“Storm Bert” and Flooding on the Site of the Lime Down Solar Park.

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Summary

It is proposed to construct a very large solar farm, called Lime Down Solar Park, in part of the South Cotswolds in North Wiltshire. A named storm, Storm Bert, caused extensive flooding in this area in 2024. This report contains a brief analysis of the rainfall that caused the floods, the effects on flow in the rivers, a comparison with a previous major flood event in November 2012, and an annotated pictorial account of the floods themselves.

1. Storm Bert

On Sunday 24th November 2024 extensive flooding occurred in North Wiltshire due to heavy rain from a Met Office named storm, “Storm Bert”. The flooding also affected other parts of SW England and S Wales. Not only did the floods affect the area proposed for the Lime Down Solar Park, but the adjacent towns and villages such as Malmesbury and Corsham, and larger communities downstream on the Bristol Avon such as Chippenham, Melksham and Bradford on Avon. In Chippenham, where several large shops suffered major damage, the flooding was reported in the local press as being the worst since 1968 [1]. This report is a preliminary hydrological analysis of the event. Quantitative data for the report was sourced from the UK Government Department of the Environment, Food and Rural Affairs’ *Hydrology Data Explorer* site [2].

Rainfall at three local sites is presented – Shipton Moyne, Great Somerford, and Badminton (Figs 1-3). Using three sites allows an assessment of the spatial variation of rainfall, and also provides a reality check. These are automated unattended sites in the Environment Agency’s network, and errors due to temporary malfunctions are possible. The data have not yet been quality checked by the relevant authorities and so must be regarded as provisional, although they look reasonable.

The rainfall at Shipton Moyne over the two days of Storm Bert is shown in Fig. 1. Shipton Moyne is the closest rain gauge to the Lime Down area, about 2.5 km N of Foxley, about 95m OD altitude. Rain started at 3 a.m. on 23 November, and some rain fell on all but 2 hours between then and 11 p.m. on 24 November. The rain was not exceptionally intense (for instance, the UK hourly rainfall record is 92 mm [3]) but unusually persistent. The total for the 24th of 58.0 mm qualifies it as an extreme daily value, defined as over 50 mm [4]. A daily rainfall of 50 mm or over would be expected about every 40 years in this area [4]. Since division of the record into calendar days is arbitrary, it can be useful, if there is a continuous record, to calculate the maximum 24-hour rainfall. The 24 hour period up to 21:45 on the 24th had the highest 24-hour rainfall during the storm: 64.5 mm. So this was certainly an exceptional rainfall event with 78.4 mm of rain in total during the storm. Rainfall statistics for all three sites are shown in Table 1.

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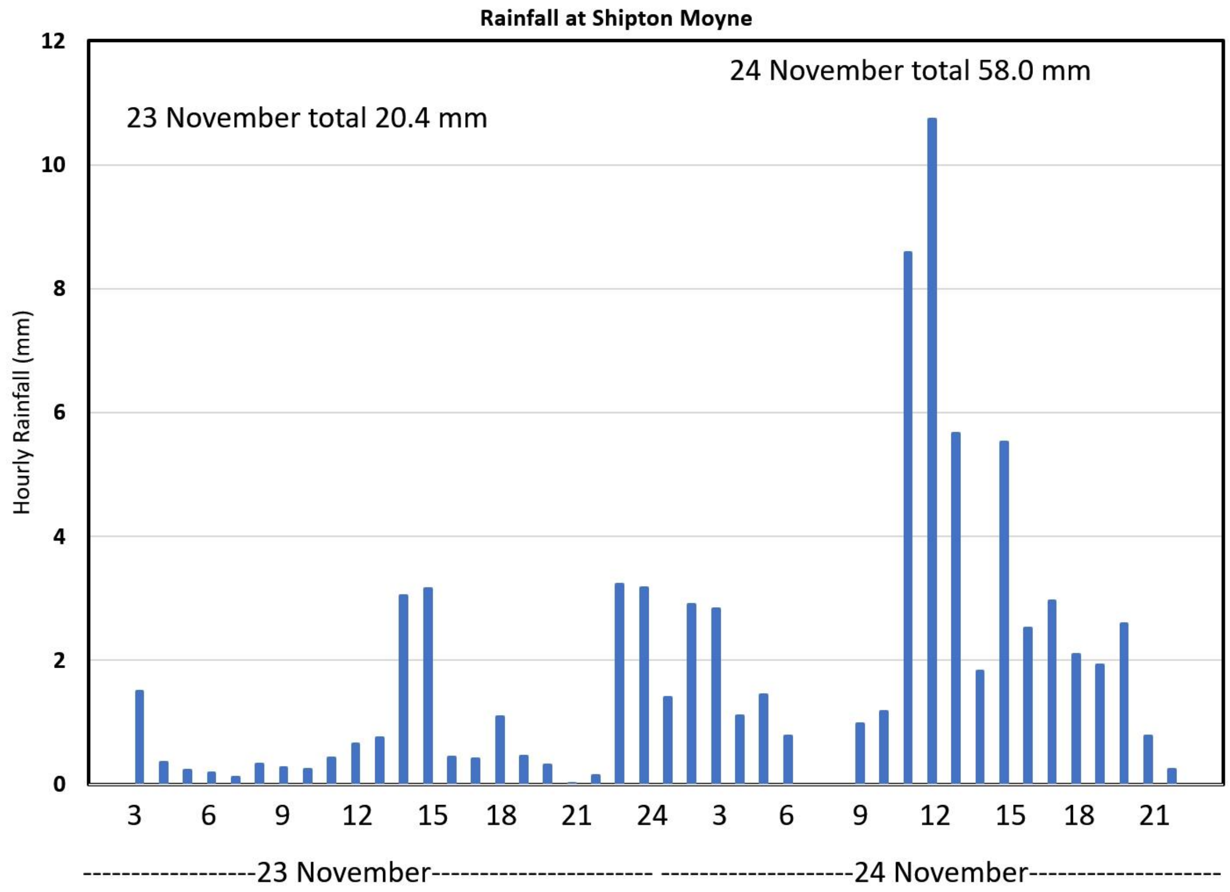

Fig. 1. Rainfall due to Storm Bert at Shipton Moyne

The next closest raingauge is at Great Somerford, 7.5 km SE of Foxley and at a considerably lower altitude of 60 m. The rainfall total was lower at 58.1 mm and the total rainfall on the 24th at 41.8 mm was less than the 50 mm required to qualify as extreme (Fig. 2). The maximum 24 hour total was 46.6 mm. Though the pattern is similar to Shipton Moyne, it is missing the very high peaks at 11:00 and 12:00 on the 24th.

Badminton is the next closest raingauge, at 8.3 km SW of Foxley and 115 m OD. The pattern was very similar to Shipton Moyne (Fig.3), but with slightly lower total of 70.5 mm. The peaks at 11:00 and 12:00 are present, but unlike Shipton Moyne the 11 am peak was larger than the 12 am peak, consistent with the storm moving from West to East. There was 51.5 mm on the 24th and 19.0 mm on the 23rd and the highest 24-hour total was 57.8 mm.

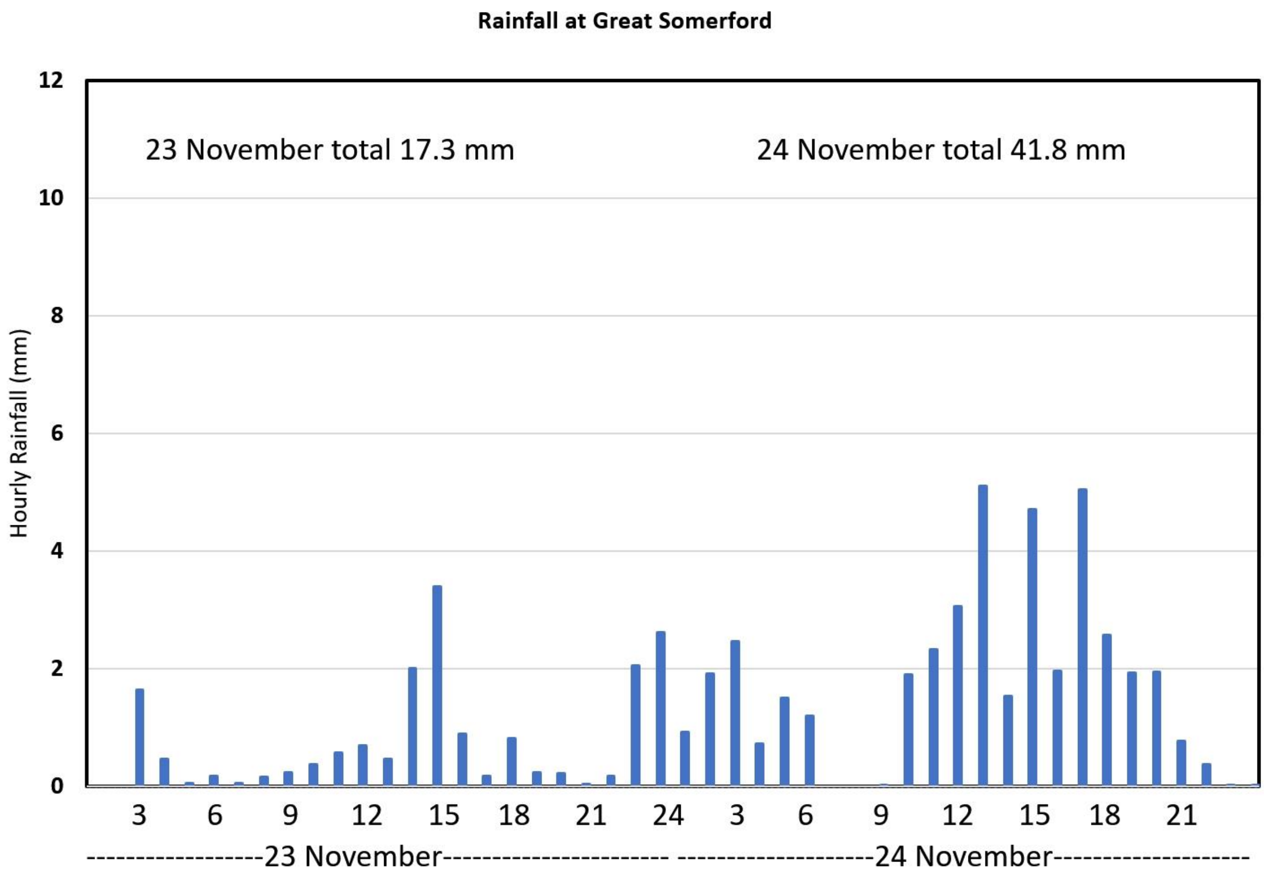

Fig. 2. Rainfall due to Storm Bert at Great Somerford

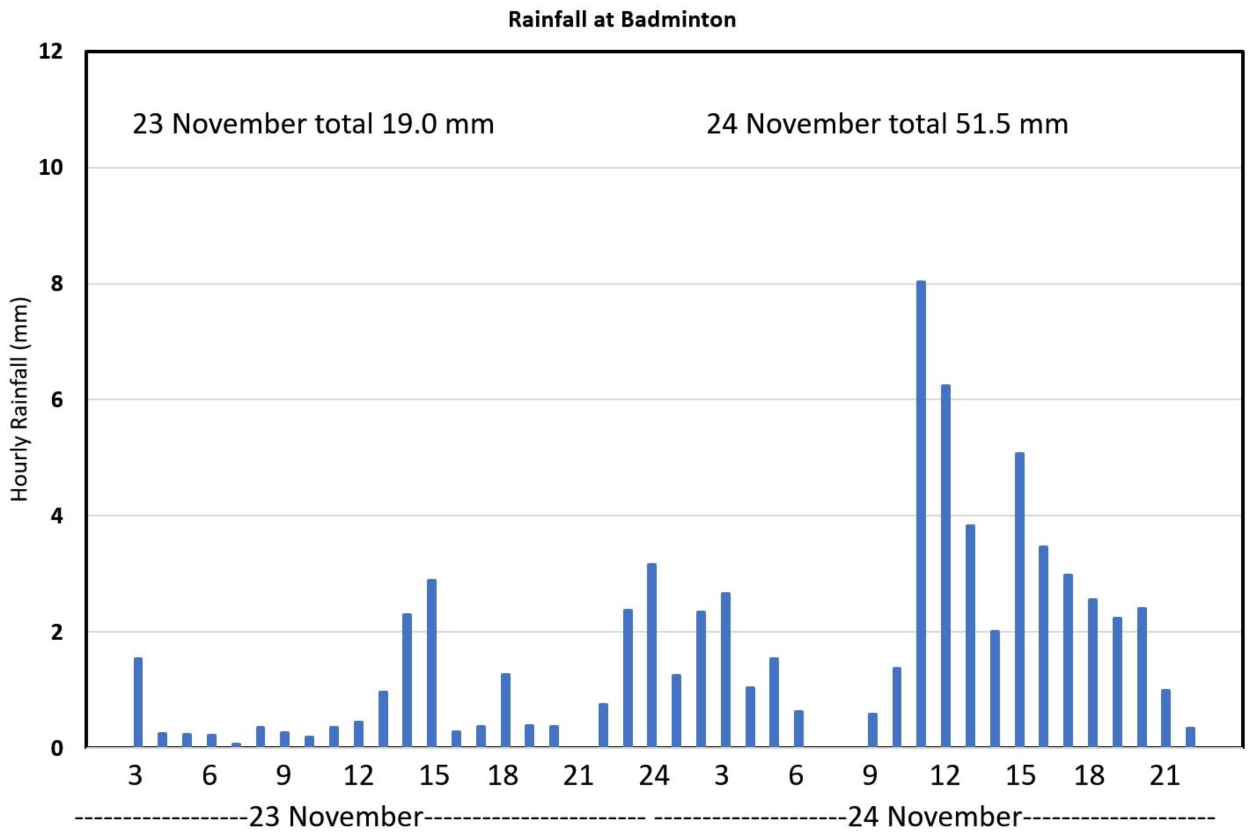

Fig. 3. Rainfall due to Storm Bert at Badminton

Rainfall statistics are summarized in Table 1.

Site	Location	Height (m OD)	Rain Total (mm)	Rain 23rd Nov	Rain 24th Nov	24-hour maximum	Maximum Hourly rain
Shipton Moyne	ST899886	95	78.4	20.4	58.0	64.5	10.7
Great Somerford	ST964833	60	58.1	17.3	41.8	46.6	5.1
Badminton	ST815831	115	70.5	19.0	51.5	57.8	8.0

Table 1: Rainfall statistics for Storm Bert. All rainfall values are in mm.

Overall, Bert was a large storm and fairly self-contained in that there was little rain in the 3 preceding days, and only about 1mm on the following day. The 24 hour rain totals at two of the raingauge sites qualify it as an extreme event, with a return period very provisionally of c.50 years[4].

The response of the Sherston Avon at Fosseway is shown in Fig. 4.

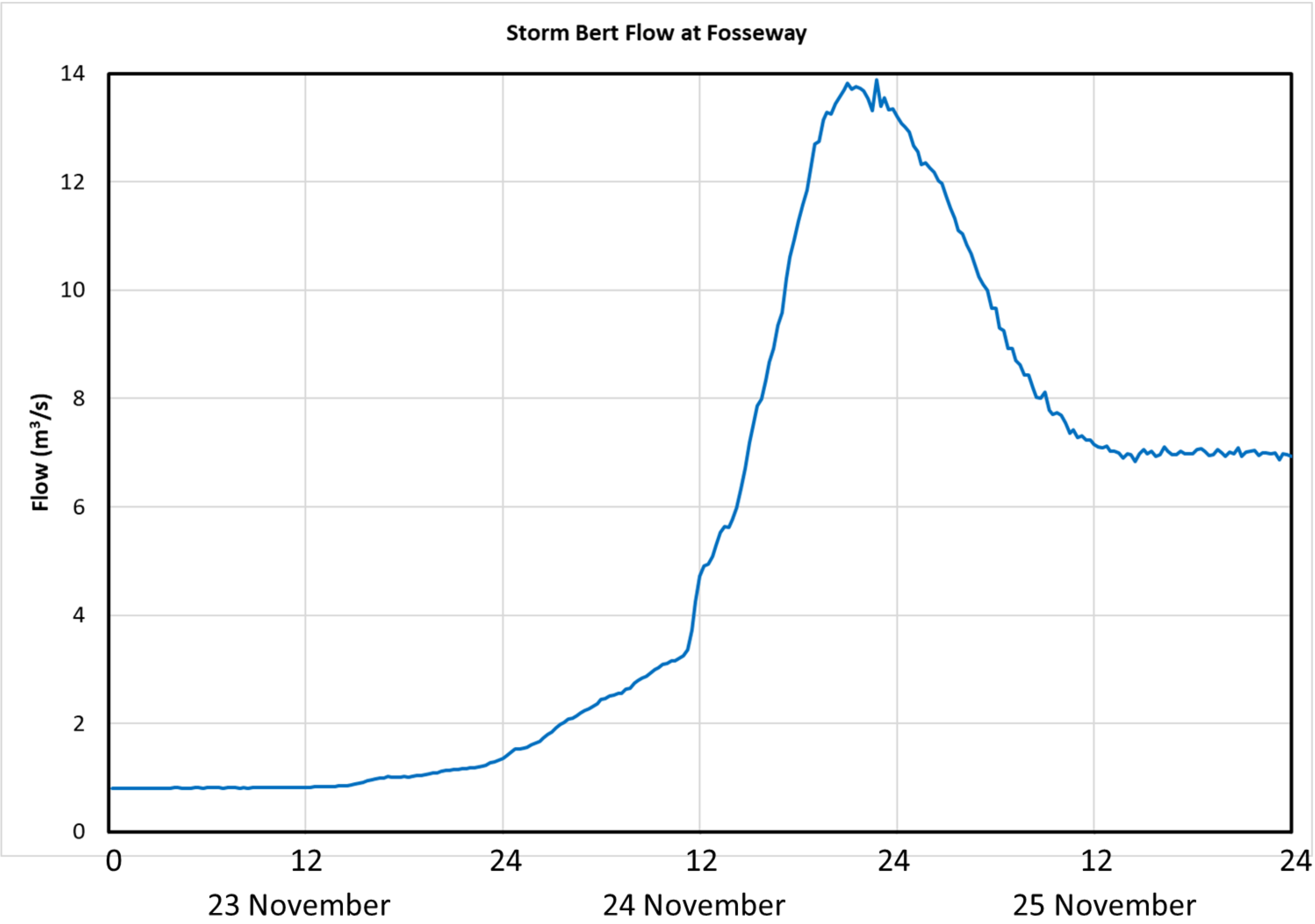

Fig. 4. Flow in the Sherston Avon at Fosseway during Storm Bert

The Avon hardly responded to the initial rain of Storm Bert until 2 hours of somewhat harder rain arrived at 14:00 on the 23rd. Thereafter there was a fairly slow increase in flow in response to moderately heavy rain in the small hours of the 24th, until the advent of 2 hours of very heavy rain starting at 10:30 of the 24th (Figs. 1 and 3). Then there was a sharp increase in river flow which continued to a peak of 13.9 m^3/s at 22:30, by which time the rain had stopped. Flow then declined until 14:00, when it stabilised at around 7 m^3/s. A little rain fell about this time, but not enough (< 1mm) to account for the stabilisation, which may be due to the arrival of groundwater flow from higher in the catchment.

The river was in an average state at the beginning of the storm, with a flow of 0.8 m^3/s, which is about the 44th percentile on an annual basis [5] (i.e. 44% of flows are larger than this). The flow stabilised at 7 m^3/s, which is the 0.2nd percentile. Flow records at the site stretch back to 1976, and this is the second highest storm peak: the highest was 18.2 m^3/s on 25 November 2012 [5]. In view of this it is interesting to ask why downstream flooding was so bad this time compared to 2012 given much higher flows in 2012, although the downstream towns are also influenced by runoff from other catchments.

The Gauzebrook is a tributary of the Avon which flows through the Lime Down area and will drain Area D of the Scheme. It is responsible for periodic floods in the village of Corston and on the main road between Malmesbury and the M4. The Gauzebrook is generally more responsive to rainfall than the mainstream Avon, both rising and falling more quickly. This is starkly illustrated by the response to Storm Bert. Fig. 5 shows the response of both streams plotted on the same graph.

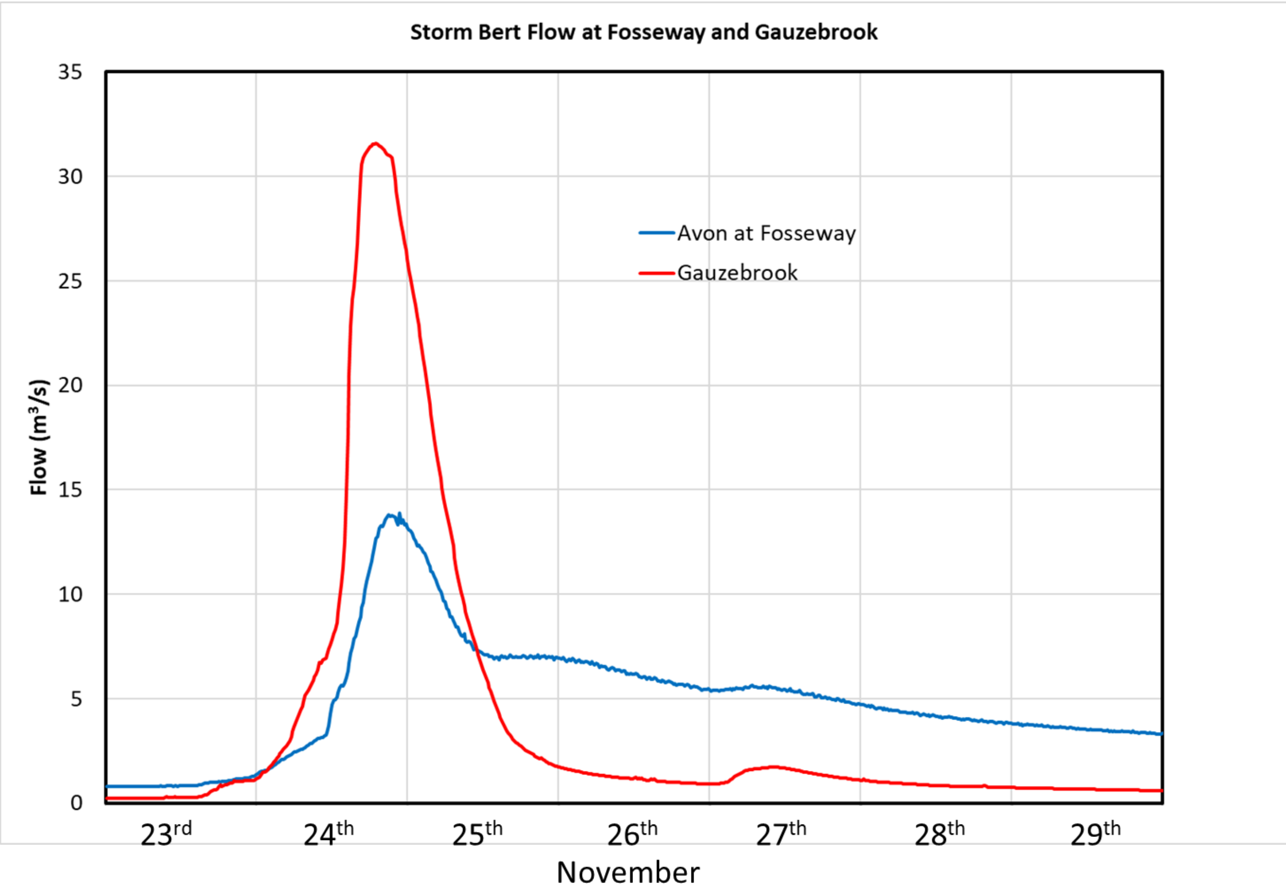

Fig. 5 Flow in the Sherston Avon and Gauzebrook during Storm Bert

Flow in the Gauzebrook peaked at 31.58 m^3/s, 227% higher than the Avon, in spite of the catchment being only 31% of the size (28.2 km^2 as opposed to 89.7 km^2 for the Avon). Peak flow was reached at 18:45, 3.75 hours earlier than the Avon, and the reduction in flow once rain had stopped was much quicker than the Avon, without the 12 hour period of stabilisation. Inspection of the flow record shows that this pattern is a common one for the Gauzebrook.

As with rainfall, the data are unchecked by official bodies. The Gauzebrook flow peak was calculated from stream height data, which is also available on [2], and a flow rating curve from 13:30 on the 24th to 7:45 on the 25th. The rating curve was constructed from the relationship between flow and stream height in the two days before the storm. Flow gauges often fail or are partially bypassed during extreme storms, but these data look credible.

2. Comparison with Storms of November 2012

At Fosseway, the flow in the Avon of 13.881 m^3/s at 22.30 on 24 November 2024 was the second highest in the record [5], which stretches back to 1 November 1976. The highest was considerably higher: 18.219 m^3/s at 06:00 on 25 November 2012. On this occasion there were severe floods in Malmesbury [6], but exceptional flooding downstream was not recorded.

In the Gauzebrook, in contrast, the situation is reversed. The peak flow in the Gauzebrook was the highest on record for Storm Bert at 31.58 m^3/s, and the second highest was 26.21 m^3/s at 05:30 on 25 November 2012 [2]. The Gauzebrook record extends back to 1968. On the Avon at Great Somerford, peak flow for Storm Bert was 99.08 m^3/s at 00:30 on 25 November 2024, higher than in 2012 when the peak flow was 85.67 m^3/s at 11.00 on the 25 November 2012.

Flow in both the Avon at Fosseway and the Gauzebrook in November 2012 is shown in Fig. 6.

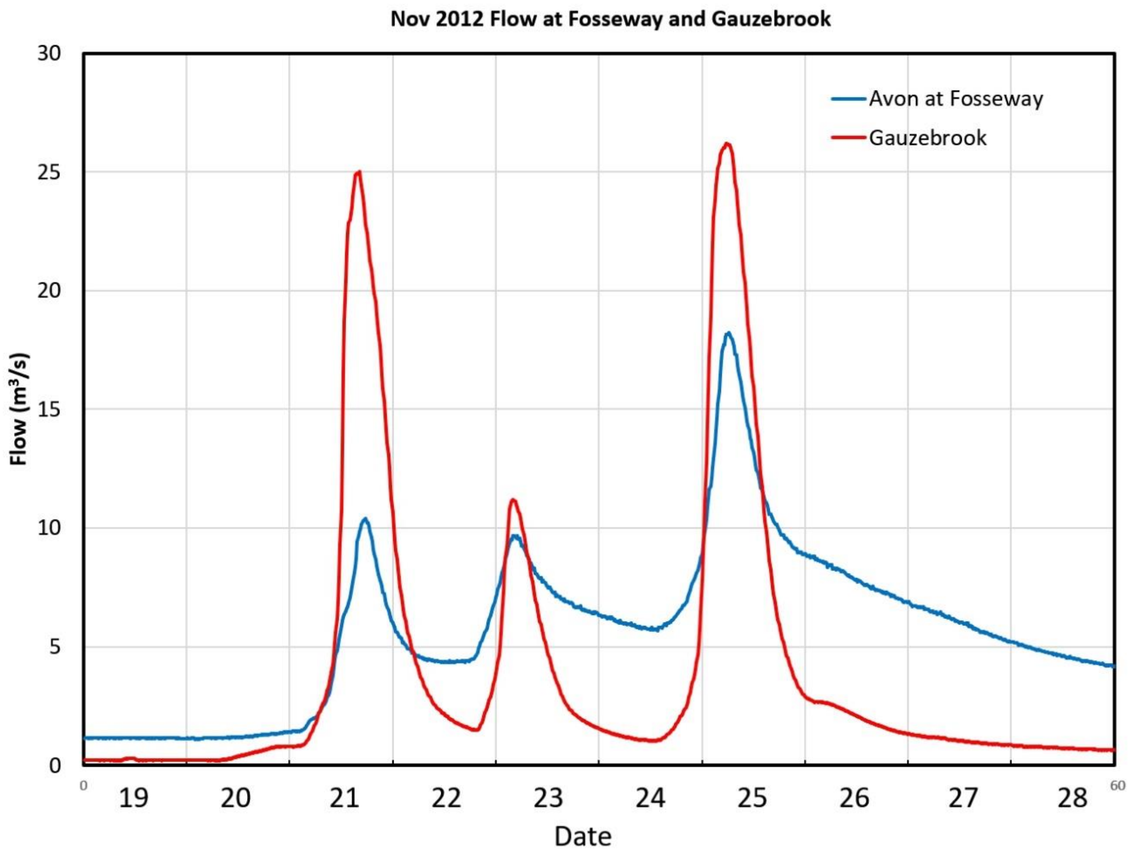

Fig. 6 Flow in the Sherston Avon and Gauzebrook in November 2012

The November 2012 storms were a more complex event than Storm Bert, with three separate storm peaks. The pattern is similar to Fig. 5, with the Gauzebrook rising and falling more quickly than the

Avon, and a larger flow peak. The cumulative effect of the three events can be clearly seen in the Avon. The recession curves become shallower after each event. This probably indicates outflow from groundwater and soil water sources which have been topped up by the storms. These sources are evidently less important for the Gauzebrook.

At the beginning of the storm pattern on the 19th, the Avon at Fosseway was higher than it was for Storm Bert, with a flow of 1.14 m^3/s as opposed to 0.8 m^3/s, which is 32% exceedance (32% of flows are higher than this) as opposed to 44% for Storm Bert.

Comparative flow data are available for other local sites. At Brokenborough on the Tetbury Avon, the flow peak in 2012 was 9.50 m^3/s, compared to 9.93 m^3/s for Bert. Crabb Mill near Malmesbury is on the Woodbridge Brook which flows into the Avon and drains an impermeable clay catchment. It has much higher flow peaks: 87 m^3/s in 2012 (recorded as suspect) and an unlikely 209 m^3/s for Bert (this is more than double the volume of the flow peak in the Avon at Great Somerford downstream for the same event). Height data only are available for St Johns Weir in Malmesbury on the Sherston Avon, which is close to the locus of flooding: 1.475m in 2012 and 1.454m for Bert. The overall pattern is thus that Bert has the highest flow peaks except on the Sherston Avon, when peaks were higher in 2012.

Hourly rainfall at Great Somerford over the same period is shown in Fig. 7. The scale is the same as Figs 1-3. Though the pattern of rain leading to the three flow episodes can be clearly seen, there are no very high values at the time of the final record flow peak, unlike in Figs 1 and 3. In the database[2], the rainfall during this period at Great Somerford is marked as "suspect" although it is not clear why. Table 2 shows daily rainfall for four local sites. Great Somerford has a very similar pattern to Tetbury, though the absolute amounts are lower. At Shipton Moyne and Badminton, however, there is no rainfall on the 24th and 25th which would explain the extreme flow peak on the 25th, which contradicts rainfall records at the other two sites (and my own memory of the event).

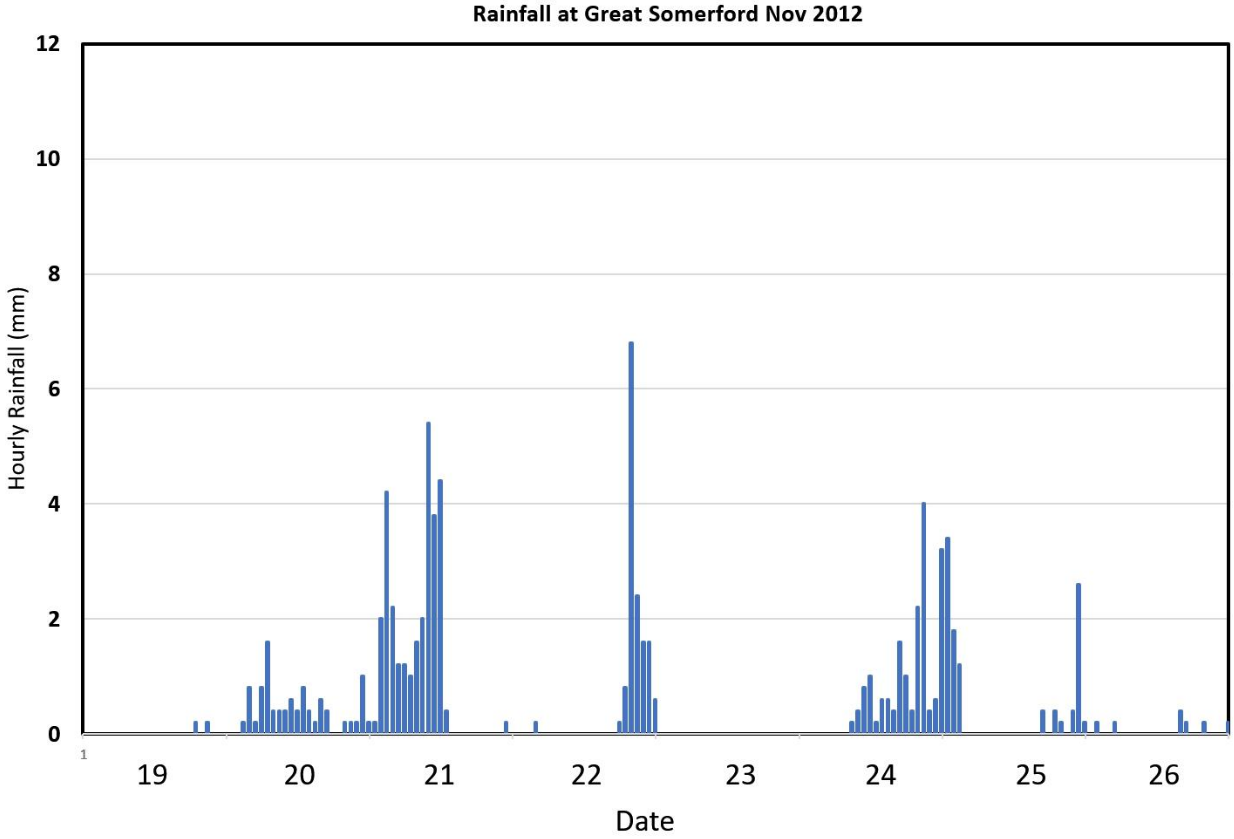

Fig. 7 Rainfall at Great Somerford, November 2012

Either there was some rather extreme spatial variation in rainfall on those days or the raingauge records are inaccurate. At none of the raingauge sites did the daily totals exceed 50 mm in the November 2012 event, nor did the 24-hour maximum totals (43.4 mm for Tetbury on the 21st being the largest).

Table 2: Daily rainfall (mm) at four sites, November 2012

Site/Date	19	20	21	22	23	24	25	26	27	Total
Great Somerford	0.4	10.0	29.8	14.2	0.2	17.6	14.6	1.6	1.4	89.8
Tetbury	0.8	11.2	38.6	20.0	0.0	24.8	11.8	1.4	0.8	109.4
Shipton Moyne	0.8	4.8	20.4	12.2	0.0	0.0	1.8	0.2	0.6	40.8
Badminton	1.4	11.2	32.2	18.2	0.2	0.2	3.2	1.8	0.8	69.2

3. An Annotated Pictorial Record of Flooding due to Storm Bert

Some pictures of the effects of Storm Bert on the Lime Down and some adjacent areas are given below. Some were taken under difficult circumstances and the quality is sometimes inevitably not good. These pictures were contributed by local residents for the purpose of illustrating the vulnerability of the area to flooding, and their permission to use them in this report has been assumed. Where the picture shows part of one of the five Lime Down areas (A to E), this is mentioned, as is the EA Flood Risk Classification[7]. Information about the solar farm is as given in the initial public consultation by Island Green Power in March 2024. There may have been changes to the plans since then.

P1. Alderton Main Street.

Just west of Lime Down Area C.

P2. Looking W into Area C from Farleaze.

Land shown in P2 is in EA Flood Zone 1 (<0.1% risk of flooding per year). Surface runoff over saturated ground and concomitant soil erosion can be seen.

P3. Flooding on Area A the day after Storm Bert. Dated 26.11.24 at 10:52.

Land shown in P3 is in EA Flood Zone 1 (<0.1% risk of flooding per year). These fields are mostly scheduled for panels (Area A) at the time of writing. Saturated ground in the background can be seen draining down the slight slope into the surface water, which is backed up against a field boundary.

P4 and P5 Tanners Hill Bridge, Sherston.

Runoff from Area A is contributing to water running down the roads to the right and left of the houses, and can be seen pouring into the Avon in P5.

P6 Folorn Bridge, Sherston, during Storm Bert

Runoff from Area A is contributing to water flowing down the road to the right and the road behind the camera.

There are no photographs of the underside of Folorn Bridge during Storm Bert. However, there are pictures from the 2012 flood event. Pictures P7 and P8 show the situation as the third flow peak of November 2012 was receding. Flow at the time was 13.0 m^3/s, very close to the Storm Bert flow peak of 13.9 m^3/s, so the situation was very probably similar. The two arches of the bridge are almost completely submerged. In 2012, the flow peak was 18.2 m^3/s, 29% higher than in the photograph.

Flow restriction at Folorn Bridge causes the water to back up as shown in P8. The inundated area is in EA Flood Zone 3 (>1% risk of flooding per year). Wessex Water's Sherston sewage treatment works is just out of sight in the distance. Though the water retention here could be providing some flood protection for Malmesbury downstream, it must also be putting the bridge at risk.

P7 Folorn Bridge, 25.11.2012, 12:00.

P8 Above Folorn Bridge, 25.11.2012, 12:01.

A little further downstream, the bridge at Easton Grey was also almost submerged by Storm Bert (P9). This was about an hour before the Storm Bert flow peak, which was 15 cm higher.

P9 Easton Grey Bridge, 24.11.2024, 21:38.

Sites in P3-9 are all potentially affected by runoff from Lime Down Area A.

P10 below shows flooding in Lime Down Area C. The ephemeral watercourse behind the hedge is in EA Flood Zone 3, and the field beyond (which will have panels) in Flood Zone 1. The watercourse will feed runoff from Area C into the Avon near Foxley. Surface runoff can be seen flowing down the saturated soil in the field.

P10 Flooding at Fosse Farm due to Storm Bert.

P11 Flooding due to Storm Bert between Foxley and Norton

This field is due to be covered in solar panels as part of Lime Down Area B. It is in EA Flood Zone 1 (<0.1% risk of flooding per year). There are signs of compaction by agricultural machinery in the foreground.

P12 and P13 show the Splash at Norton, a small bridge which overflows onto a normally dry ford on the small stream which will drain Area C and part of Area B into the Avon near Foxley.

P12 The Splash at Norton, Storm Bert

P13 The Splash at Norton, 24.11.2024, 12:51

P12 is the view towards the Vine Tree public house with the Splash in the distance. P13 shows the Splash itself, with the stream running from right to left towards the fenced structure, which is a submerged bridge. The depth was recorded variously as between 0.55 and 1.2 m. A car failed to pass the ford later in the day and was abandoned.

P14 below shows a stretch of road between Hullavington and Norton near Bradfield Manor. This stretch frequently floods after heavy rain. Proposed BESS site on the left, Area D on the right. Both sides are in EA Flood Zone 1.

P15 below is close by, looking over fields in Area D. Most of the picture is in Flood Zone 1, but the ephemeral watercourse in front of the hedge is Flood Zone 3.

P14. Hullavington Norton road, Storm Bert

P15 From Bradfield Wood 24.11.2024. 11:50.

The Gauzebrook provided some of the most spectacular images of flooding. P16 shows the Gauzebrook valley above Corston. The left side of the picture is scheduled to be covered in solar panels at the extreme end of Area D. All of Area D and the BESS would drain into this area. The entire inundated area in the picture is in Flood Zone 3.

P16 The Gauzebrook above Corston.

P17 Corston Road Bridge, Storm Bert

P17 shows the Gauzebrook flowing under the main A429 Malmesbury – Chippenham road. The top of the arches can just be seen.

On the surface, the Gauzebrook flooded onto the main road, which was closed for a while (P18). This situation occurs even when the flooding is not so extreme.

P18. A429 at Corston during Storm Bert.

P19 Rodbourne Bottom after Storm Bert.

Area E drains into Rodbourne Bottom. The Rodbourne Brook runs behind the fence to the left. The Area pictured is in Flood Zone 3. No panels are scheduled here, but they do occupy part of Flood Zone 3 higher up the valley.

4. Conclusions

Storm Bert qualifies as an exceptional rainfall event. It caused widespread flooding over the area proposed for the Lime Down Solar Park. Flooding was extensive even in areas where officially flood risk is in the lowest category. Local roads and the main Malmesbury – Chippenham road became impassable at times. The floods propagated downstream to the larger settlements of Chippenham, Melksham and Bradford on Avon, where flood defences proved inadequate to defend all properties. Bert was the largest flood since mid-1968 except in the Sherston Avon where it was the second largest after November 2012. This may be because of the spatial variation of rainfall in the final event of 2012, with more rain in the Sherston Avon catchment than other local catchments, but the rainfall data available to me are not good enough to determine this. This may also explain why the effects of Bert were much larger downstream than the events of 2012. Initial works from the Malmesbury Flood Defence scheme may have reduced flood peaks in Malmesbury due to Bert.

In contrast to the Sherston Avon, the Gauzebrook peak flow was higher for Bert than in 2012. Possibly the Gauzebrook has become more sensitive to rainfall in the years between 2012 and 2024. There have been two significant changes in the catchment since then. Firstly sewage from Grittleton was diverted to Hullavington in 2014, adding effluent from about 400 people to the Gauzebrook catchment [8]. Secondly, two relatively small solar farms were constructed at Hullavington and just downstream of Corston, which may have increased runoff rates. Again, the data are not good enough to determine whether these changes are significant.

Storm Bert illustrated the vulnerability of the Lime Down area to flooding, perhaps surprisingly in view of the fact that the entire area apart from the far eastern side is Jurassic limestone. The complexity of hydrological relations in the area is noted in the reports on the Malmesbury Groundwater Scheme [9]. Under low or average flow conditions, the mainstream Avon is indeed not very responsive to precipitation. However, the underlying Great Oolite aquifer fills quite rapidly in the event of rainfall, and as it becomes saturated, faults in the Malmesbury area can transmit water quickly to the river. Smaller side streams such as the Gauzebrook and the Rodbourne Brook also originate in fault-controlled Great Oolite springs, according to [9], and would also respond to the aquifer filling by rising more quickly. The prevalence of slowly-permeable soils over some of the area, and the mudstone variant of the Forest Marble geological formation, will also lead to flood sensitivity. What Storm Bert and the November 2012 event have in common is that there is a period of moderate but prolonged rainfall in the day or days beforehand to fill the groundwater stores and expand the surface saturated area, followed by a period of intense rain which ran off unexpectedly quickly to provide the flood peak. It is an area where it would be easy to increase the frequency and intensity of flooding by inappropriate development.

6. References

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