as the course of the Main River. This is now designated as a Southern Water sewer. Instead, the course should show the more easterly route as identified in Figure 3.4 and it is recommended that both datasets are updated accordingly.

- **Flood Map for Surface Water (FMfSW) / Flood Zones:** The FMfSW data generally coincides well with the Flood Zones where this is expected, i.e. near Main Rivers and the Sea. However, in Shalmsford Street, both datasets appear to indicate a flow route for the Petham Bourne which is not consistent with past evidence of flooding and site inspection (route should be via the fishing lakes on the downstream side of the railway line). It is recommended that improved topographic mapping of the likely course of the Bourne is undertaken since upstream of Shalmford Street there is no visible channel. It is important to note that the relationship between groundwater and surface water is critical in understanding the likely course. (see Table 4.2).

- **LiDAR data:** The Environment Agency LiDAR data catalogue (October 2011) shows that high resolution data (0.5m or better) is available in part along the north coast of Canterbury, particularly for Whitstable and Herne Bay. Elsewhere, data resolution is 1m or lower. 1m data is available along the majority of the Great Stour, Nailbourne and Little Stour corridors. However, there is poor coverage along the Petham Bourne, particularly downstream of Thruxted. Improved LiDAR coverage of the Petham Bourne as well as high resolution data (0.5m or better) for Canterbury City would enable improved mapping of flood risk (see Table 4.2).

- **Areas Susceptible to Groundwater Flooding:** The AStGWF data generally coincides well with the Jacobs Groundwater Emergence Maps (GEMs) across the District and therefore provides a high level indication of where groundwater flooding could occur. However, the mapping is known to be coarse and could be improved through more detailed local study, particularly as the southern part of Canterbury District is dominated by chalk (see Table 4.2).

2.3 Suitability of SuDS

To reduce the risk of flooding, the Flood and Water Management Act 2010, PPS25 and the Environment Agency encourage the use of Sustainable Drainage Systems (SuDS). There are many types of SuDS and most development sites will have opportunities to incorporate SuDS in their surface water drainage systems. Where possible and safe, SuDS based on infiltration of surface runoff into the ground are preferred over SuDS based on attenuation of runoff.

The Core Strategy is currently under development but is anticipated to promote the use of appropriate SuDS techniques across the District. Although the following factors provide an indication of where different SuDS techniques may be applicable, site investigation should be used to confirm any assumptions as local conditions can vary substantially:

- **Geology:** The south of the District is dominated by Chalk which is typically suitable for infiltration-based SuDS, although the valleys will contain superficial deposits of clay with flints. To the north of the Chalk, the geology changes firstly to an often clayey Thanet Sand Formation (overlain by superficial deposits of alluvium) and then London Clay towards the coast. Neither of these formations is typically suited to infiltration-based SuDS and attenuation SuDS may be most applicable.

- **Soils:** Soils within the District range from shallow lime-rich soils over the high Chalk areas in the south (although with clayey soils with impeded drainage in the valleys), through generally freely draining soils in the central band to soils in the north which overly London Clay and could be seasonally wet or have naturally high groundwater levels. Therefore with respect to soils, the high ground over the Chalk and the central band may be suitable for infiltration based SuDS.

- **Source Protection Zones (SPZs):** Groundwater SPZs are geographical areas established to protect the groundwater source for a public water supply. Infiltration-based SuDS that may allow pollution to enter the aquifer are restricted within SPZ 1 (inner) and to a lesser extent within SPZ 2 (outer). SPZs are defined in the District in the Chalk to the south of Canterbury, with the highest protected areas (Zone 1) around Chartham and Barham.

- **Groundwater Emergence Zones:** When groundwater is able to rise close to the surface, infiltration techniques that rely on surface water being able to discharge slowly into the ground may fail to operate and thereby pose a surface water flood risk. Therefore, locations along the Nailbourne/Little Stour, Petham Bourne and Great Stour corridors may need to consider the impact of high groundwater levels on any infiltration-based SuDS.

2.4 Proposed or Allocated Development Sites

Proposed or allocated development sites as, for example, set out in the Canterbury District Local Plan published in 2006[8] and the Herne Bay Area Action Plan published in 2010[9], are currently being reviewed. Previously published sites, if retained, may be supplemented with additional sites based on a Strategic Housing Land Availability Assessment (SHLAA) which closed in November 2011. The revised list is not anticipated until the middle of 2012.

Therefore, whilst no comment is made on specific sites in this initial report, the maps in Appendix A show a number of proposed locations where local flood risk should be taken into account during any planning process and which may present opportunities for improved local flood risk management. Key development locations could be in Whitstable (including Swalecliffe), Herne Bay (including around Greenhill and Beltinge) and Canterbury.

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[8] Canterbury City Council (2006) Canterbury District Local Plan. First Review. July 2006. Available at: http://www.cartogold.co.uk/canterbury/

[9] Canterbury City Council (2010) Herne Bay Area Action Plan. April 2010. Available at: http://www.canterbury.gov.uk/main.cfm?objectid=1020

3 History of Flooding and Flood Mechanisms

3.1 Introduction

This section presents a summary of the known occurrences and mechanisms of flooding across the District, as well as the risk predicted by available modelling and mapping. A summary of the locations where flood events have been recorded, as well as the predicted risk from surface water and groundwater flooding is provided in the PFRA (see Figure 3.1).

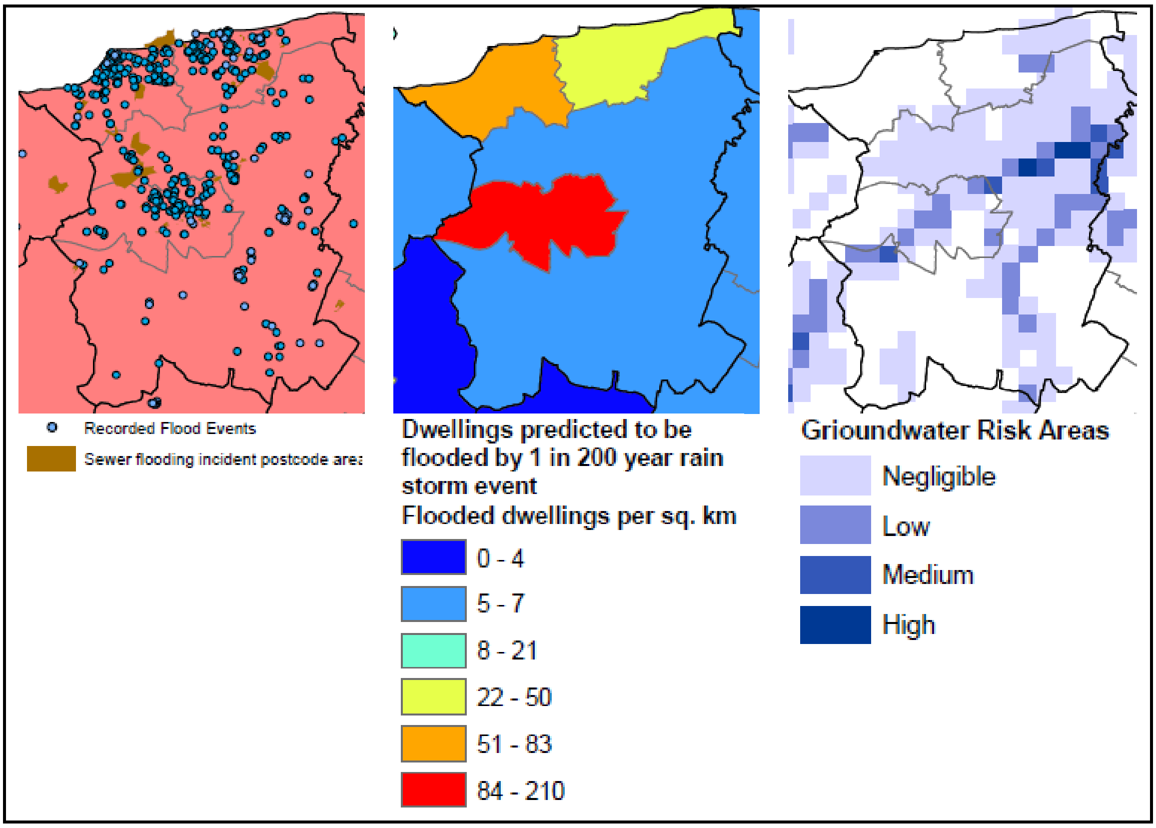

Figure 3.1 Preliminary Risk Assessment maps for Canterbury District

In addition to the PFRA, evidence has been collated from the various sources listed in Section 2. This evidence was used to inform a programme of site visits to the most flood prone areas, and a summary of observations from these is included here. Finally, interim conclusions from reviewing the available evidence and site inspections have been discussed with representatives from the Partner organisations.

The evidence has been collated to identify the locations in the District with the *highest* risk of *local* flooding. Locations which are known to be *primarily* at risk of flooding from the Main Rivers and/or the sea are not included (see Section 1.2). Sections 3.2 to 3.7 are, therefore, the flood prone areas where a major element of flood risk is from local sources, although likely interactions with Main Rivers and the Sea are noted.

In addition to specific mechanisms or risks of flooding discussed in the remainder of this chapter, the following general points are noted:

- CCC generally consider that about 25mm rain in about 12 hours is the threshold when minor flooding (roads etc) starts to happen across the District. As stated in the PFRA, UKCP09 predictions of a changed climate by the 2080s suggest that there could be three times more days in winter with rainfall of more than 25mm.
- The ongoing poor condition of roadside ditches is noted (particular problem areas of Broad Oak, Chestfield, South Street and Blean are noted.)
- Much drainage infrastructure (particularly in rural areas) is blocked by sediment from surface runoff which causes flooding. Land management practices to reduce sediment runoff are also important.

3.2 Shalmsford Street

The Petham Bourne is a groundwater fed bourne (non-Main River) which runs in an undefined dry Chalk valley to Shalmsford Street, where it joins the Great Stour. The Bourne flows infrequently; most recently observed in 2000/1 and 1930. In Shalmsford Street, the course of the bourne is poorly defined, although it appears to pass across the Canterbury to Ashford railway line adjacent to the fishing lakes at 'Stour Lake' where a channel runs to the Great Stour.

CCC confirmed that the railway was flooded in 2000/1 and the SFRA states that properties have been flooded, most likely from a combination of fluvial flooding from the Great Stour and groundwater activation of the Petham Bourne and/or local springs. Mapping identifies the Petham Bourne and Shalmsford Street as a Groundwater Emergence Zone[10] where deep (>0.3m) ponding of surface water could occur[11]. Indeed, Shalmsford Street is identified in the PFRA as a 1km^2 area where either more than 200 people are at risk of flooding in a 0.5% surface water flood, more than 20 non-residential properties are at risk and/or more than one critical service is at risk. Although the CCC Flooding Scrutiny Panel Action Plan contains reference to about 20 properties being flooded in villages along the Bourne in 2000/1, there is no specific evidence of flooding in Petham Village.

The following key observations (see Figure 3.2) were made during the site inspections:

- The likely flow-route of the Petham Bourne is poorly defined and could fill a depression of low ground adjacent to Shalmsford Street where adjacent properties have low thresholds.
- The drainage under the railway, at the point where the Petham Bourne crosses was not observed due to vegetation and maintenance is likely to be required.
- Upstream of Shalmford Street a number of hedges, rural roads, isolated properties and ditches criss-cross the lower valley. These will be impacted when the Petham Bourne is active.

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[10] Groundwater Emergence Zones are defined as areas where, in a winter hydrologically similar to 2000/1, groundwater could rise to within 2m of the ground surface. For further details, see: Jacobs (2004) Groundwater Flooding Scoping Study (LDS23). Final Report. May 2004.

[11] As defined in the Environment Agency Flood Map for Surface Water national mapping. For further details, see Environment Agency (2010) What is the Flood Map for Surface Water? November 2010.

Dry valley flow route is poorly defined

Depression adjacent to Shalmsford Street

Railway line through Shalmsford Street over which dry valley flowroute passes

Some properties have low thresholds

Figure 3.2 Photographs of key features in the Shalmsford Street area

3.3 Blean

Blean is identified as an area where drainage problems reoccur. It is suggested in the SFRA that surface water stands for long periods due to a perched water table on the London Clay and that maintenance of drainage infrastructure has been poor. Recorded incidents of flooding are connected with the highway drainage and the combined sewer. Improvement works to the sewer system have been undertaken by Southern Water in the Badgers Close area although problems may remain. Tight control of surface runoff from this area is required since ground conditions (thick layer of London Clay overlain by thin clayey soils) make drainage challenging. The watercourse through Blean – which further downstream becomes the Sarre Penn – is in a deep channel under Blean Hill road which is unlikely to cause a constriction.

The following key observations (see Figure 3.3) were made during the site inspections:

- At least two properties adjacent to Blean Hill road had thresholds well below road level where surface water exceeding the capacity of the drains could cause flooding.
- Road drains were observed on Blean Hill road outside these properties, although no discharge outlet was observed in the adjacent watercourse (the channel banks were, however, heavily vegetated). The drainage arrangements outside these properties could not be established during the site inspection.

Some properties adjacent to the Blean Hill road have thresholds below road level

The watercourse through Blean is in a deep channel under the road

Figure 3.3 Photographs of key features in the Blean area

3.4 Whitstable

Three of the five Oyster Coast Brooks flow into and through Whitstable: the Gorrell Stream, Swalecliffe Brook and Kite Farm Ditch. These are heavily modified channels flowing over relatively small and steep London Clay catchments with a tidal outfall to the sea:

- **Gorrell Stream:** The stream flows in culvert from Millstrood Road to the Gorrell Tank via an eastern bypass route, with the culvert owned by the Environment Agency following enmainment in 2006 (see Figure 3.4). The Gorrell Tank has a design capacity of around 18,300m^3 as well as a pumping station for evacuation at high tide. Southern Water can operate three pumps during periods of heavy rain. The old route of the Gorrell Stream runs to the west of this (along Stream Walk) and is a Southern Water surface water sewer (approximate diameter 1400mm).

- **Swalecliffe Brook:** Although draining a much larger catchment than the Gorrell Stream, much of the catchment to the Chestfield/South Street area is rural. Outflow is through a culvert at Long Rock which was enlarged following flooding in 2000/1.

- **Kite Farm Ditch:** Mostly a natural channel except for a few culverts. The ditch runs through the extremely flat area around Colewood Road and links to a Southern Water surface water sewer.

Whitstable is suggested to be an area of groundwater emergence, both from the Duncan Downs and to the south east of the town centre and the Thurston Park area. Sewer flooding has occurred in Whitstable, particularly in low lying areas, connected with the Gorrell Stream and the Gorrell Tank, with some floodwater being contaminated with effluent. (Whitstable has a large combined sewer network.) On 21st August 2007[12], intense rainfall caused internal flooding of up to 50 properties, predominantly in the areas of Regent St, Action Rd, Reservoir Rd, Westgate Terrace, Warwick Rd, Belmont Rd and Millstrood Road. These central locations were identified in the PFRA as a 1km^2 area where either more than 200 people are at risk of flooding in a 0.5% surface water flood, more than 20 non-residential

[12] The SFRA mentions flooding on 12 August 2007 rather than 21st August as stated in the CCC Flooding Scrutiny Panel Report

properties are at risk and/or more than one critical service is at risk. Mapping identifies that the central area of Whitstable is at risk of deep (>0.3m) ponding of surface water, with the triangle of land between the railway, Stream Walk and the football ground being a topographic depression. Improved maintenance of the Gorrell Stream near St Andrew's Close appeared to prevent flooding at this location.

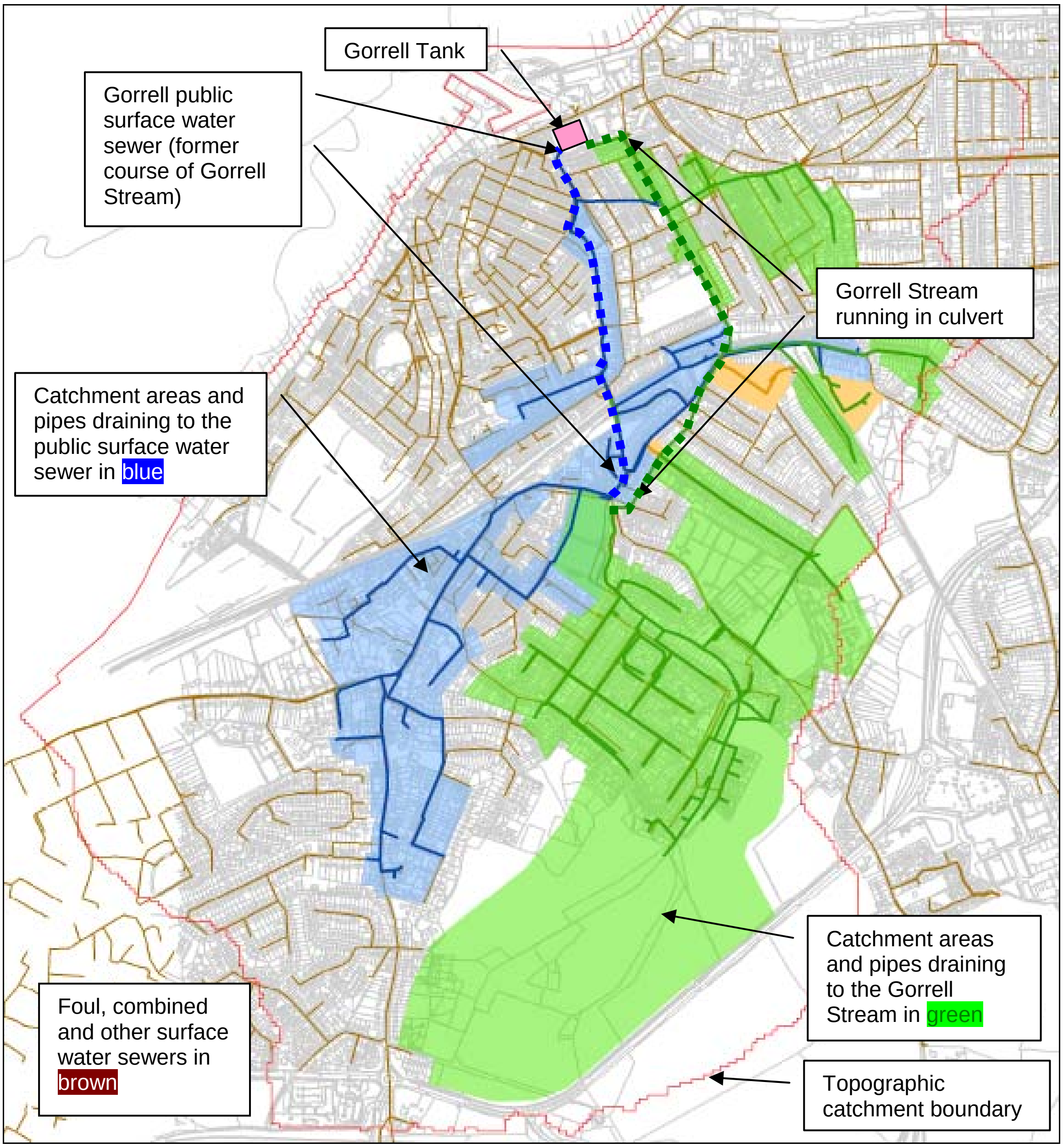


Figure 3.4 Overview of Whitstable drainage system (taken from Gorrell Stream Model Study Final Report, Jacobs 2009)

Properties through Chestfield and Swalecliffe north of Herne Bay Road are known to be at risk. Since 1999, approximately 40 properties have been flooded from the Swalecliffe Brook and the Kite Farm Ditch. Drainage in Chestfield is highlighted in the SFRA as being restricted during prolonged periods of rainfall, partly due to thin clayey soils overlying a thick layer of London Clay. Similarly to Blean, maintenance of ditches should be continued and any further development should be subject to tight control of surface water runoff. Flooding connected with the sewers has occurred in South Street although drainage improvement works have been undertaken, including clearance of roadside ditches.

The following key observations (see Figure 3.5) were made during the site inspections:

- The Gorrell Stream upstream of St Luke's Close is a small channel through steeply sloping open ground. The topography is not suitable for attenuation storage and the upstream catchment is small.

- Between Grimshill and Belmont Roads, the Gorrell Stream runs in a concrete lined trapezoidal channel which could be restored to improve the environmental and social habitat of the area, as well as provide some increase in flood storage volume.

- The cricket and football grounds adjacent to the Gorrell Stream may be in a suitable location for underground attenuation storage for high flows in the Gorrell Stream. These are located close to the entrance of the culverted sections of the Stream.

- The Southern Water surface water sewer follows the course of Stream Walk which is a busy pedestrian thoroughfare to the Gorrell Tank area and also forms part of the Sustrans National Cycle Network Route No.1. Stream Walk is between 2 and 4m wide and passes between properties until it becomes a road. There is unlikely to be space for fully deculverting the sewer along Stream Walk as well as retaining it as an important access route. However, there may be a possibility for partial deculverting.

- The Gorrell Tank contains grills which allow water to surcharge upwards, if the tank capacity is exceed, to flood the car parking area. With appropriate planning and communication, there may be opportunity to raise the existing wall around the perimeter of the car park and include flood gates to increase the storage capacity.

- There is a triangle of open land adjacent to the Swalecliffe Brook upstream of Thanet Way which could be considered for additional fluvial storage if additional protection of Swalecliffe is required.

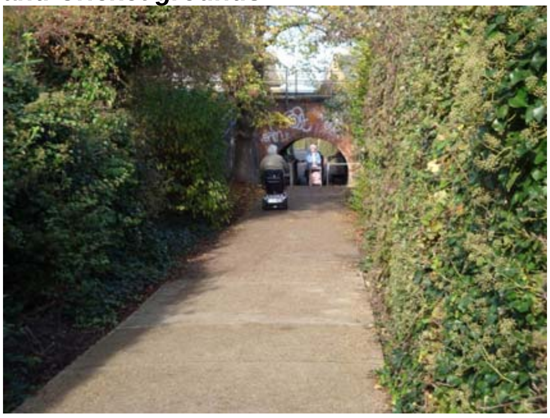
- St John's Road dips under the railway underpass and is a location where regular, but not deep, flooding occurs. However, considerable traffic disruption could be caused (e.g. to emergency vehicles) if this access route from north to south was blocked. There are small areas of open space adjacent to St John's Road where it passes under the railway which could be considered for kerbside attenuation storage. This could be considered alongside improved maintenance of the existing drainage infrastructure.

- The risk from the Kite Farm Ditch in the Colewood Road area appears to arise from a combination of backing up from the tidal outfall in a flat area and an adverse camber on Colewood Road which could direct water into properties on the south side of the road.

Any proposed development in Whitstable could provide opportunities for improved flood risk management e.g. town centre enlargement, including tight controls on surface water runoff. It is noted that the Environment Agency have improvement works on the Kite Farm Ditch planned for 2012.

Gorrell Stream adjacent to the Football and Cricket grounds

Whitstable cricket ground



Stream Walk near the railway underpass

The Gorrell Tank car park

Swalecliffe Brook upstream of Thanet Way

Railway underpass at the junction of St John's Way and Thanet Way

Figure 3.5 Photographs of key features in Whitstable

3.5 Herne Bay

The remaining two Oyster Coast Brooks flow into and through Herne Bay: the West Brook and Plenty Brook. Similarly to the brooks through Whitstable, these are heavily modified channels flowing over relatively small and steep London Clay catchments with a tidal outfall to the sea:

- **Westbrook:** A predominantly rural watercourse until it reaches Studd Hill where it is joined by the Greenhill Ditch from Greenhill. This ditch is piped for much of its course and is periodically blocked by debris. Following flooding in Greenhill in February 2001, Southern Water cleared the piped sections of the ditch.

- **Plenty Brook:** A predominantly rural watercourse which passes under the railway and remains in culvert until its outfall to the sea. The brick-lined culvert has a 2-3m^2 cross-sectional area and is designated as a Southern Water surface water sewer. The culverted section used to run at full capacity with surcharging of linked road gullies. However, following recent flooding (e.g. 18 properties flooded in Eddington from the Plenty Brook on 4 April 2000 following 50mm rain in 12 hours) the following measures were constructed or improved to reduce flooding from the Plenty Brook:
  - Full clearance and extension to 26,000m^3 of Southern Water reservoir at Eddington
  - New on-line balancing pond (35,000m^3) at Bullockstone[13]
  - Private off-line 10,000m^3 balancing pond near Herne

  It is the view of the council that these measures have largely been successful, providing a Standard of Protection of between 1% and 2%.

Herne Bay is served by both surface water and combined sewer networks. The surface water sewer in parts of Herne Bay (typically the newer areas) is connected to the Plenty Brook. Typically, the older parts of Herne Bay connect to the combined sewer system which is not in any way connected to the Plenty Brook and its culvert through Herne Bay. Prior to the 1990s, there was flooding in the lower lying areas within Herne Bay (e.g. to the south of the High Street where there is high ground) primarily as a result of the combined sewer network being surcharged. However, installation of a new tank sewer and pumping station has significantly reduced this risk. The large auxiliary sewer was built to accommodate excess water when it rained and is linked to a new screening plant and pump station at Kings Hall to the east of Herne Bay. Under normal conditions, the water is pumped up to the sewage treatment plant. At times of high flow, when the pumped system reaches capacity, the excess is screened and pumped out to sea.

Flooding of 60 properties (mainly basement flats in Central Parade and Mortimer Street) in Herne Bay on 26 August 2010 is thought by Southern Water to have been caused by pump failure at Kings Hall which caused storm water to back up into the sewage system. The flooding is not thought to have been caused by or connected to the Plenty Brook – the period prior to the 26 August had below average rainfall and the 26mm of rainfall experienced between 15:00 and midnight on the 25th August would only typically cause minor flooding on roads around the District[14].It is understood that Southern Water has subsequently installed a new pump and switch system which should prevent this happening again. In summary, it is the view of the council and Southern Water that only failures of the pumping station or during prolonged above average rainfall could the combined sewer system experience problems.

In February 2001, 25 properties plus a school and business premises were flooded in Greenhill and Hampton, with flooding in Greenhill concentrated around the Aldridge Road and Fife Road areas. The EA Flood Map for Surface Water (FMfSW) also identifies this as an area which could be at risk of deep (>0.3m) ponding of surface water and which could be connected with restricted drainage (via the 'Greenhill Ditch') from this point under the Thanet Way before joining the Westbrook.

The EA Flood Map for Surface Water (FMfSW) identifies that a number of areas of Herne Bay are at risk of deep (>0.3m) ponding of surface water. The areas which

[13] Taylor Wimpy is the registered undertaker under the Reservoirs Act
[14] T. Edwards (2011) Pers. Comm.

are least connected with fluvial flooding are the Aldridge Close area of Greenhill, Sea Street, the area between Cherry Gardens and the High Street, including Memorial Park, and the area of Beltinge to the south east of Reculver Road. The central locations in Herne Bay are identified in the PFRA as 1km^2 areas where either more than 200 people are at risk of flooding in a 0.5% surface water flood, more than 20 non-residential properties are at risk and/or more than one critical service is at risk. However, Herne Bay is not identified as a significant 'cluster' of these 1km^2 areas with respect to the FMfSW[15].

The following key observations (see Figure 3.6) were made during the site inspections:

- A raised drain/sewer was observed in Aldridge Close, Greenhill, which is in line with a ditch ('Greenhill Ditch') which flows northwards to join with the West Brook. The area is extremely flat and the suitability of the existing drainage arrangements could be reviewed. There appears to be sufficient open space or wide pavements adjacent to a number of the roads in the area to consider 'green' kerbside storage (e.g. rain gardens).

- Memorial Park is an area of relatively low ground adjacent to the culverted course of the Plenty Brook. There is a level difference of more than 1m between the northern grassed portion of the park and the boating lake to the south. Although ideally placed for potential storage for high flows in the Plenty Brook, lowering the northern portion of Memorial Park is unlikely to be feasible due to the groundwater level.

- Beltinge is extremely flat with land drainage collected by a ditch to the south of Highfields Avenue which appears to discharge into an open ditch running approximately north east towards the sea. The ditch was observed running between properties and under Terminus Drive. There is a sheltered housing complex in the predicted 'deep' ponding area which is likely to originate from this sewer/ditch. The sufficiency of the existing drainage arrangements, including maintenance, should be reviewed.

Any proposed development in Herne Bay could provide opportunities for improved flood risk management e.g. Herne Bay Area Action Plan (2010).

3.6 Villages Along the Nailbourne and Little Stour

The Nailbourne and Little Stour are Environment Agency Main Rivers (the Upper Nailbourne was enmained in April 2006) which are groundwater fed from the Chalk. On average, the rivers flow broadly once every seven years, although recently have been activated in 2000/1, 2003 and 2010.

The villages along the Nailbourne/Little Stour have been flooded from the watercourse, from rising groundwater, emergence of springs, surface runoff and, as a result, surcharging and backing up of the sewers. For example, an estimated 60 properties and a number of roads in Barham, Kingston, Bishopsbourne, Bridge, Patrixbourne, Littlebourne, Ickham and Wickhanbreux were flooded in the winter of 2000/1. In Bridge, Patrixbourne and Bekesbourne groundwater is known to have entered into the foul sewer causing surcharging.

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[15] It is noted, though, that Herne Bay is identified as a significant 'cluster' when the analysis is based on the earlier Areas Susceptible to Surface Water Flooding (AStSWF) maps.

Aldridge Close in Greenhill which has an unusual raised drain and open space adjacent to the road for water storage

Memorial Park to the south of the High Street

Drain entrance in the ditch to the south of Highfields Avenue in Beltinge

Ditch which passes under Terminus Drive in Beltinge

Figure 3.6 Photographs of key features in Herne Bay

Following the 2000/1 flooding, many improvements to increase channel capacity and culverts (including diversion channel at Littlebourne) were made and the risk of flooding is estimated to have been reduced to between 1% and 2% AEP at all villages down the river. However, the need for ongoing maintenance of the watercourse and drainage infrastructure is highlighted. Furthermore, as stated in the Stour CFMP, although the current risk appears to be appropriately managed, the anticipated increase in flood risk in a changing climate should be better understood and appropriate management responses identified.

3.7 Canterbury City

The historic city of Canterbury lies in the centre of the District between the Chalk of the south and the London Clay of the north. The geology of the central region is dominated by the often clayey Thanet Sand Formation overlain by superficial deposits of alluvium. Correspondingly, the Great Stour which follows the central geological band receives much of its input in the District from small streams and groundwater. The Great Stour runs through Canterbury and appears to be well managed to keep the risk of flooding low. In particular, the storage reservoirs constructed near Ashford offer protection from flooding up to a standard of approximately 1% (1 in 100) AEP in a single event, although the risk is greater when events have two or more closely occurring peaks. The risk of flooding from the Great Stour remains higher in Shalmsford Street and Chartham to the west, as well as Fordwich to the east where the river is tidally influenced.

Mapping identifies that a number of areas of Canterbury are at risk of deep (>0.3m) ponding of surface water. The areas which are least connected with fluvial flooding are St Dunstan's, St Stephen's, Hales Place, St Martin's and Martyr's Field. The majority of Canterbury city is identified in the PFRA as 1km^2 areas where either more than 200 people are at risk of flooding in a 0.5% surface water flood, more than 20 non-residential properties are at risk and/or more than one critical service is at risk. Because of this density of predicted flood risk, Canterbury is identified as a significant 'cluster' of these 1km^2 areas and ranks 50th in England (out of 219 'clusters') in terms of the number of people at risk. The City also ranks 1st in England in terms of the number of scheduled monuments at risk of flooding (9 monuments) and 13th in terms of the number of listed buildings at risk in a 0.5% event (3 listed buildings). Furthermore, portions of Canterbury City are identified as areas which could be subject to groundwater flooding, with the band of susceptibility broadly following the Great Stour river valley. Similarly to Whitstable and Herne Bay, Canterbury City is served by an aging combined sewer network and flooding has occurred from the sewer system in the city (e.g. along St Thomas Hill leading down from the north into St Dunstans). Within Southern Water's Sewer Incident Report Forms (SIRF) database, all locations of internal property flooding from the combined sewer, except for one in Blean, are located in the city. Instances of sewer flooding further into the city have often been linked with high levels in the Great Stour.

The city of Canterbury, therefore, has a high predicted risk of flooding from surface water, groundwater and the sewers. Indeed, flooding from all of these sources has occurred, e.g. in the winters of 2000/1 and 2002. However, flooding from local sources on the scale of that experienced elsewhere in the District (e.g. Whitstable and Herne Bay) has not occurred in the recent past. Instead, the flooding which has occurred is largely around the northern perimeter of the city (Harbledown round to Broad Oak) and is connected with non-functioning land drains, poorly maintained ditches and unchecked overland flow across grass hillsides. The undercapacity of the sewer system is understood to be a contributory factor to the problems experienced around the perimeter of the city, and linked to the very old combined system in the oldest parts of the city. However, the risk of flooding from the sewers is considered to be low. Drainage experts at Canterbury City Council suggest that the importance of the city centre and the Cathedral mean that road gullies and drains are regularly cleared and this may alleviate a proportion of the surface runoff. Table 3.1 provides a selected record of daily rainfall totals, measured by a private rain gauge at Boughton 4 miles west of the city, as well as comments by CCC.

Table 3.1 Selected daily rainfall measured at Boughton (near Canterbury)

Date	Daily Rainfall	Date	Daily Rainfall
24th Dec 1999	60.6mm. Some localized flooding within the city	8th Jan 2001	34.6mm. Some properties flooded internally and many gardens, but this was due to the continuing build up of wet weather
4th Apr 2000	39.6mm. A few properties in the city were flooded internally whilst severe flooding occurred towards the coast	23rd Nov 2003	45.2mm. Some localised internal flooding plus a number of gardens
12th Oct 2000	65.4mm. Similar scenario to 4 April 2000 but the river also caused flooding	25th May 2008	44.6mm No serious flooding in the city
2nd Nov 2000	33.6mm. Similar scenario to 4 Apr and 12 Oct 2000 but flooding predominantly from the river		

Canterbury has been identified as a Regional Hub and the majority of future development in the District is likely to be in the city itself. Any proposed development could provide opportunities for improved flood risk management. The Stour CFMP identifies the city as an area of very high social vulnerability.

3.8 History of Local Flooding Across the District

The above sections have presented a summary of the mechanisms and occurrences of the local flood risk in identified locations across the District. Table 3.2 summarises much of this same information in chronological order of flood event. The source, pathway and receptors of flooding are identified where known, with the information taken from the sources identified in Section 3.1.

Table 3.2 History of local flooding in Canterbury District

Date	Area	Source(s)	Pathway(s)	Receptor(s)	References
November 2000 – April 2001	Canterbury District	Over 180% of long-term average rainfall across Kent for eight months from September 2000. In addition, a number of more localised intense rainfall events as listed below.	Rising groundwater through unconfined Chalk, emergence of new springs, high baseflow and flooding from groundwater dominated watercourses	At least 290 properties flooded internally across the District, as well as roads. Flooding occurred in places for many months. Flooding peaked in February 2001.	Marsh and Dale (2002)* SFRA (2011) Flooding Scrutiny Panel (2007)
4 April 2000	Swalecliffe, Chestfield and South Street	Rainfall of up to 50mm in 12 hours or more. Estimated probability of between 10% and 5% AEP.	Swalecliffe Brook, Kite Farm Ditch	A total of 40 properties in Swalecliffe and Chestfield since December 1999, with some flooded on more than one occasion	Flooding Scrutiny Panel (2007)
	Eddington		Plenty Brook	Internal flooding of 18 properties	SFRA (2011)
12 October 2000	Swalecliffe and Chestfield	Rainfall of up to 50mm in 12 hours or more.	Swalecliffe Brook, Kite Farm Ditch	A total of 40 properties across both locations since December 1999, with some flooded on more than one occasion	Flooding Scrutiny Panel (2007)
8 February 2001	St Andrews Close & Westgate Terrace areas, Whitstable	Rainfall of up to 50mm in 12 hours or more. Estimated probability of between 10% and 5% AEP.	Blocking of Gorrell Stream by rubbish and failure of Gorrell Tank pumps	20 properties within Whitstable	Flooding Scrutiny Panel (2007)
	Swalecliffe and Chestfield		Swalecliffe Brook, Kite Farm Ditch	A total of 40 properties across both locations since December 1999, with some flooded on more than one occasion	Flooding Scrutiny Panel (2007)
	North and south of the railway in Eddington, and Cherry Gardens in Herne Bay		Plenty Brook, Southern Water sewer under Herne Bay and the various balancing ponds	45 residential properties flooded at Eddington and Herne Bay.	Flooding Scrutiny Panel (2007)

Date	Area	Source(s)	Pathway(s)	Receptor(s)	References
	Hampton and Greenhill		Westbrook and Greenhill Ditch. Tide locking of the Westbrook and bridge restrictions are contributing factors.	Properties on Aldridge Road and Fife Road in Greenhill, as well as the Studd Cottages in Herne Bay. Sea Street was temporarily impassable.	Flooding Scrutiny Panel (2007)
21 October 2001	Littlebourne	Rainfall of up to 50mm in 12 hours or more. Estimated probability of 7% (1 in 15) AEP.	Mostly surface water from highways	Unknown	Flooding Scrutiny Panel (2007)
2nd August 2007	Sturry	High intensity storm	Not known	Internal flooding of 5 properties	Flooding Scrutiny Panel (2007)
21st August 2007	Whitstable – three primary areas: • North of the railway (Regent St, Action Rd, Reservoir Rd, Westgate Terrace, Warwick Rd) • Belmont Rd, Millstrood Rd • Borstal Hill	Short duration intense storm with estimated probability of 3.33% (1 in 30) AEP. Rainfall of 50mm in 2 hours and 60mm within 5 hours.	Flooding in the two northern areas was heavily influenced by the failure of an automated sluice gate used to evacuate the Gorrell Tank which causing backing up in the system	Between 30 and 50 properties flooded internally	Whitstable Flood Report (2007) Technical Note on Hydrology (2007)
26 August 2010	Herne Bay - mainly basement flats in Central Parade and Mortimer Street	Heavy rain (approximately 26mm) between 15:00 and midnight on 25 August 2010	Pump failure at the Kings Hall pumping station which caused storm water to back up the combined sewage system and into properties.	Flooding (mostly internal) of 60 properties	BBC News website T. Edwards pers. comm.

*Note: * Marsh, T.J. & Dale, M., (2002). The UK Floods of 2000-2001: A Hydrometeorological Appraisal. Jnl. CIWEM, 16, p180 – p188*

3.9 Source, Pathway and Receptors in Flood Prone Areas

Based on the current understanding of risk and mechanisms of flooding, Table 3.3 lists the source(s), pathway(s) and receptor(s) in identified flood prone areas. Where an area is at risk from multiple sources, these are indicated. The sources, pathways and receptors for some of the major locations are identified on maps in Appendix B.

Table 3.3 Sources, Pathways and Receptors for areas prone to flooding from multiple sources

Flood Prone Area	Source(s)	Pathway(s)	Receptor(s)
Shalmsford Street	• Groundwater through emergence of springs and activation of the Petham Bourne • Fluvial risk from the Great Stour	• Poorly defined Petham Bourne channel, including uncertain drainage under the railway line • Backing up along small watercourse from Stour Lake fishing lakes driven by high levels in the Great Stour	• Properties with low thresholds adjacent to Shalmsford Street • Properties sited on top of or near to springs • Railway line • Shalmsford Street road
Whitstable	• Flashy high flows in the Gorrell Stream caused by intense and localised rainfall in the upper catchment • Intense rainfall in low lying areas of central Whitstable • Potentially limited capacity of the Gorrell Tank, tidal outlets and pumps during high tides • Failure of pumps	• Gorrell Stream • Southern Water surface water sewer • Roads, particularly in low lying central areas	• Properties, particularly in low lying central areas • Roads and Gorrell Tank car park • Cricket pitch • Stream Walk
Swalecliffe and Chestfield	• Rainfall over the St John's Road, Chestfield Road and Thanet Way area • Rainfall over clay geology of Chestfield which limits effective drainage	• Roads • Overwhelmed highway drainage • Surface flow over clay geology	• Railway underpass on St John's Road • Properties in Chestfield
Greenhill	• Rainfall over the Greenhill residential area • Blockage of the Greenhill Ditch • Possibly high levels in the West Brook	• Roads • Backing up from Greenhill Ditch and possibly from West Brook	• Properties with low thresholds, particularly around Aldridge Road and Fife Close • Roads

Flood Prone Area	Source(s)	Pathway(s)	Receptor(s)
Herne Bay	• Flashy high flows in the Plenty Brook caused by intense rainfall in the upper catchment • Intense rainfall in low lying areas of central Herne Bay • Capacity of tidal outlets and pumps during high tides • Failure of pumps for the combined sewer	• Plenty Brook and links with surface water sewer / highway drainage • Southern Water combined sewer • Roads, particularly in low lying central areas	• Properties, particularly in low lying central areas and those served by combined sewers • Roads • Memorial Park
Beltinge	• Runoff from open land to the south • Intense rainfall in low lying areas of Beltinge	• Roads • Ditch / sewer through Beltinge	• Properties, particularly in low lying areas following the course of the ditch/sewer, including a sheltered accommodation block • Roads
Blean	• Intense rainfall on Blean Hill road	• Blean Hill road • Backing up of road drains	• Properties with low thresholds at the bottom of Blean Hill road • Road
Canterbury City	• Prolonged above-average rainfall • Intense rainfall over the city centre • High levels in the Great Stour	• Surface runoff from fields • Roads • Southern Water combined and surface water sewers • Great Stour	• Properties, particularly with low thresholds or connected to the combined sewer system • Roads • Potentially historic buildings and monuments
Villages along the Nailbourne and Little Stour	• Groundwater through emergence of springs, activation of the Nailbourne/Little Stour and runoff from surrounding land • Intense rainfall, particularly if coinciding with high groundwater levels	• Nailbourne/Little Stour channel • Roads • Fields and open land	• Properties with low thresholds • Properties sited on top of or near to springs • Roads

4 Recommended Actions

Based on the review of available evidence, consultation with SWMP Partners and site inspections, a plan for further work to better understand and manage local flood risk is proposed in this Chapter.

Table 4.1 lists the opportunities which are apparent without further work, including those relating to policy which could be generically applied across the District.
Table 4.2 lists the actions proposed to better understand or manage the risk of local flooding in specific locations. The tables provide the following information:

- **Where:** For location-specific actions, the location.
- **What:** The description of the action.
- **How:** The suggested approach to implementing the action.
- **Who:** The partner organisation(s) best placed to lead implementation.
- **When:** An indication of the timescales within which the action is suggested to be implemented:
  - Priority 1: A 'quick win' or action urgently required within 12 months
  - Priority 2: Consider now for implementation in the next 1-5 years
  - Priority 3: Consider now for longer term implementation (5 years+)
  - Priority O: Consider implementing if opportunity arises

  This priority therefore balances the degree of flood risk with the likely required timescale for implementation.
- **Cost:** An indication of the relative cost of the action (Low, Medium, High or Very High).

These proposed actions will be discussed at a SWMP Partnership meeting to be held early in 2012 and this report subsequently finalised.

Table 4.1 Proposed easy win or policy-related management actions

Action ('What?')	Priority Actions ('How?)	Primary Action Owners ('Who?')[1]	Priority ('When?')[2]	Indicative Relative Cost
Raise awareness of arrangements for local flood risk management Raise awareness of surface water flood risk and the agreed arrangements for management within the Partner organisations and with the wider public. Link with encouraging use of green roofs, rainwater harvesting, rain gardens and other source control measures, as well as uptake of property level resistance/resilience measures as appropriate.	1. Review and agree arrangements for management of local flood risk through inter-agency cooperation 2. Brief council teams (particularly Planning Policy) on surface water flood risk 3. Publicise arrangements for management of local flood risk, including public responsibilities e.g. riparian ownership and clearance of ditches 4. Provide guidance on use of rainwater harvesting, water butts, other source control measures and property level resistance and resilience measures. High priority for property resistance/resilience for low threshold properties in Blean. 5. Target properties at risk of infrequent groundwater flooding for awareness raising through written reports and the Local Resilience Forum so knowledge transcends change of ownership. Particularly relevant along the course of the Petham Bourne. 6. Publicise new Environment Agency groundwater flooding alert service and promote property resistance/resilience measures to those flooded from groundwater (e.g. along the course of the Petham Bourne). 7. Coordinate recording of flood events with KCC as LLFA and SW where potentially related to sewers	• CCC	1	Low
Clarify asset ownership/responsibility for maintenance Partners should work together towards a comprehensive understanding of the details of existing drainage infrastructure including who owns and/or is responsible for maintaining it. Records of assets should be available to all partners.	• Clarify ownership of drain/sewer through Beltinge and organise a programme of maintenance • Clarify GIS data relating to the Gorrell Stream/Southern Water sewer through Whitstable	• KCC	1	Low
Maintain targeted maintenance schedule All Partners should continue targeted maintenance so that highway gullies, drains, sewers and associated storage (tanks) and pumping infrastructure, as well as other drainage assets (including SuDS) and ditches and watercourses operate effectively to their design capacity. Maintenance should be targeted in flood prone areas identified in this report.	1. CCC to organise clearance of the Greenhill Ditch (Herne Bay) 2. KCC to clear the drains on Blean Hill road adjacent to the low threshold properties and investigate linkage of drains to the adjacent Sarre Penn watercourse.	• CCC • KCC • IDB	1	Medium
Develop CCC planning policy to promote the use of appropriate SuDS Use ongoing development of the CCC Core Strategy to develop a policy to promote the use of appropriate SuDS for all new development.	1. Promote locally agreed surface water information map to identify natural drainage routes which future development should respect. Development should also respect local landform to ensure sufficient property thresholds. 2. Planning policy to require tight controls on surface water discharge for new development in known problem areas e.g. Blean and Whitstable 3. Develop a map indicating the broad suitability of locations for appropriate SuDS.	• CCC	1	Low
Improve management of agricultural land to reduce runoff volume and sediment transport Improve land management practices to reduce surface runoff and associated erosion and sediment transport.	1. Identify land adjacent to natural flow routes which could be considered for Higher Level Stewardship schemes and promote and assist with applications to Higher Level Stewardship which tackle potential impacts of climate change, diffuse pollution, erosion, water quality and quantity.	• CCC • IDB	2	Low
Use highway design to improve management of surface water Permit temporary routing of surface flow along roads where practicable. Design roundabouts to accommodate shallow storage where beneficial and install green street planters to receive surface runoff where space permits.	1. Develop KCC policy regarding use of roads for temporary flow routing ('roads as rivers'), using traffic calming as required. 2. Consider use of green street planters/raingardens in dense residential areas e.g. Greenhill, Whitstable, Herne Bay and Canterbury	• KCC • CCC	2	Low

Notes: [1] EA – Environment Agency; CCC – Canterbury City Council; IDB – The River Stour (Kent) Internal Drainage Board; KCC – Kent County Council; SW – Southern Water
[2] Priority 1: A 'quick win' or action urgently required within 12 months; Priority 2: Consider now for implementation in the next 1-5 years; Priority 3: Consider now for longer term implementation (5 years+); Priority O: Consider implementing if opportunity arises

Table 4.2 Proposed actions for better understanding or improved management of local flooding

Action Location ('Where?')	Action ('What?')	Priority Actions ('How?')	Primary Action Owners ('Who?')[1]	Priority ('When?')[2]	Indicative Cost
Whitstable	***Develop Options for Improved Flood Risk Management*** The requirement for, and feasibility of, a scheme to improve flood risk management within the central area of Whitstable should be determined. The following options could be considered: • Restoration of the Gorrell Stream channel between Grimshill and Belmont Roads, including soft banks and a two-stage channel. Whilst a small additional volume of flood storage could be provided, the benefits will largely arise from habitat creation and social amenity. • Underground storage beneath the council-owned football or cricket pitches. These locations provide the only sufficiently large open space upstream of the Gorrell Stream culverts with substantial contributing areas. • Partial deculverting of the Southern Water sewer which follows the line of Stream Walk. Through raising kerbs along the edges of Stream Walk and using traffic calming and road profiling to route flow across road sections, lower Stream Walk and link with underground sewer through grates to provide additional storage during peak flows. Fully deculverting the sewer under Stream Walk is unlikely to be viable since: o It is a key access route to/from town centre for pedestrians, cyclists, mobility scooters etc o It is narrow in places (<4m) and unlikely to be able to support access and an open channel side by side o There is the potential for increased maintenance of the Gorrell Tank due to increased debris in the open channel • Raising the existing walls and/or inclusion of flood gates around the perimeter of the car park overlying the Gorrell Tank to increase the storage capacity in this area.	1. Commission pre-feasibility study	• KCC • EA	1	<£25k for pre-feasibility study to determine preferred option
Ditch at Green Hill estate	***Clarify asset ownership/responsibility for maintenance*** • Clarify ownership of ditch at the Green Hill estate to the south of Herne Bay. • Organise any necessary clearance/maintenance to be undertaken by relevant landowner.	1. Carry out ditch survey	• KCC	2	<£25 for survey
Nailbourne/Little Stour and Petham Bourne	***Improve Understanding and Management of Groundwater Flood Risk*** Undertake a study to better understand the hydrogeology of the Nailbourne/Little Stour and Petham Bourne ephemeral watercourses, particularly in light of a changing climate. Link with improved mapping of the Petham Bourne to identify flood risk areas. Identify appropriate management response to the groundwater flood risk.	1. Submit FDGiA funding bid to undertake study	• KCC • EA • IDB	2	£26k - £50k for study
Chestfield	***Develop Options for Improved Flood Risk Management*** The feasibility of improving drainage of St John's Road/Thanet Way near the railway underpass should be determined. The following option could be considered: • Green street planters/rain gardens adjacent to Herne Bay Road and St John's Road on the northern side of the railway underpass. These would provide attenuation storage for highway runoff and provide social and environmental enhancements.	1. Commission pre-feasibility study	• KCC	2	<£25k for a pre-feasibility study
Canterbury City	***Prepare a Surface Water Management Plan*** Canterbury City has a predicted high risk of surface water flooding although past records of flooding do not demonstrate this. However, given the number of people and properties at risk (including buildings of historic importance) it is important to better understand the risk posed by runoff from the surrounding land into the urban area, runoff within the urban area itself, the old combined sewer system and interactions with high groundwater levels and the Great Stour. It will be important to understand the existing tolerance of the drainage system to establish an overall surface water probability threshold. It is noted that Southern Water has a detailed model of the public foul/combined sewerage system in Canterbury which incorporates a small extent of the public surface water sewers where the combined system can overflow to surface water sewers. Therefore, there is little of the public surface water sewerage system(s) which is modelled.	1. Commission SWMP study	• KCC • CCC • EA • SW • IDB	2	£51k - £100k for a full SWMP study
Along the course of the Petham Bourne	***Improve Mapping*** Map the course of the Petham Bourne dry valley flow route through collecting and analysing high resolution LiDAR data.	2. Request inclusion of the Petham Bourne in the EA's LiDAR data collection schedule	• KCC • EA	0	<£25k for LiDAR data collection and analysis

Notes: [1] EA – Environment Agency; CCC – Canterbury City Council; IDB – The River Stour (Kent) Internal Drainage Board; KCC – Kent County Council; SW – Southern Water
[2] Priority 1: A 'quick win' or action urgently required within 12 months; Priority 2: Consider now for implementation in the next 1-5 years; Priority 3: Consider now for longer term implementation (5 years+); Priority O: Consider implementing if opportunity arises

Appendix A SWMP Preliminary Risk Assessment Maps

Appendix B Source – Pathway – Receptor Maps

The following pages present source – pathway – receptor models for the following locations, as identified in Table 3.3:

- Shalmsford Street
- Whitstable
- Chestfield and Swalecliffe
- Greenhill and Herne Bay
- Canterbury City

The schematic maps show the following where relevant:

- Sources
    - The type of rainfall which could lead to flooding, typically prolonged above-average rainfall to saturate soil and raise groundwater levels or short-duration intense rainfall
    - Watercourses which may carry high flows into the area and cause or exacerbate local flooding
    - Key infrastructure which may block or fail
- Pathways
    - Major pathways: typically recognised watercourses
    - Diffuse pathways: ephemeral drainage pathways whose routes are not well defined
    - Natural drainage routes: derived from 'rolling-ball' analysis of the 5m IfSAR bare earth DEM, these indicate natural drainage routes down hillsides, streets etc.
- Receptors: broad areas, typically based on the Flood Map for Surface Water, within which properties, roads and railways may be at risk