# NOTE TO FILE

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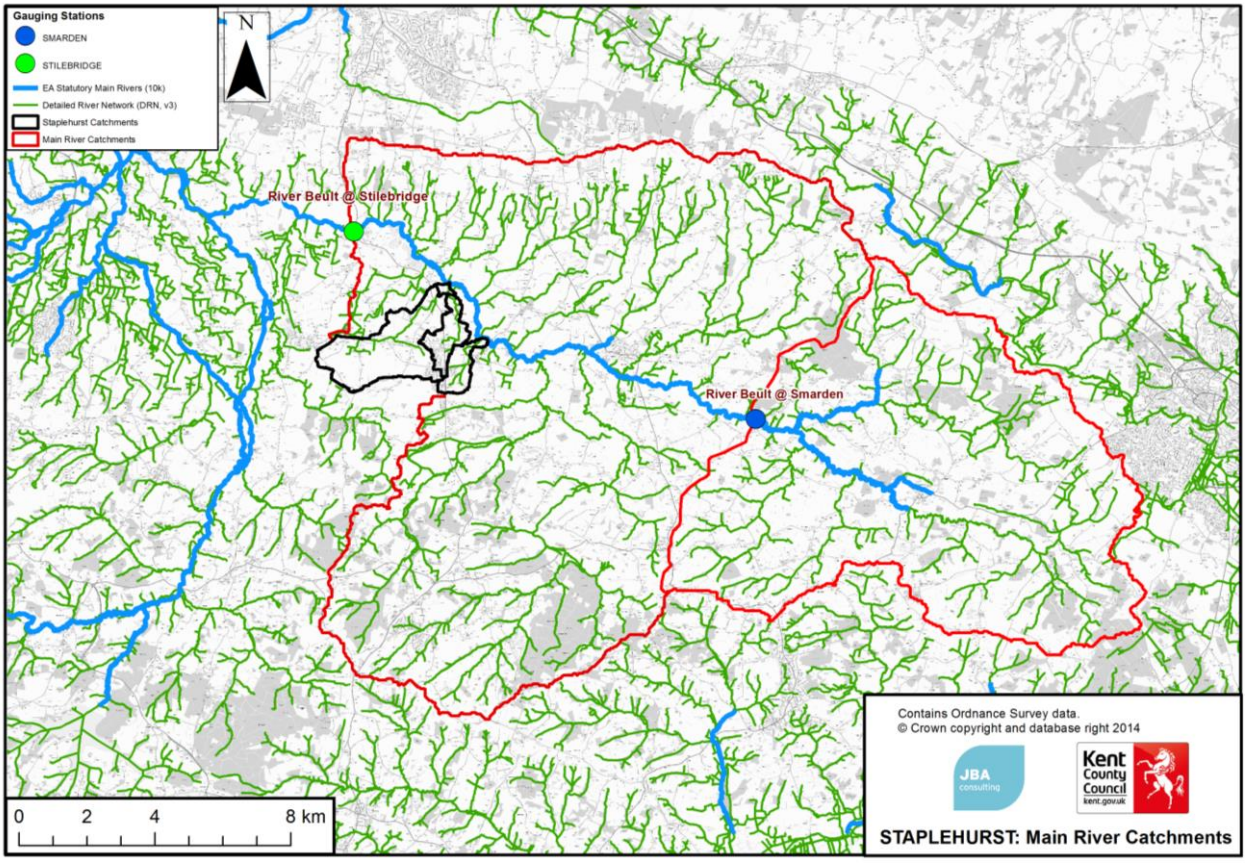
## 1 Introduction

The purpose of this report is to better understand the rainfall events that lead to flooding within Staplehurst in order to determine any potential interactions between adjacent Main River levels (River Beult) and the surface water drainage network within Staplehurst.

The large village of Staplehurst is located in the lower River Beult catchment. The Stilebridge gauging station is located nearly 4km to the north of Staplehurst (approximately 6km downstream on the River Beult) and the Smarden gauging station is located approximately 10km to the south-east of Staplehurst (approximately 14km upstream on the River Beult). Figure 1-1 below illustrates the Staplehurst catchments in relation to the gauged catchments at Stilebridge and Smarden.

**Figure 1-1: Main River catchments**




The majority of the historical flood information available within Marden, Headcorn and Staplehurst is qualitative data i.e. reported flood incidents, highways records, flood hotspots, sources of flooding and occasionally observed flood extents. There are no flow or level gauges within the Staplehurst catchments and therefore Tipping Bucket Raingauges (TBRs) will form the basis of the quantitative assessment of event rarity within Staplehurst.

Surface water flooding events usually tend to be as a result of convective summer storms i.e. short intense rainfall events, and therefore 'higher peaked' rainfall profiles would usually be expected if a convective summer event is the main cause of the surface water flooding. These convective summer events also tend to be more critical in urbanised areas.

## 2 Catchment characteristics

Staplehurst is a large village located approximately 12km south of Maidstone, Kent. The drain catchments within Staplehurst are predominantly small, draining a total area of 8.6 km$^2$. The land use within the catchment include the urban area of the village itself and the rural surrounding where land uses includes Arable (Horticultural) land with a mixture of woodland and grassland.

The catchments within Staplehurst are underlain predominantly by mudstone deposits (Weald Clay formation) and therefore the catchments are quite impermeable and consequently a more flashy response is expected. This is supported by fairly low BFIHOST values in the range of 0.234 to 0.383; the average SPRHOST value is 46%. These geological formations are overlain by superficial deposits of Alluvium and River Terrace deposits which mainly consist of sands, gravel, clays and silts. The superficial deposits are mostly confined to around the centre of Staplehurst and along some of the drainage ditches.

The soils within the Staplehurst predominantly consist of slowly permeable wet clayey soils with impeded drainage. There are also loamy and clayey floodplain soils with naturally high groundwater to the east of Staplehurst (associated with the floodplain of the River Beult).

There is fairly shallow gradient across the catchment with the highest elevation point at approximately 40mAOD (Marden Thorn) and the lowest elevation point at approximately 15mAOD at the downstream model extent.

## 3 Data availability

There is data available for seven Tipping-Bucket Raingauges (TBRs) in and around Marden, Staplehurst and Headcorn: Staplehurst, Horsmonden STW, Headcorn, Sutton Valance, Charing PS, Bethersden STW and Hollingbourne (Table 3-1 and Figure 3-2). A brief analysis of rainfall data coverage in the catchment was undertaken using Thiessen polygons and the most representative TBRs for the catchment within Marden are Horsmonden STW and Staplehurst TBR.

Table 3-1: Tipping-bucket raingauge information

| Gauge | Altitude (m) | Aspect |
|---|---|---|
| Staplehurst | 19.5 | NE |
| Horsmonden STW | 34.5 | ENE |
| Headcorn | 20.5 | SSE |

*Staplehurst*

The Staplehurst TBR has a slightly shorter record than Horsmonden and rainfall data is only available up until 19th January 2014. The gauge appears to be fairly reliable and compares well with Horsmonden. There are no periods of data flagged as missing but between March 2000 and March 2001 the gauge is recording zero rainfall. There is one potential outlier in May 2003 where 63mm of rain was recorded in 2 hours which was not observed at the other gauges. Staplehurst has quite low annual totals when compared against the other gauges.

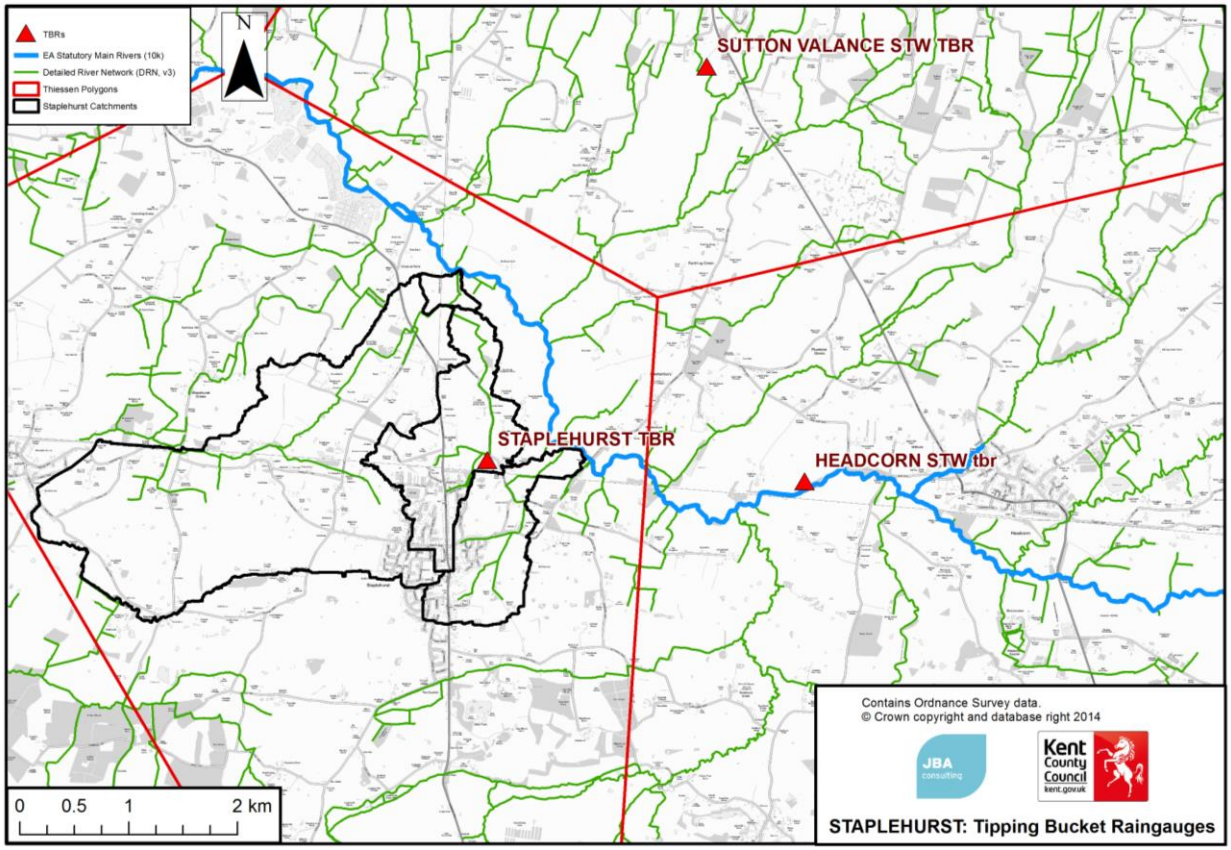
*Horsmonden*

Overall the Horsmonden TBR looks reasonably reliable. There is a period of missing data from November 1996 until July 1997 with another brief gap in August 1997. Between November 2001 and March 2002 the gauge is recording zero rainfall but this has not been flagged as missing. There are no data points associated with unduly high rainfall intensities. The yearly totals from Horsmonden are quite high but appear to match well with a nearby rainfall storage gauge at Pembury. In the earlier years Horsmonden observed 5 to 10% less rainfall than Pembury but in later years (2003 onwards) Horsmonden has been recording slightly more rainfall than Pembury; this may be a result of a recalibration or re-siting of the gauge. The gauge also appears to significantly under record during the October 2000 event.

*Headcorn*

Overall, the Headcorn TBR appears to be good. There are no prolonged periods of missing data. However, the gauge was decommissioned in 2011 and therefore did not record the most recent winter events. As the other two TBRs were either not recording (Staplehurst) or under-recording (Horsmonden) for the Autumn 2000 events, the Headcorn raingauge has been used to determine the rarity of this event.

Figure 3-1: TBR coverage in Staplehurst




## 4 Historical flood events

This section looks at the flood events in Staplehurst as identified during the flood history search.

There are limited reports of flooding within Staplehurst to base this assessment on. However, all of the observed flood events are fairly recent and the source of flooding has also been reported (see Table 4-1).

Table 4-1: Reported flood history within Staplehurst

| Date | Source |
|---|---|
| November 2009 | Foul sewer, Surface water |
| February 2010 | Foul sewer, Fluvial near Clappers Lane |
| March 2010 | Foul sewer, Surface water |
| January 2014 | Foul sewer |

Based on the reported flood events within Staplehurst, it appears as though all of the reported flood events occur during the winter season (November – March). The majority of the flood events seem to be as a result of foul sewer and surface water flooding. Given that the catchments within Staplehurst are generally impermeable and slightly urbanised, it would be expected that Staplehurst would be more

susceptible to short intense rainfall events which are typically observed during the summer months. Therefore, this suggests that Staplehurst may be more susceptible to flooding based on elevated Main River levels in the River Beult which would prevent excess surface water from being cleared from the surface water drainage network i.e. a rise in the water table and nearby Main River levels during periods of higher than normal rainfall may mean that land drainage networks, such as storm sewers, will be unable to discharge excess surface water properly if the water table is higher than normal. Therefore, flooding within Staplehurst may be as a result of the inability to discharge excess surface water during Main River flood events.

## 4.1 Rainfall analysis

This section summarises analysis into the return period and duration of rainfall which lead to flooding in Staplehurst.

In order to estimate the order of magnitude of the main flood events within Staplehurst, the same TBR should be used across all of the reported events to enable consistency between return period estimates. Therefore as the rainfall data recorded at the Staplehurst gauge is located within the Staplehurst catchments available up until January 2014, the Staplehurst TBR will be used to assess event rarity for the majority of the reported events (Table 4-2).

Table 4-2: Rainfall analysis

| Date | Rainfall Depth (mm) | Duration (hours) | Rainfall profile | Return Period (years) | Raingauge |
|---|---|---|---|---|---|
| November 2009 | 55.2 | 59.75 | Mixed profile | 3 | Staplehurst |
| February 2010 | 32.8 | 112.00 | Mixed profile | <1 | Staplehurst |
| March 2010 | 54.4 | 179.50 | Mixed profile | 1 | Staplehurst |
| January 2014 | 51.2 | 108.75 | Mixed profile | 1 | Staplehurst |
| *Other peak rainfall events (no significant flooding reported within Staplehurst) – but raised levels in the River Beult at Smarden and Stilebridge)* | | | | | |
| 12/10/2000 | 73.2 | 16.25 | Winter | 35 | Headcorn |
| January 2008 | 32.4 | 21.75 | Winter | 2 | Headcorn |

## 4.2 Main River analysis

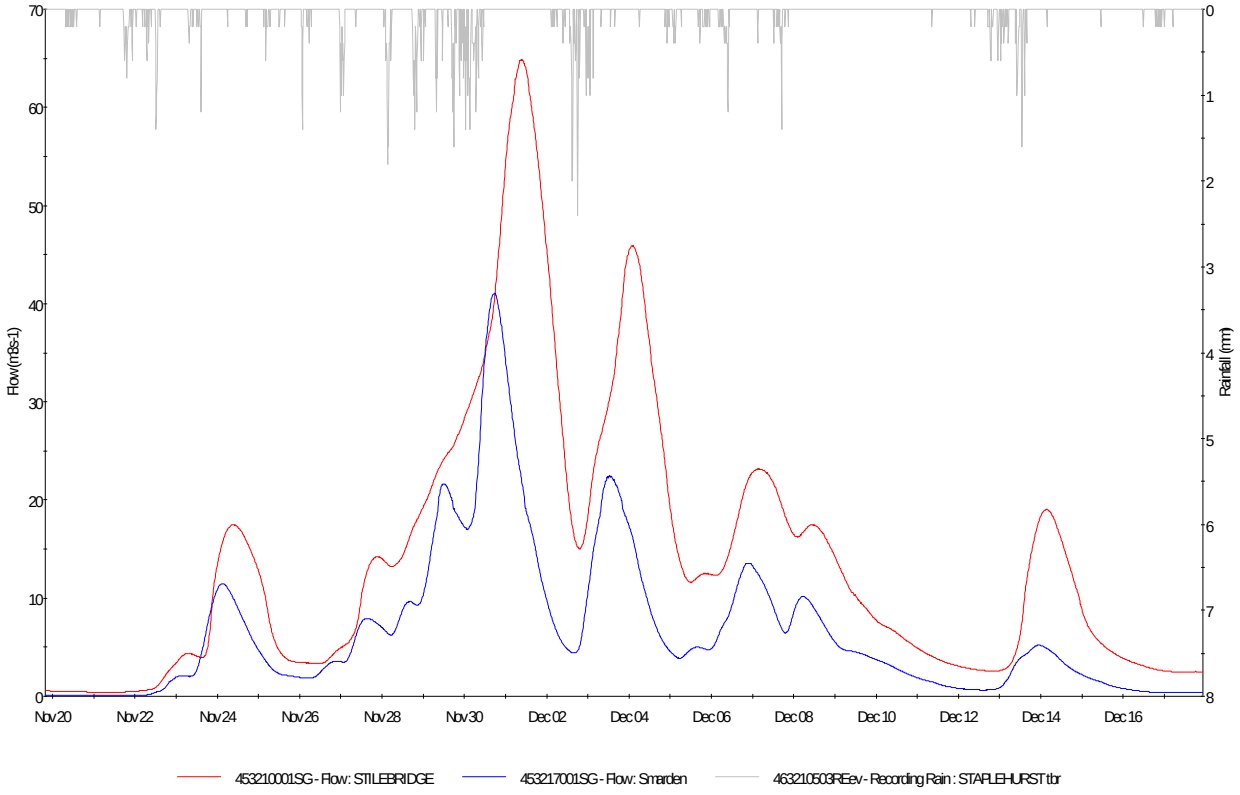
The purpose of this section is to analyse flow patterns on the River Beult at the time when flood events have occurred in Staplehurst. This analyses will test our hypothesis that local flooding events in Staplehurst coincide with high water levels on the Main Rivers.

Observed hydrographs for the Smarden and Stilebridge gauging stations are shown for each of the reported flood events within Staplehurst. Also included on these hydrometric plots is a continuous rainfall record from nearby representative raingauges (dependent on data availability at the TBRs).

### 4.2.1 November 2009

In November 2009 surface water and foul sewer flooding occurred in Staplehurst. The rainfall recorded at Staplehurst TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-1.

Figure 4-1: November 2009 event



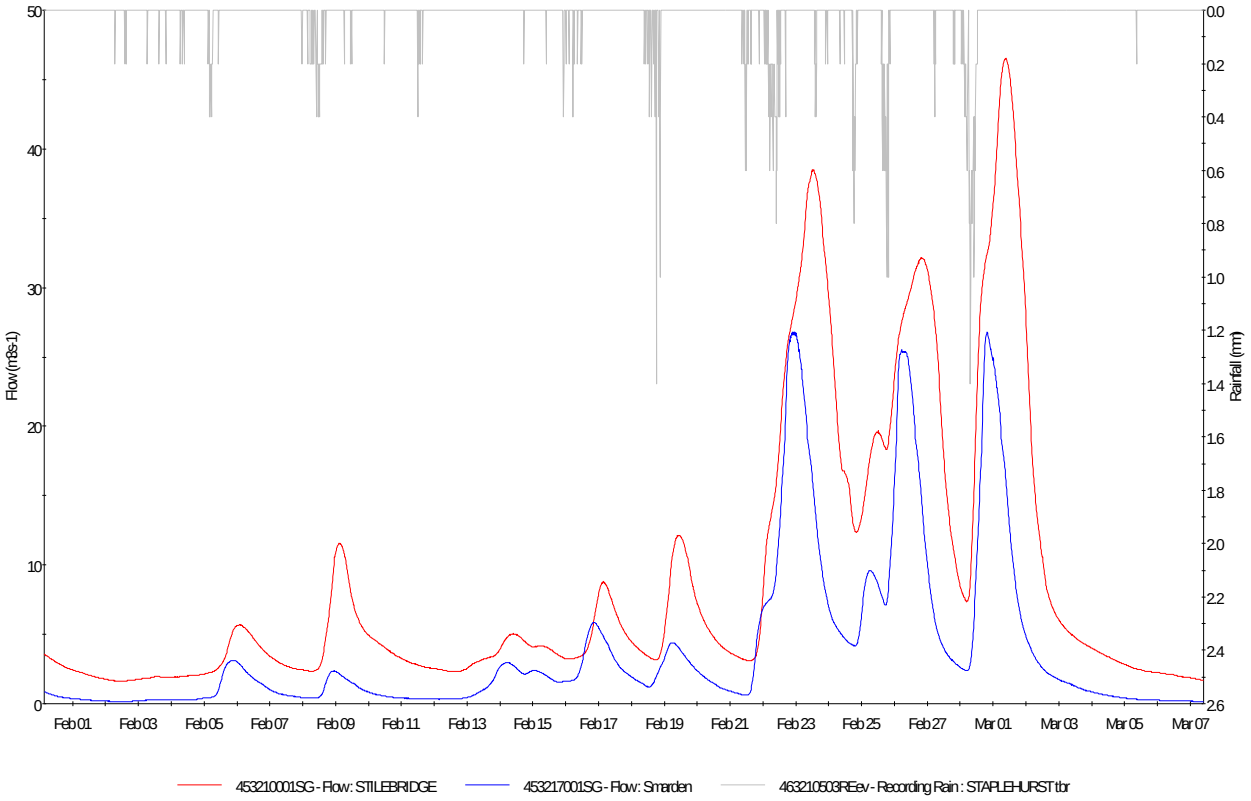

The November 2009 flood event was a result of a sustained period of reasonably intense rainfall (Winter profile) within the River Beult. There are also a series of intense rainfall events and corresponding peak flows in the River Beult in December 2009. Given the underlying impermeable geology, soil types and urbanised areas within the Staplehurst catchments, it is likely that the sustained period of rainfall resulted in a combination of fluvial and surface water flooding. This may have also been exacerbated by the elevated Main River levels in the River Beult as the peak flood volumes during November/December 2009 event would have prevented excess surface water from being passed through the drainage network within Staplehurst.

### 4.2.2 February 2010

In February 2010, fluvial flooding occurred at Clappers Lane and foul flooding occurred in Staplehurst. The rainfall recorded at Staplehurst TBR and the flow recorded on the River Beult at Stilebridge and

Smarden are shown in Figure 4-2.

Figure 4-2: February 2010 event

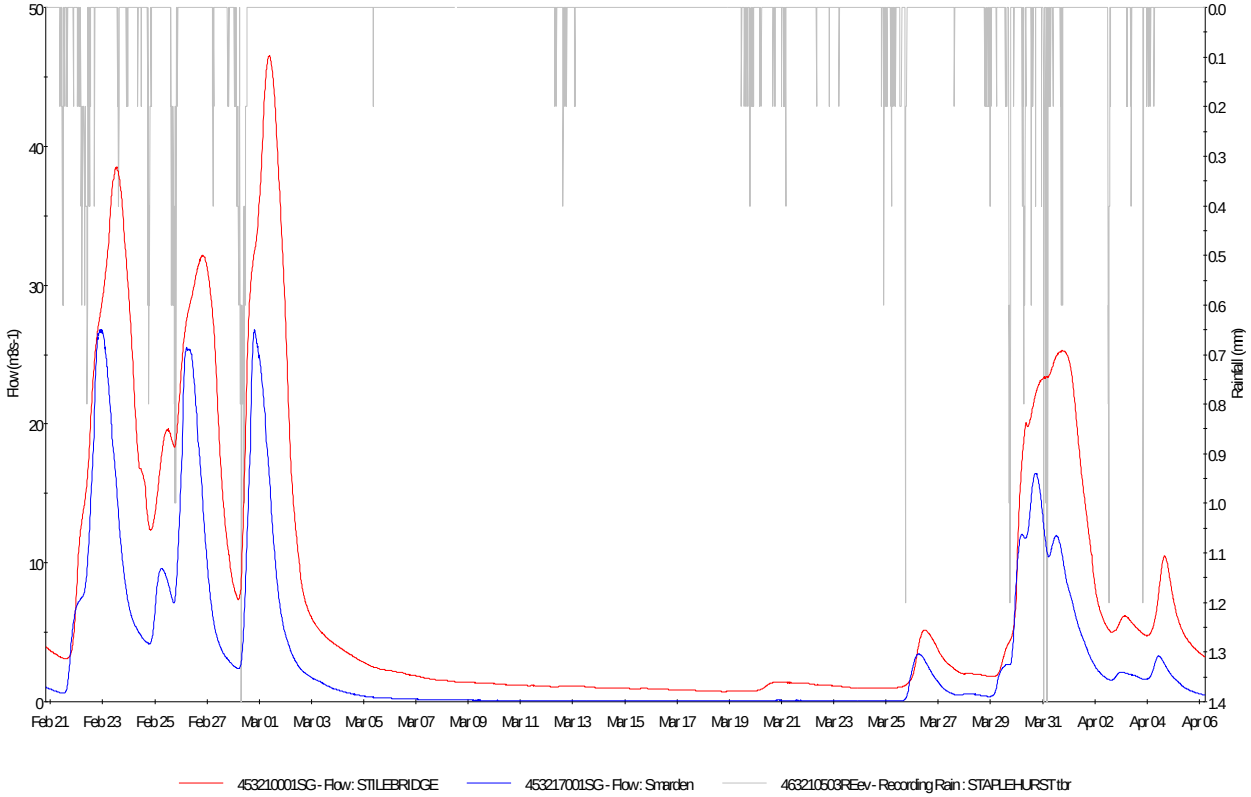



The February 2010 flood event was a result of three intense rainfall bursts at the end of February which lead to the higher peak flow at the beginning of March. It appears as though the rainfall profiles for these events are more characteristic of a summer storm (short intense periods of rainfall). Given the underlying impermeable geology, soil types and urbanised areas within the Staplehurst catchments, it is likely to have resulted in a combination of surface water and sewer flooding as the drainage network within Staplehurst became overloaded with surface water. This may have also been exacerbated by the elevated Main River levels in the River Beult as the peak flood volumes would have prevented excess surface water from being passed through the drainage network within Staplehurst.

### 4.2.3 March 2010

In March 2010, surface water and foul sewer flooding was reported in Staplehurst. The rainfall recorded at Staplehurst TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-3.

Figure 4-3: March 2010 event

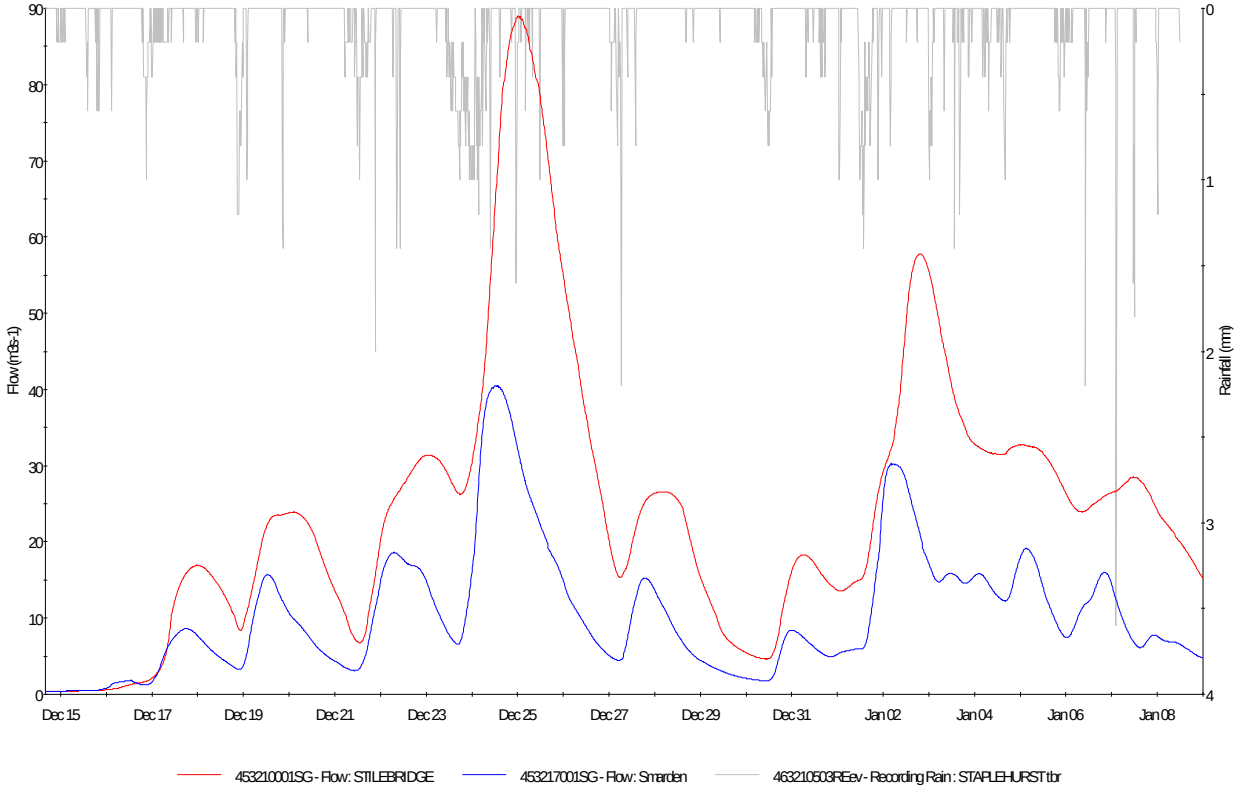



The 2 March 2010 flood event was due to a combination of wet antecedent conditions (as a result of the two previous peak flow events) and a short period of intense rainfall. It appears as though the rainfall profiles for these events are more characteristic of a summer storm (short intense periods of rainfall). There is also a peak flow event on 31 March – 1 April 2010. It is unknown which event the reported flood history refers to but it is likely that flooding was due to the multi-peak events at the end of February / beginning of March due to higher flows and levels in the River Beult. Given the underlying impermeable geology, soil types and urbanised areas within the Staplehurst catchments, it is likely to have resulted in a combination of surface water and sewer flooding as the drainage network within Staplehurst became overloaded with surface water. This may have also been exacerbated by the elevated Main River levels in the River Beult as the peak flood volumes would have prevented excess surface water from being passed through the drainage network within Staplehurst.

### 4.2.4 January 2014

In January 2014 foul sewer flooding was reported in Staplehurst. The rainfall recorded at Staplehurst TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-4.

Figure 4-4: Winter 2013/14 events




For the winter 2013-14 events, the River Beult was characterised by numerous storm events that led to fluvial flooding. The largest peak flows were seen on 24-25 December 2013. However, the reported flooding occurred in January 2014. Smaller peaks were seen following the storms of 1 January 2014.

The December 2013 event is the second highest ranked event at Stilebridge and the 5th highest ranked event at Smarden. Therefore it is expected that these events were also significant for the Staplehurst catchments. Unfortunately, there is no information on severity or magnitude within the reported flood history in Staplehurst. The return period for the rainfall that fell on the 2nd January is less than 1 year. However, it is expected that the return period of the sustained rainfall totals across December 2013 – January 2014 would be significantly higher.

## 5 Conclusions

The majority of the reported flood events are in the winter months and this therefore suggests that the Staplehurst catchments may be more prone to longer duration frontal rainfall events. However, the Staplehurst catchments are also sensitive to short intense rainfall events due to the underlying impermeable geology and urbanised impervious areas. The reported flood events within Staplehurst generally coincide with elevated Main River levels and high flows in the River Beult. However, there is no reported flooding within Staplehurst for some of the major Main River events; October 2000 and December 2013. Therefore it is likely that a particular combination of factors are required for flooding to occur in Staplehurst; wet antecedent conditions prior to multiple intense rainfall events. Some of the flood events could be as a direct result of sewer or surface water flooding and would therefore most likely be due to short intense rainfall events; therefore these events may not always be observed in the Main Rivers.

It is highly likely that the catchments within Staplehurst may be more sensitive to short intense rainfall events during periods when there are elevated Main River levels. This would exacerbate the surface water flooding as the excess surface water is unable to be cleared from the surface water drainage network. Therefore flooding within Staplehurst may be as a result of the inability to discharge excess surface water during Main River flood events.