Derbyshire County Council Section 19 Hydrology Technical Appendix – Storm Babet 18/10/23 – 21/10/23

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Derbyshire County Council Section 19
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Contents

1. Derwent Management Catchment 3

1.1 Derwent Management Catchment Event Hydrology 3

2. Don and Rother Management Catchment 21

2.1 Don and Rother Catchment Event Hydrology 21

3. Dove Management Catchment 37

3.1 Dove Catchment Event Hydrology 37

4. Idle and Torne Management Catchment 47

4.1 Idle and Torne Catchment Event Hydrology 47

5. Trent Lower and Erewash Management Catchment 60

5.1 Trent Lower and Erewash Catchment Event Hydrology 60

1. Derwent Management Catchment

1.1 Derwent Management Catchment Event Hydrology

1.1.1 Catchment Characteristics

The Derwent sub-catchment spans through the centre of Derbyshire from east of Manchester near Glossop to south of Derby. The sub-catchment has an area over 1000km2.

The Main River in this sub-catchment is the River Derwent, flowing through the centre of Derbyshire from its source in the south-east through Bamford, Grindleford, Baslow, Rowsley, Matlock, Belper, Duffield and Derby until it combines with the River Trent southwest of Long Eaton. The main tributaries include the River Westend, River Ashop, River Noe, River Wye, River Ecclesbourne and Markeaton Brook on the right bank, and Bar Brook, River Amber, Bentley Brook and Bottle Brook on the left bank.

Waterbodies within the sub-catchment include Derwent, Ladybower and Howden reservoirs on the River Derwent and Ogston reservoir on the River Amber. The Carsington Water reservoir, located in the River Dove catchment, takes water through the tunnels and aqueduct straight from the River Derwent in Ambergate.

The bedrock geology consists mostly of Triassic and Carboniferous mudstone, siltstone, sandstone occasionally with high iron content, and Carboniferous limestones (Figure 1-2). Limestone dominates in the north-western part of the catchment, whereas the eastern and southern parts are dominated by sedimentary rocks. Peats occur in the most upstream part of the Derwent sub-catchment and silt and silty loam are developed on limestone. Loam is also associated with sedimentary rocks, with higher permeability in the central and upstream part of the catchment (sandy loam) and lower permeability in the downstream part (clayey loam). Groundwater recharge is impeded mostly in the downstream part of the catchment, the areas in the central and upstream part have moderate permeability due to fissured (limestone) and intergranular (sedimentary rocks) groundwater flow.

The catchment is relatively rural in the north with most urbanised areas being concentrated in the south of the catchment toward the River Trent and Derby. Average annual rainfall received is similar across the catchment, with higher average rainfall in the northern part of the catchment.

Figure 1-1 indicates the sub-catchment extent in respect of the Derbyshire area, in addition to showing the location of the groundwater, rainfall, river flow and level gauges within the sub-catchment. It also highlights urban areas within the sub-catchment.

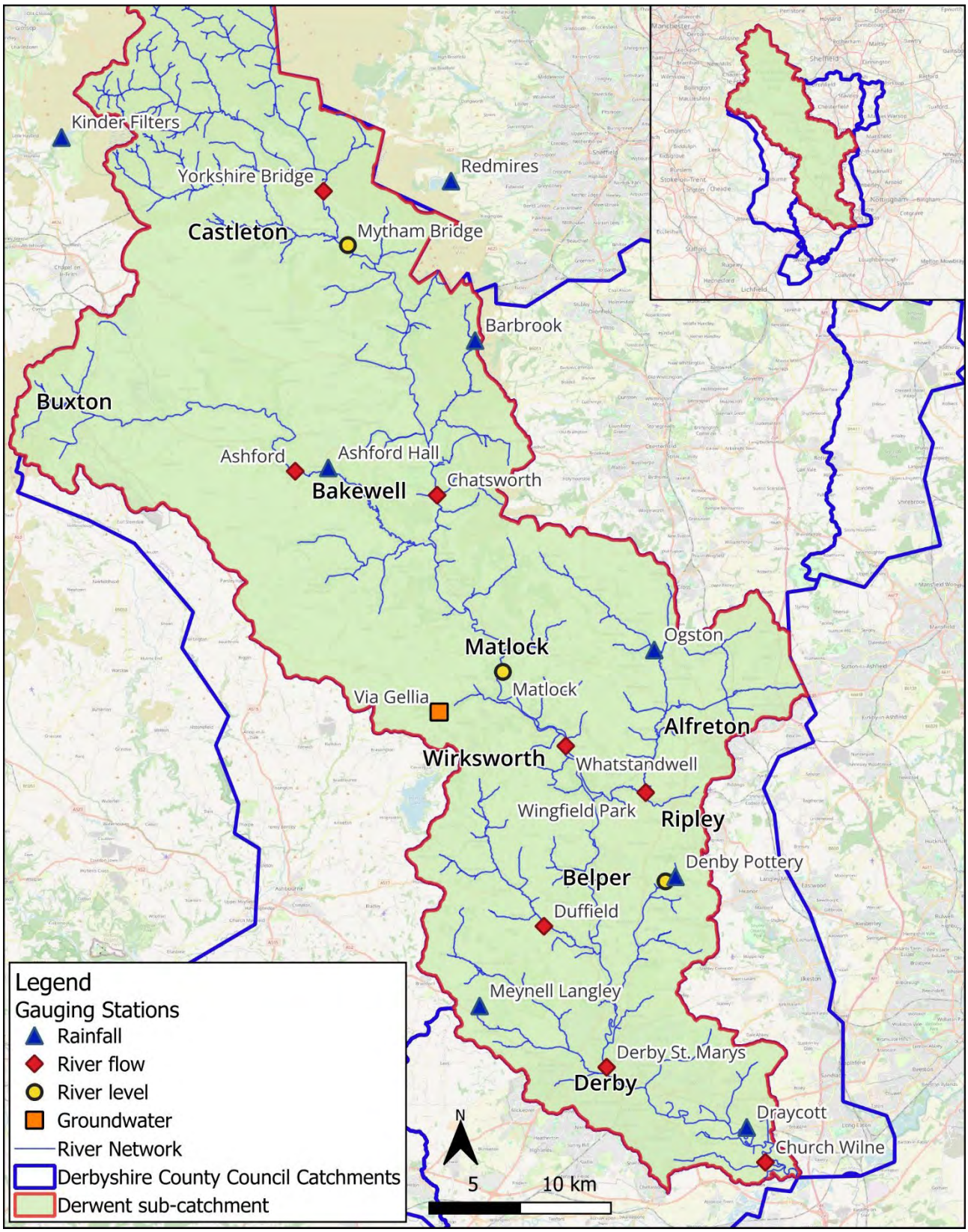

Figure 1-1: Derwent Derbyshire catchment extent and groundwater, rainfall, river flow and river level gauges

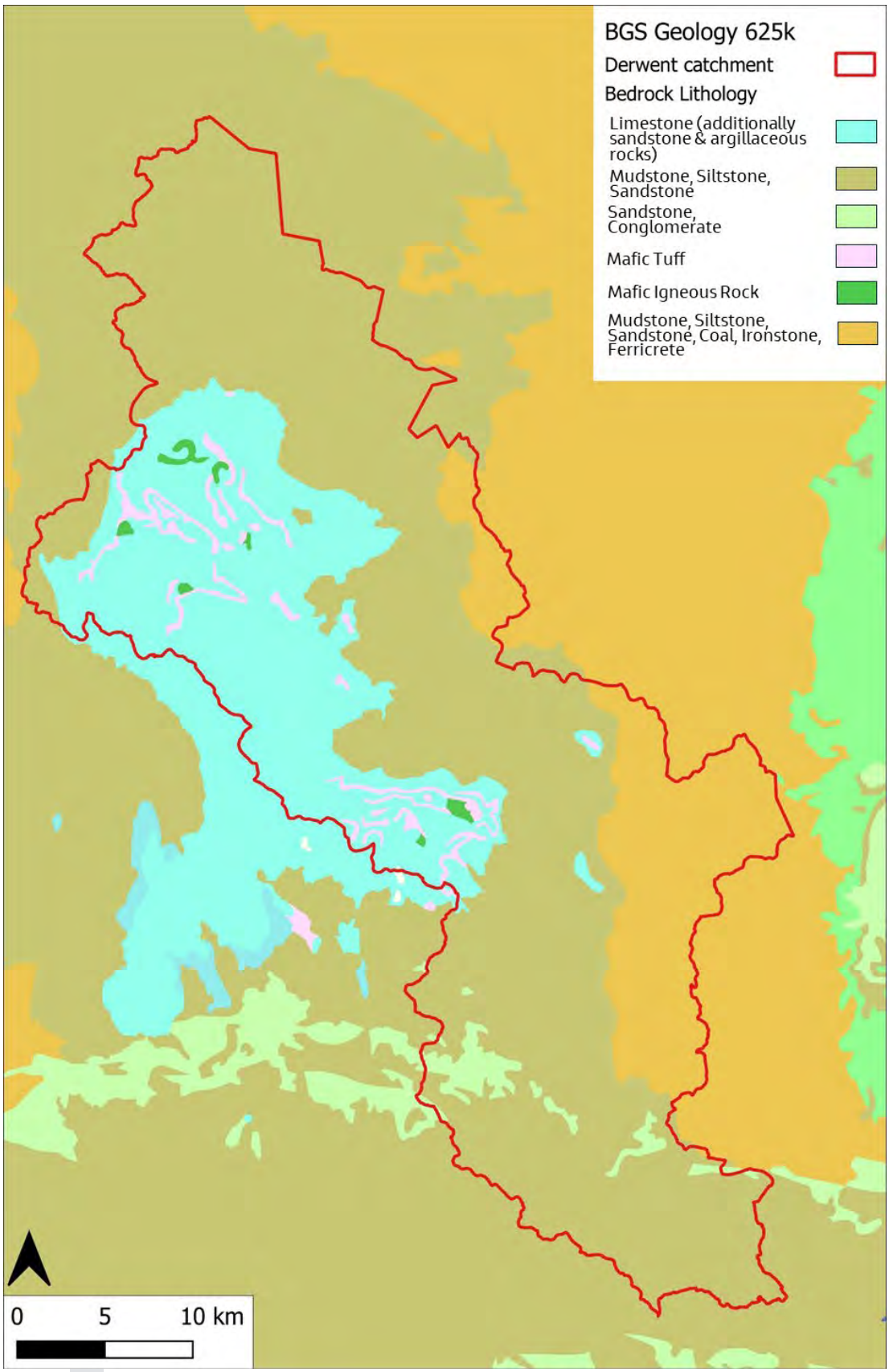

Figure 1-2: Bedrock lithology in Derwent catchment (based on British Geological Survey 1:625 000-scale geological map)

1.1.2 Rainfall Records

Eight Environment Agency rain gauges are within or near to the Derwent sub-catchment, as indicated in Figure 1-1. The rainfall recorded at these gauges is displayed in Figure 1-3 to Figure 1-10.

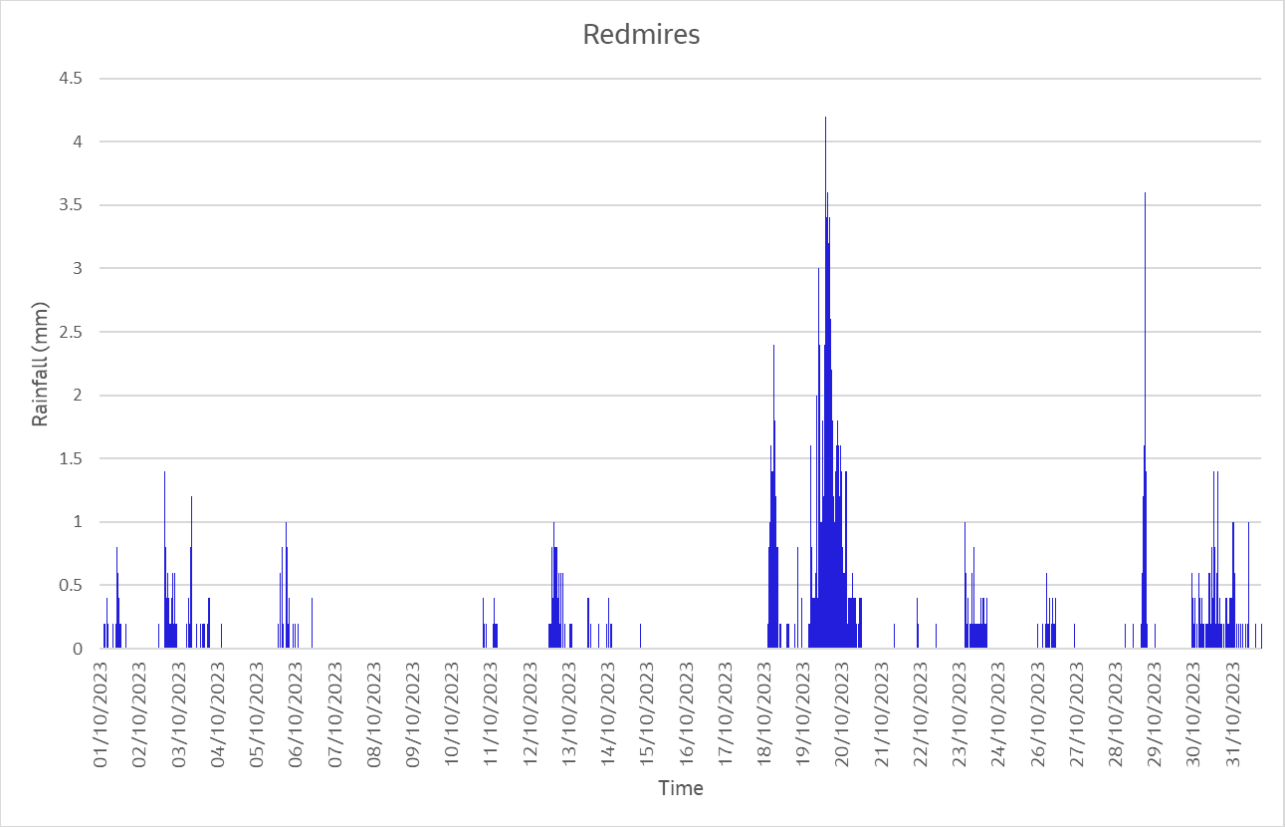

Figure 1-3: 15-minute rainfall data recorded in October 2023 at Redmires rain gauge

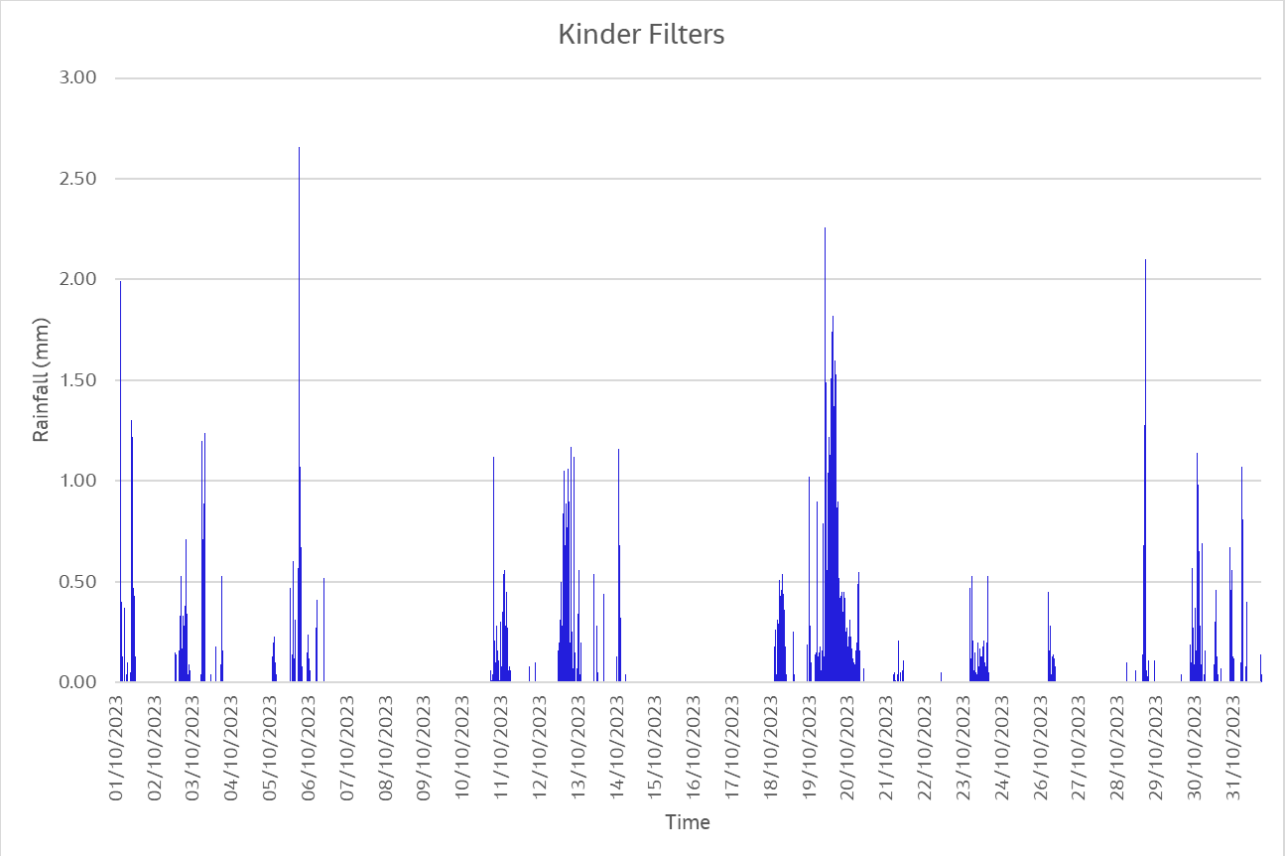

Figure 1-4: 15-minute rainfall data recorded in October 2023 at Kinder Filters rain gauge

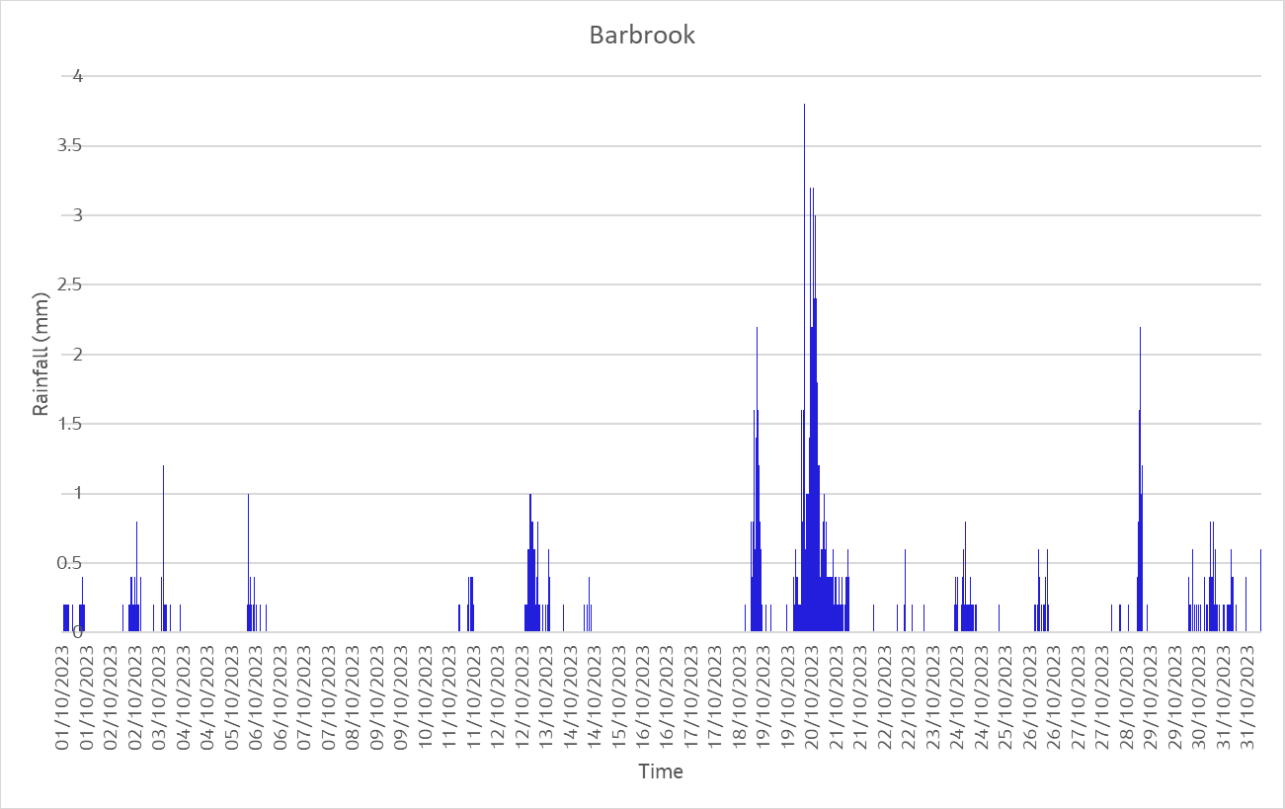

Figure 1-5: 15-minute rainfall data recorded in October 2023 at Barbrook rain gauge

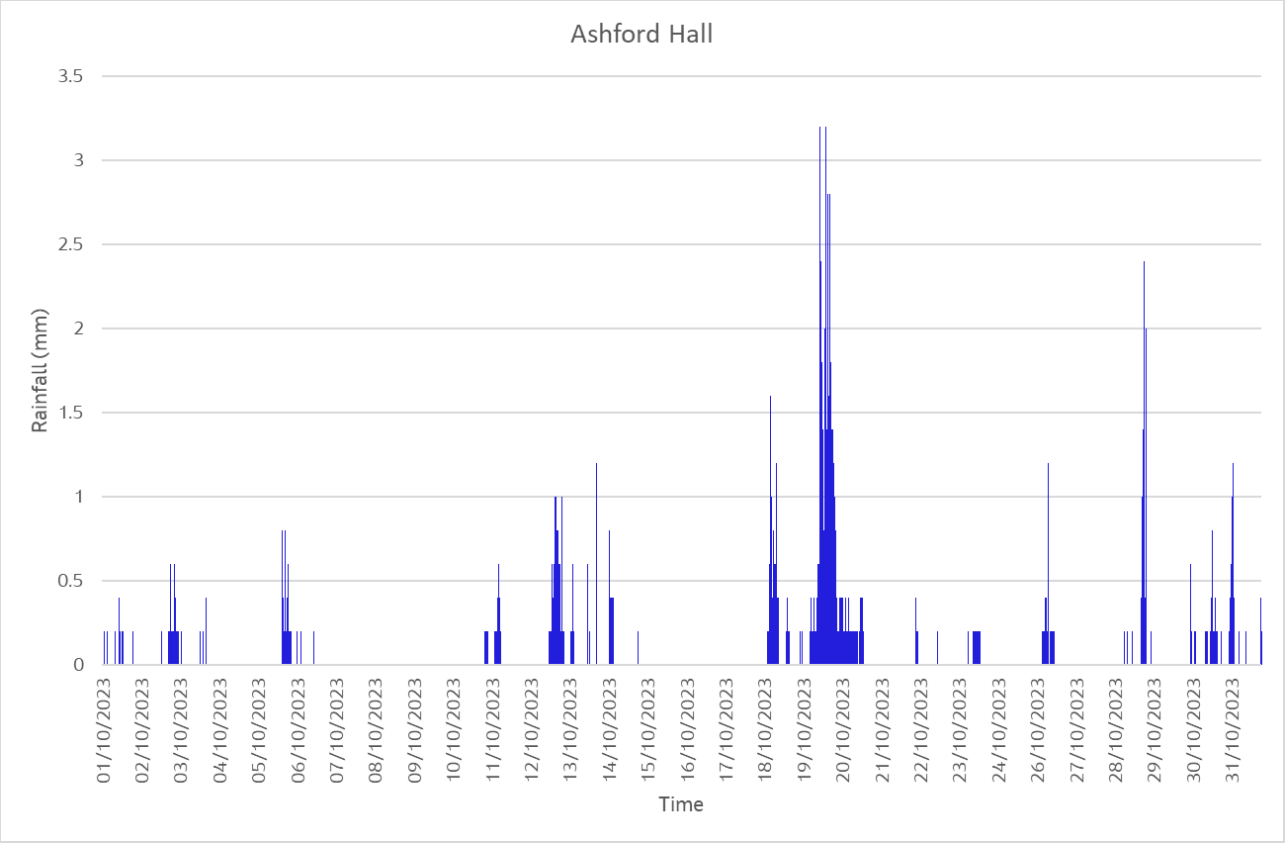

Figure 1-6: 15-minute rainfall data recorded in October 2023 at Ashford Hall rain gauge

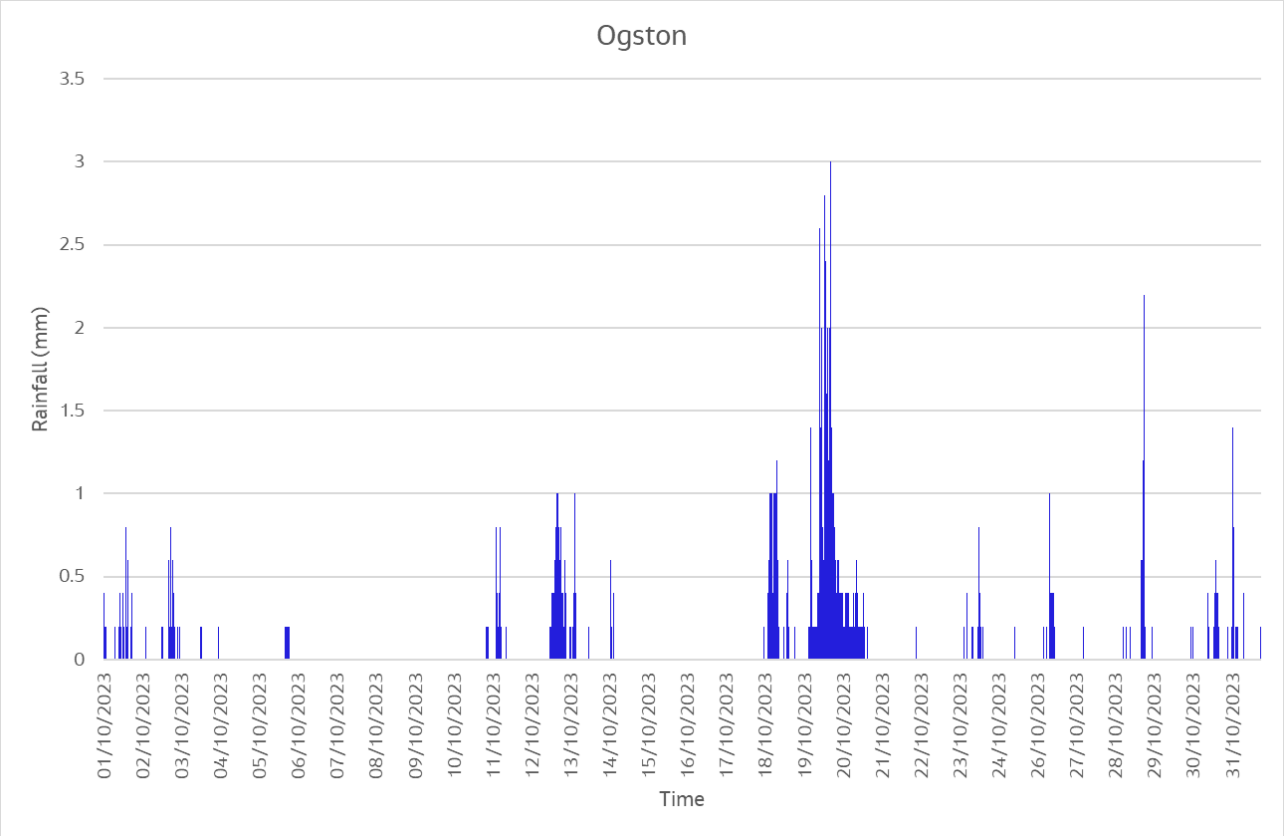

Figure 1-7: 15-minute rainfall data recorded in October 2023 at Ogston rain gauge

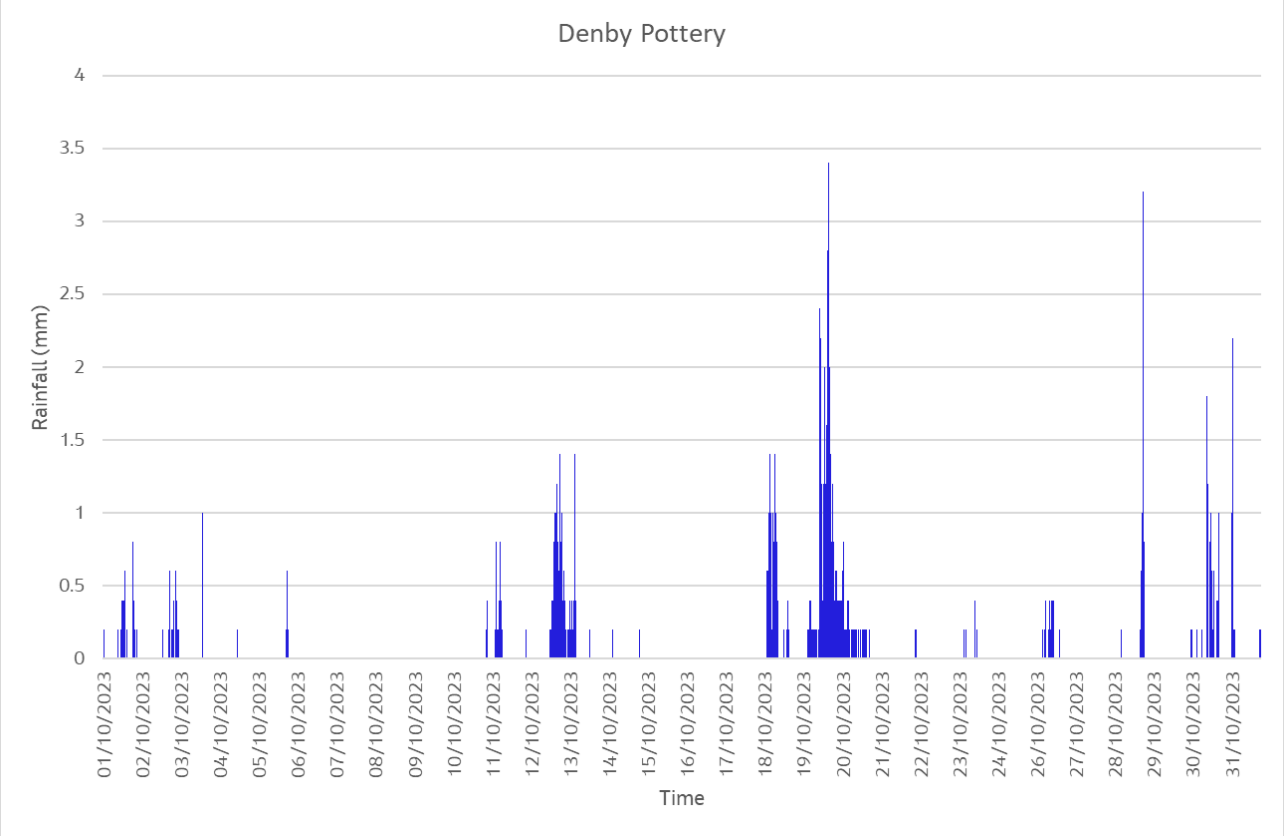

Figure 1-8: 15-minute rainfall data recorded in October 2023 at Denby Pottery rain gauge

Figure 1-9: 15-minute rainfall data recorded in October 2023 at Meynell Langley rain gauge

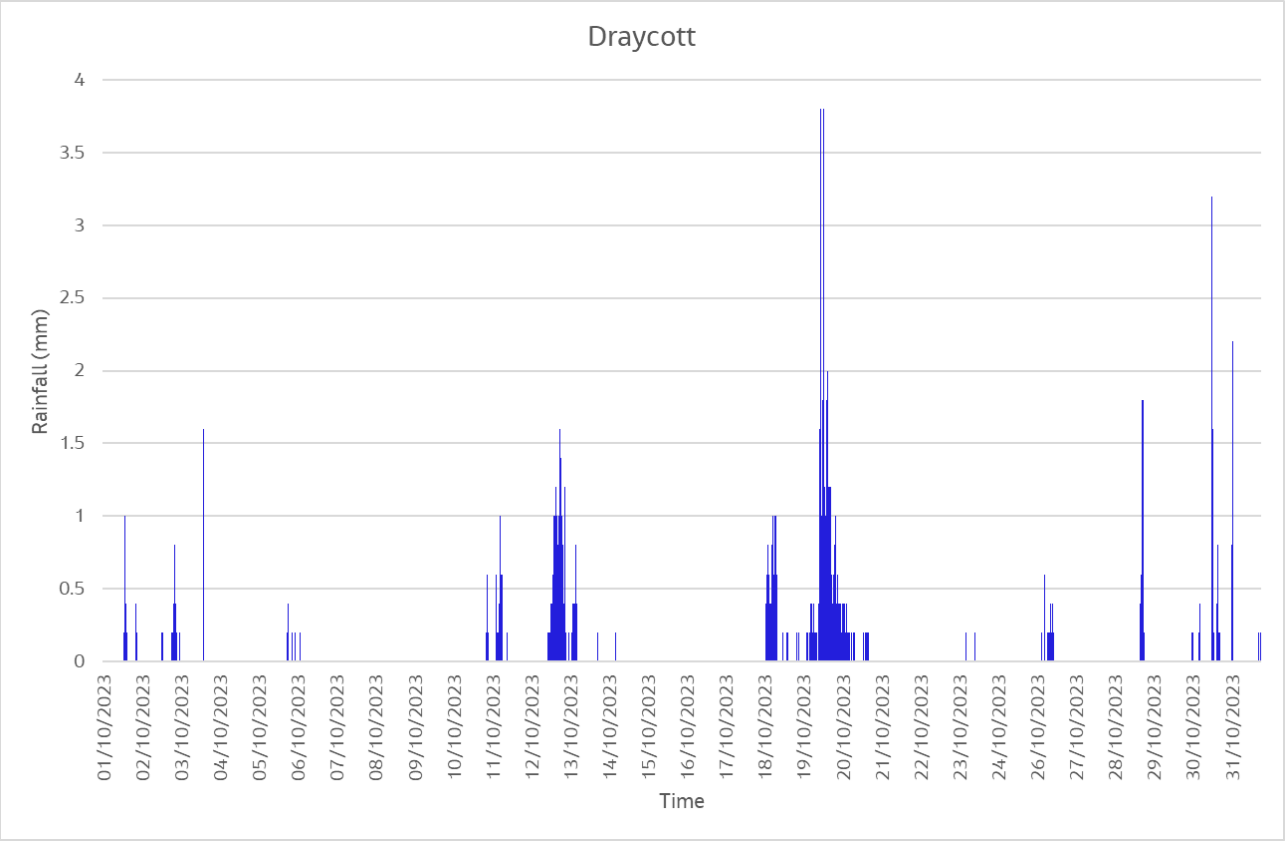

Figure 1-10: 15-minute rainfall data recorded in October 2023 at Draycott rain gauge

Figure 1-3 to Figure 1-10 indicate a prolonged heavy rainfall event from the 18th to the 21st of October. Table 1-1 shows rainfall recorded during Storm Babet at each rainfall gauge, the most intense storm episodes for rainfall recorded and associated Annual Exceedance Probability (AEPs). AEPs across the sub-catchment range from 25% at Kinder Filters station, to the north-west of the sub-catchment to 0.3% at Redmires to the north-east of the sub catchment.

The most intense episode of rainfall recorded at each station was from 9:00pm on the 19th of October to 4:30am on the 21st October. Between 54 and 127mm of rain fell during this period equating to 62-86% of the total rainfall from Storm Babet. This corresponds to an AEP of 17% at Kinder Filters and 0.5% at Redmires.

Table 1-1: Estimated Storm Babet AEPs: event totals and most intense rainfall period

Gauging Station	Rainfall total for Storm Babet (mm)	AEP (%)	Rainfall total recorded during peak of storm (mm)	Percentage of Storm Babet Rainfall (%)	AEP (%)
Redmires	169	0.3	127	75	0.5
Kinder Filters	73	25	62	85	17
Barbrook	125	1	78	63	5
Ashford Hall	102	3	79	77	4
Ogston	99	1	66	62	3
Denby Pottery	71	4	61	86	4
Meynell Langley	84	3	54	65	8
Draycott	81	2	60	74	5

Table 1-2 indicates 6-16% of annual average rainfall fell during Storm Babet. Rainfall totals for Storm Babet account for 65-148% of the long-term average (LTA) October rainfall total for Kinder Filters and Redmires stations respectively. Moreover, rainfall totals for Storm Babet exceeded LTA October rainfall totals by 25-48% for Ogston, Barbrook and Redmires stations. Generally, the highest and most extreme rainfall totals during Storm Babet were noted in the north-eastern part of the Derwent catchment.

Table 1-2: Total event rainfall for Storm Babet compared the long-term monthly average rainfall for October and annual average rainfall[1]

Gauging Station	Rainfall total for Storm Babet (mm)	Percentage of LTA October rainfall (%)	Percentage of annual average rainfall (%)
Redmires	169	148	16
Kinder Filters	73	65	6
Barbrook	125	131	13
Ashford Hall	102	106	11
Ogston	99	125	13
Denby Pottery	71	90	9
Meynell Langley	84	108	11
Draycott	81	114	13

1.1.3 River Gauge Records

Figure 1-1 illustrates there are eight Environment Agency river flow gauges and four river level gauges within the Derwent catchment. Yorkshire Bridge, Chatsworth, Whatstandwell, Mytham Bridge, Matlock, St. Mary's Bridge and Church Wilne gauges are located on the River Derwent in upper, middle, and lower reaches. Ashford flow gauge is located on the River Wye at Ashford in the Water (north-west Derbyshire). Wingfield Park flow gauge is located on the River Amber close to the confluence with River Derwent. Duffield flow gauge is located on the River Ecclesbourne in the downstream part of the Derwent catchment. Smithy Houses river level gauge is located on the Bottle Brook just upstream of Derby.

All flows and levels at Yorkshire Bridge, Chatsworth, Ashford, Wingfield Park, Duffield, St. Mary's Bridge, Matlock, Church Wilne and Mytham Bridge have been checked by the Environment Agency. It should be noted at Whatstandwell all flows are unchecked by the Environment Agency except from the 1st to the 3rd of October. Levels at Smithy Houses are unchecked by the Environment Agency.

Figure 1-11 to Figure 1-14 indicate a large increase in river flow or level from the 20th to the 21st of October.

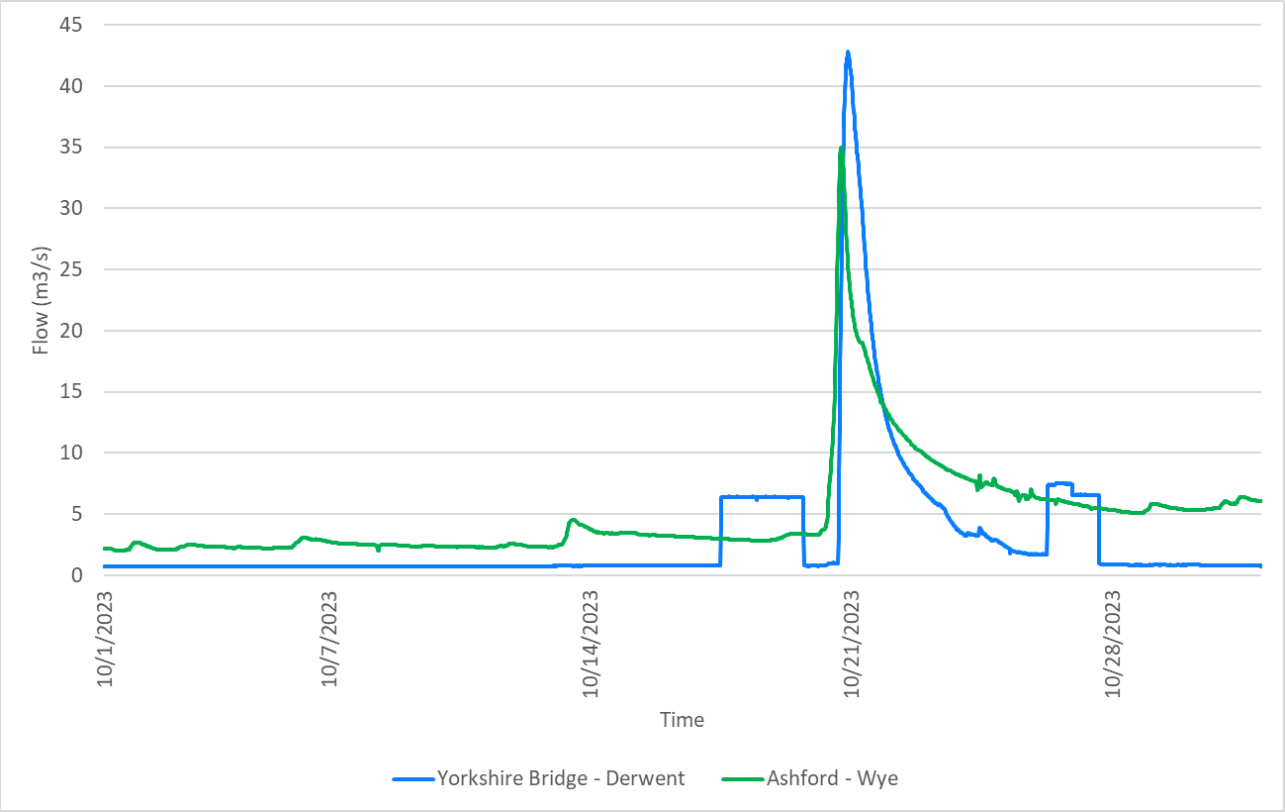

Figure 1-11: 15-minute flow data recorded in October 2023 from Yorkshire Bridge on the River Derwent and Ashford on the River Wye gauging stations. Drawdown from the reservoir, before the onset of Storm Babet, can be seen in the flows recorded at Yorkshire Bridge on the River Derwent

Figure 1-11 illustrates flows in the upstream part of the Derwent catchment. High flows were recorded at Derwent (Yorkshire Bridge) from 4:30pm on the 20th of October 2023 until 2:15pm on the 22nd of October 2023. A peak flow of 43 m3/s was recorded at 10:15pm on the 20th of October 2023 and it was not registered as extreme (29th highest flow recorded).

High flows were recorded on the River Wye (Ashford) from 10:45am on the 20th of October 2023 until 12:45am on the 24th of October 2023. A peak flow of 35m^3/s was recorded at 5:45pm on 20th of October 2023. This is the fourth highest flow recorded since 1964.

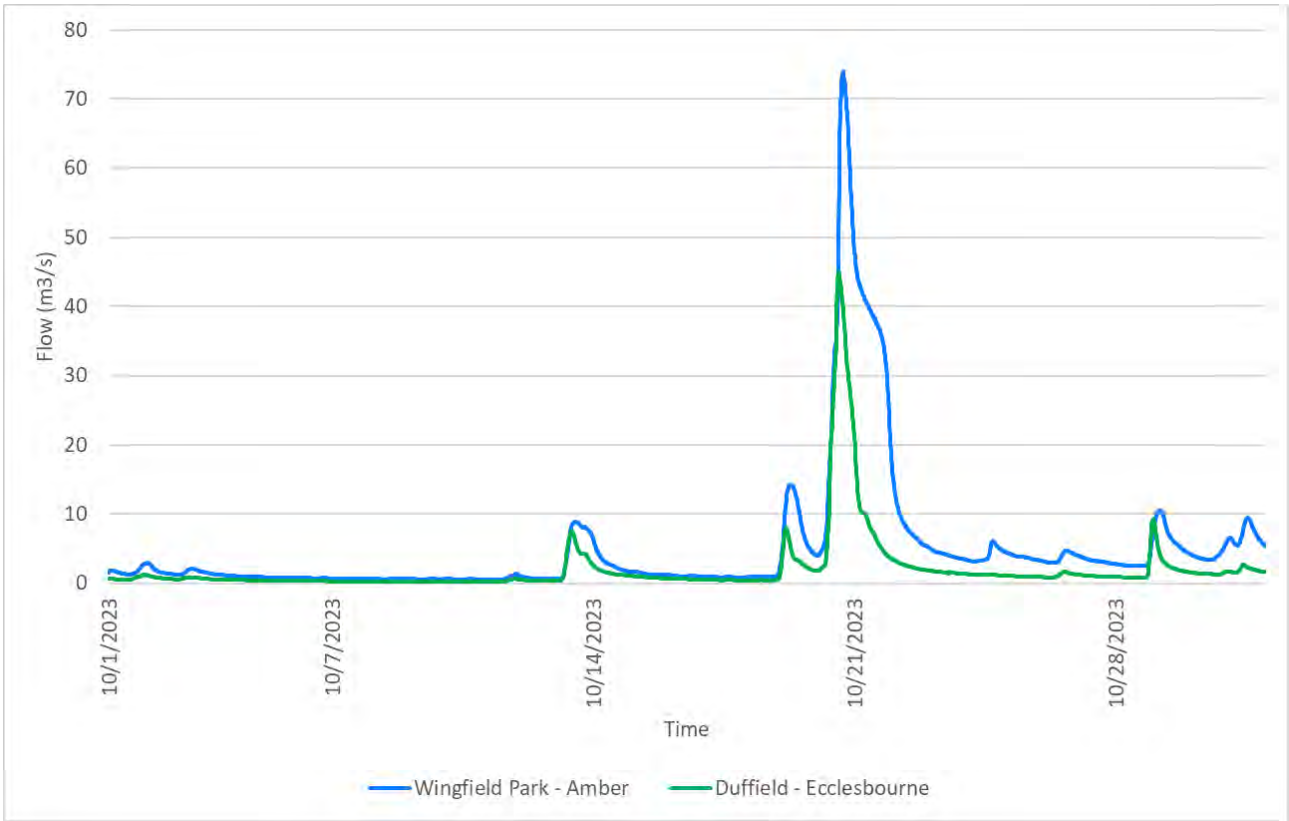

Figure 1-12: 15-minute flow data recorded in October 2023 from Duffield on the River Ecclesbourne and Wingfield Park on the River Amber gauging stations

Figure 1-12 illustrates flows at River Derwent tributaries in the central and downstream part of the catchment. High flows were recorded on the River Amber (Wingfield Park) from 4:45am on the 20th of October 2023 until 5:45pm on the 22nd of October 2023. A peak flow of 74m3/s was recorded at 4:30pm on the 20th of October 2023. This is the highest flow recorded since 1971.

High flows were recorded on the River Ecclesbourne (Duffield) from 7:15am on the 20th of October 2023 until 10:15am on the 21st of October 2023. A peak flow of 45m3/s was recorded at 1:30pm on the 20th of October 2023. This is the highest flow recorded since 1971.

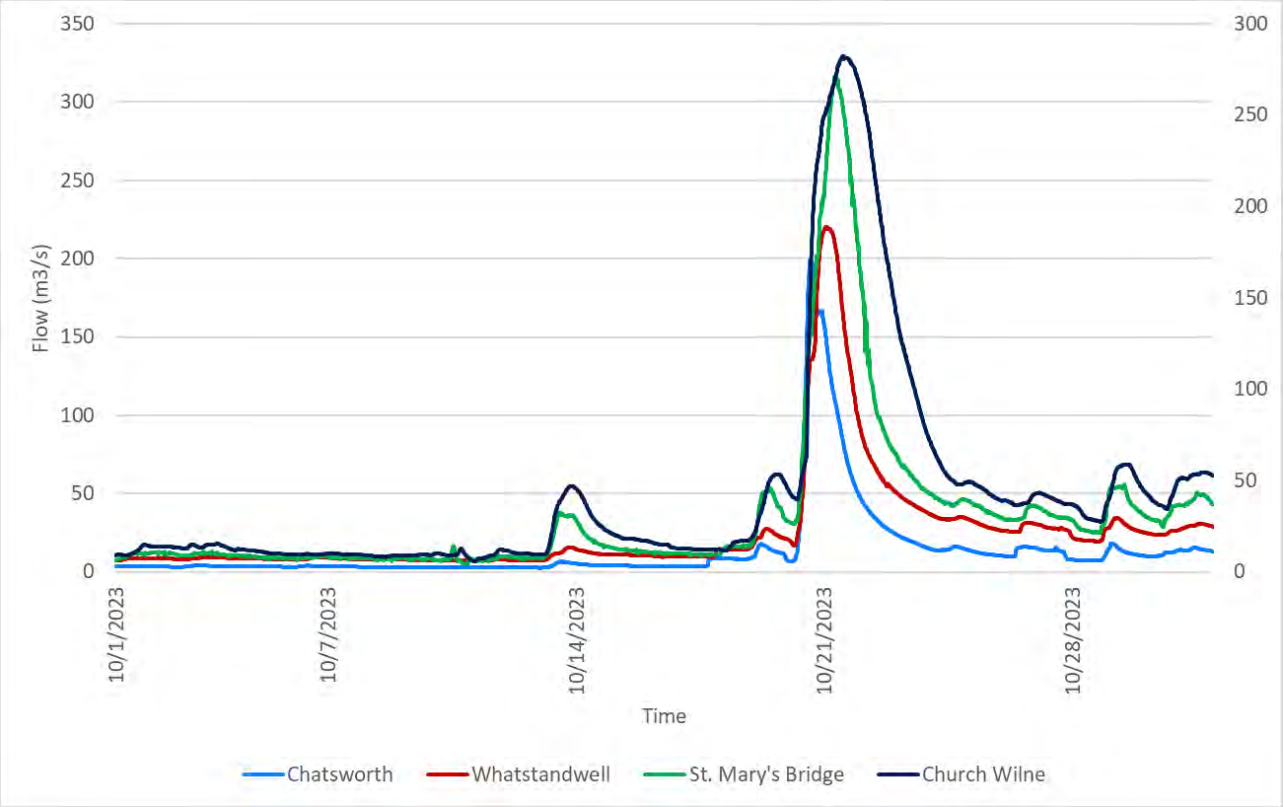

Figure 1-13: 15-minute flow data recorded in October 2023 from Chatsworth, Whatstandwell, St. Mary's Bridge and Church Wilne gauging stations on the River Derwent.

Figure 1-13 illustrates flows on the River Derwent in the central and downstream part of the catchment. High flows were recorded at Chatsworth from 7:15am on the 20th of October 2023 until 8:45am on the 23rd of October 2023. A peak flow of 200m3/s was recorded at 3:15pm on the 20th of October 2023. This is the third highest flow recorded since 1975. It is worth noting that peak flow recorded at the most upstream flow gauge on the River Derwent (Yorkshire Bridge, see Figure 1-11) occurred seven hours later than at Chatsworth.

High flows were recorded at Whatstandwell from 9:00am on the 20th of October 2023 until 7:45pm on the 23rd of October 2023. A peak flow of 220m3/s was recorded at 1:15am on the 21st of October 2023. This is the fourth highest flow recorded in the station's 32-year history. It should be noted gauge recordings of river flow were unchecked for the whole period of Storm Babet.

High flows were recorded at St. Mary's Bridge from 8:30am on the 20th of October 2023 until 11:00pm on the 23rd of October 2023. A peak flow of 316m3/s was recorded at 7:15am on the 21st of October 2023. This is the highest flow recorded since 1935. The previous record (304m3/s) was from the 8th of November 2019. Peak flow travel time between Chatsworth and Derby St. Mary's at River Derwent was 16 hours during Storm Babet.

High flows were recorded at Church Wilne from 6:15am on the 20th of October 2023 until 10:30am on the 24th of October 2023. A peak flow of 282 m3/s was recorded at 12:45pm on the 21st of October 2023. This is the highest flow recorded in the station's 51-year history. Travel time of peak flow between Derby St. Mary's and Church Wilne on the River Derwent was 5.5 hours during Storm Babet.

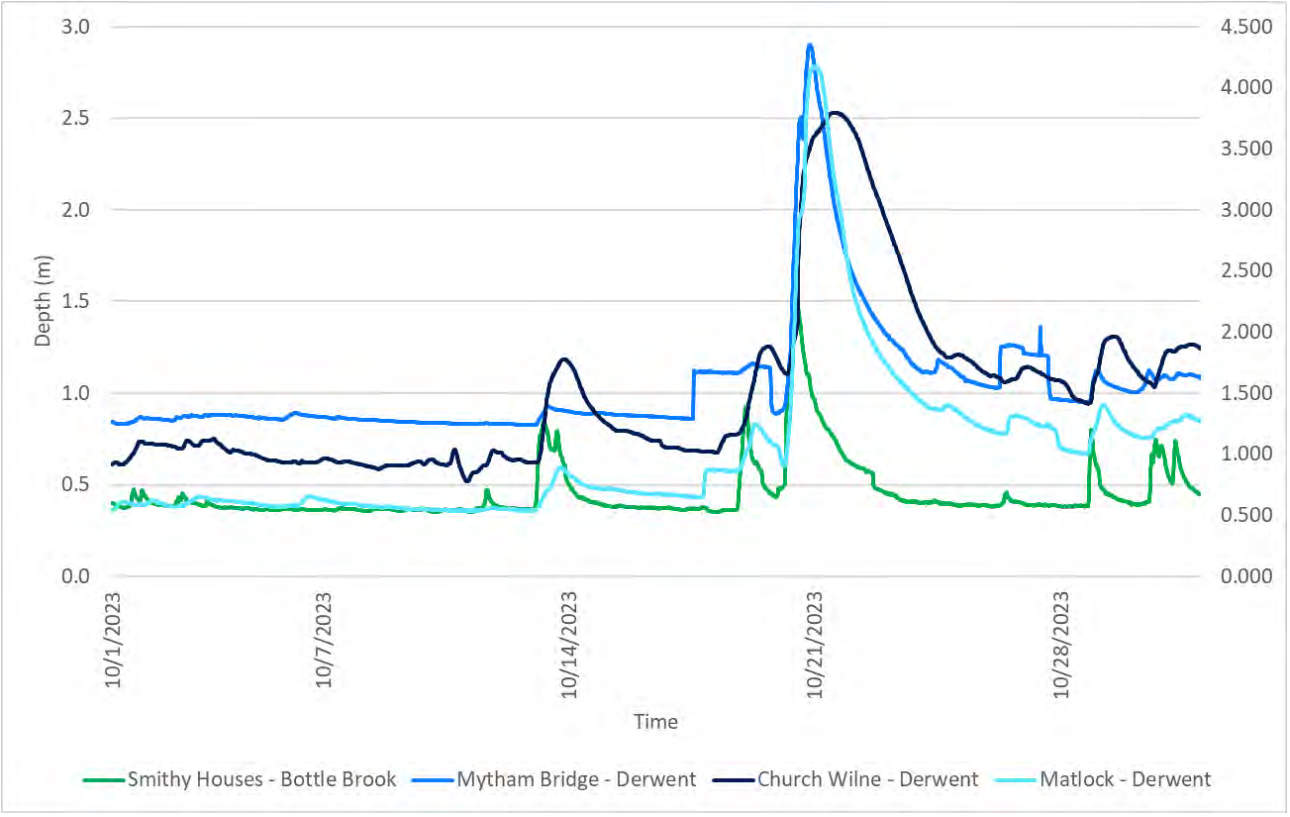

Figure 1-14: 15-minute river level data recorded in October 2023 from Mytham Bridge, Matlock and Church Wilne gauging stations on the River Derwent and Smithy Houses gauging station on the Bottle Brook.

Figure 1-14 illustrates river levels on the upstream (Mytham Bridge), middle (Matlock) and downstream (Church Wilne) reaches of the River Derwent and at Bottle Brook, a downstream tributary of the River Derwent (Smithy Houses).

High levels were recorded in the upstream reaches of the River Derwent at Mytham Bridge gauging station from 8:45am on the 20th of October 2023 until 6:00pm on the 22nd of October 2023. This is the 16th highest level recorded in the station's 51-year history. A peak level of 2.9m was recorded at 9:00pm on the 20th of October 2023, which is similar to the time of peak flow at nearby Yorkshire Bridge (Figure 1-11).

High levels were recorded in the middle reaches of the River Derwent at Matlock gauging station from 3:45am on the 20th of October 2023 until 7:15pm on the 22nd of October 2023. A peak level of 4.2m was recorded at 11:30pm on the 20th of October 2023, which is similar to the time of peak flow at Yorkshire Bridge and Mytham Bridge. This is the 8th highest level recorded in the station's 66-year history.

High levels were recorded in the downstream reaches of the River Derwent at Church Wilne gauging station from 9:30am on the 20th of October 2023 until 12:30pm on the 24th of October 2023. A peak level of 2.5m was recorded at 12:45pm on the 21st of October 2023, which is nearly 16 hours later than the time of peak flow at Mytham Bridge and 13.25 hours later than the time of peak flow at Matlock. This is the highest level recorded in the station's 51-year history.

High levels were recorded on the Bottle Brook at Smithy Houses gauging station from 5:15am on the 20th of October 2023 until 10:15am on the 21st of October 2023. A peak level of 1.5m was recorded at 12:15pm on the 20th of October 2023. This is the highest level recorded in the stations 20-year history. The timing of peak level was consistent with the timing of peak flow on the River Ecclesbourne at Duffield, another downstream tributary to the River Derwent. It should be noted river level recordings on the Bottle Brook were not checked by Environment Agency for the duration of Storm Babet.

Overall, river flows align with the Environment Agency's monthly water situation report for October 2023, which found all river flow monitoring sites recorded above normal river flows across the Midlands. Table 1-3

summarises peak river flows, timing of peak flow, ranking at of peak flow at each station and the length of the station's record indicating Storm Babet recorded the highest river flows and levels at each station.

A shorter, flashier response to Storm Babet was recorded on downstream tributaries of the River Derwent, on the River Ecclesbourne and Bottle Brook. The first station to peak was Smithy Houses on the Bottle Brook. The latest station to peak was St. Mary's Bridge on the River Derwent. This station is located furthest downstream on the River Derwent. The later peak is reflective of multiple tributaries to the River Derwent. The most upstream part of the Derwent catchment (Yorkshire Bridge, Mytham Bridge) was less affected by Storm Babet, as peak flow and level rankings are 29th and 16th respectively.

Table 1-3: Peak flow, peak level, timing and ranking of each peak and station data record length recorded at each station within the Derwent sub-catchment.

Station	Peak Flow (m3/s)	Date and Time	Peak Flow Ranking	Station record length (years)
Yorkshire Bridge (Derwent)	43	20/10/2023 10:15pm	29	52
Chatsworth (Derwent)	200	20/10/2023 3:15pm	3	49
Whatstandwell (Derwent)	220	21/10/2023 1:15am	4	32
Derby St. Mary's (Derwent)	316	21/10/2023 7:15am	1	89
Church Wilne (Derwent)	282	21/10/2023 12:45pm	1	51
Ashford (Wye)	35	20/10/2023 5:45pm	4	60
Wingfield Park (Amber)	74	20/10/2023 4:30pm	1	53
Duffield (Ecclesbourne)	45	20/10/2023 1:30pm	1	53
Station	**Peak Level (m)**	**Date and Time**	**Peak Flow Ranking**	**Station record length (years)**
Mytham Bridge (Derwent)	2.9	20/10/2023 9:00pm	16	51
Matlock (Derwent)	4.2	20/10/2023 11:30pm	8	66
Church Wilne (Derwent)	2.5	21/10/2023 12:45pm	1	51
Smithy Houses (Bottle Brook)	1.5	20/10/2023 12:15pm	1	20

Figure 1-15 to Figure 1-19 summarise the recorded rainfall and river response to Storm Babet from gauges across the sub -catchment.

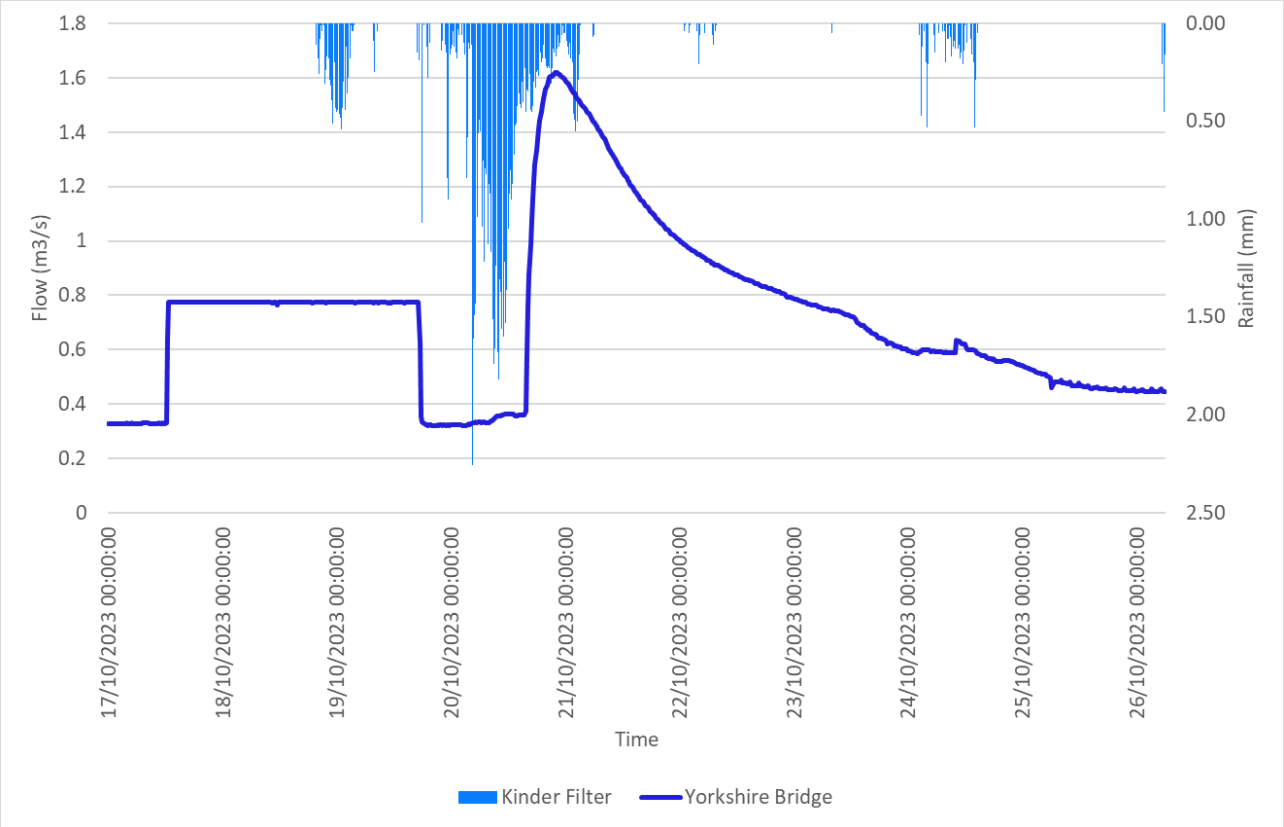

Figure 1-15: Hydrograph from the 17th to the 26th of October illustrating recorded river flow data from Yorkshire Bridge gauging station and recorded rainfall data from Kinder Filter rain gauge.

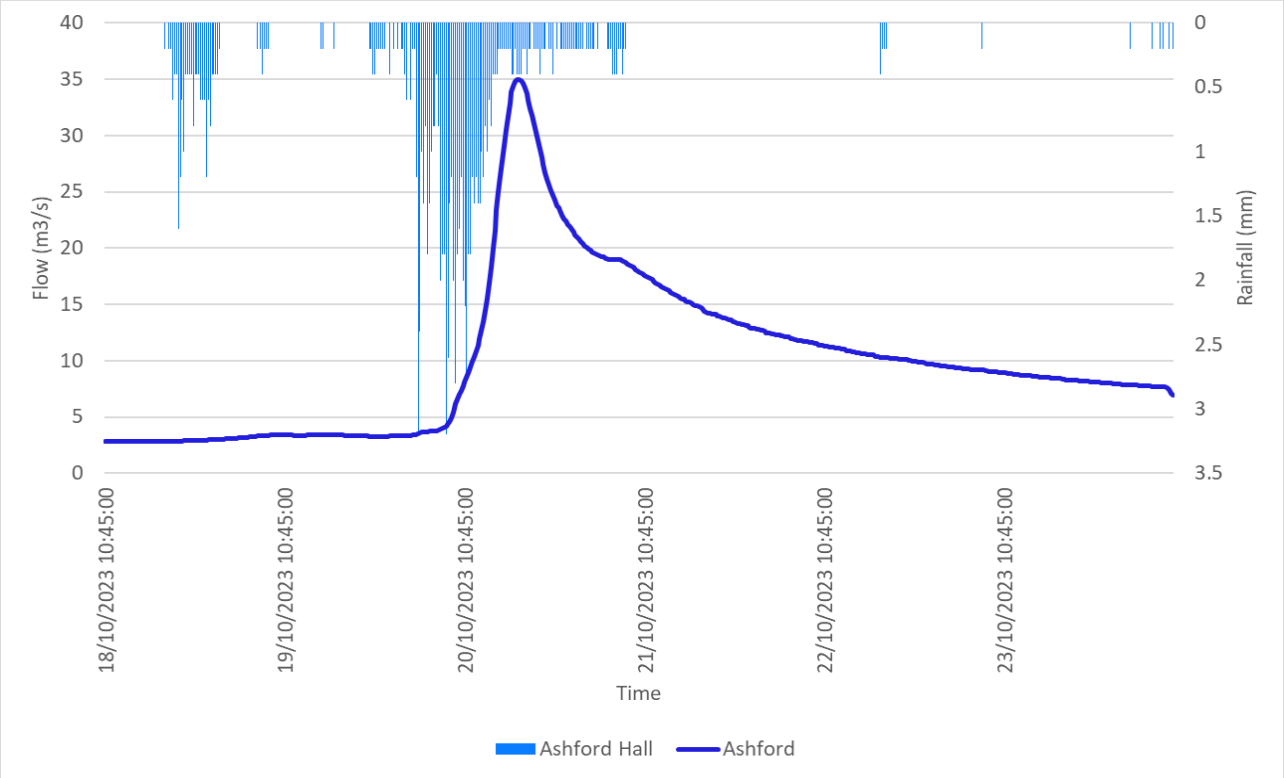

Figure 1-16: Hydrograph from the 18th to the 23rd of October illustrating recorded river flow data from Ashford gauging station and recorded rainfall data from Ashford Hall rain gauge

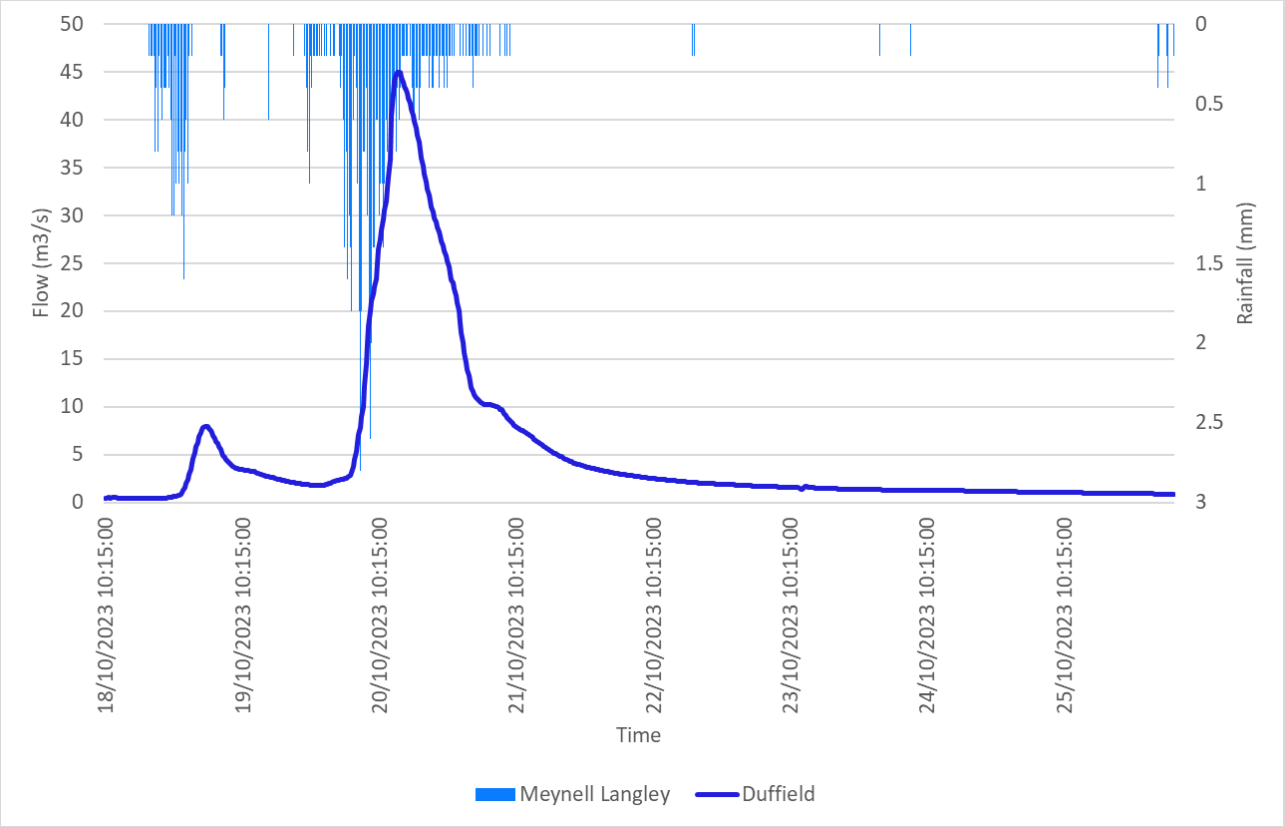

Figure 1-17: Hydrograph from the 18th to the 25th of October illustrating recorded river flow data from Duffield gauging station and recorded rainfall data from Meynell Langley rain gauge

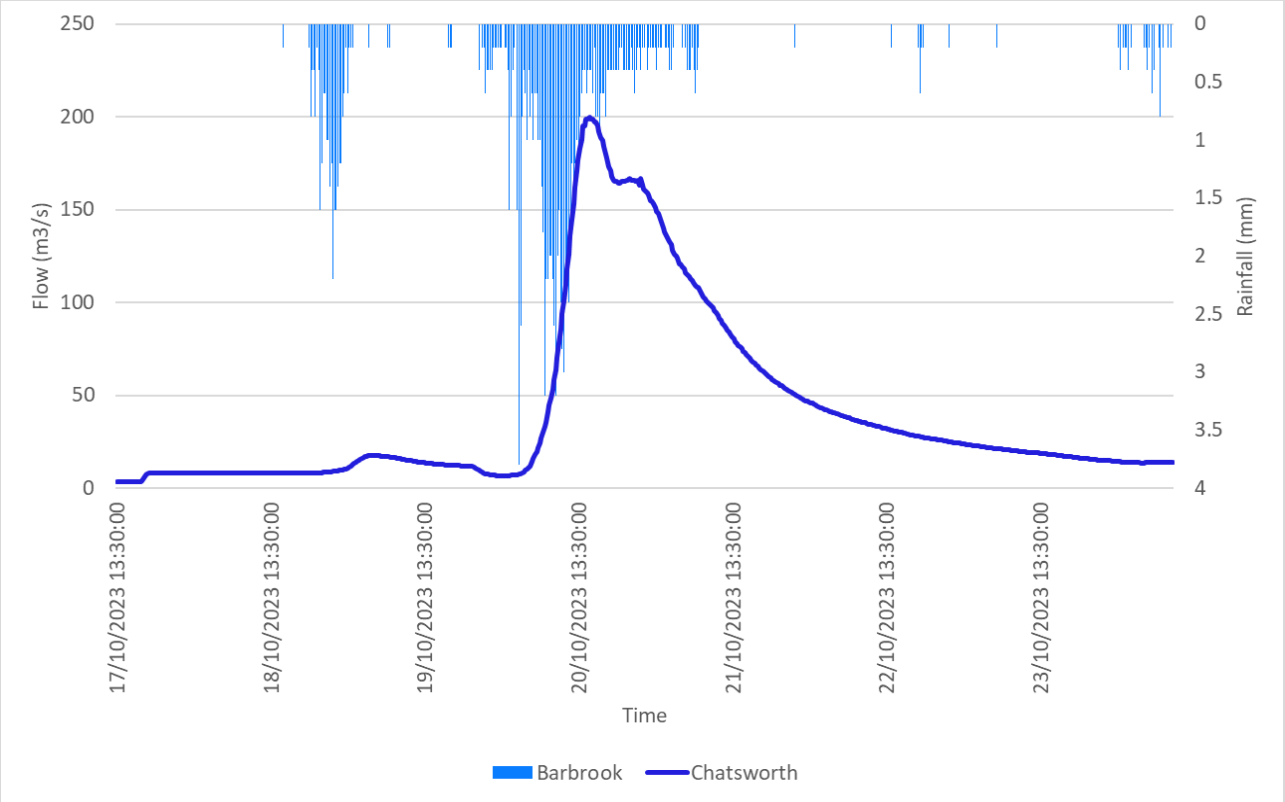

Figure 1-18: Hydrograph from the 17th to the 23rd of October illustrating recorded river flow data from Chatsworth gauging station and recorded rainfall data from Barbrook rain gauge

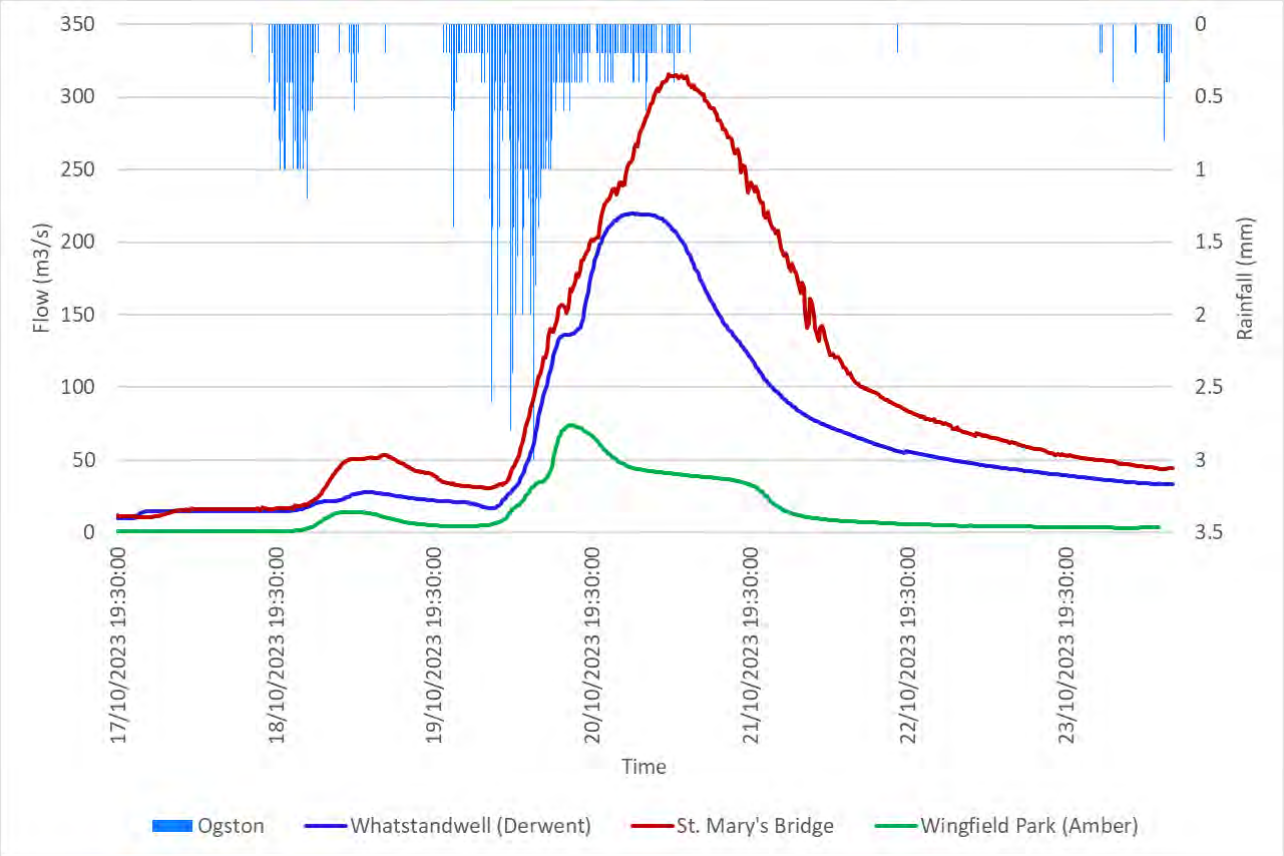

Figure 1-19: Hydrograph from the 17th to the 23rd of October illustrating recorded river flow data from Whatstandwell, St. Mary's Bridge and Wingfield Park gauging stations and recorded rainfall data from Ogston rain gauge

1.1.4 Groundwater Records

Figure 1-20 shows that only Via Gellia Environment Agency groundwater station is within the Derwent sub-catchment. Hourly groundwater level data from October 2018 to March 2024 is provided in Figure 1-20. The bedrock at this station is limestone. All data until the 2nd of January 2024 has been checked by the Environment Agency.

As one groundwater station is located within this sub-catchment, it is important to recognise results discussed in this section may not be representative of the whole sub-catchment.

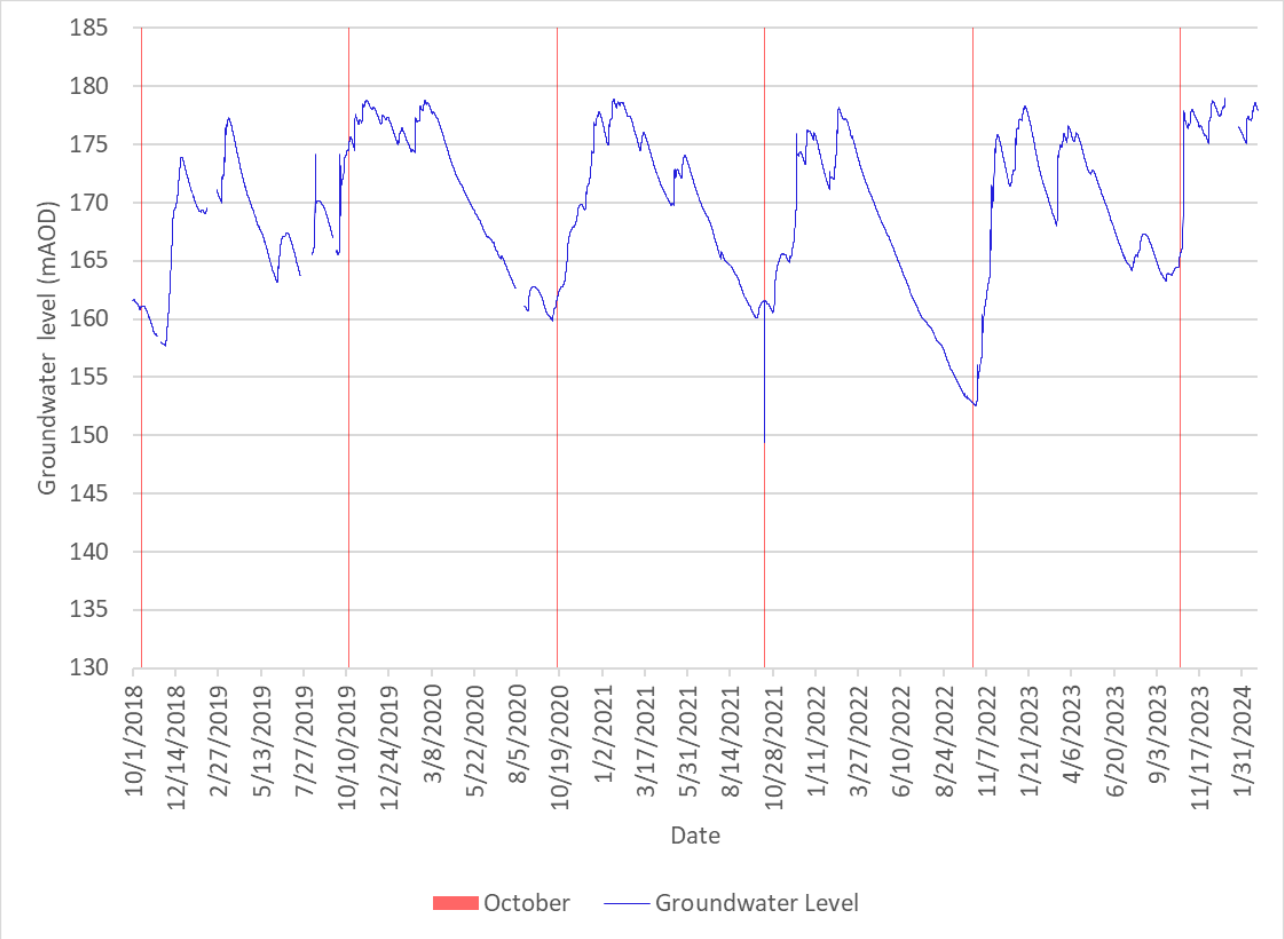

Figure 1-20: Via Gellia hourly groundwater levels from October 2018 to March 2024. The red line indicates October

Figure 1-20 indicates groundwater levels recorded in October 2023 are higher than levels recorded in the month of October over the preceding 5 years. A rapid increase in groundwater levels is evident in October 2023 in response to Storm Babet. Groundwater level achieved by the end of October 2023 was not reached until later months in the preceding years. Groundwater remains high from October 2023 to March 2024, which is a contrasting pattern to the rise in groundwater level experienced from October to March in 2018, 2020, 2021 and 2022. Groundwater levels likely remained constant due to natural recharge, which is evidenced in previous years after October by the rise in groundwater levels.

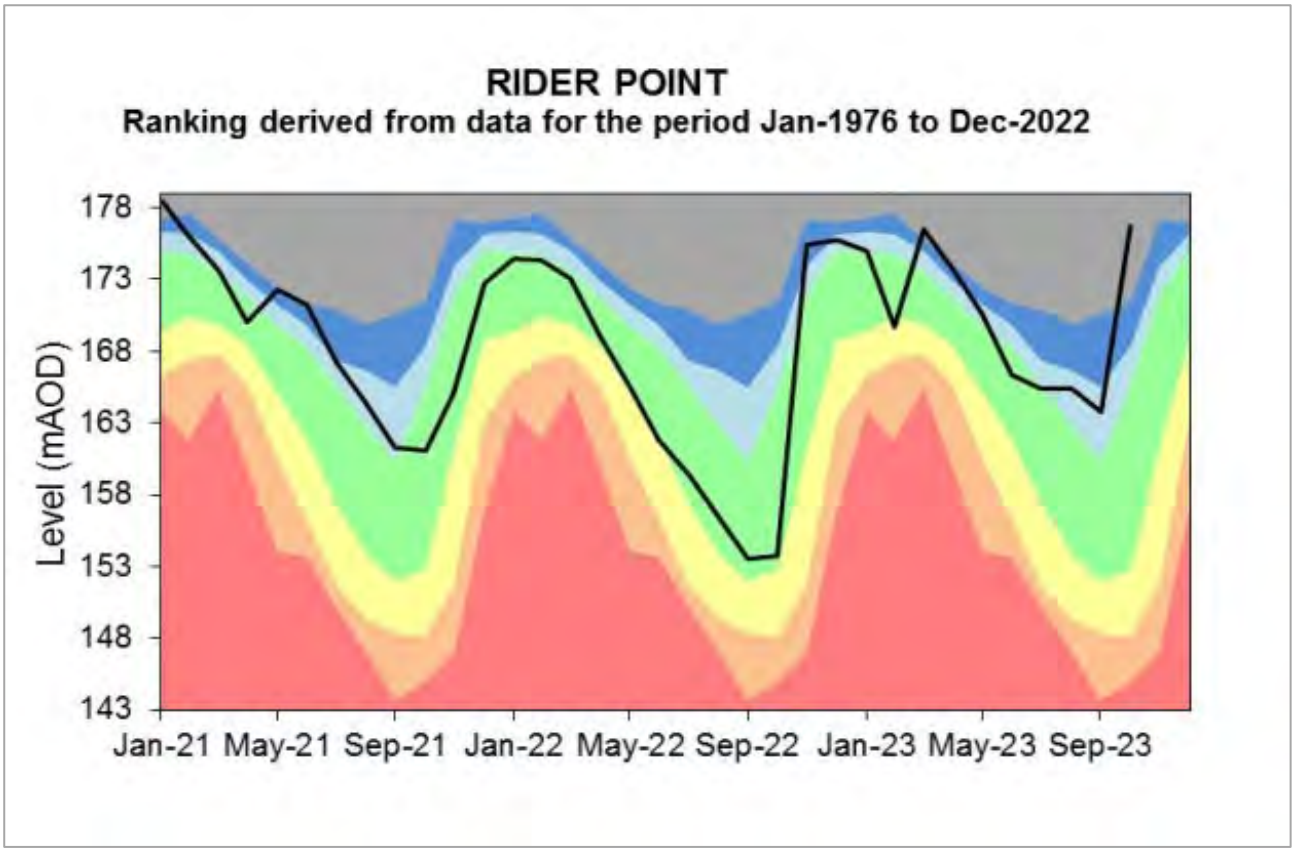

Figure 1-21: End of month groundwater levels at Via Gellia (here signed as Ryder Point) groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023

Figure 1-21 indicates groundwater levels at the end of October were exceptionally high compared to the LTA. This suggests at Via Gellia (Ryder Point) groundwater levels were raised considerably by Storm Babet.

1.1.5 Hydrological Summary

Overall, heavier and more extreme rainfall was recorded in the northeastern part of the Derwent sub-catchment over Stoney Middleton, Baslow and Thornhill. Rainfall peaked early on the 20th of October from 4:15am to 10:00am. Total rainfall recorded equated to 0.3-4% AEP events at all stations except Kinder Filters, located to the north-west, outside the Derwent sub-catchment (25% AEP).

Rapid responses to heavy rainfall were recorded in the downstream tributaries of the River Derwent, near the towns of Duffield and Rawson Green. The shortest lag time between peak rainfall and peak flow was recorded at Duffield on the River Ecclesbourne (7 hours) while the longest was recorded at St. Mary's Bridge (27 hours). This pattern corresponds with the duration of high flow recorded at each station.

St. Mary's Bridge on the River Derwent, and gauging stations on the River Ecclesbourne, River Amber and Bottle Brook produced the highest ranked flows or levels on record in response to Storm Babet. These stations are located in Derby, Rawson Green and Lower Hartshay. Peak river flows and levels in the upstream regions of the River Derwent (Yorkshire Bridge, Mytham Bridge) did not record high ranking flows. This is due to drawdown of Ladybower Reservoir, creating flood storage capacity before Storm Babet. High groundwater levels compared to the last five years were recorded at Via Gellia groundwater station for this time of year.

2. Don and Rother Management Catchment

2.1 Don and Rother Catchment Event Hydrology

2.1.1 Catchment Characteristics

The Don and Rother sub-catchment is located in the north-east of Derbyshire, south of Sheffield, encompassing Chesterfield down to Clay Cross. The River Rother headwaters are near Clay Cross, to the south of the sub-catchment. The river passes northwards through North Wingfield and Wingerworth before flowing through the centre of Chesterfield. The river then flows north of Staveley and up to Killamarsh. This is the total extent of the River Rother within Derbyshire, although it continues further north to its confluence with the River Don in Rotherham. The main tributaries include the River Doe Lea on the right bank, and River Hipper, River Drone and River Whitting on the left bank.

The sub-catchment referred to in this report has an area of 300km2. Figure 2-1 indicates the sub-catchment extent in respect of the Derbyshire area, in addition to the location of the groundwater, rainfall, river flow and level gauges within the sub-catchment.

Waterbodies within the sub-catchment include Linacre Reservoir, Crowhole Reservoir, Renishaw Lake, Pools Brook and Walton Dam.

The bedrock geology consists mostly of Triassic and Carboniferous mudstones, siltstones and sandstones (Figure 2-2). Sections of harder sandstone are located near Wingerworth. Most of the soil covering the sub-catchment is seasonally wet, loamy and clayey with impeded drainage to the stream network. There are sections of free draining loamy and sandy soils draining to groundwater near Chesterfield.

Key catchment descriptors for the river catchments of the Rother at Whittington and Woodhouse Mill, Whitting at Sheepbridge and Doe Lea at Staveley were examined to allow a comparison of each watercourses response to heavy rainfall within the sub-catchment[1]. Baseflow is similar across the whole catchment. There are few lakes and reservoirs that would cause attenuation of flows in the catchment. The catchment is relatively rural in the north and west, with more urbanised areas being concentrated at the centre of the catchment toward the River Rother and along the A61 from Clay Cross to Chesterfield. Average annual rainfall received is also similar across the sub-catchment, with higher average rainfall being at Whittington and Sheepbridge at the centre of the sub-catchment.

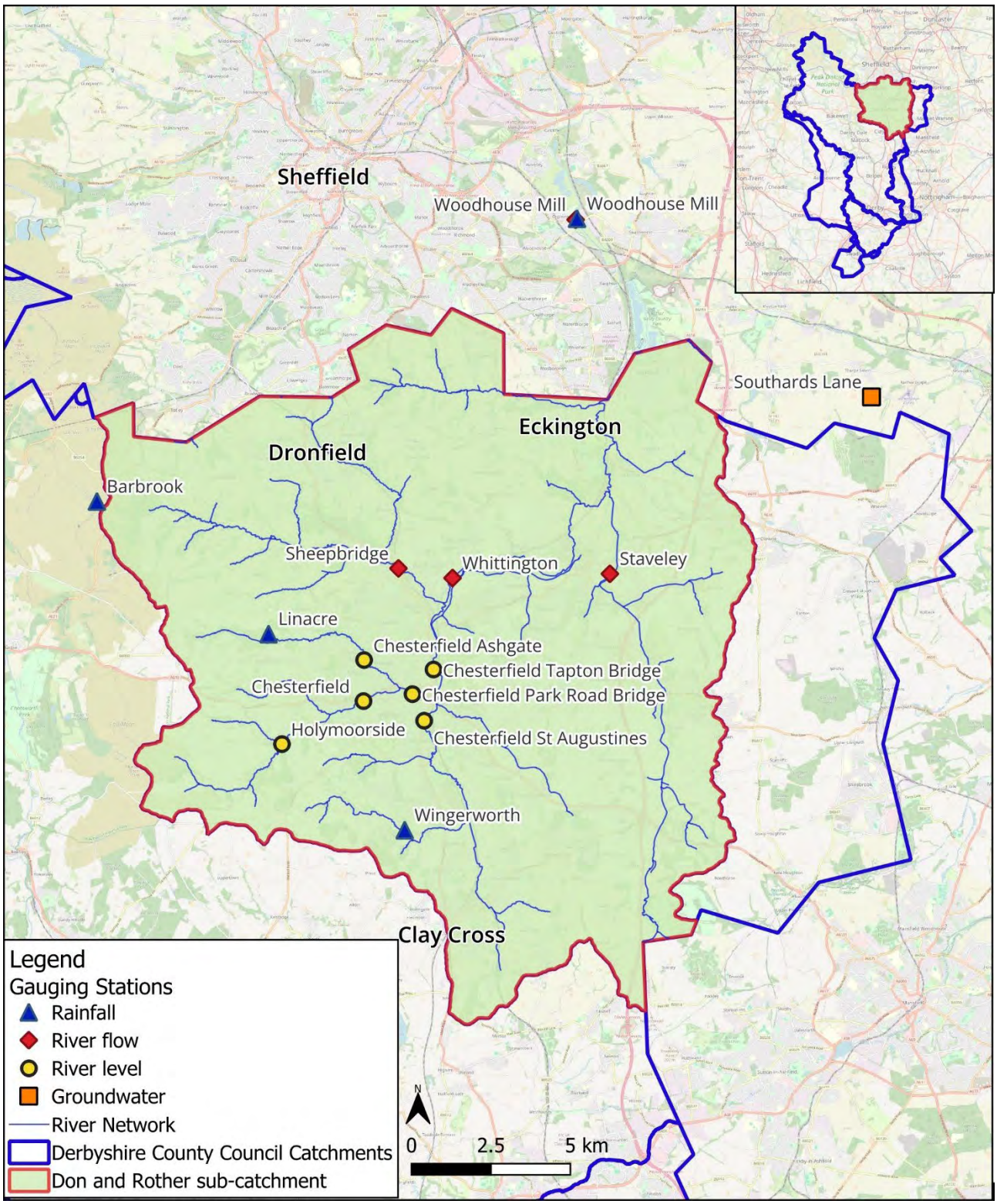

Figure 2-1 Catchment extent and groundwater, rainfall, river flow and river level gauges

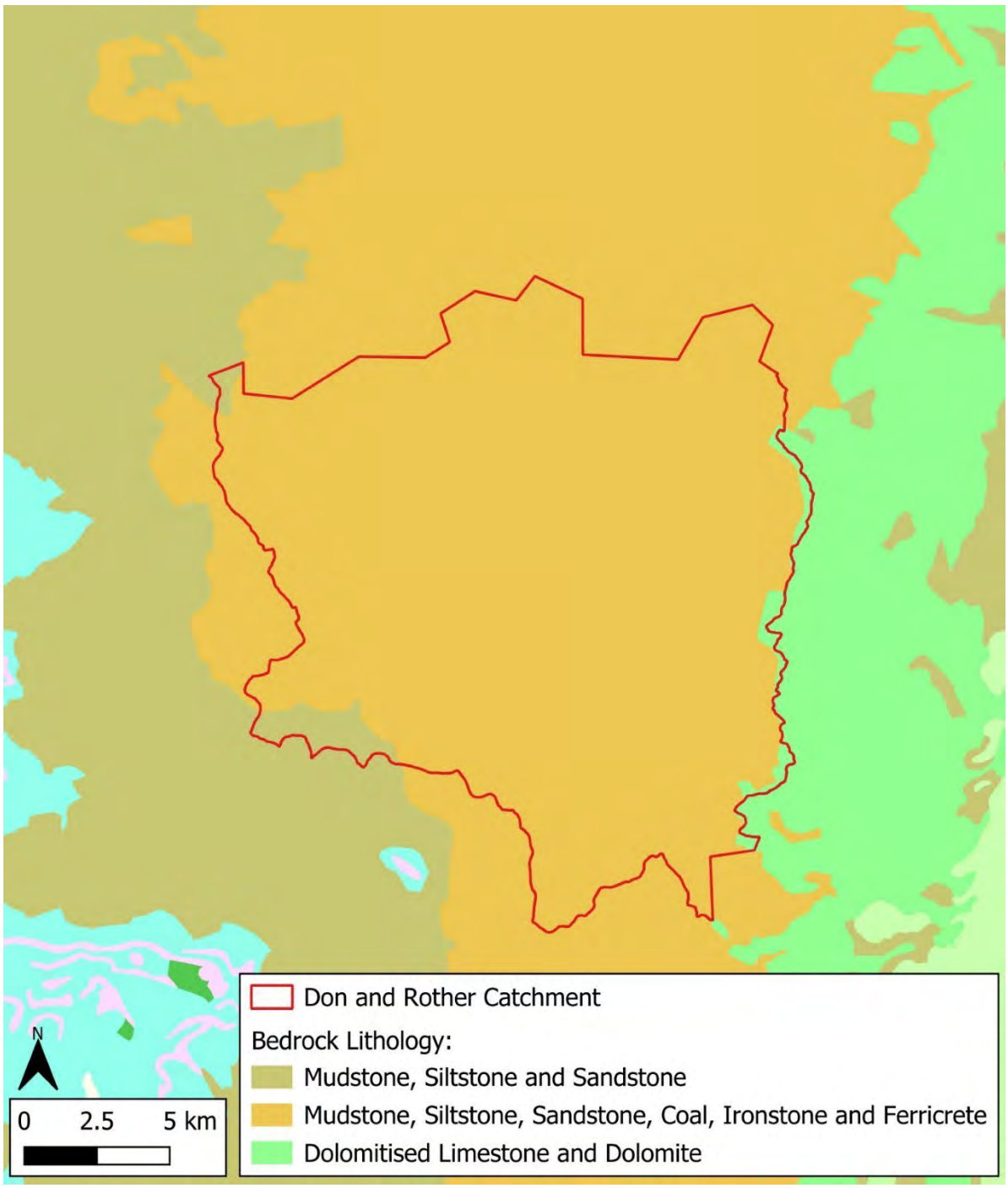

Figure 2-2: Bedrock lithology of the Don and Rother catchment (based on British Geological Survey 1:625,000-scale geological map)

2.1.2 Rainfall Records

Four Environment Agency rain gauges are located within or near to the Don and Rother sub-catchment, as indicated in Figure 2-1. The rainfall recorded at these gauges is displayed in Figure 2-3 to Figure 2-6.

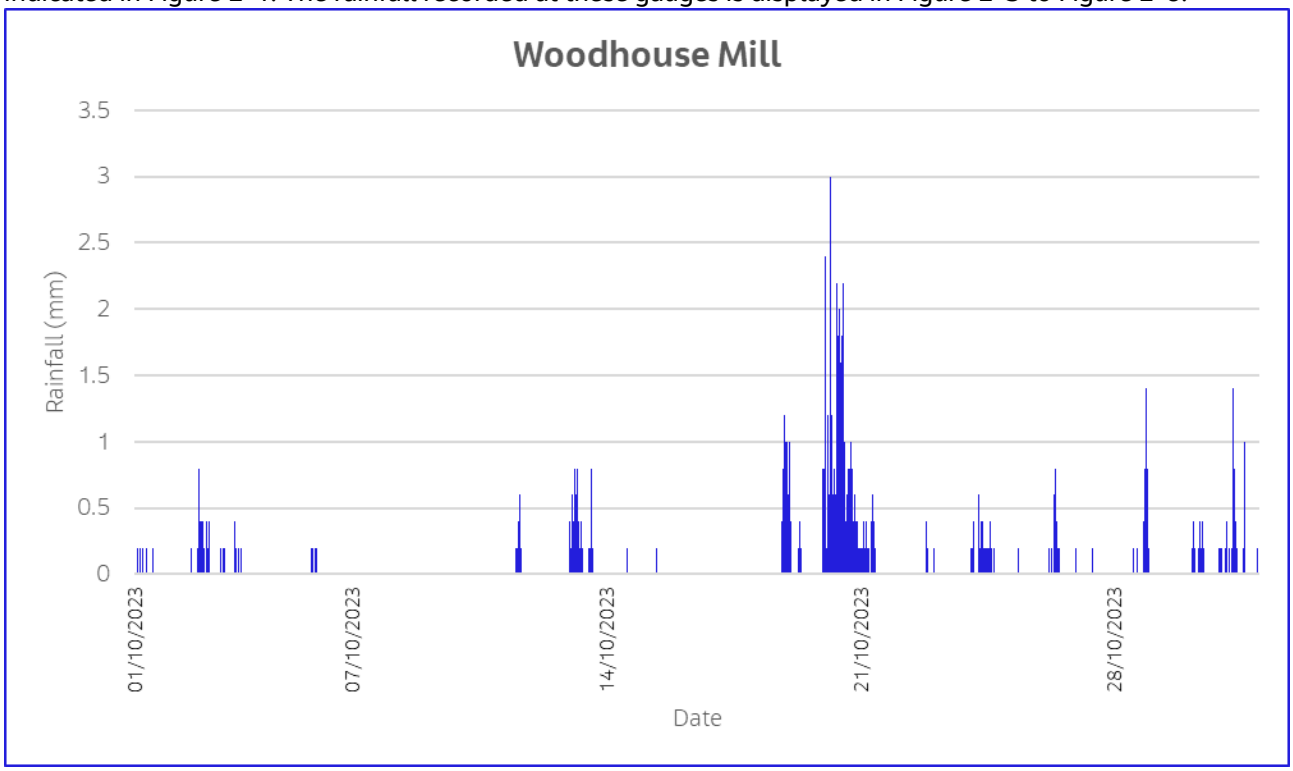

Figure 2-3: 15-minute rainfall data recorded in October 2023 at Woodhouse Mill rain gauge

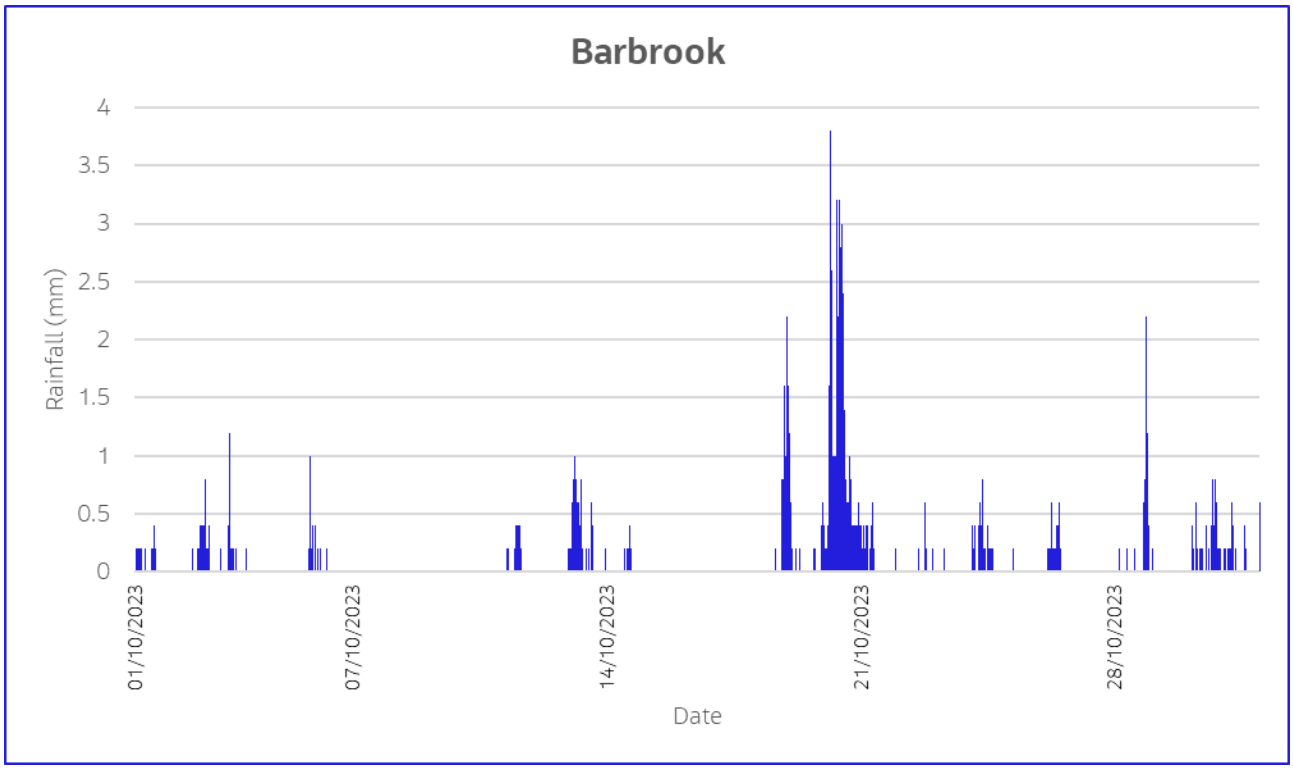

Figure 2-4: 15-minute rainfall data recorded in October 2023 at Barbrook rain gauge

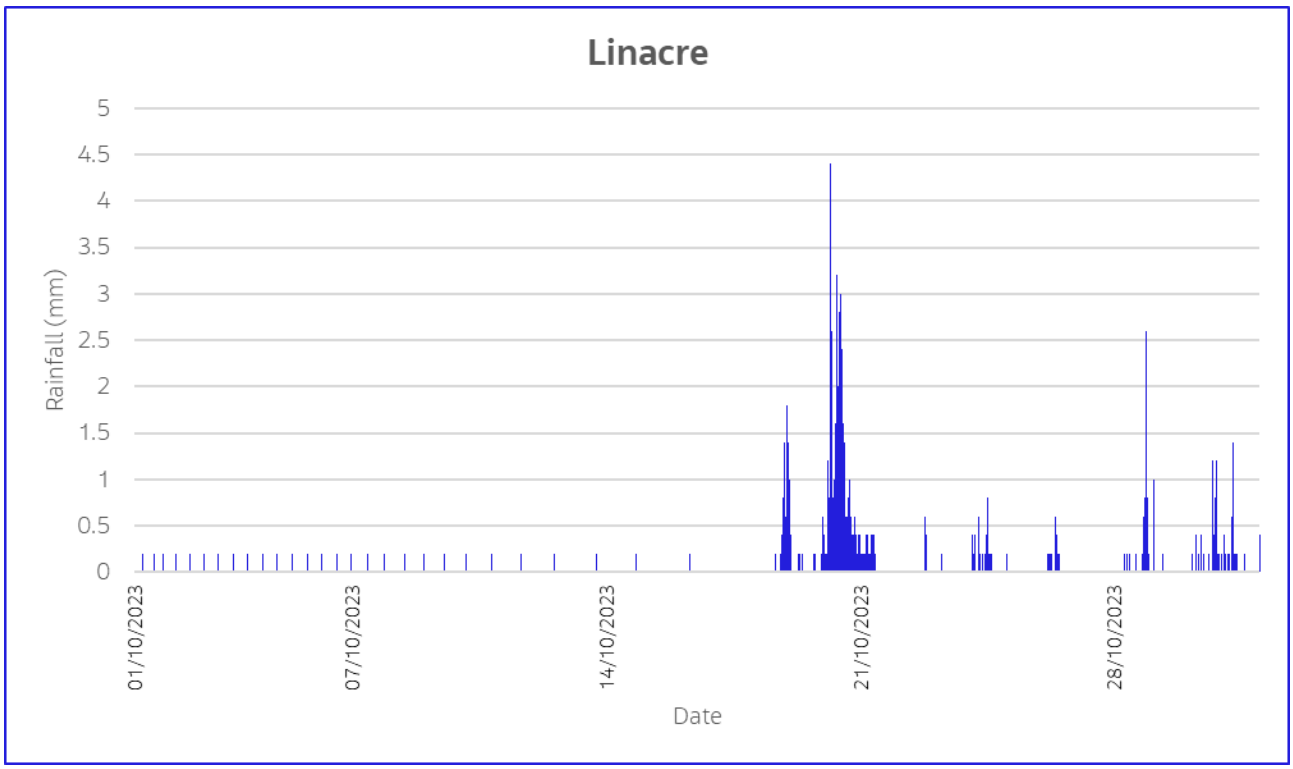

Figure 2-5: 15-minute rainfall data recorded in October 2023 at Linacre rain gauge

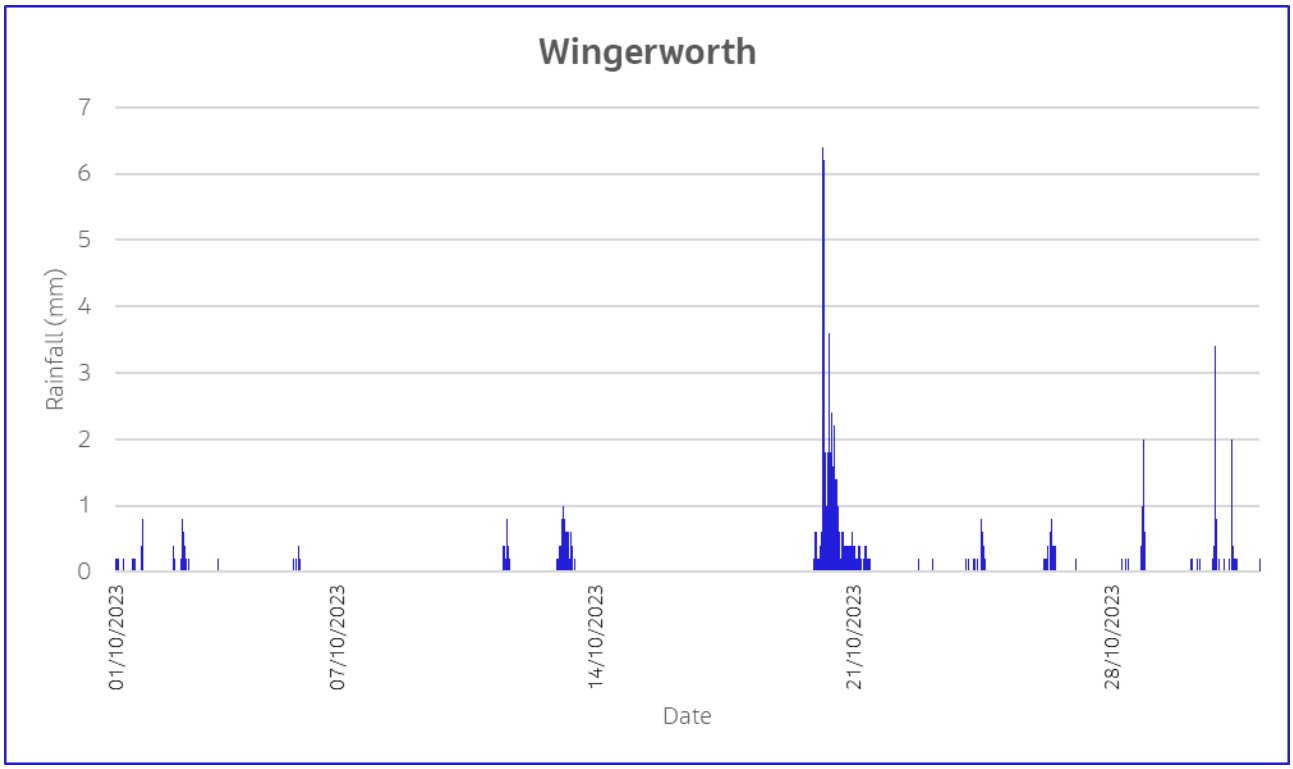

Figure 2-6: 15-minute rainfall data recorded in October 2023 at Wingerworth rain gauge

Figure 2-3 to Figure 2-6 indicate a prolonged heavy rainfall event from the 19th of October 2023 to the 21st of October. Table 2-1 indicates AEPs for the duration of Storm Babet and the most intense storm periods for rainfall recorded at each rainfall gauge. AEPs vary from 3% at Woodhouse Mill to the north of the sub-catchment to 1% at Wingerworth to the south of the sub-catchment.

The most intense period of rainfall recorded at each station was from 2:00am on the 20th of October 2023 to 8:00am on the 21st of October 2023. Between 55 and 76mm of rain fell during this period equating to 29-74% of the total rainfall from Storm Babet. This corresponds to an AEP of between 6% at Woodhouse Mill and 1% at Wingerworth.

Table 2-1: Estimated Storm Babet AEPs: event totals and most intense rainfall period

Gauging Station	Rainfall total for Storm Babet (mm)	AEP (%)	Rainfall total recorded during peak of storm (mm)	Percentage of Storm Babet Rainfall (%)	AEP (%)
Woodhouse Mill	81	3	60	74	6
Barbrook	99	2	76	29	5
Linacre	92	2	55	59	5
Wingerworth	97	1	71	74	1

Table 2-2 indicates 11-12% of annual average rainfall fell during Storm Babet. Rainfall totals for Storm Babet exceeded the LTA October rainfall totals by 4-10%.

Table 2-2: Total event rainfall recorded at each gauging station for Storm Babet compared the long-term monthly average rainfall for October and annual average rainfall[2]

Gauging Station	Rainfall total for Storm Babet (mm)	Percentage of LTA October rainfall (%)	Percentage of annual average rainfall (%)
Woodhouse Mill	81	110	12
Barbrook	99	104	11
Linacre	92	106	11
Wingerworth	97	108	12

Overall, more rainfall was recorded to the east of the Don and Rother sub-catchment (Barbrook, Wingerworth, Linacre) compared to north of the catchment at Woodhouse Mill. However, extremity of rainfall was relatively similar across the sub-catchment. Peak rainfall was experienced at all stations between 4:00am and 4:15am on the 20th of October 2023.

2.1.3 River Gauge Records

Figure 2-1 illustrates there are four Environment Agency river flow gauges and six river level gauges within or near the Don and Rother sub-catchment. Whittington and Woodhouse Mill flow gauges are on the middle and upper reaches of the River Rother. Staveley flow gauge is on the River Doe Lea, and Sheepbridge is on the River Whitting. There are a series of level gauges within Chesterfield. Chesterfield Ashgate level gauge is on the Holme Brook. Holymoorside, Chesterfield and Chesterfield Park Road level gauges are on the upper and lower reaches of the River Hipper. Chesterfield St Augustines and Chesterfield Tapton Bridge level gauges are on the middle reaches of the River Rother. All recorded flows and levels for the duration of Storm Babet have been checked by the Environment Agency with the exception of river levels at Holymoorside.

Figure 2-7 to Figure 2-12 plot the river responses recorded during Storm Babet. They show a large increase in river flow or level from the 20th of October lasting until the 23rd of October 2023.

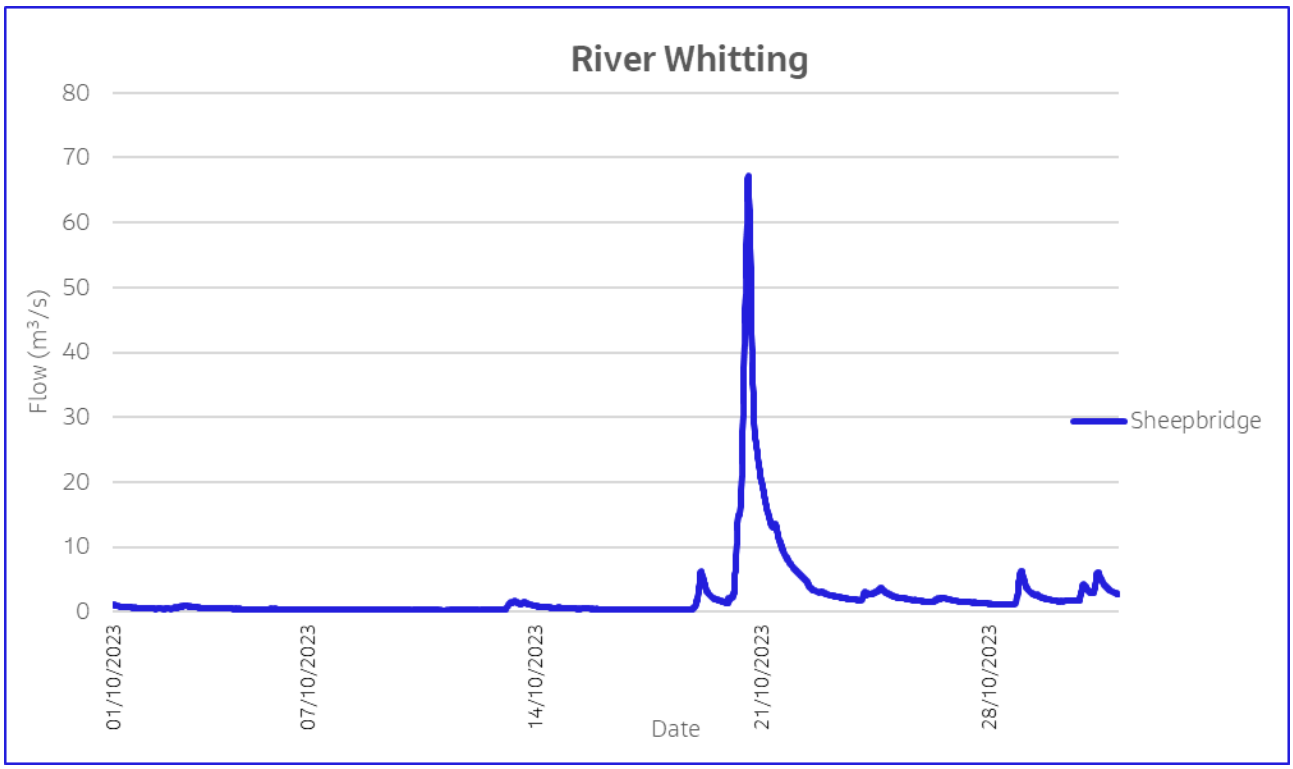

Figure 2-7: 15-minute river flow data recorded in October 2023 from Sheepbridge gauging station on the River Whitting

Figure 2-7 illustrates high flows were recorded at Sheepbridge compared to the rest of October from 4:15am on the 20th of October 2023 until 8:30pm on the 21st. A peak flow of 67m3/s was recorded at 2:00pm on the 20th of October 2023. This is the highest flow recorded in the station's 48-year history.

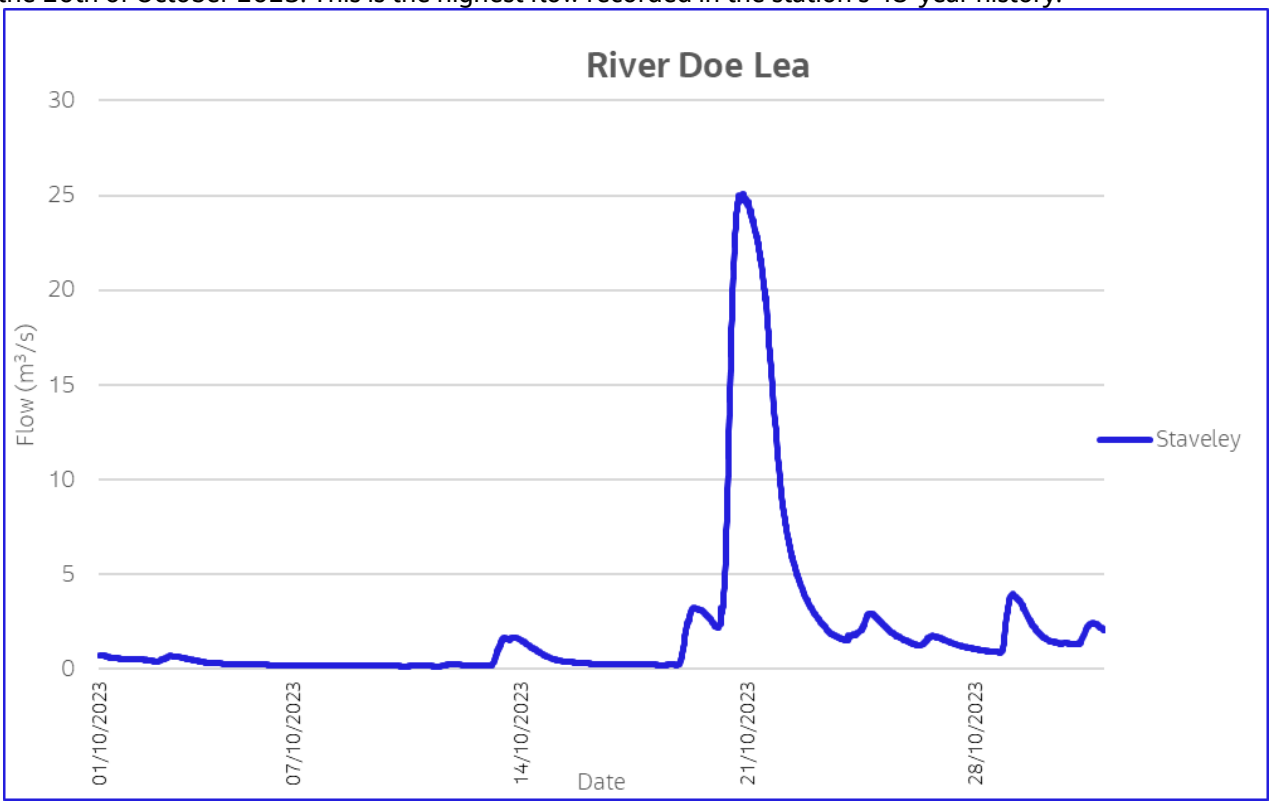

Figure 2-8: 15-minute river flow data recorded in October 2023 from Staveley gauging station on the River Doe Lea

Figure 2-8 shows that high flows were recorded at Staveley compared to the rest of October from 3:30am on the 20th of October 2023 until 9:00am on the 23rd. A peak flow of 25m3/s was recorded at 7:45pm on the 20th of October of 2023. This is the highest flow recorded in the station's 54-year history.

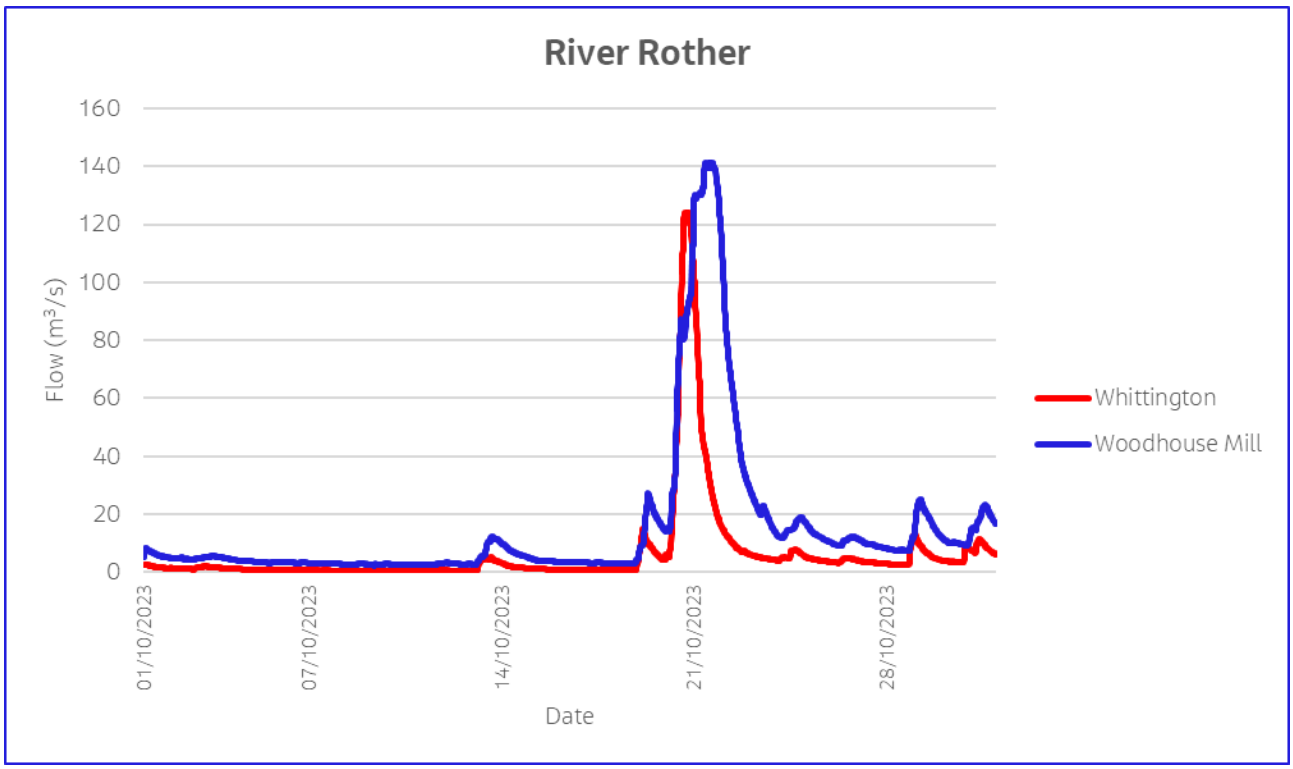

Figure 2-9: 15-minute river flow data recorded in October 2023 from Whittington and Woodhouse Mill gauging stations on the River Rother

Figure 2-9 illustrates high flows were recorded at Whittington from 2:30am on the 20th October 2023 until 5:45pm on the 22nd. A peak flow of 124m3/s was recorded at 4:00pm on the 20th of October 2023. This is the second highest flow recorded in the station's 60-year history. High flows were recorded at Woodhouse Mill from 2:30am on the 20th of October 2023 until 9:15am on the 23rd. A peak flow of 141m3/s was recorded at 4:00pm on the 20th of October 2023. This is the highest flow recorded in the stations 50-year history. A short increase in flows was also recorded on the 19th of October 2023. Figure 2-9 indicates a shorter, earlier and flashier response was recorded in the middle reaches of the River Rother (Whittington) compared to the lower reaches at Woodhouse Mill.

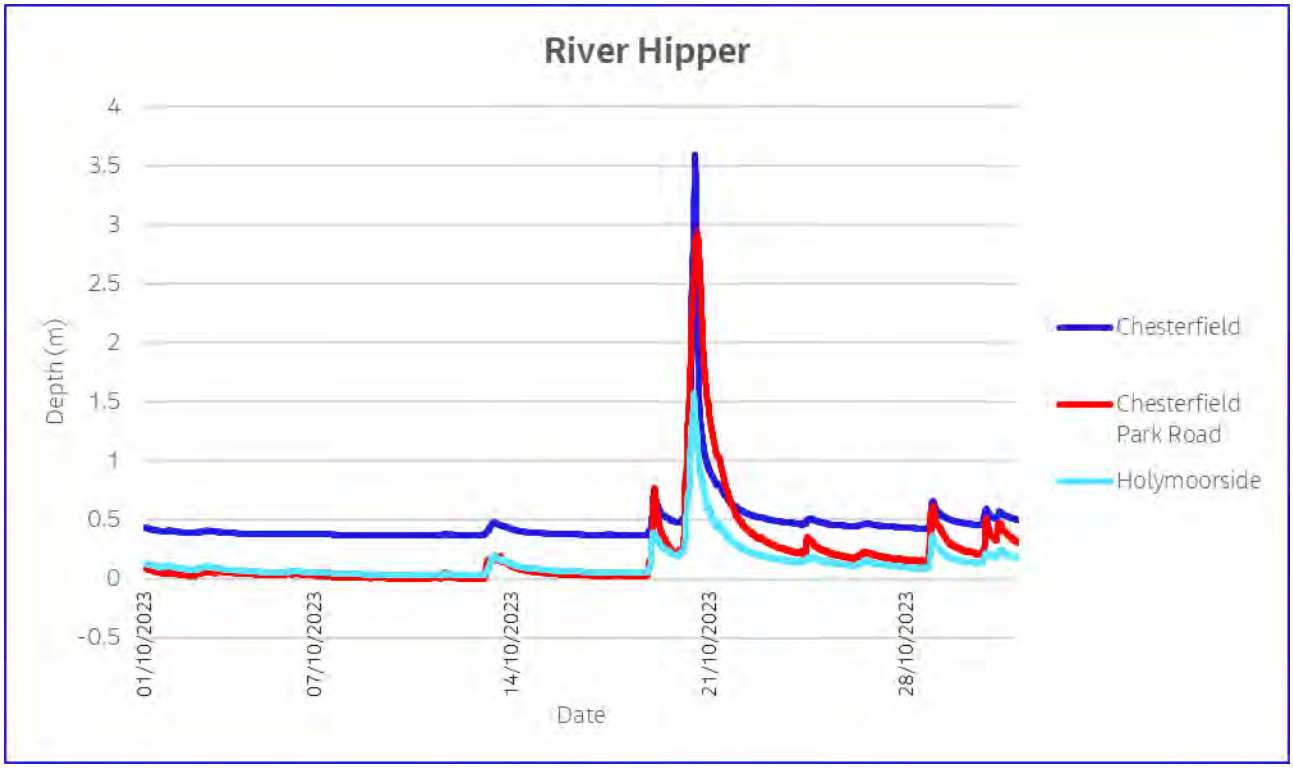

Figure 2-10: 15-minute river level data recorded in October 2023 from Chesterfield, Chesterfield Park Road Bridge and Holymoorside gauging stations on the River Hipper

Figure 2-10 illustrates high levels were recorded on the River Hipper from late on the 19th of October 2023 until the 22nd of October. A short increase in levels was also recorded from the 18th to the 19th of October 2023 at all stations. High levels were recorded at Chesterfield from 3:30am on the 20th of October 2023 until midnight on the 22nd. A peak level of 3.6m was recorded at 1:00pm on the 20th of October 2023. This is the highest level recorded in the station's 24-year history.

High levels were recorded at Chesterfield Park Road Bridge from 1:15am on the 20th of October 2023 until 2:15am on the 22nd. A peak level of 2.9m was recorded at 2:30pm on the 20th of October 2023. This is the second highest level recorded in the station's 21-year history.

High levels were recorded at Holymoorside from 8:00pm on the 19th of October 2023 until 8:45pm on the 22nd. A peak level of 1.6m was recorded at midday on the 20th of October 2023. This is the highest level recorded in the station's 19-year history.

Figure 2-10 indicates the River Hipper responded in a flashier, quicker manner to heavy rainfall. A more prolonged response was recorded at Chesterfield Park Road Bridge in the lower reaches of the River Hipper.

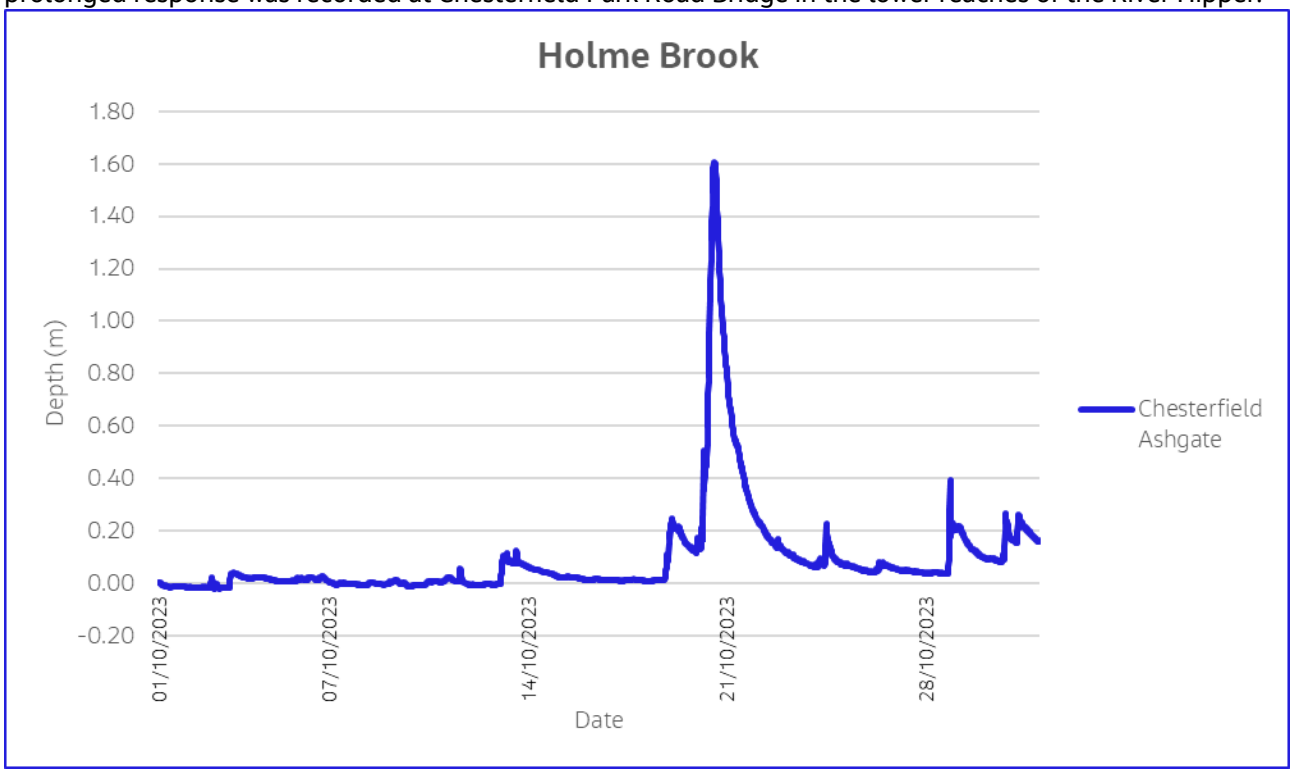

Figure 2-11: 15-minute river level data recorded in October 2023 from Chesterfield Ashgate gauging station on Holme Brook

Figure 2-11 illustrates high levels were recorded at Chesterfield Ashgate compared to the rest of October from 10:15pm on the 19th of October 2023 until 9:45pm on the 22nd. A peak level of 1.6m was recorded at 1:30pm on the 20th of October 2023. This is the second highest level recorded in the station's 19-year history.

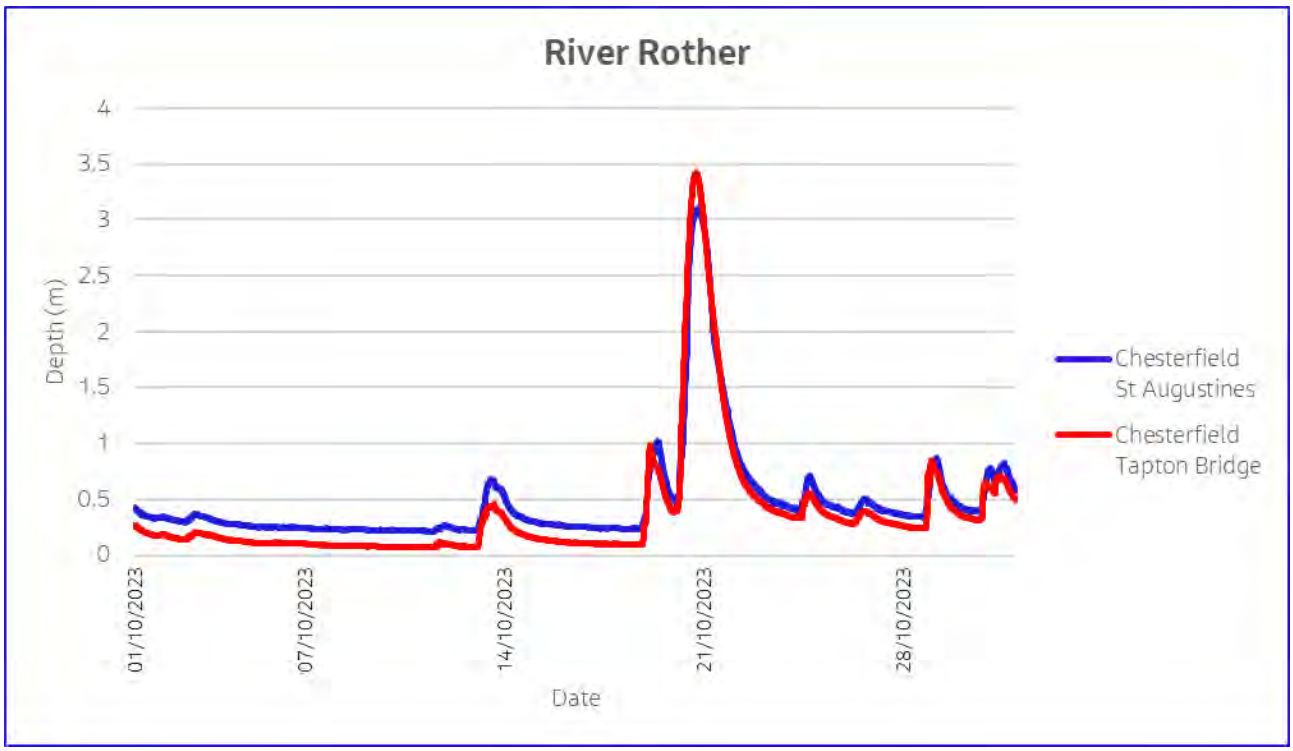

Figure 2-12: 15-minute river level data recorded in October 2023 from Chesterfield St Augustines and Chesterfield Tapton Bridge gauging stations on the River Rother

Figure 2-12 illustrates high levels were recorded on the River Rother from the 20th to the 22nd of October. A short increase in levels was also recorded on the 19th. Chesterfield St Augustines recorded high levels from 1:45am on the 20th of October 2023 until 10:30pm on the 22nd. A peak level of 3.1m was recorded at 6:45pm on the 20th of October 2023. This is the highest level recorded in the station's 21-year history.

High levels were recorded at Chesterfield Tapton Bridge from 2:45am on the 20th of October 2023 until 8:15pm on the 22nd. A peak level of 3.4m was recorded at 5:15pm on the 20th of October 2023. This is the highest level recorded in the station's 21-year history.

Overall, river flows align with the Environment Agency's monthly water situation report for October 2023, which found all river flow monitoring sites recorded above normal river flows across the Midlands. Table 2-3 summarises peak flow, timing, ranking of peak flow and length of data records at each station indicating Storm Babet recorded the highest or second highest river flows and levels at each station.

Flashier increases in flow and level were recorded on the River Hipper at Chesterfield, Holymoorside and Chesterfield Park Road gauging stations and on the middle reaches of Rivers Whitting and Rother at Sheepbridge and Whittington gauging stations. Staveley, Woodhouse Mill, Chesterfield Ashgate, Chesterfield St Augustines, and Chesterfield Tapton Bridge all showed more prolonged increases in flow from the 20th of October 2023 until the 23rd of October 2023. These stations are located on the River Doe Lea, and lower and upper reaches of the River Rother respectively.

The first stations to peak were Chesterfield, Chesterfield Ashgate, Chesterfield Park Road Bridge and Sheepbridge gauging stations at 1:00pm-2:30pm on the 20th of October. The latest peak in flow was recorded at Woodhouse Mill at 10:00am on the 21st of October. Stations recording earlier and flashier responses to heavy rainfall are located on smaller tributaries to the River Rother or in upper reaches of the River Rother. Slower, prolonged responses were recorded at Woodhouse Mill which is closer to the confluence of the Rother with the River Don.

Table 2-3: Peak flow, peak level, timing and ranking of each peak and station data record length recorded at each station within the Don and Rother sub-catchment.

Station	Peak Flow (m3/s)	Date and Time	Peak Flow Ranking	Station record length (years)
Sheepbridge	67	20/10/2023 2:00pm	1	48

Staverley	25	20/10/2023 7:45pm	1	54
Whittington	124	20/10/2023 4:00pm	2	60
Woodhouse Mill	141	21/10/2023 10:00am	1	50

Station	Peak Level (m)	Date and Time	Peak Level Ranking	Station record length (years)
Chesterfield	3.6	20/10/2023 1:00pm	1	24
Chesterfield Park Road Bridge	2.9	20/10/2023 2:30pm	2	21
Chesterfield Ashgate	1.6	20/10/2023 3:00pm	2	19
Chesterfield St Augustines	3.1	20/10/2023 6:45pm	1	21
Chesterfield Tapton Bridge	3.4	20/10/2023 5:15pm	1	21
Holymoorside	1.6	20/10/2023 12:00pm	1	21

Figure 2-13 to Figure 2-19 summarise the recorded rainfall and river response to Storm Babet from gauges across the sub-catchment.

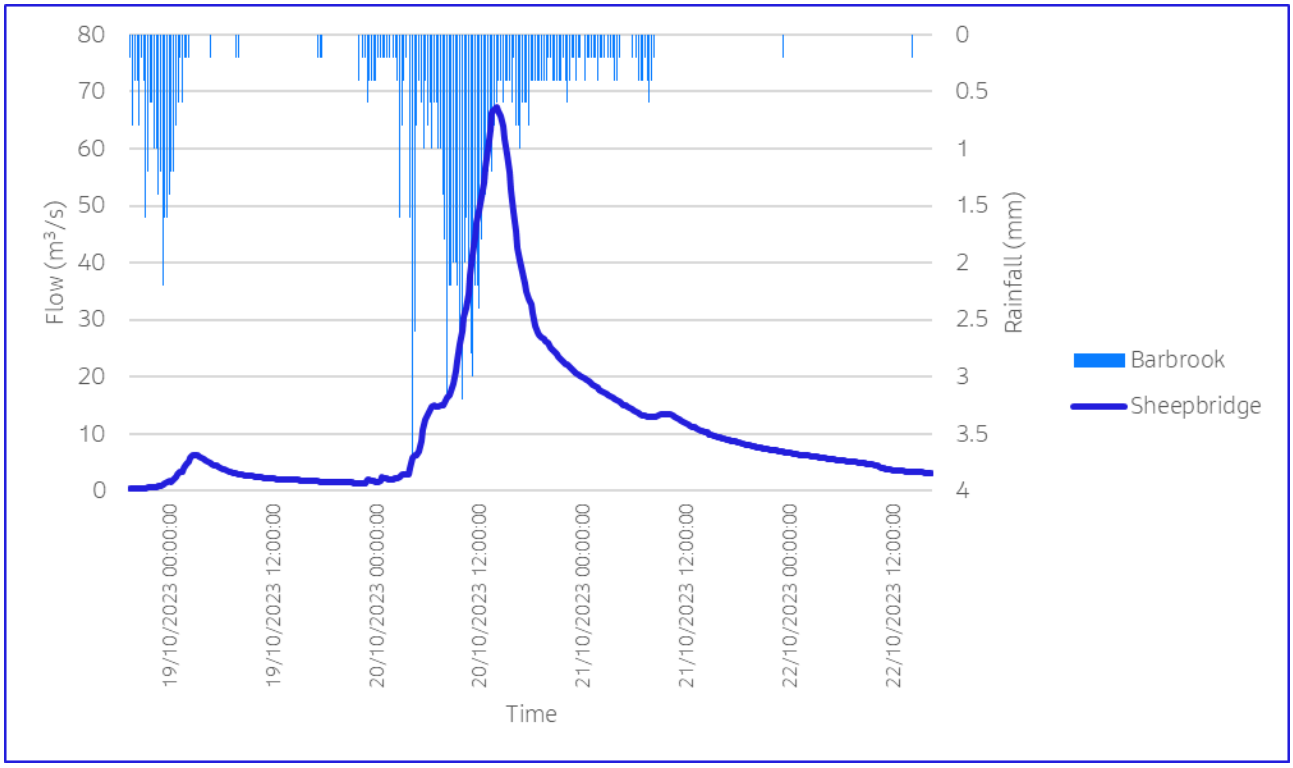

Figure 2-13: Hydrograph from the 19th to the 22nd of October illustrating recorded river flow data from Sheepbridge gauging station and recorded rainfall data from Barbrook rain gauge

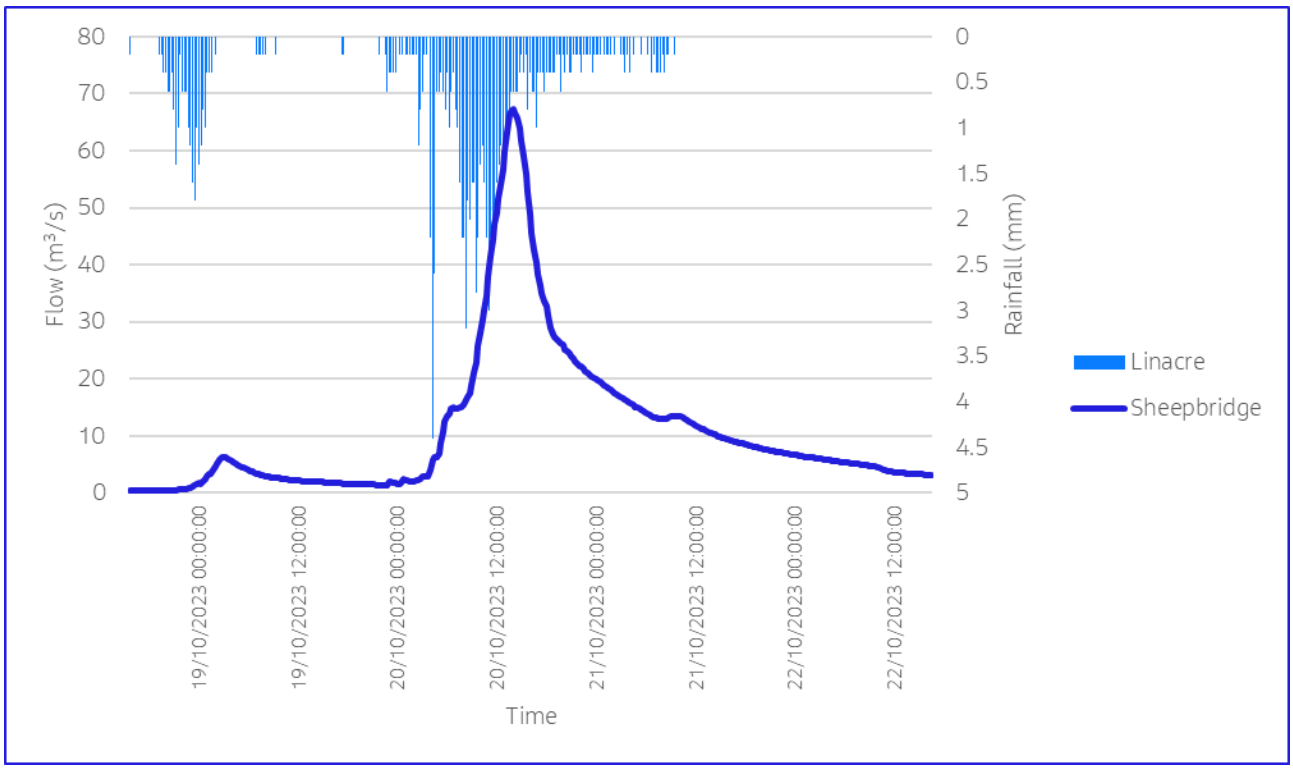

Figure 2-14: Hydrograph from the 19th to the 22nd of October illustrating recorded river flow data from Sheepbridge gauging station and recorded rainfall data from Linacre rain gauge

Figure 2-13 and Figure 2-14 indicate a lag of 14 hours between the peak rainfall recorded at Barbrook (4mm in 15 minutes) and Linacre (4mm in 15 minutes) and the peak river flow recorded at Sheepbridge (67m³/s).

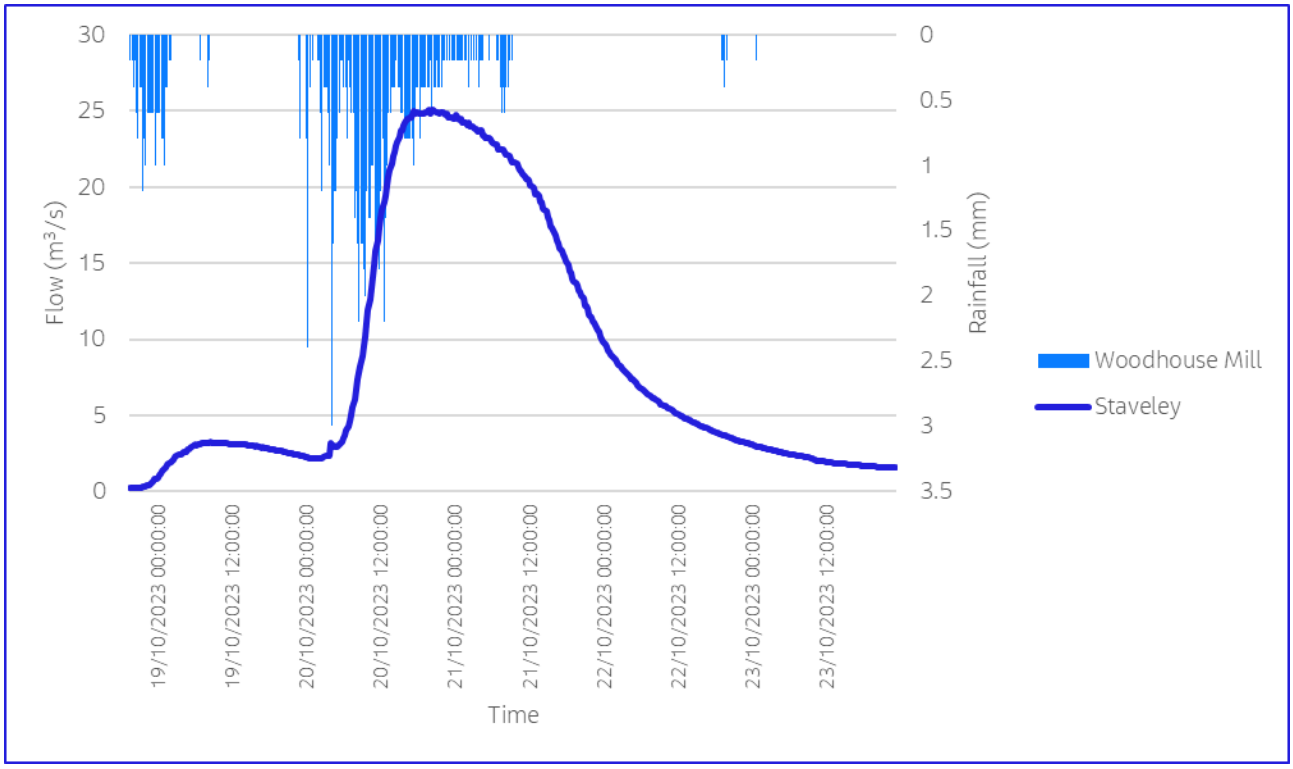

Figure 2-16: Hydrograph from the 19th to the 23rd of October illustrating recorded river flow data from Staveley gauging station and recorded rainfall data from Woodhouse Mill rain gauge

Figure 2-16 indicates a lag of 8 hours between peak rainfall recorded at Woodhouse Mill (3mm in 15 minutes) and peak river flow recorded at Staveley (25.1m³/s).

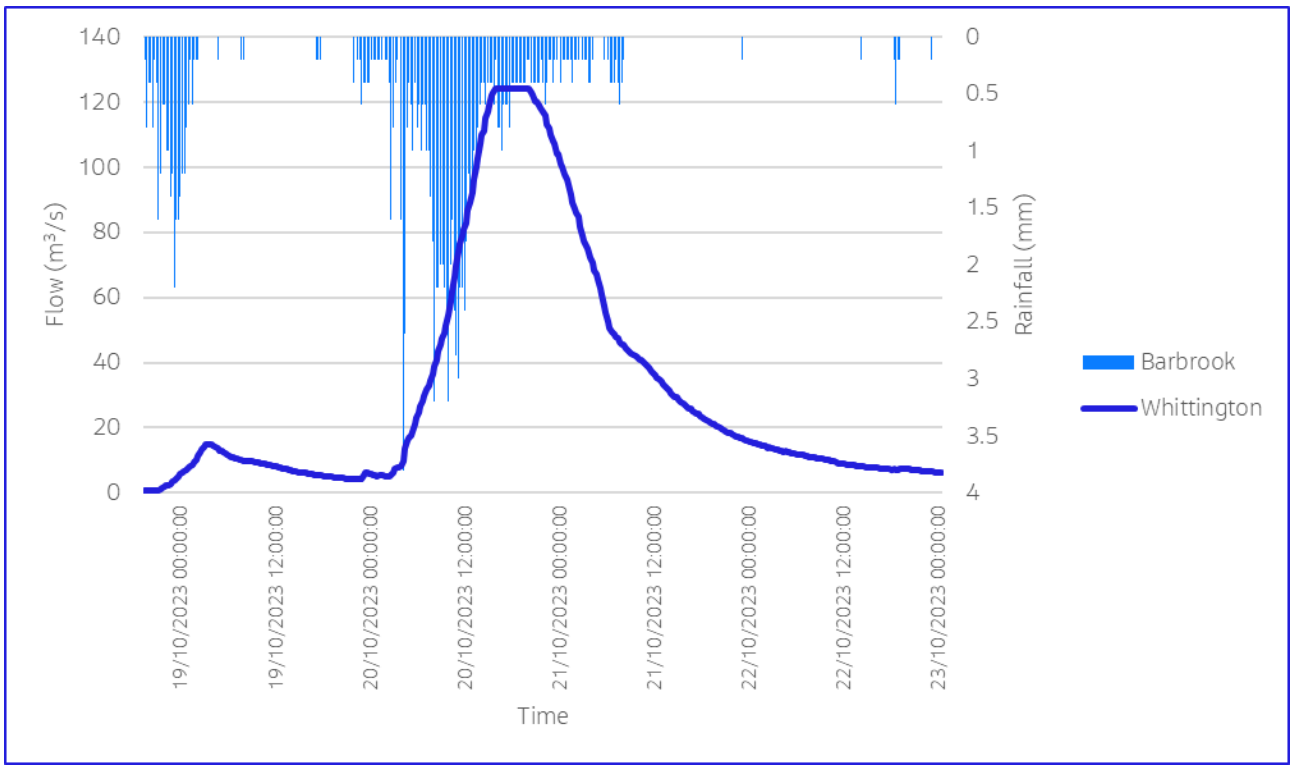

Figure 2-17: Hydrograph from 19th to the 23rd of October illustrating recorded river flow data from Whittington gauging station and recorded rainfall data from Barbrook rain gauge

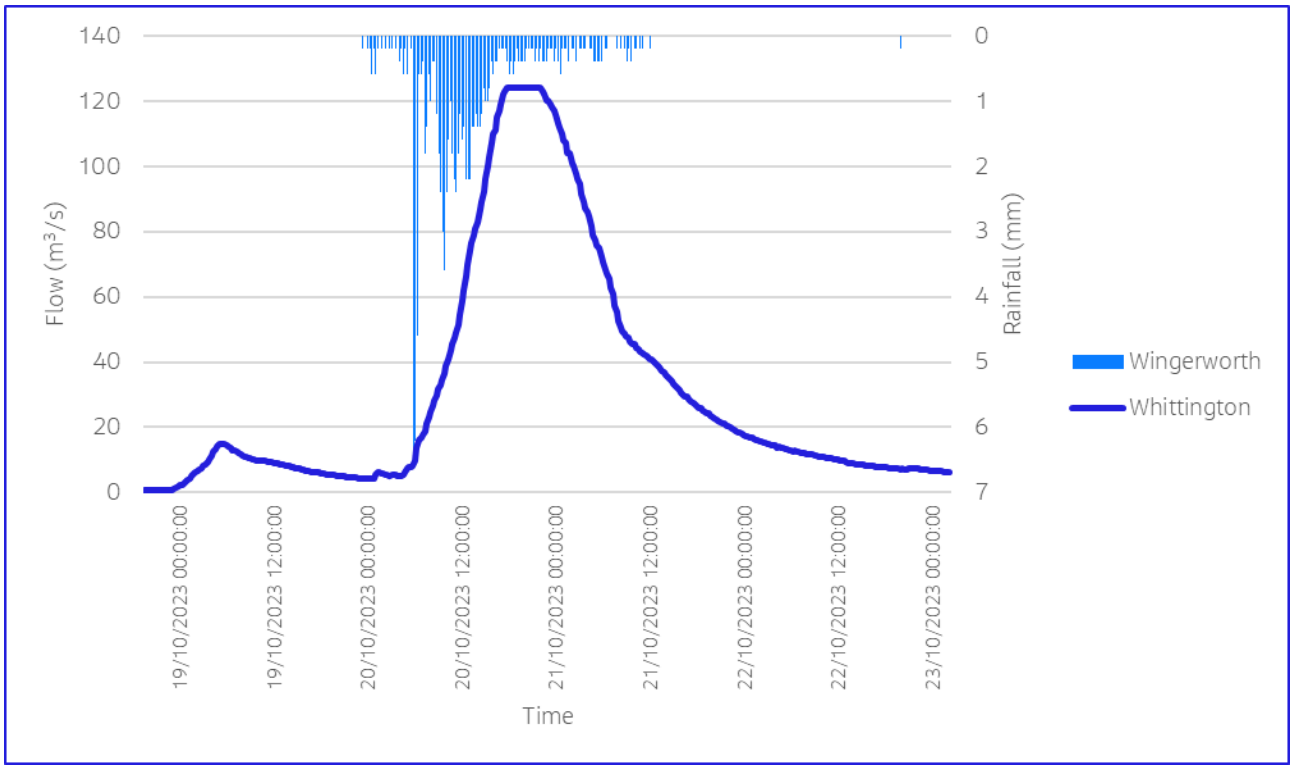

Figure 2-18: Hydrograph from the 19th to the 23rd of October illustrating recorded river flow data from Whittington gauging station and recorded rainfall from Wingerworth rain gauge

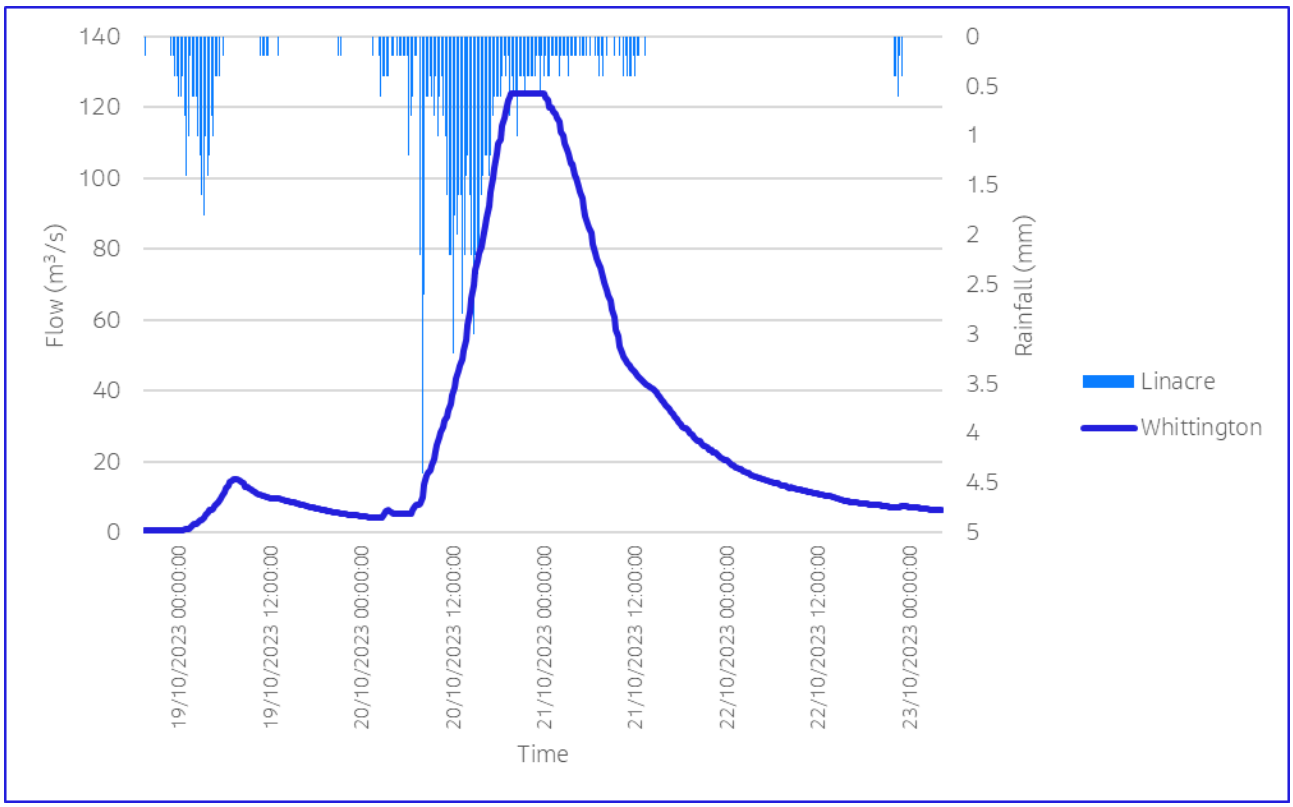

Figure 2-19: Hydrograph from the 19th to the 23rd of October illustrating recorded river flow data from Whittington gauging station and recorded rainfall from Linacre gauging station

Figure 2-16, Figure 2-17 and Figure 2-18 indicate lags of 12 hours between peak rainfall recorded at Barbrook (3.8mm in 15 minutes), Wingerworth (6.2mm in 15 minutes) and Linacre (4.4mm in 15 minutes) and peak river flow recorded at Whittington (124m³/s).

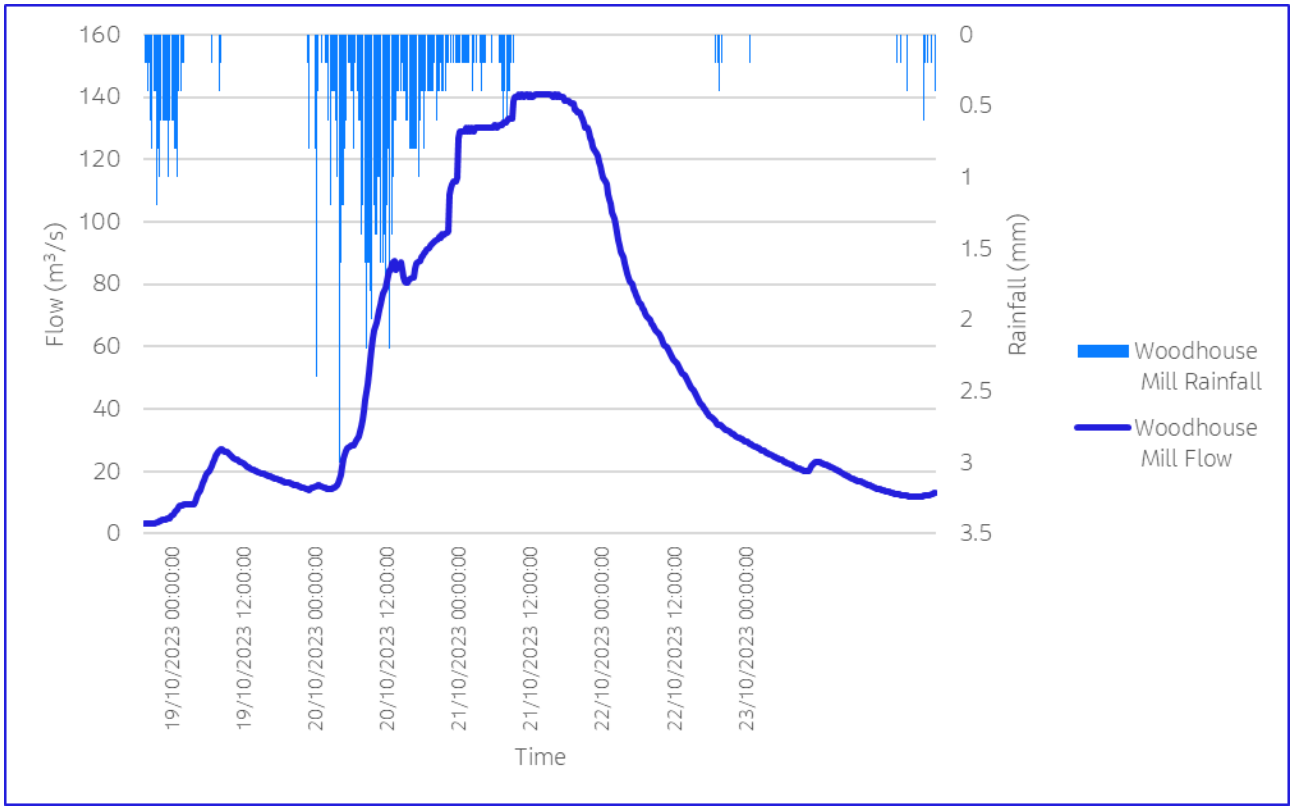

Figure 2-20: Hydrograph from the 19th to the 23rd of October illustrating recorded river flow data and rainfall data from Woodhouse Mill gauging station and Woodhouse Mill rain gauge

Figure 2-20 indicates a lag of 18 hours between peak rainfall (3mm in 15 minutes) and peak river flow recorded at Woodhouse Mill (141m3/s). This suggests there was a slower response to heavy rainfall and

runoff in the lower reaches of the River Rother compared to the upper reaches and its tributaries during Storm Babet.

2.1.4 Groundwater Records

Figure 2-2 shows that there is one Environment Agency groundwater station located proximal to the Don and Rother sub-catchment. Hourly groundwater level data from October 2018 to March 2024 is provided in Figure 2-21. The bedrock at this station is sedimentary Dolostone. All data until the 23rd of December 2023 has been checked by the Environment Agency.

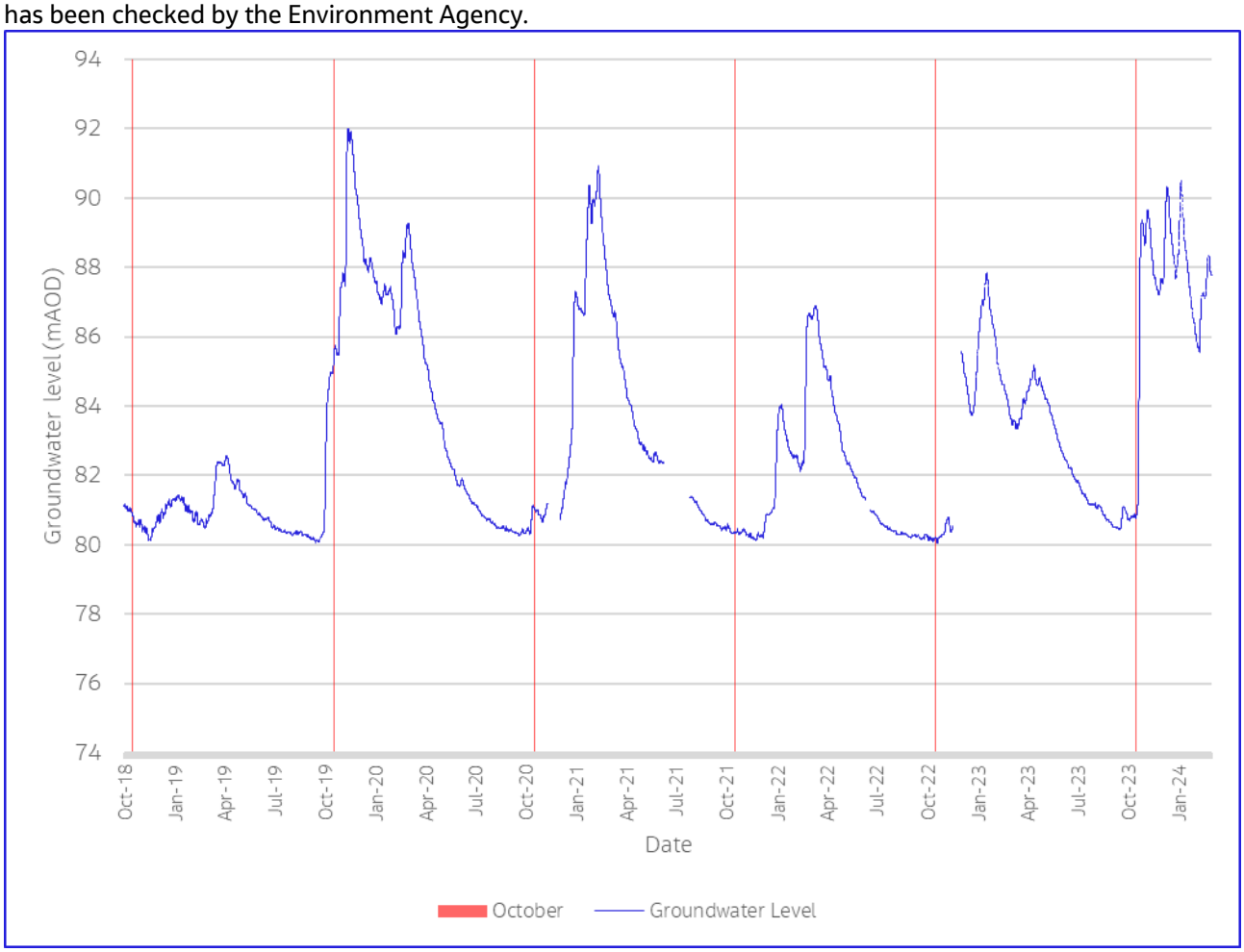

Figure 2-21: Southards Lane hourly groundwater levels from October 2018 to March 2024. The red line indicates October.

Figure 2-21 indicates groundwater levels recorded in October 2023 are higher than levels recorded in the month of October in the preceding years. A rapid increase in groundwater levels is evident in October 2023 in response to Storm Babet. The groundwater level recorded by the end of October 2023 was not achieved until November in 2019 and January in 2021. The groundwater level in October 2023 exceeds the annual peak groundwater level in 2022.

Groundwater remains high from October 2023 to March 2023 which is a contrasting pattern to the rise in groundwater level experienced from October to March in 2018, 2020, 2021 and 2022. Groundwater levels likely remained constant due to natural recharge, which is evidenced in previous years after October by the rise in groundwater levels.

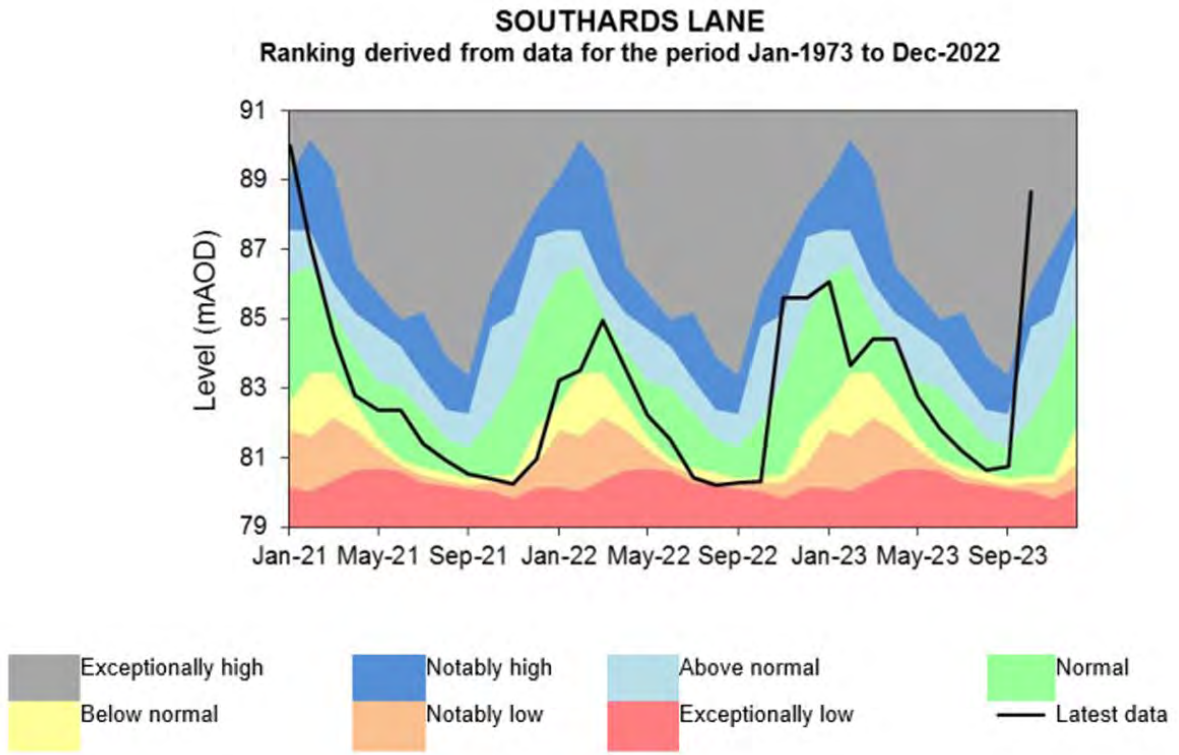

Figure 2-22: End of month groundwater levels at Southards Lane groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023

Figure 2-22 indicates groundwater levels at the end of October were exceptionally high compared to the LTA. This suggests Southards Lane groundwater levels were raised by Storm Babet.

2.1.5 Hydrological Summary

Overall, heavier rainfall was recorded to the east of the Don and Rother sub-catchment compared to the north during Storm Babet. However, the relative extremity of this rainfall was similar across the sub-catchment. Rainfall peaked early on the 20th of October from 4:00am-4.15am. Total rainfall recorded equated to 1-3% AEP events with the most intense rainfall equating to 1-6% AEP events.

Flashier and earlier river responses to heavy rainfall were recorded on tributaries to the River Rother (Rivers Whitting and Hipper) and the Upper to Middle reaches of the River Rother. Slower and more prolonged responses to Storm Babet were recorded in the lower reaches of the River Rother at Woodhouse Mill and on the River Doe Lea.

The longest lag time between peak rainfall and peak flow was recorded at Woodhouse Mill (18 hours) while the shortest was recorded at Staveley (8 hours). All stations in the Don and Rother sub-catchment produced the highest or second highest ranked flows or levels on record in response to Storm Babet in October 2023. High groundwater levels compared to the last five years and LTA were recorded at Southards Lane groundwater station for this time of year.

3. Dove Management Catchment

3.1 Dove Catchment Event Hydrology

3.1.1 Catchment Characteristics

The River Dove, from its source near Buxton to its confluence with the River Trent near Newton Solney, forms the western boundary of Derbyshire. The river flows south through Crowdecote, Dovedale National Nature Reserve and Church Mayfield until it combines with the River Trent. The main tributaries include the River Manifold, River Churnet and River Tean on the right bank, and Bentley Brook, Henmore Brook, Brocksford Brook, Foston Brook and Hilton Brook on the left bank. Only the left bank tributaries of the River Dove are in Derbyshire, with their locations defining the sub-catchment referred to in this report.

The River Dove sub-catchment has an area of 400km2. Waterbodies within the sub-catchment include Carsington Water reservoir and Park Road Lake.

The bedrock geology consists mostly of Triassic and Carboniferous mudstones, siltstones, sandstones and Carboniferous limestones (Figure 3-2). Sections of limestone are located between Buxton and Ashbourne. Most of the soil covering the sub-catchment is freely draining loamy soils.. There are sections of seasonally wet, loamy and clayey soils with impeded drainage to the stream network in the upper Henmore Brook catchment. The central and upstream part of the catchment has a bedrock with higher permeability than the southern areas.

The Carsington Water reservoir, which is in the headwaters of the Henmore Brook, takes water through tunnels and an aqueduct straight from the River Derwent in Ambergate. Water is either pumped into the reservoir, usually during winter high flows, and released back the River Derwent, at times of low flow, in summer. According to Water Situation Report for England (November 2023) reservoir stock at the end of October was exceptionally high in the Carsington Water reservoir.

There is little urbanisation across the catchment, with more urbanised areas being concentrated in the south of the catchment toward the River Trent and Ashbourne town, at the centre of the catchment. Average annual rainfall received is similar across the catchment, with higher average rainfall being in the northern part of the catchment (based on data from Carsington Dam and Ashford Hall rainfall gauges).

Figure 3-1 indicates the sub-catchment extent in respect of the Derbyshire area, as well as showing the location of the groundwater, rainfall, river flow and level gauges within the sub-catchment.

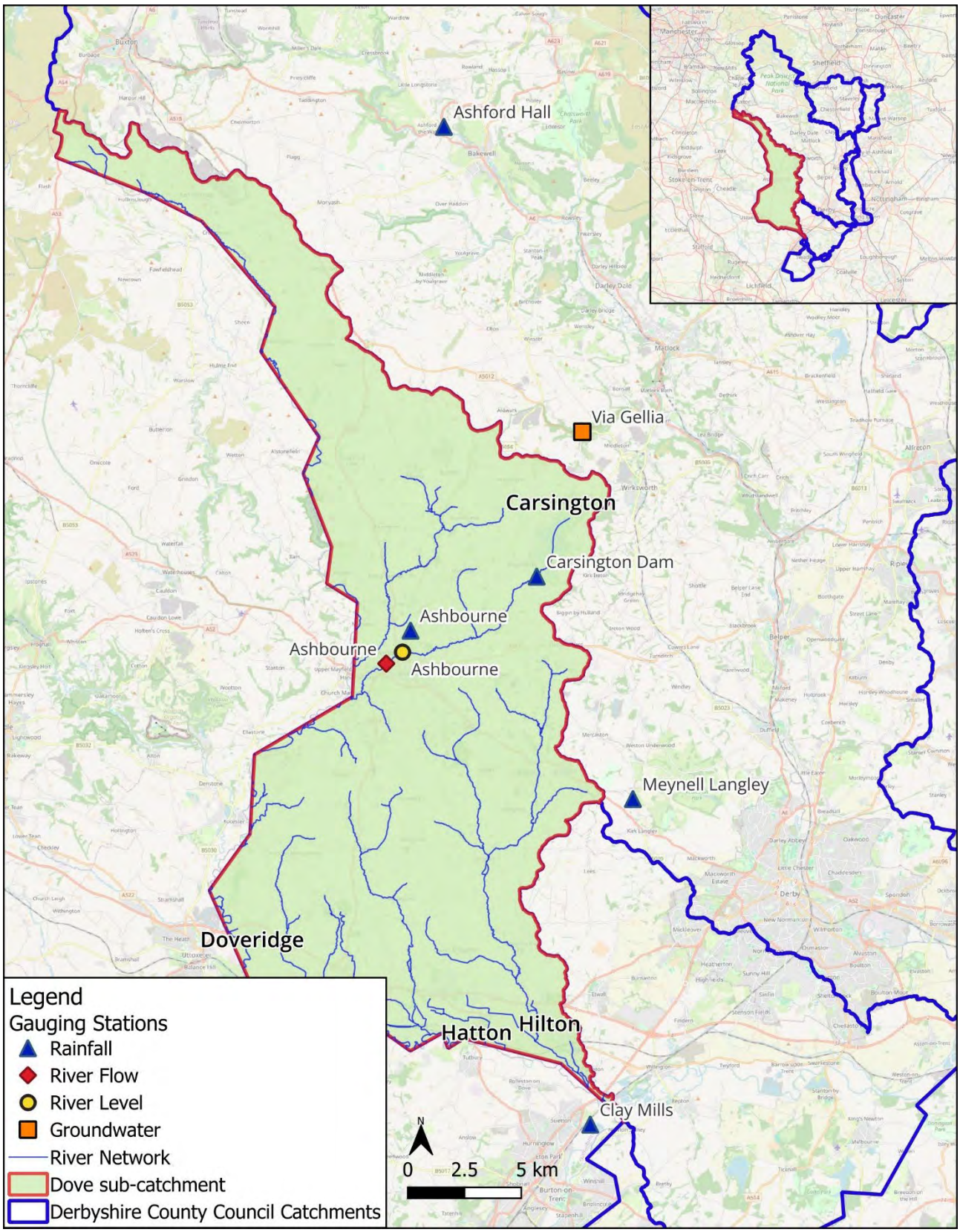

Figure 3-1: Dove catchment extent and groundwater, rainfall, river flow and river level gauges

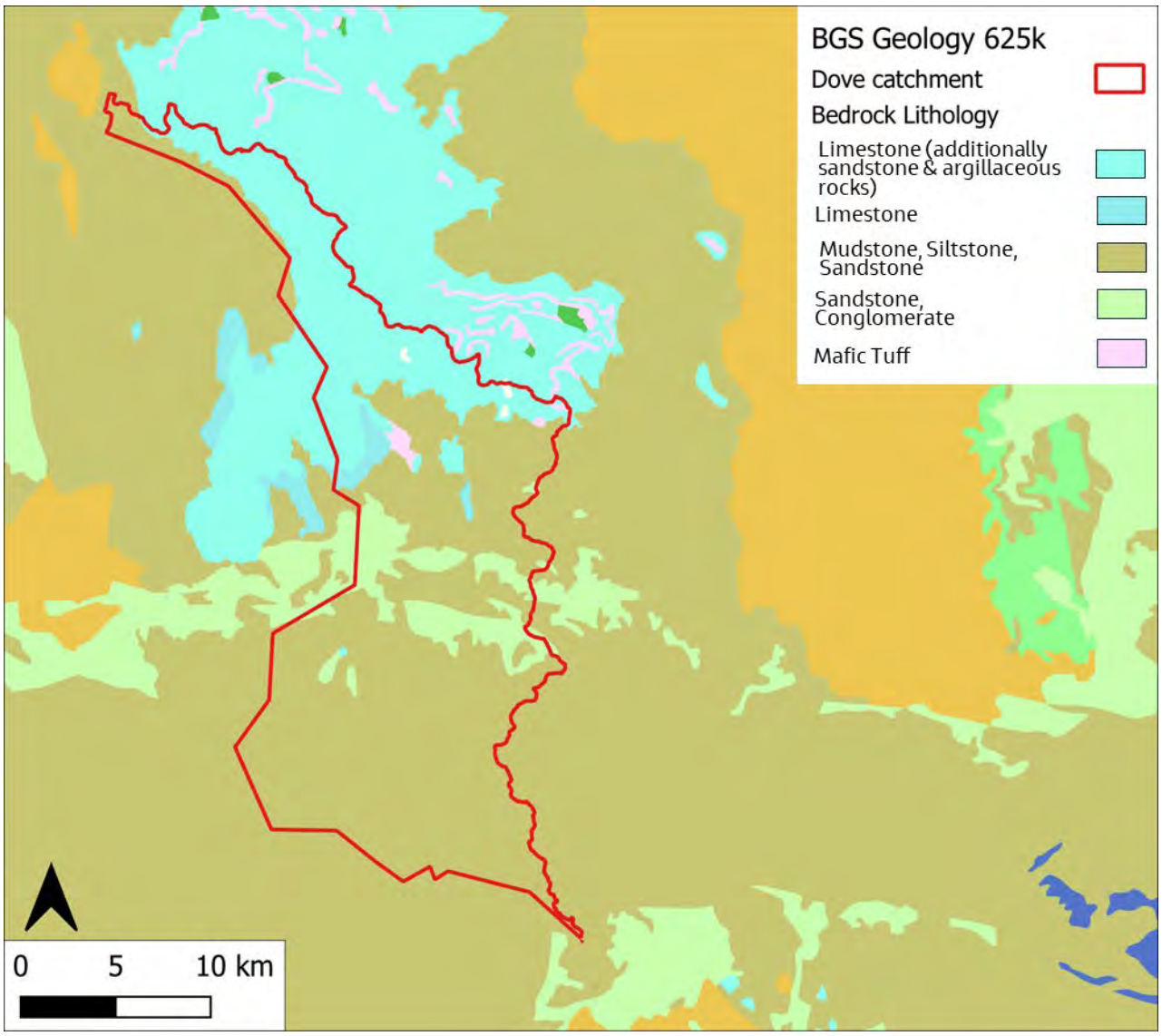

Figure 3-2: Bedrock lithology in Dove catchment (based on British Geological Survey 1:625 000-scale geological map)

3.1.2 Rainfall Records

Five Environment Agency rain gauges are within, or near to ,the Dove sub-catchment, as indicated in Figure 3-1. The rainfall recorded at these gauges is displayed in Figure 3-3 to Figure 3-7.

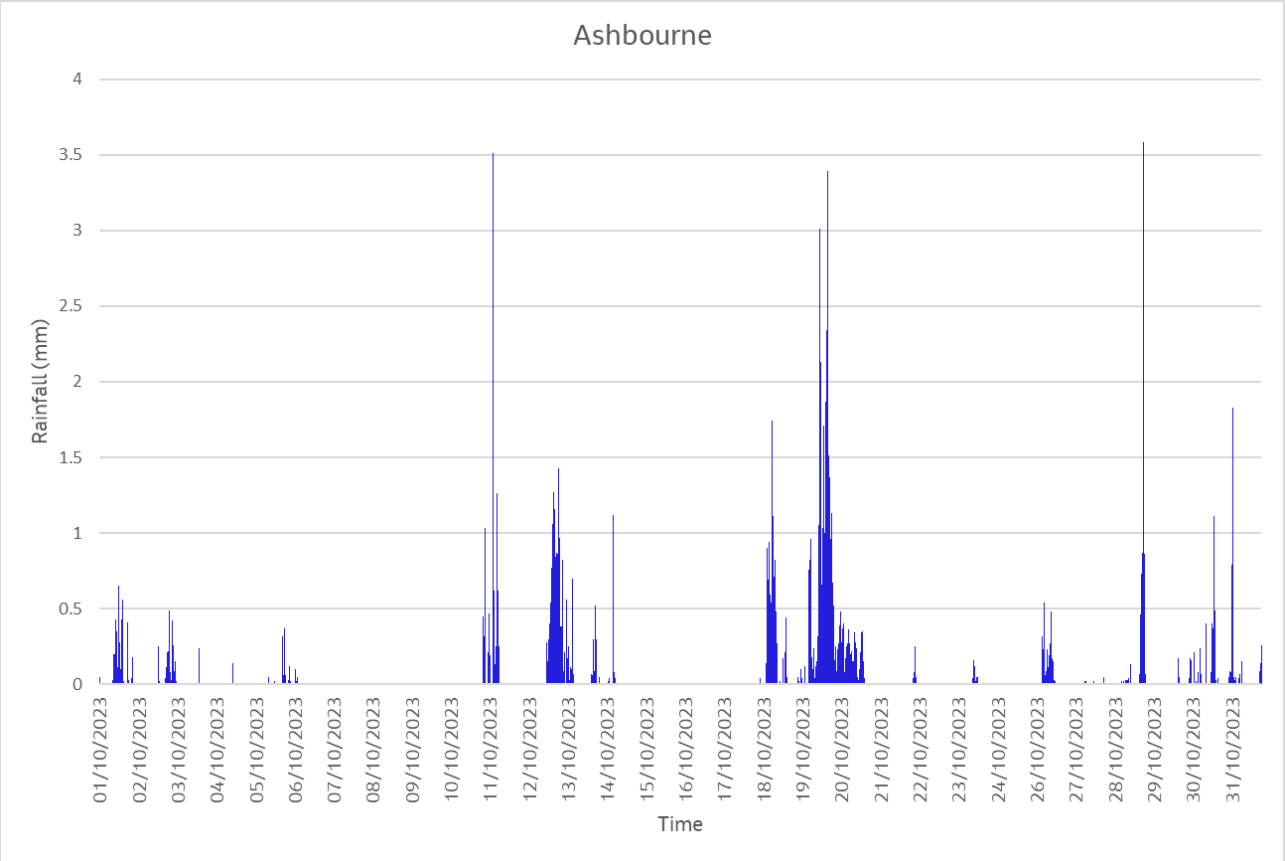

Figure 3-3: 15-minute rainfall data recorded in October 2023 at Ashbourne rain gauge

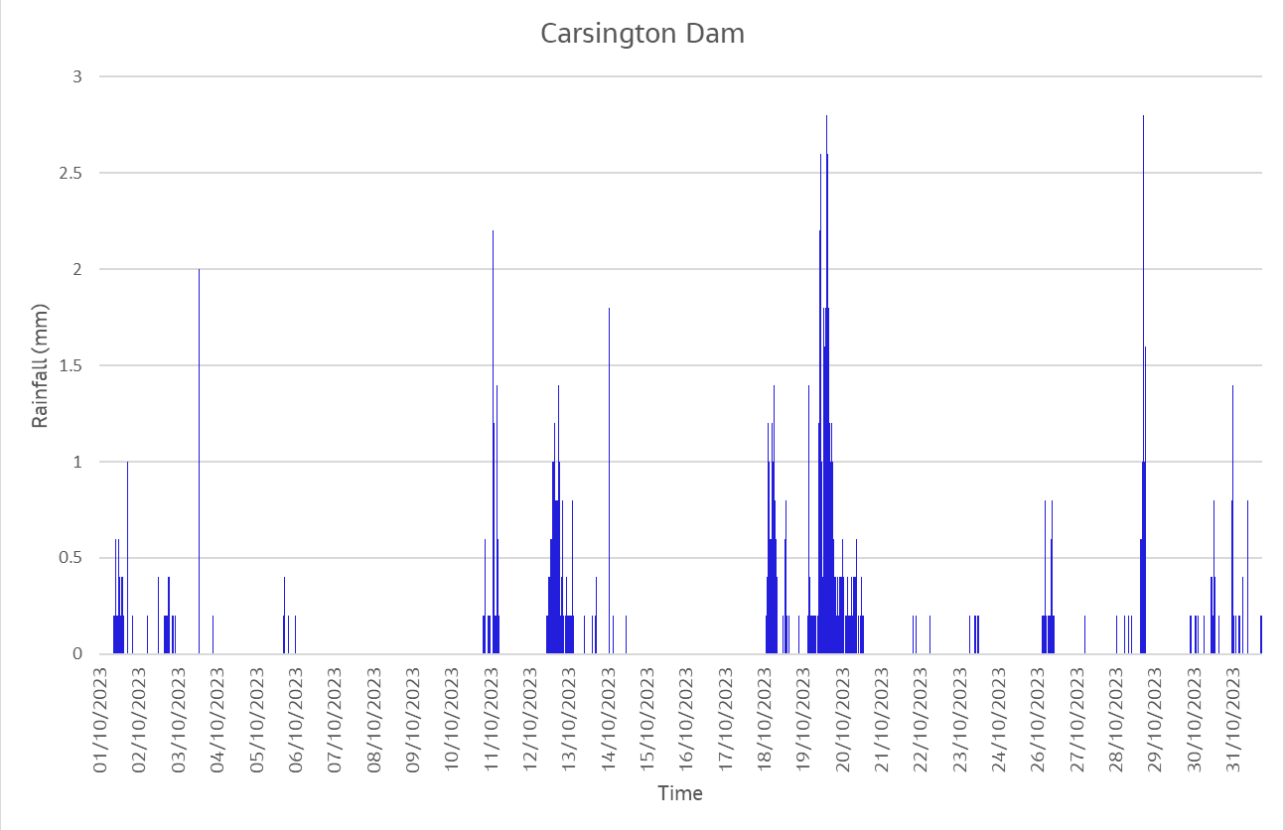

Figure 3-4: 15-minute rainfall data recorded in October 2023 at Carsington Dam rain gauge

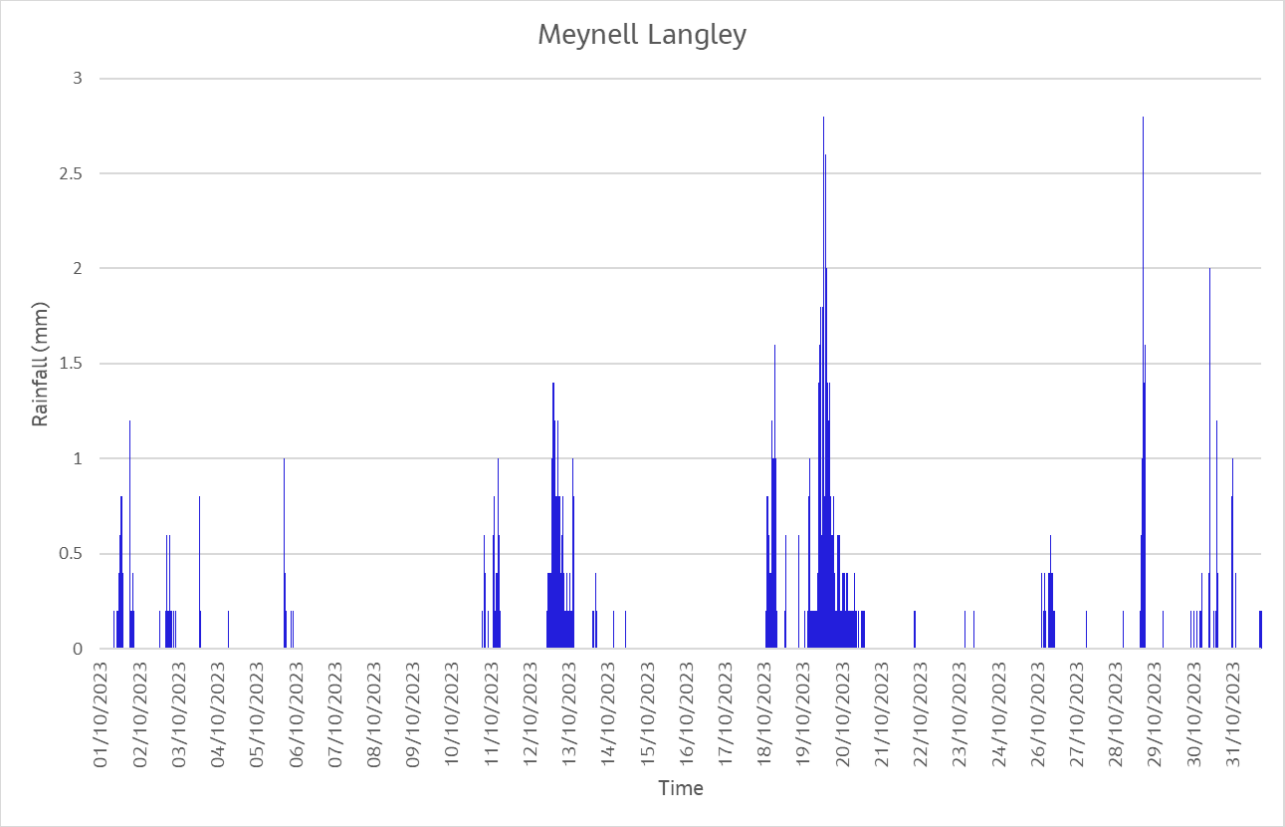

Figure 3-5: 15-minute rainfall data recorded in October 2023 at Meynell Langley rain gauge

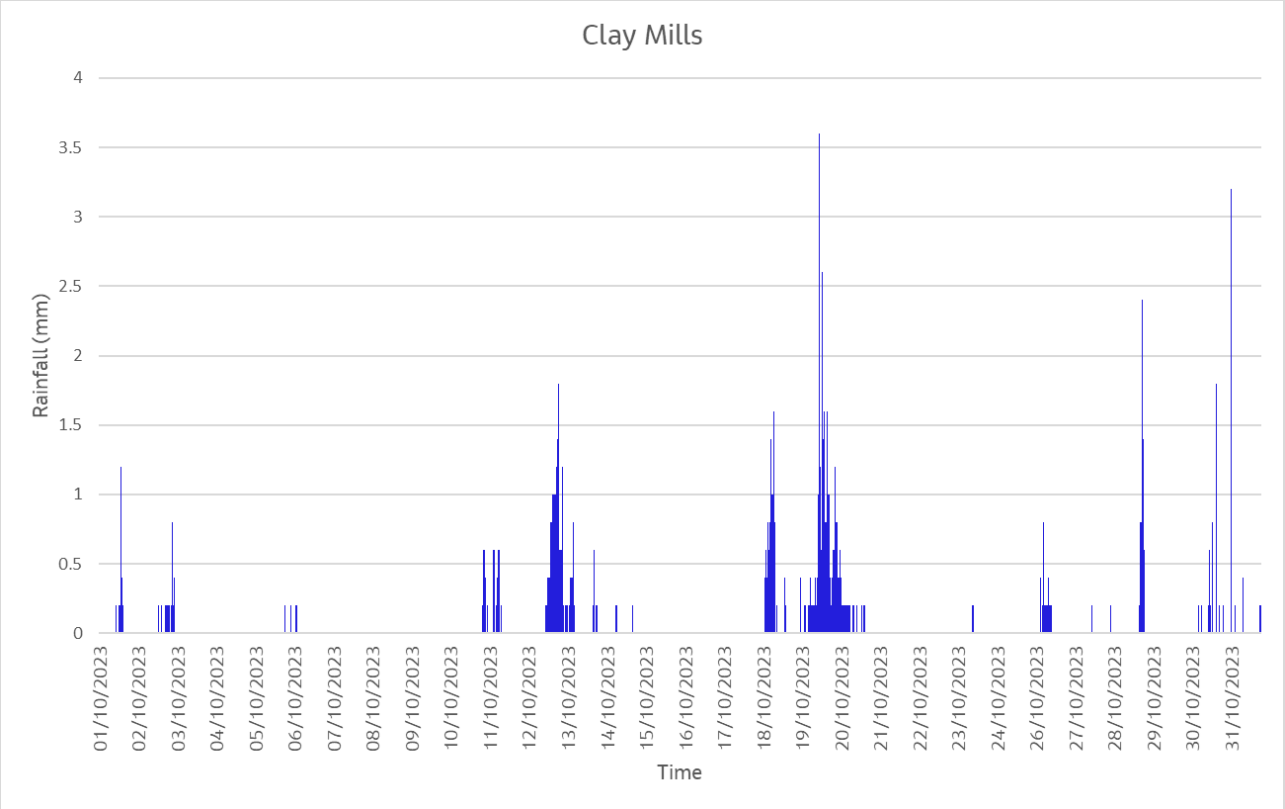

Figure 3-6: 15-minute rainfall data recorded in October 2023 at Clay Mills rain gauge

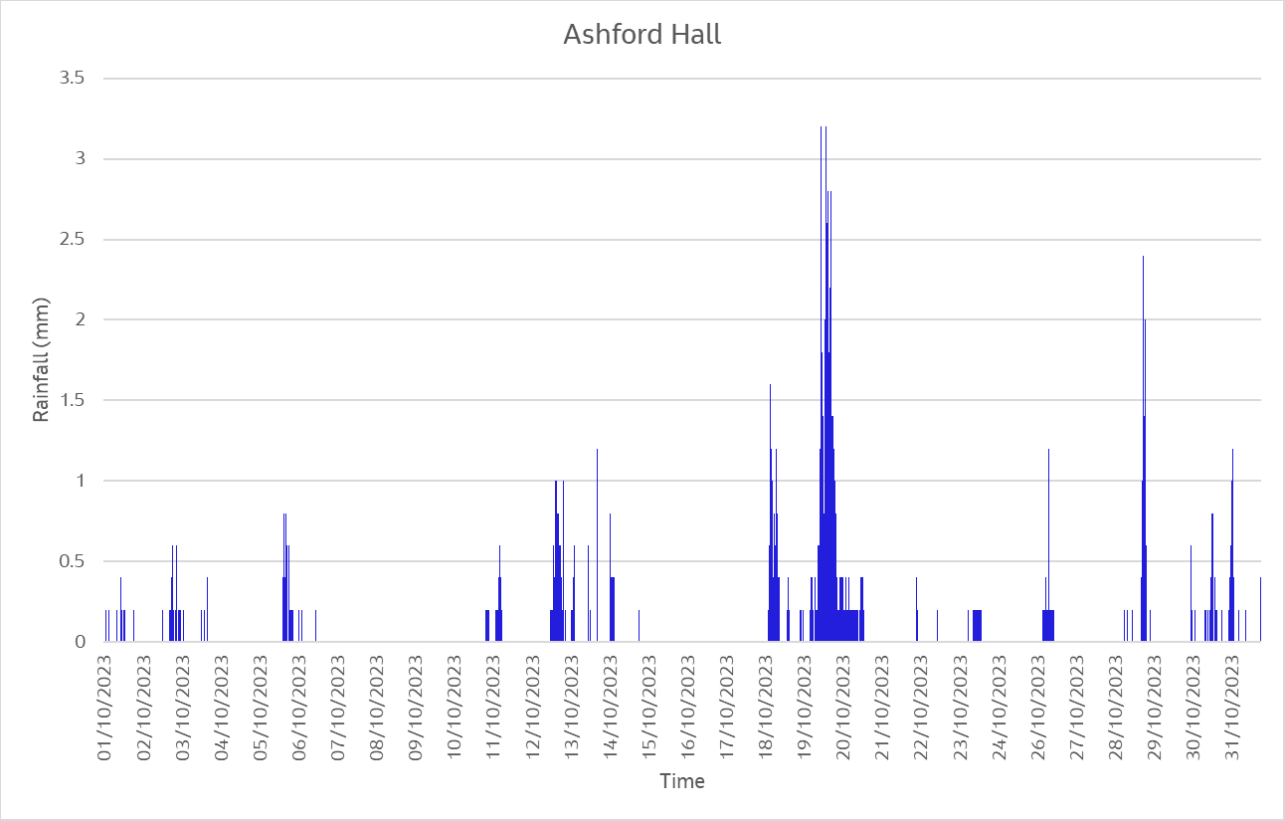

Figure 3-7: 15-minute rainfall data recorded in October 2023 at Ashford Hall rain gauge

Figure 3-3 to Figure 3-7 indicate a prolonged heavy rainfall event from the 18th to the 21st of October 2023. Table 3-1 indicates AEPs for the duration of Storm Babet and the most intense storm periods for rainfall recorded at each rainfall gauge. AEPs range from 4% at Clay Mills to the south of the sub-catchment to 2% at Carsington Dam.

The most intense period of rainfall recorded at each station was from 2:00am to 7:00pm on the 20th of October. Between 45 and 70mm of rainfall fell during this period equating to 55-69% of the total rainfall from Storm Babet. This corresponds to an AEP of 12% at Meynell Langley to the east of the sub-catchment and 3% at Ashford Hall to the north of the sub-catchment.

Table 3-1: Estimated Storm Babet AEPs: event totals and most intense rainfall period

Gauging Station	Rainfall total for Storm Babet (mm)	AEP (%)	Rainfall total recorded during peak of storm (mm)	Percentage of Storm Babet Rainfall (%)	AEP (%)
Ashbourne	90	3	50	56	9
Carsington Dam	97	2	60	62	7
Meynell Langley	82	3	45	55	12
Clay Mills	73	4	48	67	10
Ashford Hall	102	3	70	69	3

Table 3-2 indicates rainfall totals for Storm Babet account for 93% and 100% of LTA October rainfall total for Ashbourne and Carsington Dam stations respectively. Moreover, rainfall totals for Storm Babet exceeded the LTA October rainfall totals by 2-7% for Meynell Langley, Clay Mills and Ashford Hall stations.

Table 3-2: Total event rainfall for Storm Babet compared the long-term monthly average rainfall for October and annual average rainfall

Gauging Station	Rainfall total for Storm Babet (mm)	Percentage of LTA October rainfall (%)	Percentage of annual average rainfall (%)
Ashbourne	90	93	10

Carsington Dam	97	100	11
Meynell Langley	82	107	11
Clay Mills	73	102	11
Ashford Hall	102	106	11

3.1.3 River Gauge Records

Figure 3-1 illustrates there is only one Environment Agency river gauge within the Dove sub catchment. Ashbourne flow gauge is on the Henmore Brook, which is a tributary of the River Dove. All recorded flows and levels for the duration of Storm Babet have been checked by the Environment Agency.

Figure 3-8 plots the river response recorded during Storm Babet. It shows a large increase in river flow from the 18th of October 2023 lasting until the 22nd.

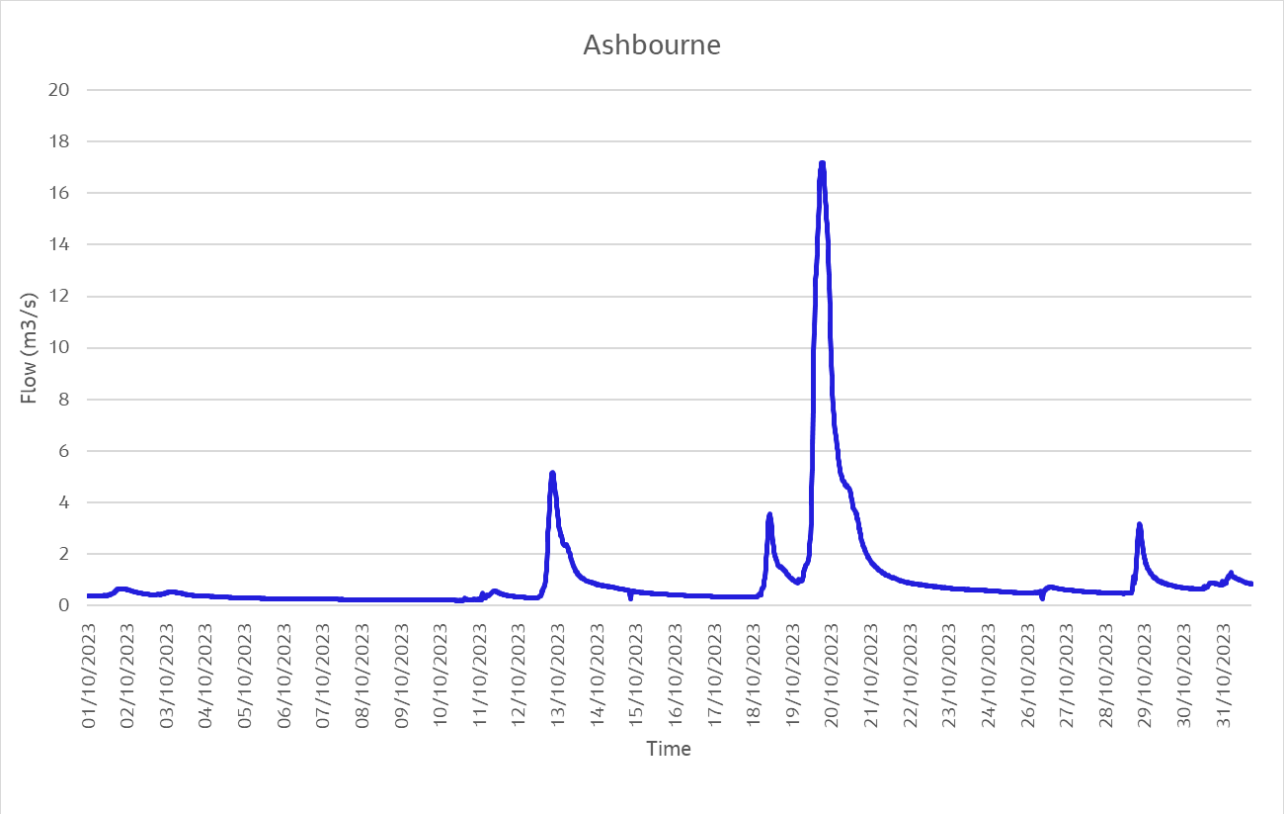

Figure 3-8: 15-minute river flow data recorded in October 2023 from Ashbourne gauging station

Figure 3-8 illustrates high flows were recorded at Ashbourne compared to the rest of October from 7:30pm on the 18th of October 2023 until 7:30pm on the 22nd. A peak flow of 17.2m3/s was recorded between 1:00pm and 1:45pm on the 20th. This is the second highest flow recorded in the station's 50-year history.

River flows align with the Environment Agency's monthly water situation report for October 2023, which found all river flow monitoring sites recorded above normal river flows across the Midlands. Table 3-3 summarises peak flow, timing and ranking of peak flow and gauging station length, indicating Storm Babet recorded the second highest river flow at Ashbourne. Ashbourne flow gauging station showed quite prolonged increases in flow from the 18th of October until the 22nd of October.

Table 3-3: Peak flow, peak level, timing and ranking of each peak and station data record length recorded at each station within the Dove sub-catchment.

Station	Peak Flow (m3/s)	Date and Time	Peak Flow Ranking	Station record length (years)
Ashbourne	17	20/10/2023 1:00pm-1:45pm	2	50

Figure 3-9 summarises the recorded rainfall and river response to Storm Babet from Ashbourne gauge.

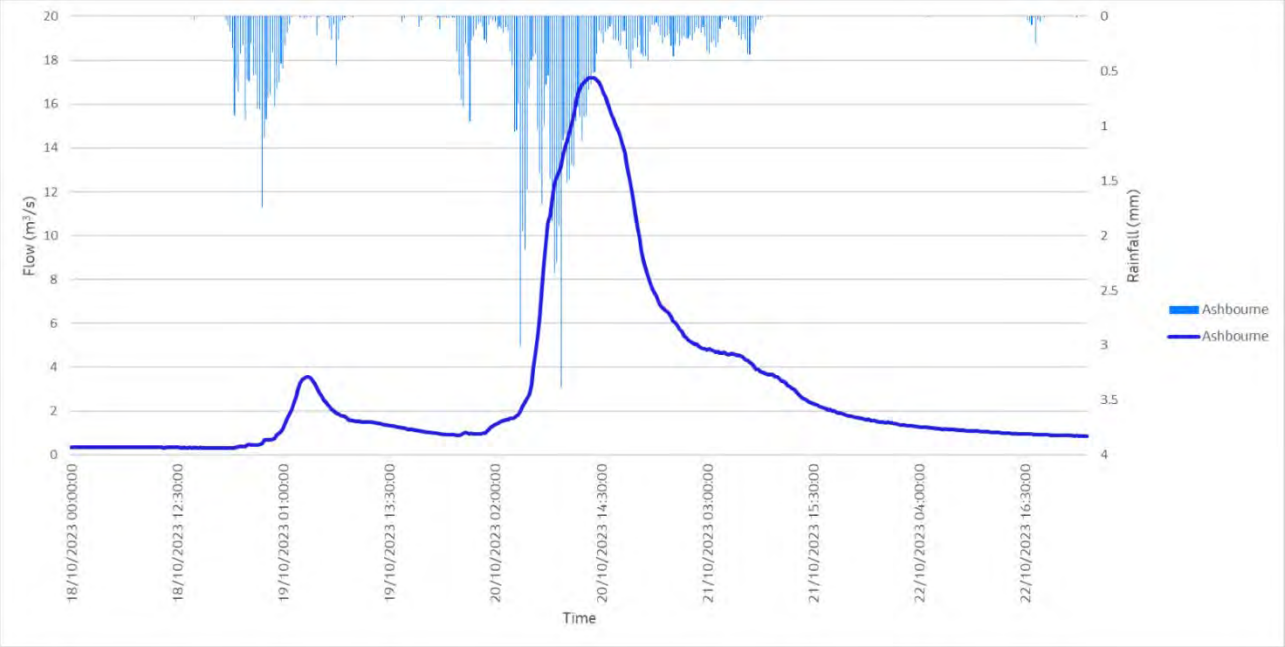

Figure 3-9: Hydrograph from the 18th to the 22nd of October illustrating recorded river flow data from Ashbourne gauging station and recorded rainfall data from Ashbourne rain gauge

Figure 3-9 indicates a lag of 3 hours between peak rainfall recorded at Ashbourne (3mm in 15 minutes) and peak river flow recorded at Ashbourne (17m3/s).

3.1.4 Groundwater Records

Figure 3-1 shows that only Via Gellia Environment Agency groundwater station is within the Derwent sub-catchment but the closest available data to the Dove sub-catchment. Hourly groundwater level data from October 2018 to March 2024 is provided in Figure 3-10. The bedrock at this station is limestone. All data until the 2nd of January 2024 has been checked by the Environment Agency.

As only one groundwater station is located adjacent to the Dove sub-catchment, it is important to recognise results discussed in this section may not be representative of the whole sub-catchment.

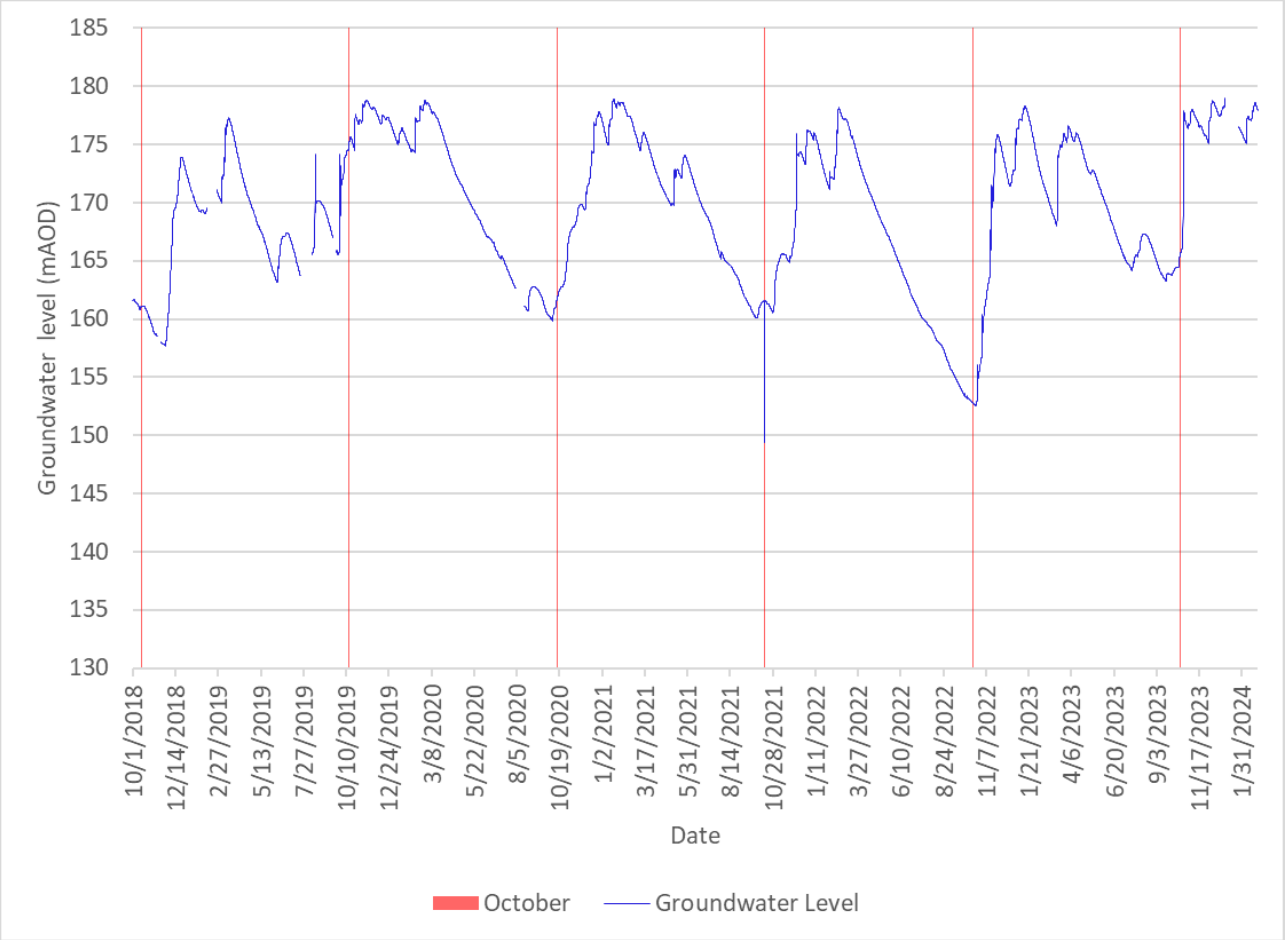

Figure 3-10: Via Gellia hourly groundwater levels from October 2018 to March 2024. The red line indicates October

Figure 3-10 indicates groundwater levels recorded in October 2023 are higher than levels recorded in the month of October over the preceding 5 years. A rapid increase in groundwater levels is evident in October 2023 in response to Storm Babet. Groundwater level achieved by the end of October 2023 was not reached until later months in the preceding years. Groundwater remains high from October 2023 to March 2024, which is a contrasting pattern to the rise in groundwater level experienced from October to March in 2018, 2020, 2021 and 2022. Groundwater levels likely remained constant due to natural recharge, which is evidenced in previous years after October by the rise in groundwater levels.

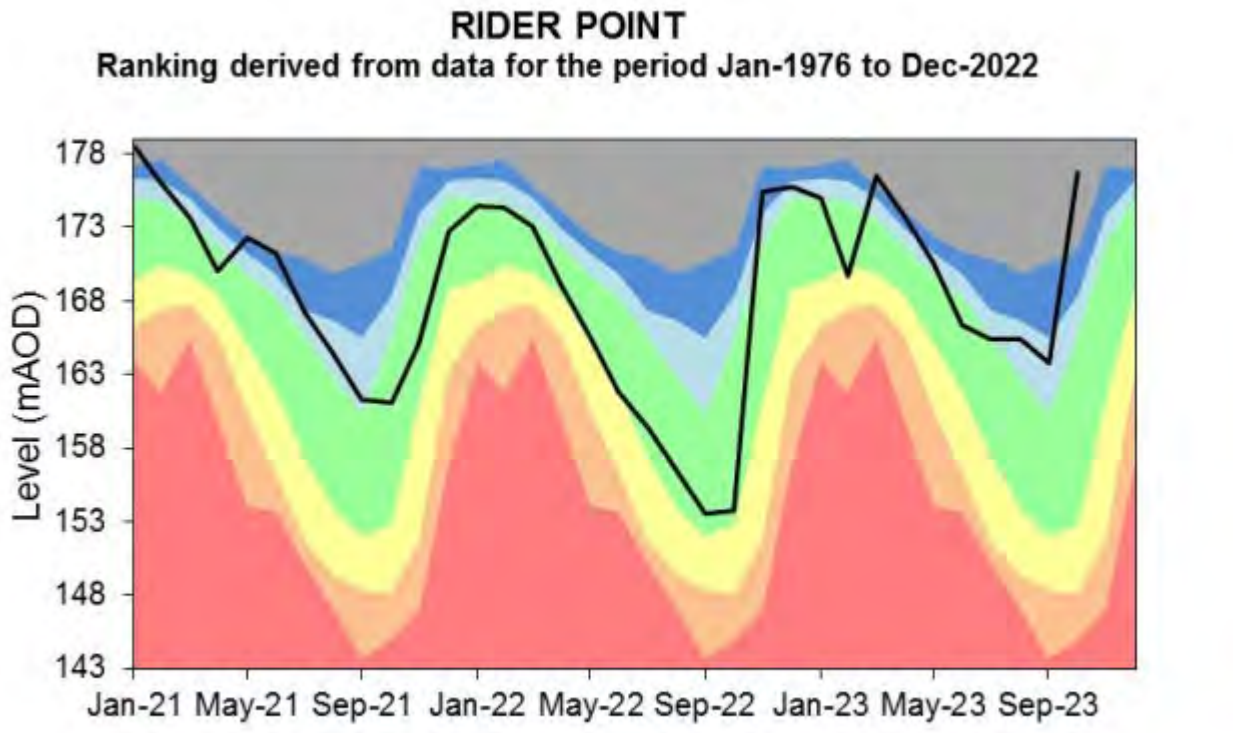

Figure 3-11: End of month groundwater levels at Via Gellia (here signed as Ryder Point) groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023

Figure 3-11 indicates groundwater levels at the end of October were exceptionally high compared to the LTA. This suggests at Via Gellia (Ryder Point) groundwater levels were raised considerably by Storm Babet.

3.1.5 Hydrological Summary

Overall, heavier rainfall was recorded to the east of the Dove sub-catchment compared to the west during Storm Babet. Rainfall peaked early on the 20th of October from 2:00am. The extremity and rarity of rainfall was similar across the catchment, with recorded rainfall equating to 2-4% AEP events at all stations.

Henmore Brook (Ashbourne flow gauging station) showed quite prolonged increases in flow from the 18th of October until the 22nd of October. The lag time between peak rainfall and peak flow was 3 hours. Ashbourne river flow gauging stations produced the second highest ranked flow on record in response to Storm Babet in October 2023.

High groundwater levels compared to the last 5 years were recorded at Via Gellia groundwater station for this time of year.

4. Idle and Torne Management Catchment

4.1 Idle and Torne Catchment Event Hydrology

4.1.1 Catchment Characteristics

The Idle and Torne sub-catchment referred to in this report is in the north-east of Derbyshire, covering the headwaters of the Rivers Poulter and Meden which meet the River Idle at Elkesley. The River Idle moves eastwards, joining with the River Trent at West Stockwith. Towns within this sub-catchment include Clowne and Shirebrook. The total extent of the Idle and Torne catchment is beyond the Derbyshire County boundary and is therefore not discussed in this report. The sub-catchment area within Derbyshire County is 90km^2.

There are few minor watercourses within the sub-catchment referred to in this report. In the north, Bondhay Dyke flows into the River Ryton near Whitwell Wood and Millwood Brook flows into the River Poulter through Creswell. The headwaters of the River Poulter are to the east of the sub-catchment in Langwith. In the south, Merril Sick flows into the River Meden near Pleasley. There are no large waterbodies within the sub-catchment. There are ponds to the north (Pebley Pond) and at Pleasley Pit County Park to the south.

The bedrock geology consists mostly of sedimentary dolostones, mudstones, siltstones and sandstones (Figure 4-2). Lime rich loamy soils, draining freely to groundwater, cover most of the sub-catchment. There are some sections of clayey soils with impeded drainage to the stream network to the north and east of the sub-catchment near Clowne, Shirebrook and Hodthorpe.

Key catchment descriptors for the river catchments of the Maun at Mansfield, Meden at Church Warsop, Poulter at Cuckney and Ryton at Worksop were examined to allow a comparison of each watercourse's expected response to heavy rainfall within the sub-catchment. Baseflow is similar across the whole catchment. There are few lakes and reservoirs that would cause attenuation of flows in any catchments. There is some urbanisation along the A61 corridor between Chesterfield and Clay Cross. Elsewhere, the catchment is largely rural. Average annual rainfall received is higher to the south and east of the catchment compared to the north.

Figure 4-1 indicates the sub-catchment extent in respect of the Derbyshire area in addition to the location of the groundwater, rainfall, river flow and level gauges used for hydrologic analysis for the sub-catchment. Only the Pleasley Chesterfield Road North level gauge on Meden River is located within the sub-catchment. It is noted the majority of these stations are outside the sub-catchment boundary referred to in this report. However, they are within the wider Idle and Torne catchment and will be representative of the hydrology within the report's sub-catchment.

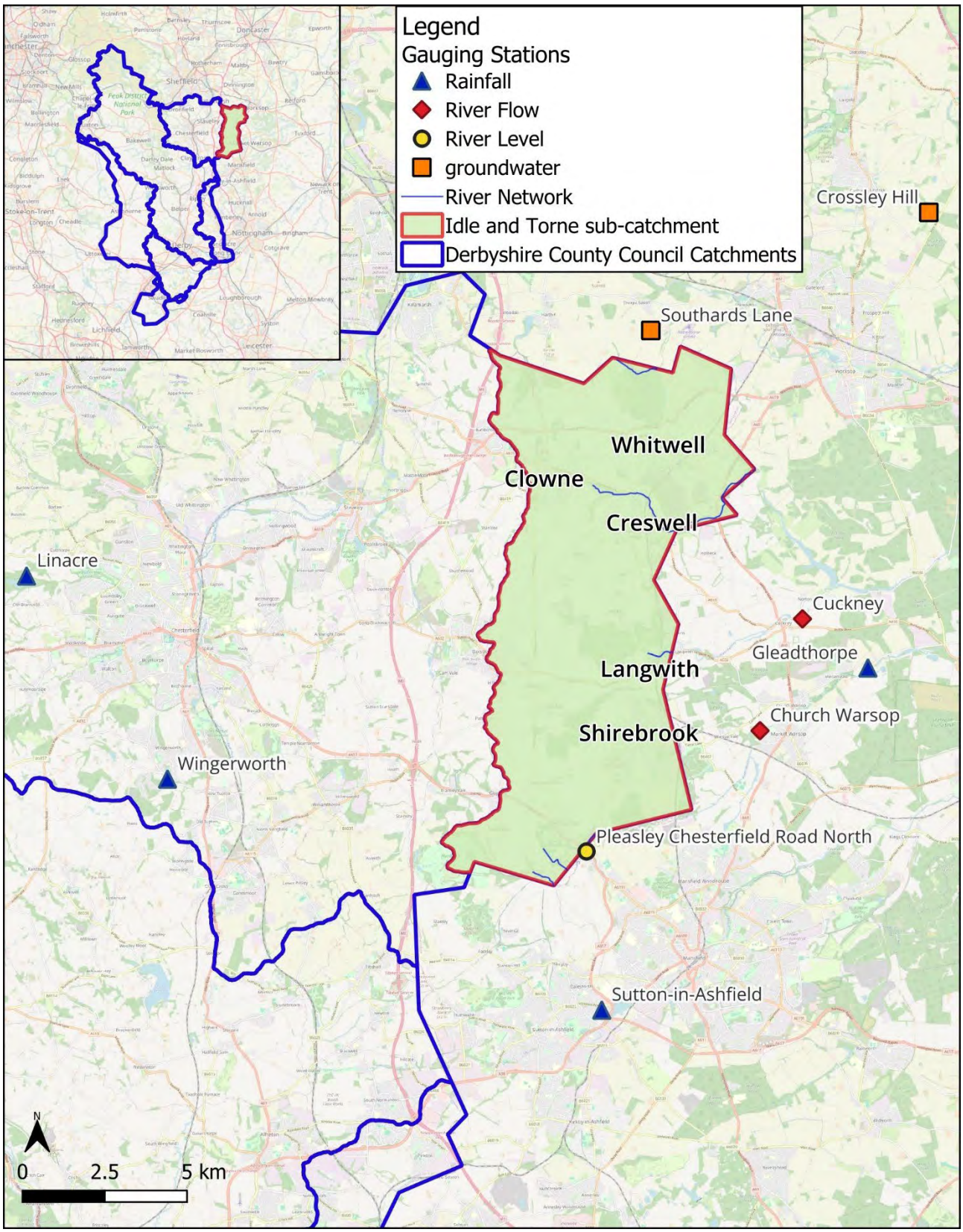

Figure 4-1: Catchment extent within Derbyshire County and groundwater, rainfall, river flow and river level gauges

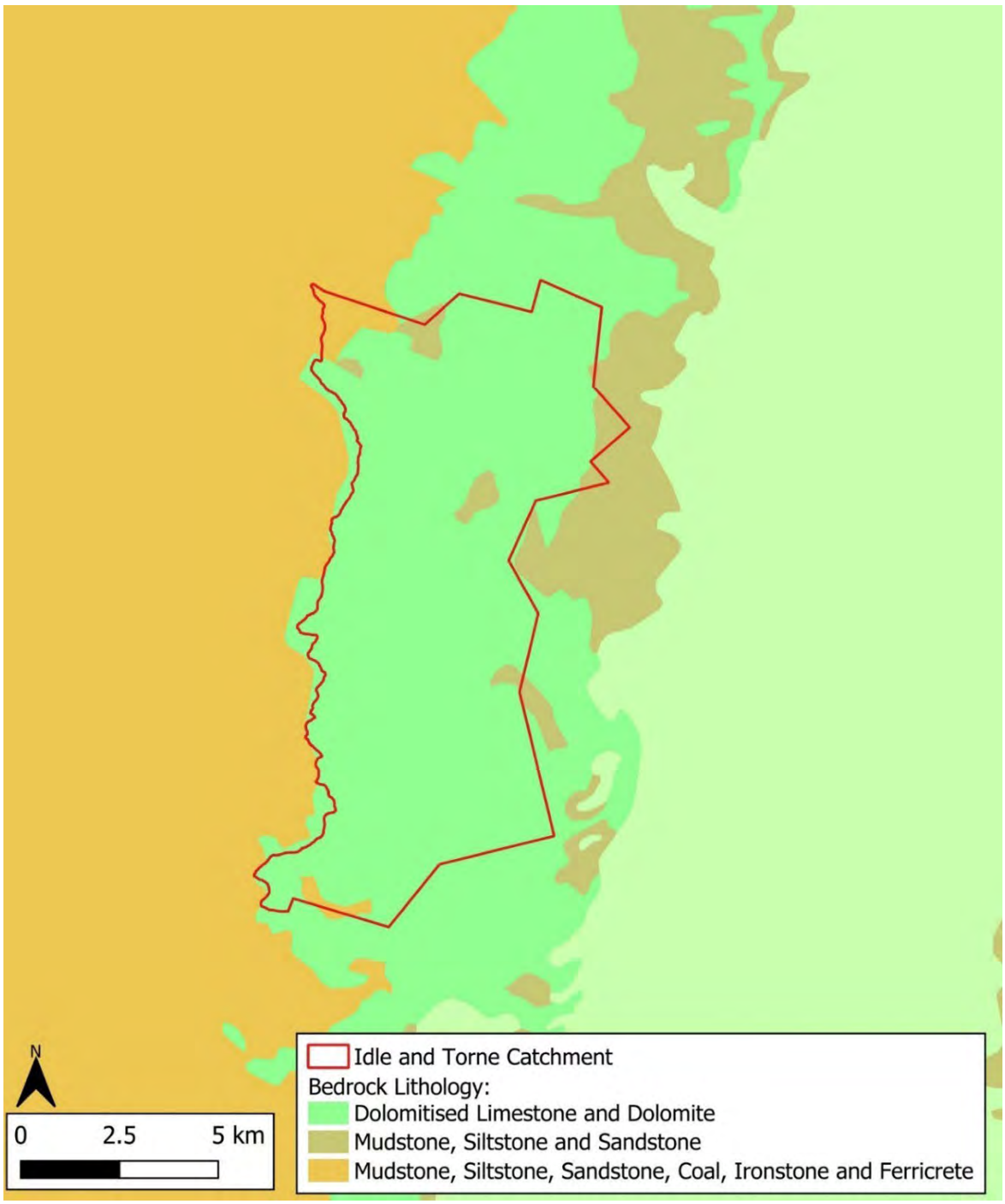

Figure 4-2: Bedrock lithology of the Idle and Torne (based on British Geological Survey 1:625,000-scale geological map)

4.1.2 Rainfall Records

Four Environment Agency rain gauges are near to the Idle and Torne sub-catchment, as indicated in Figure 4-1. The rainfall recorded at these gauges is displayed in Figure 4-3 to Figure 4-6. All rainfall depths recorded during Storm Babet have been checked by the Environment Agency.

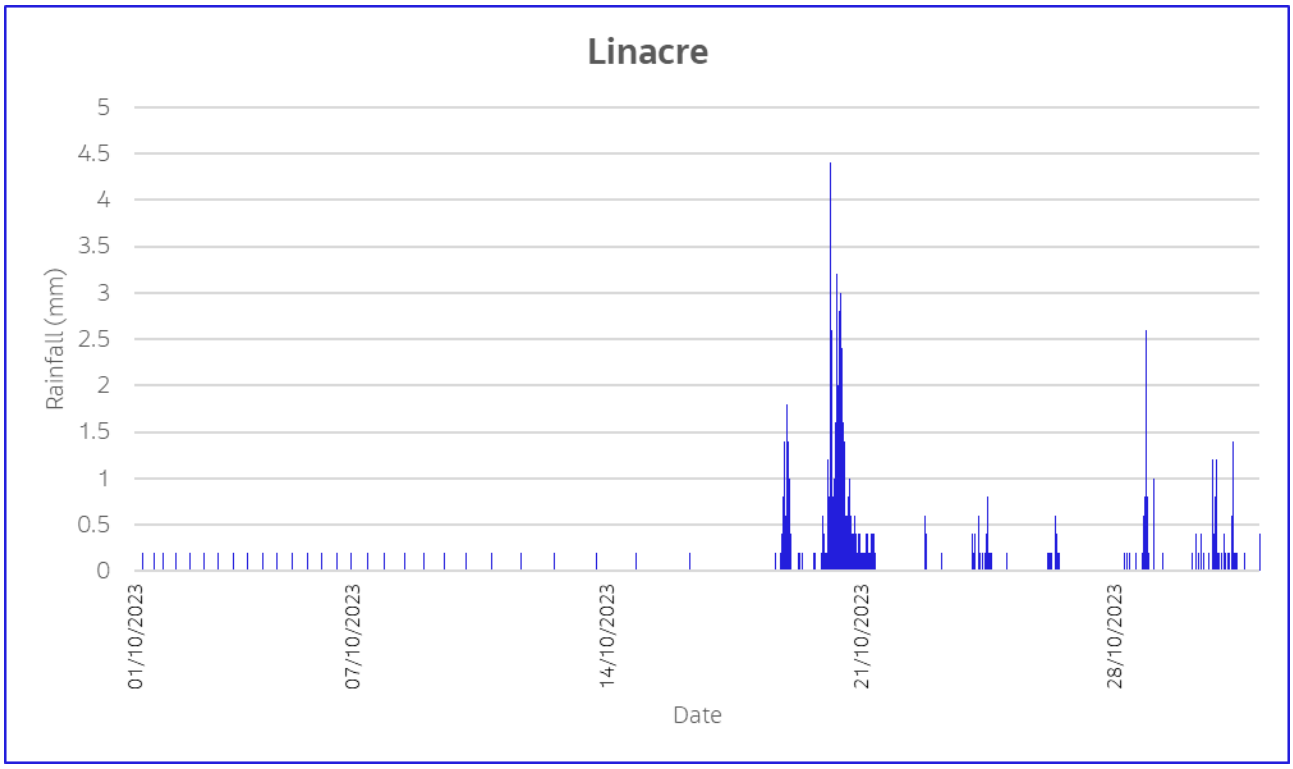

Figure 4-3: 15-minute rainfall data recorded in October 2023 at Linacre rain gauge

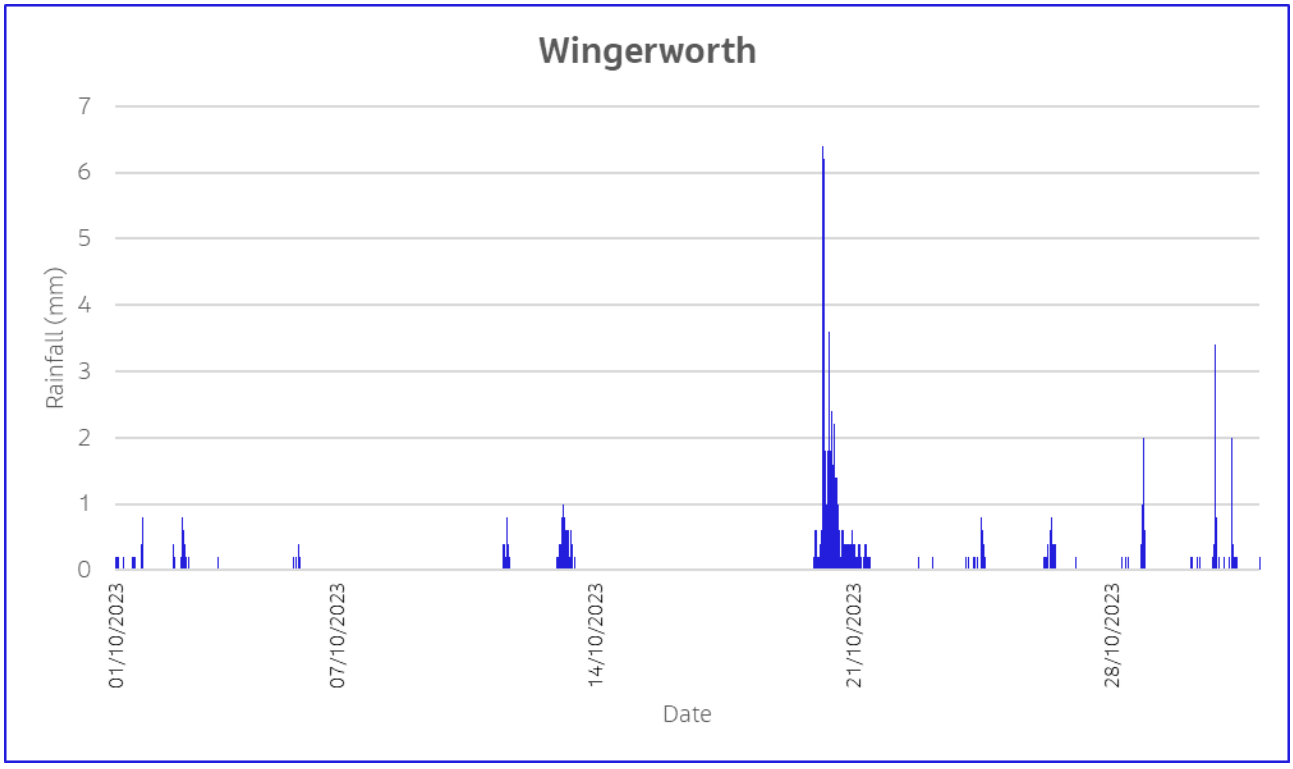

Figure 4-4: 15-minute rainfall data recorded in October 2023 at Wingerworth rain gauge

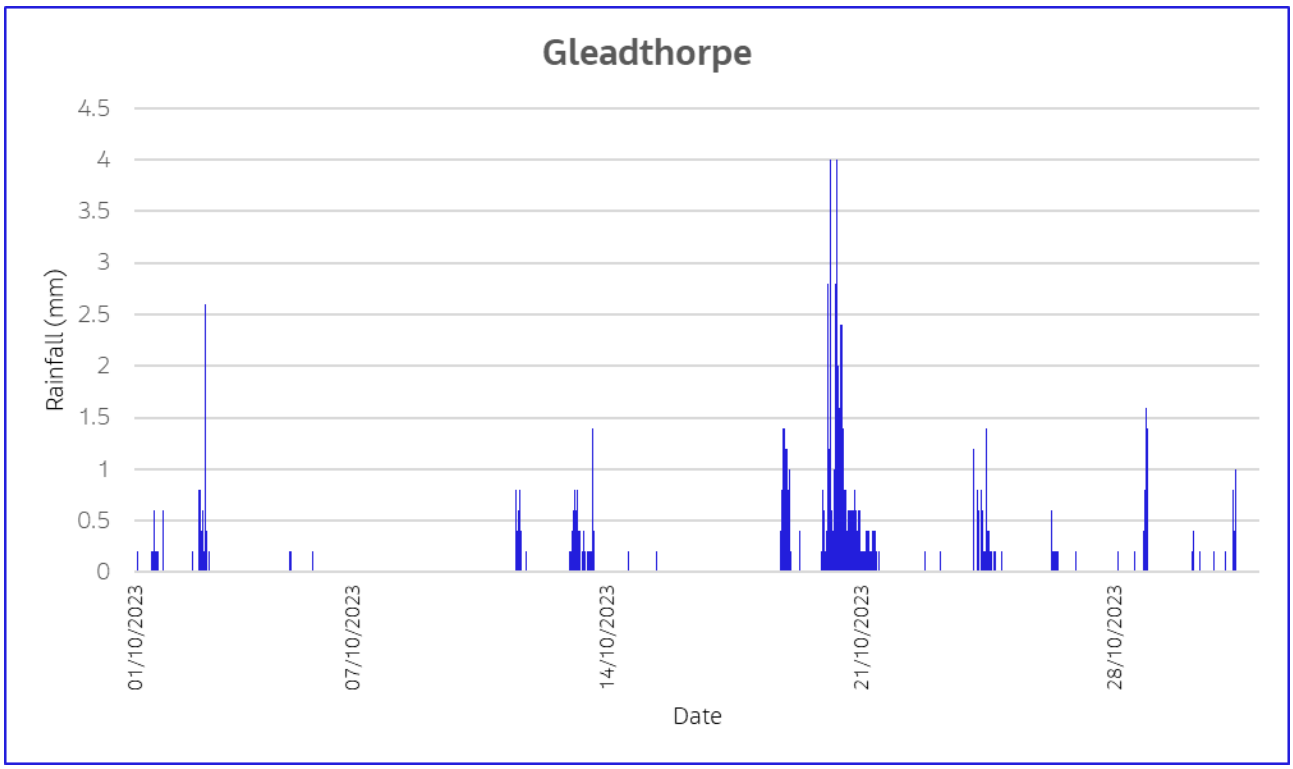

Figure 4-5: 15-minute rainfall data recorded in October 2023 at Gleadthorpe rain gauge

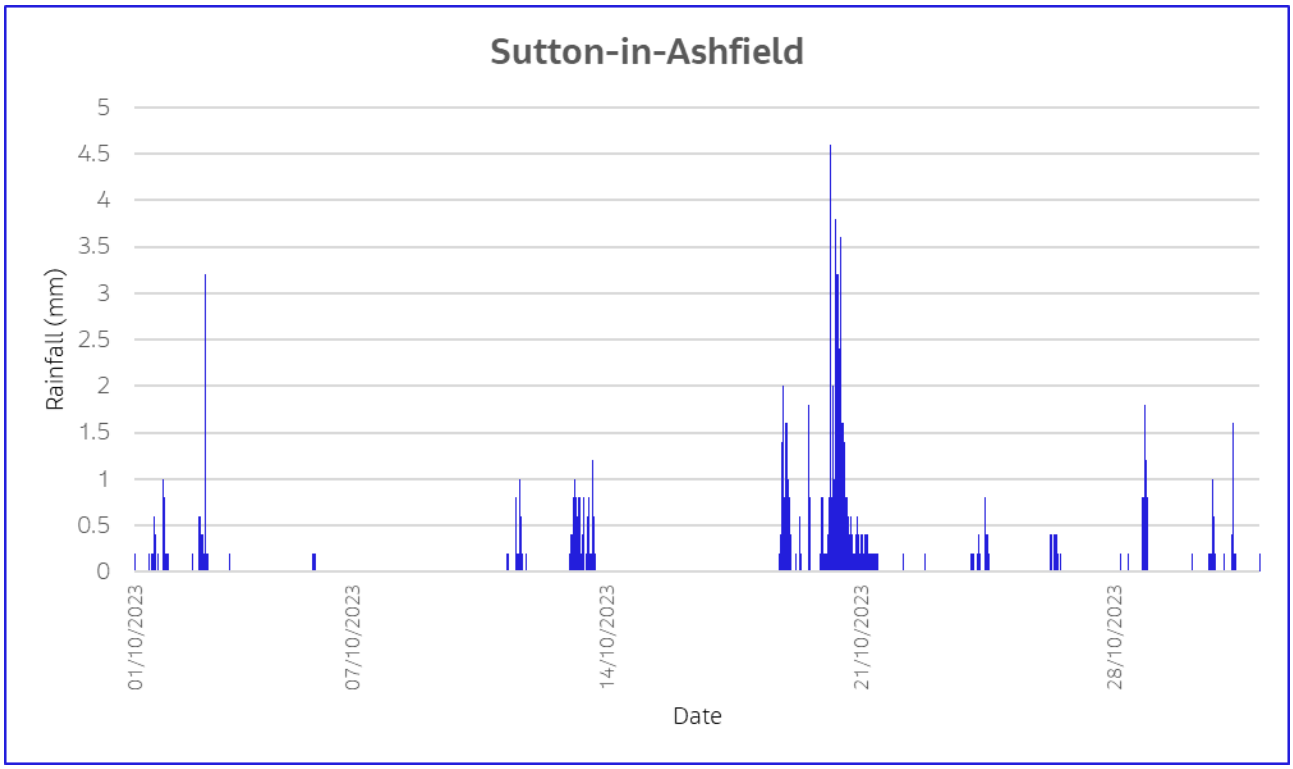

Figure 4-6: 15-minute rainfall data recorded in October 2023 at Sutton-in-Ashfield rain gauge

Figure 4-3 to Figure 4-6 indicate a prolonged heavy rainfall event from the 19th to the 21st of October. Table 4-1 indicates AEPs for the duration of Storm Babet and the most intense storm periods for rainfall recorded at each rainfall gauge. AEPs range from 2% at Linacre and 1% at Sutton-in-Ashfield.

The most intense period of rainfall recorded at each station was from 1:45am to 11:15pm on 20th of October. Between 55 and 77mm of rainfall fell during this period equating to 59-74% of the total rainfall from Storm Babet. This corresponds to an AEP of between 5% at Linacre and 1% at Sutton-in-Ashfield. Although the stations are located outside of the sub-catchment referred to in this report, results indicate towns across the sub-catchment including Clowne, Shirebrook, Whitwell, Pleasley, Creswell and Langworth would have experienced extreme rainfall during Storm Babet.

Table 4-1: Estimated Storm Babet AEPs: event totals and most intense rainfall period

Gauging Station	Rainfall total for Storm Babet (mm)	AEP (%)	Rainfall total recorded during peak of storm (mm)	Percentage of Storm Babet Rainfall (%)	AEP (%)
Gleadthorpe	91	1	67	74	3
Sutton-in-Ashfield	94	1	77	82	1
Linacre	92	2	54	59	5
Wingerworth	97	1	71	74	1

Table 4-2 indicates 7-14 % of annual average rainfall fell during Storm Babet. Rainfall totals for Storm Babet exceeded the LTA October rainfall totals by 6-20%.

Table 4-2: Total event rainfall for Storm Babet compared to the long-term monthly average rainfall for October and annual average rainfall.

Gauging Station	Rainfall total for Storm Babet (mm)	Percentage of LTA October rainfall (%)	Percentage of annual average rainfall (%)
Gleadthorpe	91	120	14
Sutton-in-Ashfield	94	121	7
Linacre	92	106	11
Wingerworth	97	108	12

Overall, rainfall distribution across the Idle and Torne catchment was relatively uniform. Peak rainfall was experienced at all stations at 3:45am-4:15am on the 20th of October.

4.1.3 River Gauge Records

Figure 4-1 illustrates there are four Environment Agency river flow gauges and three river level gauges surrounding, and in, the Idle and Torne sub-catchment. Although most stations are not located within the sub-catchment, they give an indication of the severity of the runoff produced by the storm to downstream locations. Furthermore, stations are located within the wider Idle and Torne catchment and will be representative of hydrology within the sub-catchment referred to in this report. Church Warsop flow gauge and Pleasley Chesterfield Road North level gauge are on the upper reaches of the River Meden. Cuckney flow gauge is on the River Poulter. All recorded flows at Church Warsop have been checked by the Environment Agency. Flows and levels recorded during Storm Babet at Cuckney and Chesterfield Road North have not been checked by Environment Agency.

Figure 4-7 to Figure 4-9 plot river responses recorded during Storm Babet. They show a large increase in river flow or level from the 20th to the 23rd of October.

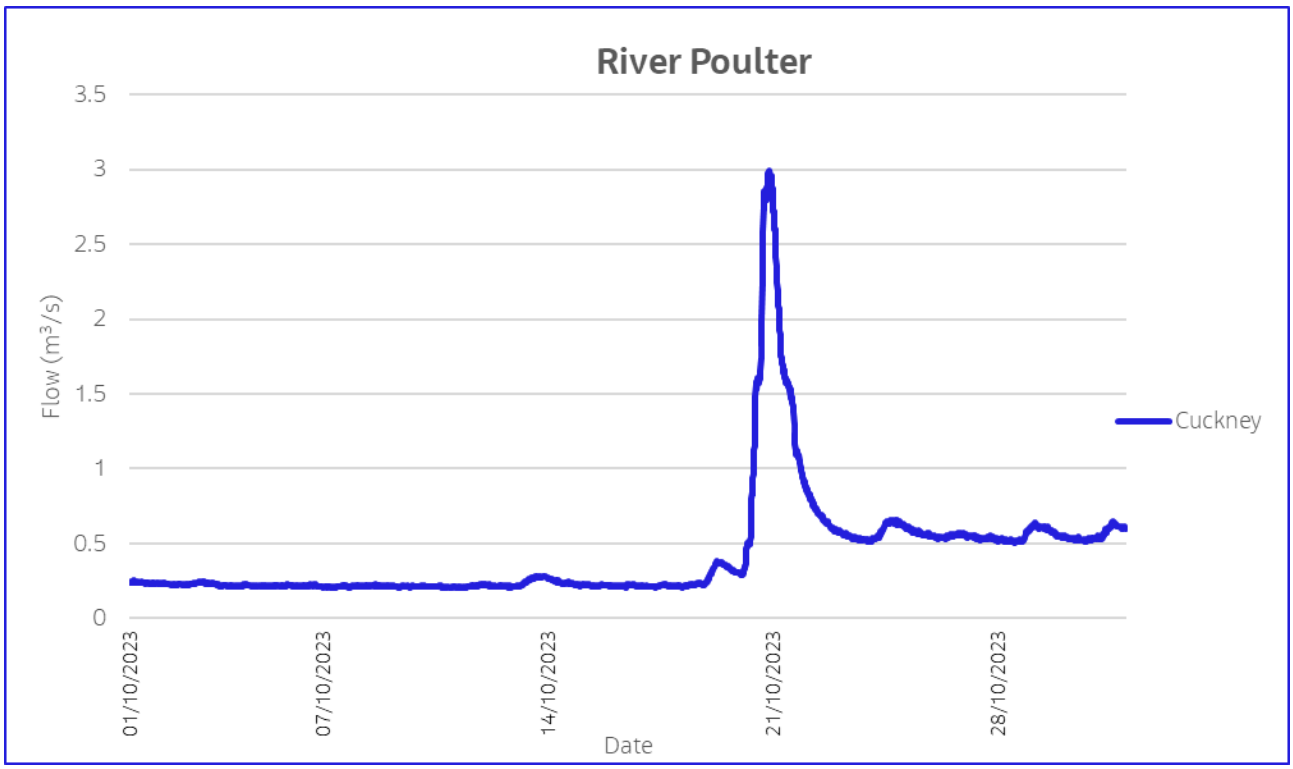

Figure 4-7: 15-minute river flow data recorded in October 2023 from Cuckney gauging station on the River Poulter

Figure 4-7 illustrates high flows were recorded at Cuckney compared to the rest of October from 5:45am on the 20th of October 2023 until 6:45pm on the 22nd. A peak flow of 3m3/s was recorded at 9:45pm on the 20th of October. This is the highest flow recorded in the station's 55-year history. However, it should be noted data was unchecked by the Environment Agency during Storm Babet and results should be taken with caution.

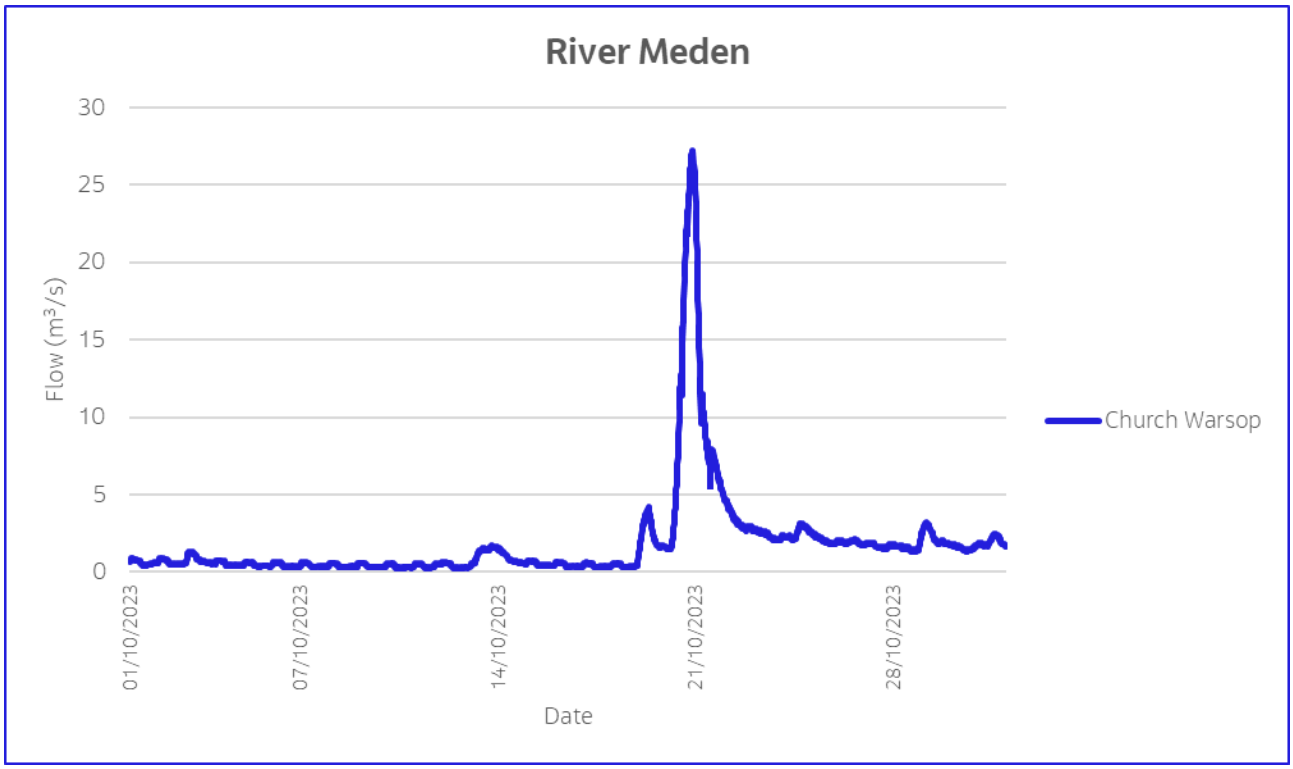

Figure 4-8: 15-minute river flow data recorded in October 2023 from Church Warsop gauging station on the River Meden

Figure 4-8 illustrates high flows were recorded at Church Warsop compared to the rest of October from 7:00am on the 20th of October 2023 until 2:30am on the 23rd. A peak flow of 27.2m3/s was recorded at 10:00pm on the 20th of October. This is the highest flow recorded in the station's 59-year history.

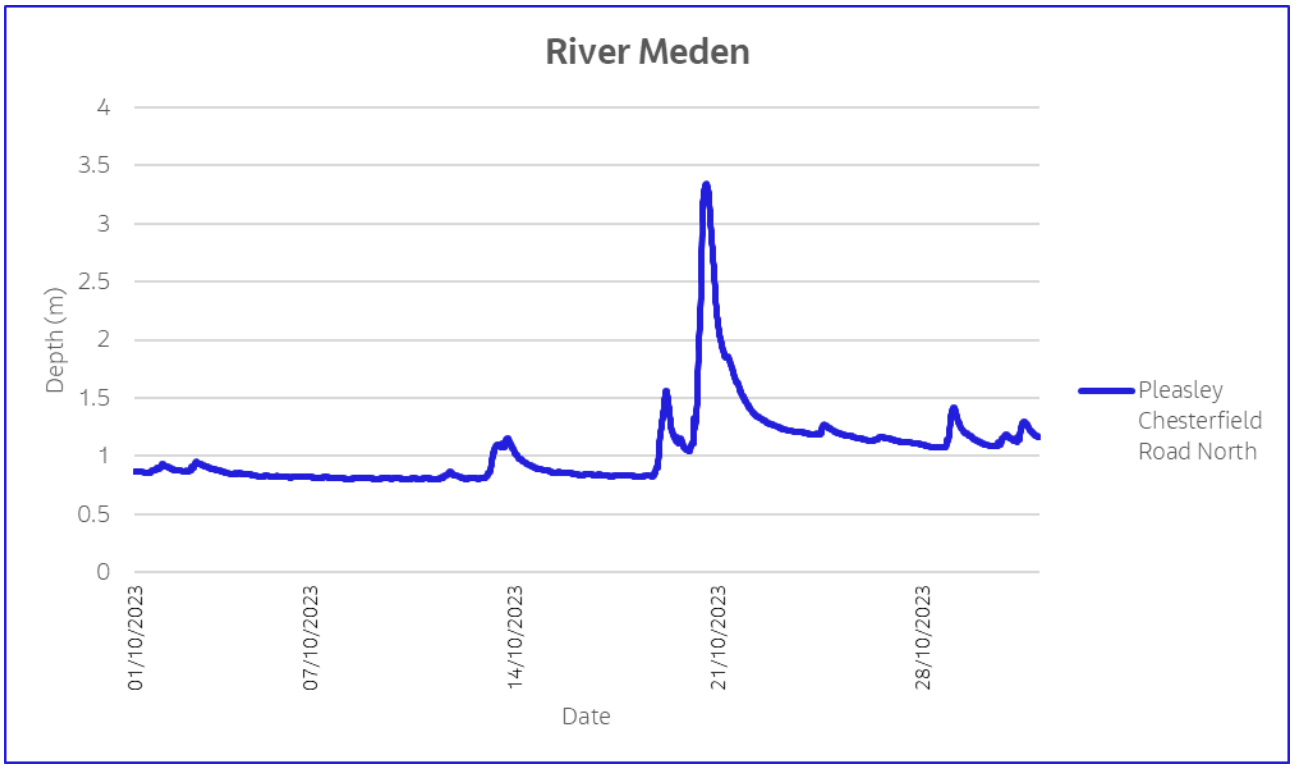

Figure 4-9: 15-minute river level data recorded in October 2023 from Pleasley Chesterfield Road North gauging station on the River Meden

Figure 4-9 illustrates high levels were recorded at Pleasley Chesterfield Road North compared to the rest of October from 5:00am on the 20th of October 2023 until 1:30am on the 23rd. A peak level of 3.3m was recorded at 2:30pm on the 20th of October 2023. This is the highest level recorded in the station's short 2-year history. However, it should be noted data was unchecked during Storm Babet and results should be taken with caution.

Overall, river flows align with the Environment Agency monthly water situation report for October 2023, which found all river flow monitoring sites recorded above normal river flows across the Midlands. Table 4-3 summarises peak flow, timing and ranking at each station, indicating Storm Babet recorded the highest river flows and levels at each station.

Quick and short increases in flow were recorded on the River Poulter at Cuckney. Church Warsop and Pleasley Chesterfield Road North, on the River Meden, showed more prolonged increases in flow from the 20th to the 23rd of October.

The first station to peak was Pleasley Chesterfield Road North at 2:30pm on the 20th of October. Later peaks in flow were recorded at Church Warsop and Cuckney gauging stations from 9:45pm-10:00pm on the 20th of October.

Table 4-3: Peak flow, peak level, timing and ranking of each peak and station data record length recorded at each station within the Idle and Torne sub-catchment.

	Peak Flow (m3/s)	Date and Time	Peak Flow Ranking	Station record length (years)
Cuckney	3	20/10/2023 9:45am	1	55
Church Warsop	27	20/10/2023 10:00pm	1	59
Station	**Peak Level (m)**	**Date and Time**	**Peak Level Ranking**	**Station record length (years)**
Pleasley Chesterfield Road North	3.3	20/10/2023 2:30pm	1	2

Figure 4-10 and Figure 4-11 summarise the recorded rainfall and river response to Storm Babet from gauges across the sub-catchment.

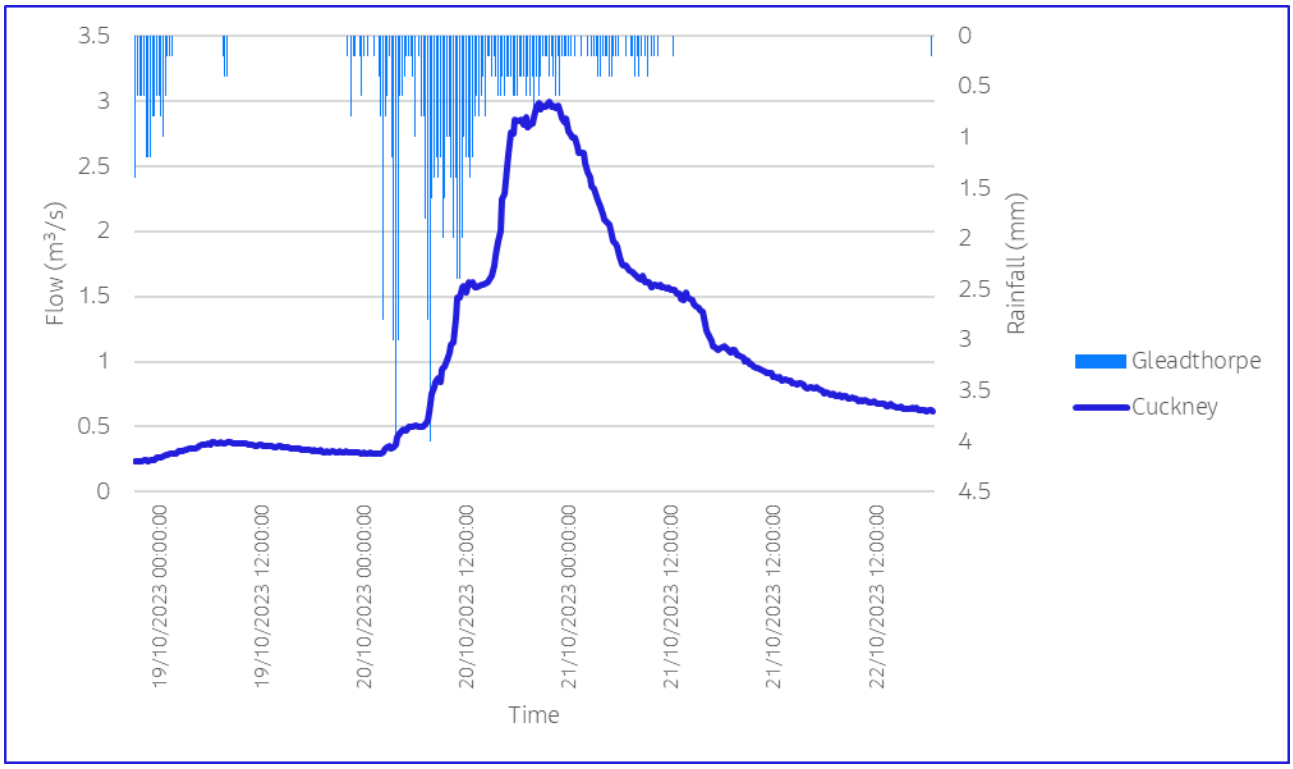

Figure 4-10: Hydrograph from the 19th to the 22nd of October illustrating recorded river flow data from Cuckney gauging station and recorded rainfall data from Gleadthorpe rain gauge

Figure 4-10 indicates a lag of 18 hours between peak rainfall recorded at Gleadthorpe (4mm in 15 minutes) and peak river flow recorded at Worksop (3m³/s).

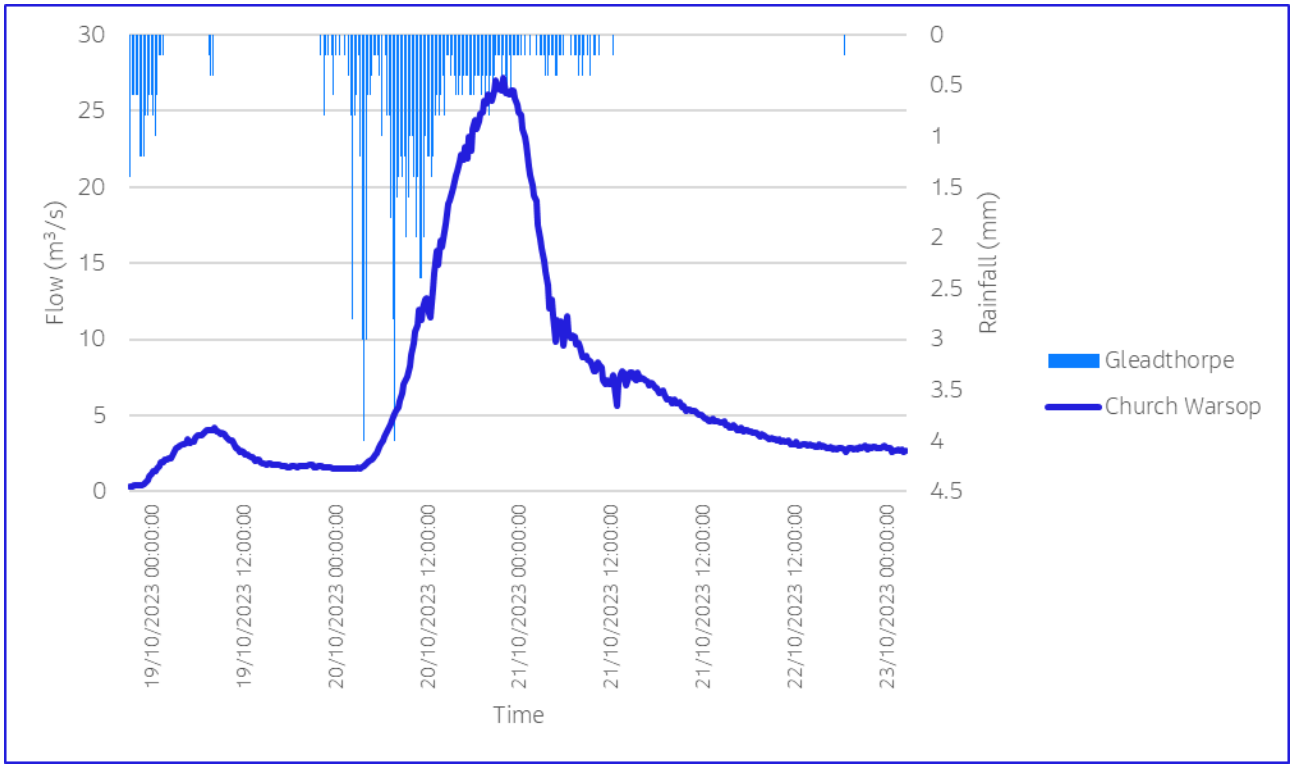

Figure 4-11: Hydrograph from the 19th to the 23rd of October illustrating recorded river flow data from Church Warsop gauging station and recorded rainfall data from Gleadthorpe rain gauge

Figure 4-11 indicates a lag of 18 hours between peak rainfall recorded at Gleadthorpe (4mm in 15 minutes) and peak river flow recorded at Church Warsop (27m3/s).

4.1.4 Groundwater Records

Figure 4-1 shows there are two Environment Agency groundwater stations located within proximity to the Idle and Torne catchment, Southards Lane (immediately to the north) and Crossley Hill to the north-east. Hourly groundwater level data from October 2018 to March 2024 is provided in Figure 4-12 and Figure 4-14. The Bedrock at Southards Lane is sedimentary Dolostone and all data until the 23rd of December 2023 has been checked by the Environment Agency. The Bedrock at Crossley Hill is sandstone and all data until the 6th of February 2024 has been checked by the Environment Agency. There are sections of missing data from 2019 and 2020.

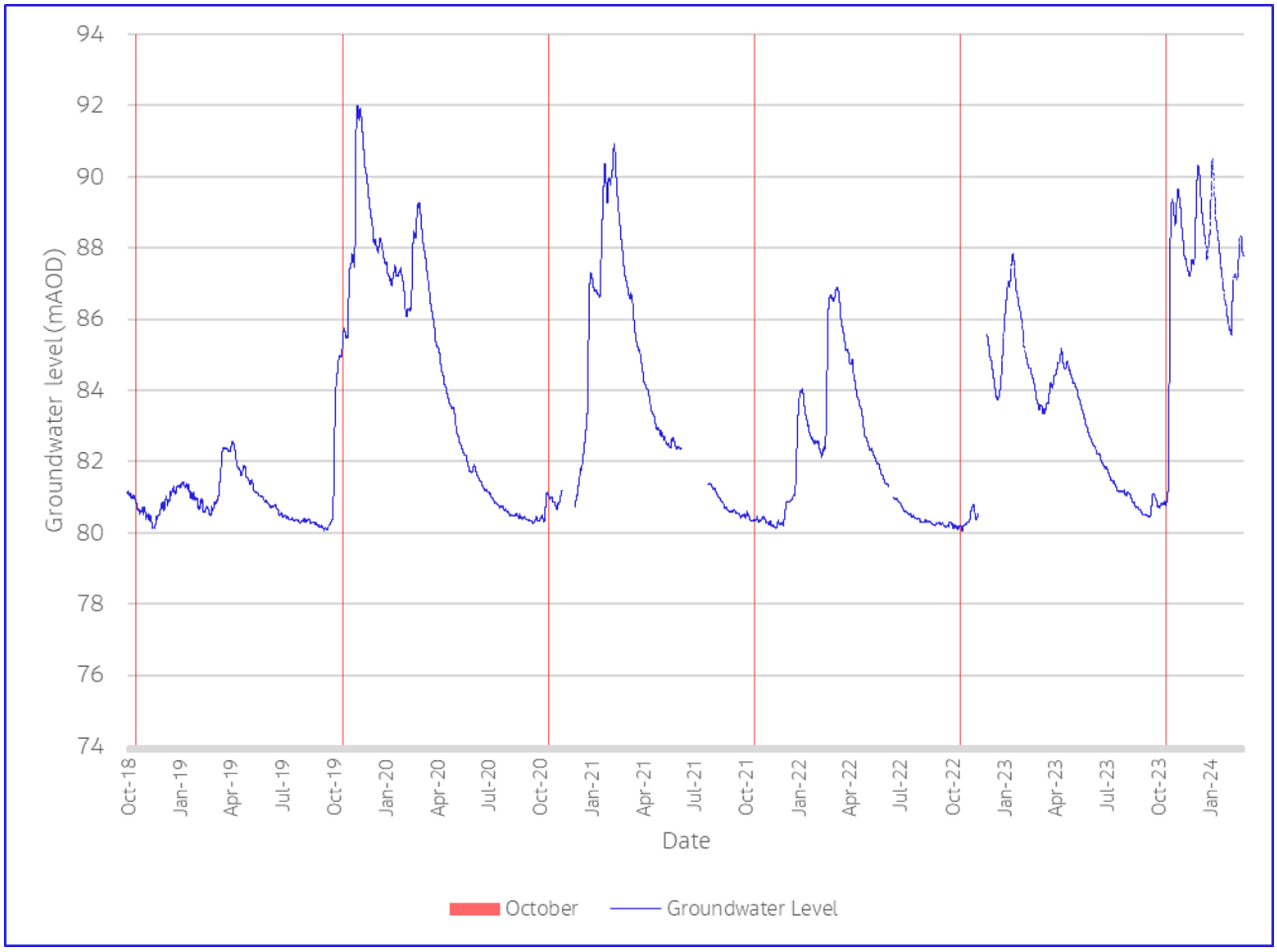

Figure 4-12: Southards Lane hourly groundwater levels from October 2018 to March 2024. The red line indicates October

Figure 4-12 indicates groundwater levels recorded in October 2023 are higher than levels recorded in the month of October in the preceding years. A rapid increase in groundwater levels is evident in October 2023 in response to Storm Babet. The groundwater level recorded by the end of October 2023 was not achieved until November in 2019 and January in 2021. Groundwater level in October 2023 exceeds annual peak groundwater level in 2022.

Groundwater remains high from October 2023 to March 2023 which is a contrasting pattern to the rise in groundwater level experienced from October to March in 2018, 2020, 2021 and 2022. Groundwater levels likely remained constant due to natural recharge, which is evidenced in previous years after October by the rise in groundwater levels.

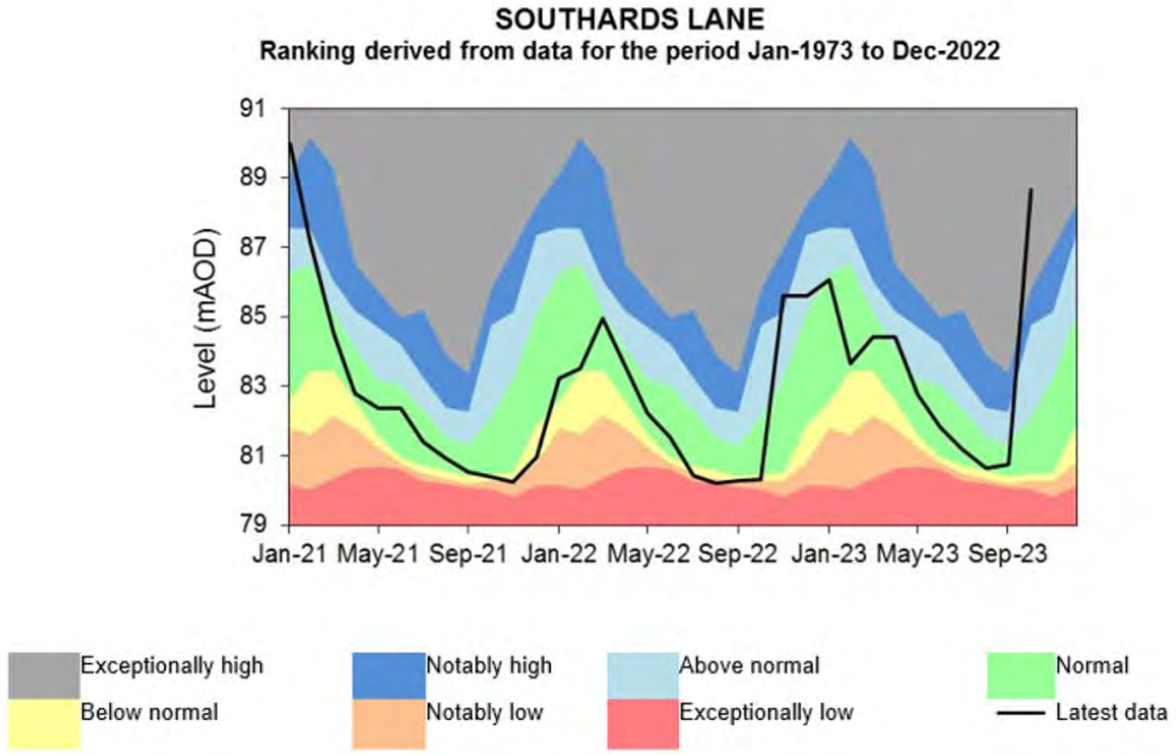

Figure 4-13: End of month groundwater levels at Southards Lane groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023[3]

Figure 4-13 indicates groundwater levels at the end of October were exceptionally high compared to the LTA. This suggests Southards Lane groundwater levels were raised by Storm Babet.

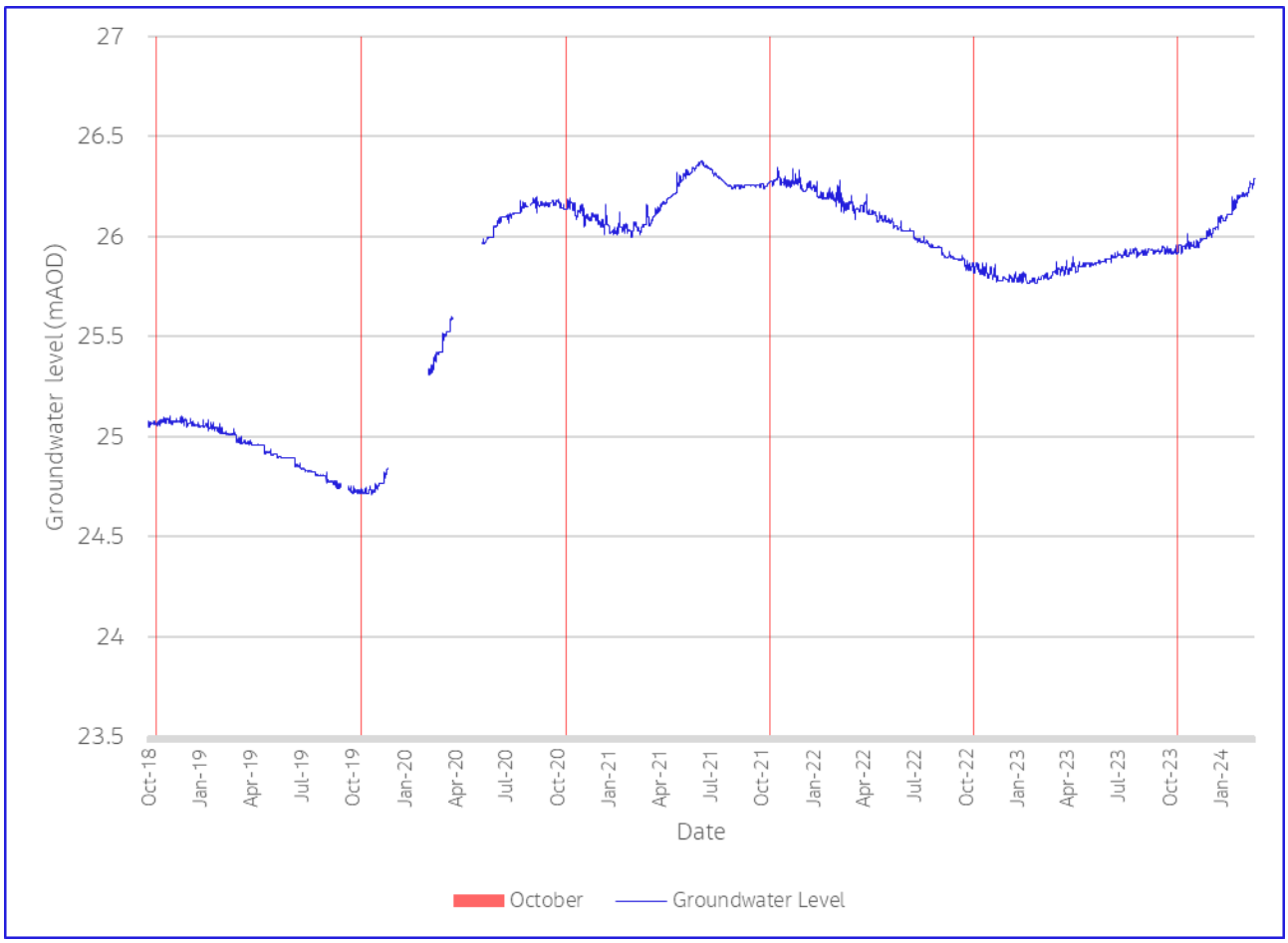

Figure 4-14: Crossley Hill hourly groundwater levels from October 2018 to March 2024. The red line indicates October

Figure 4-14 indicates a rise in groundwater levels after October 2023 at Crossley Hill which contrasts to the fall in groundwater levels evident after October 2018, 2020, 2021 and 2022. However, groundwater levels do not show any seasonality across the five-year period, with a typical minimum annual variation of <0.5m. There is a rise in early 2020 by 1m which may be due to a prolonged period of notably high rainfall. Therefore, the rise after October 2023 may be due to notably high rainfall across the month. However, this rise may also be due to natural recharge.

Groundwater levels recorded in October 2023 are similar to groundwater levels recorded in October in the preceding years. The Environment Agency monthly water situation report for October 2023 indicates groundwater levels at Crossley Hill were normal compared to the LTA for October (Figure 4-15).

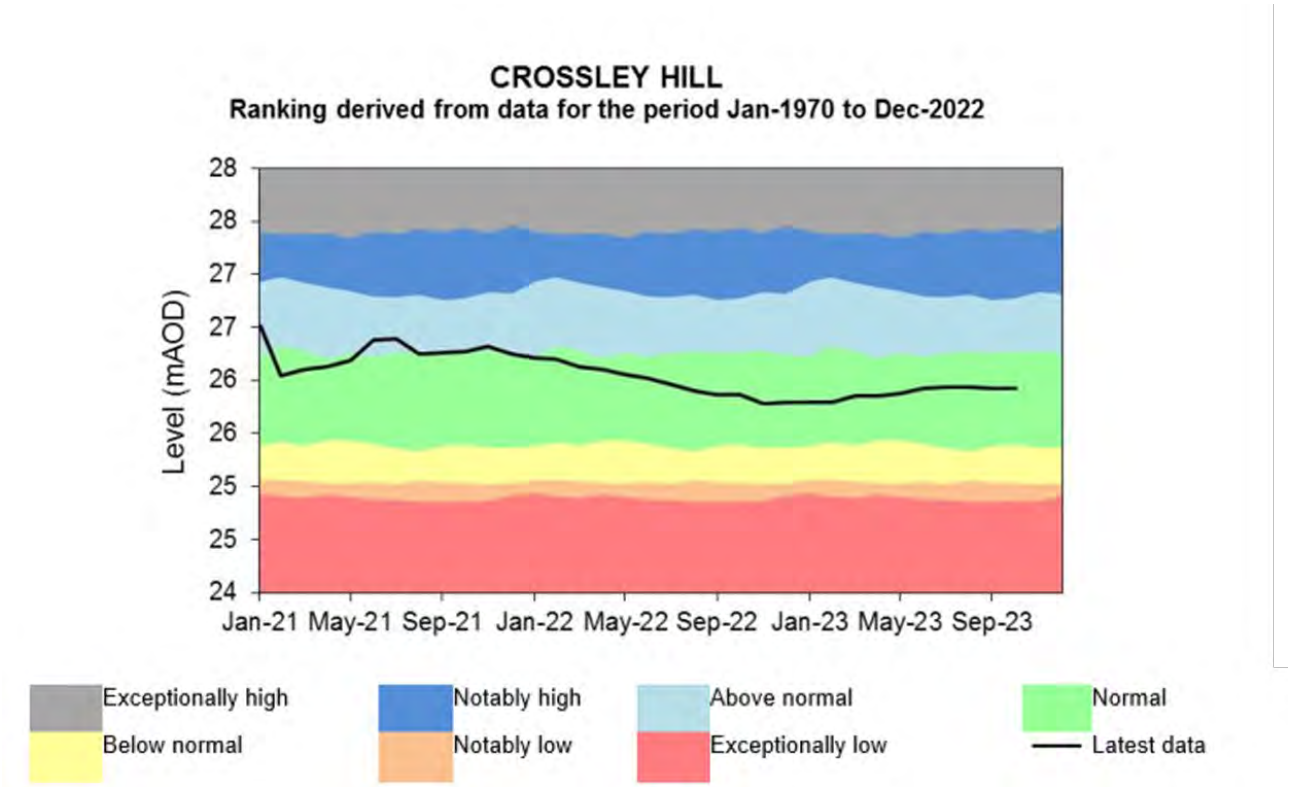

Figure 4-15: End of month groundwater levels at Crossely Lane groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023[4]

4.1.5 Hydrological Summary

Overall, similar rainfall levels were recorded across the Idle and Torne sub-catchment during Storm Babet. Rainfall peaked early on the 20th of October from 3:45am to 4:15am. Total rainfall recorded equated to 1-2% AEP events with the most intense rainfall equating to 1-5% AEP events. Stations recording earlier responses to heavy rainfall are located to the south of the sub-catchment on the upper reaches of the Rivers Maun and Meden. Stations peaking later are located to the east and north of the sub-catchment on the middle reaches of the River Meden, River Poulter and River Ryton. Flashier river responses to heavy rainfall were recorded on the River Poulter at Cuckney. Prolonged increases in flow and levels were recorded on the River Meden from the 20th to 23rd of October.

Long lag times of 18 hours between peak rainfall and peak flow were recorded at all stations from 9:45pm-10:00pm on the 20th of October. All stations surrounding the Idle and Torne catchment produced the highest ranked flows or levels on record in response to Storm Babet in October 2023.

High groundwater levels for October compared to the last five years were recorded at Southards Lane. However, groundwater levels recorded at Crossley Hill were in line with previous October levels.

5. Trent Lower and Erewash Management Catchment

5.1 Trent Lower and Erewash Catchment Event Hydrology

5.1.1 Catchment Characteristics

Only a small part of the total River Trent catchment is located within Derbyshire and included in the Trent Lower and Erewash sub-catchment referred to in this report. The Lower Trent catchment is in the south of Derbyshire while the Erewash catchment is to the east. Figure 5-1 indicates the sub-catchment extent in respect of the Derbyshire area, in addition to showing the location of the groundwater, rainfall, river flow and level gauges within or near the sub-catchment.

The total of the River Trent included in this sub-catchment extends from the Trent's confluence with the River Dove near Burton-on-Trent to the Trent's confluence with the River Derwent, south of Derby. The River Trent passes through Willington, Twyford, Barrow upon Trent and Aston-on-Trent. The sub-catchment referred to in this report has an area of 334km^2.

The River Erewash is a small urban catchment flowing south from Kirkby in Ashfield, through Pinxton, Langley Mill, Ilkeston, Sandiacre and Long Eaton before entering the Attenborough Nature Reserve. The lakes at this nature reserve outflow to the River Trent. The main tributaries include Nethergreen, Bailey, Nut and Gilt Brooks.

Large waterbodies within the sub-catchment include those at Church Wilne water treatment works on the left bank of the River Trent. In the middle region of the Erewash sub-catchment Shipley Lake and Mapperley Reservoir are located on the upper Nut Brook, a tributary of the River Erewash. At the south of the sub-catchment, the River Erewash flows into the Trent via lakes at the Attenborough Nature Reserve. Breaston Storage Lagoon is located on the Golden Brook immediately upstream of the M1.

Figure 5-2 indicates bedrock geology consists mostly of Triassic and Carboniferous mudstones, siltstones and sandstones. Soil types range from slightly acidic and loamy to clayey. Drainage is variable ranging from impeded to free draining. Water drains to groundwater, stream and river networks. The dominant land use is rural, grassland and arable with most urban areas focused within the River Erewash section of the sub-catchment.

Key catchment descriptors for the river catchments of the Trent at Shardlow and the Erewash at Sandiacre were examined to allow a comparison each watercourse's response to heavy rainfall within the sub-catchment. The River Trent has a higher baseflow index indicating a higher proportion of river flow is composed of groundwater storage than the River Erewash. This indicates the River Erewash section of the sub-catchment is more responsive to overland runoff. Few lakes and reservoirs that would cause attenuation of flows are present in either catchment. There is little urbanisation across the whole river catchments, although the sub-catchment study area contains southern Derby, in the Lower Trent and Long Eaton and Ilkeston in the Erewash catchment. The annual average rainfall received is similar across the two catchments.

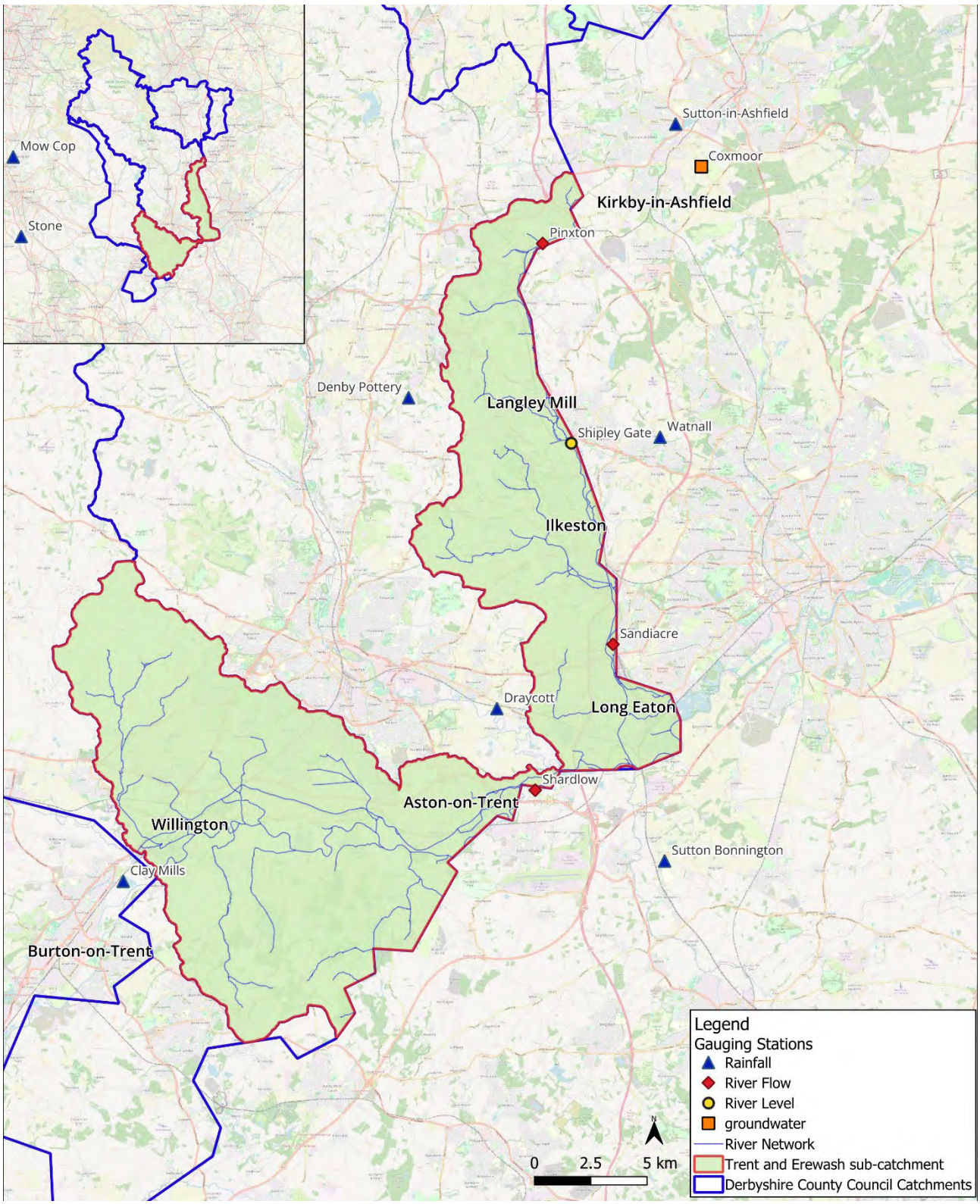

Figure 5-1: Catchment extent and groundwater, rainfall, river flow and river level gauges

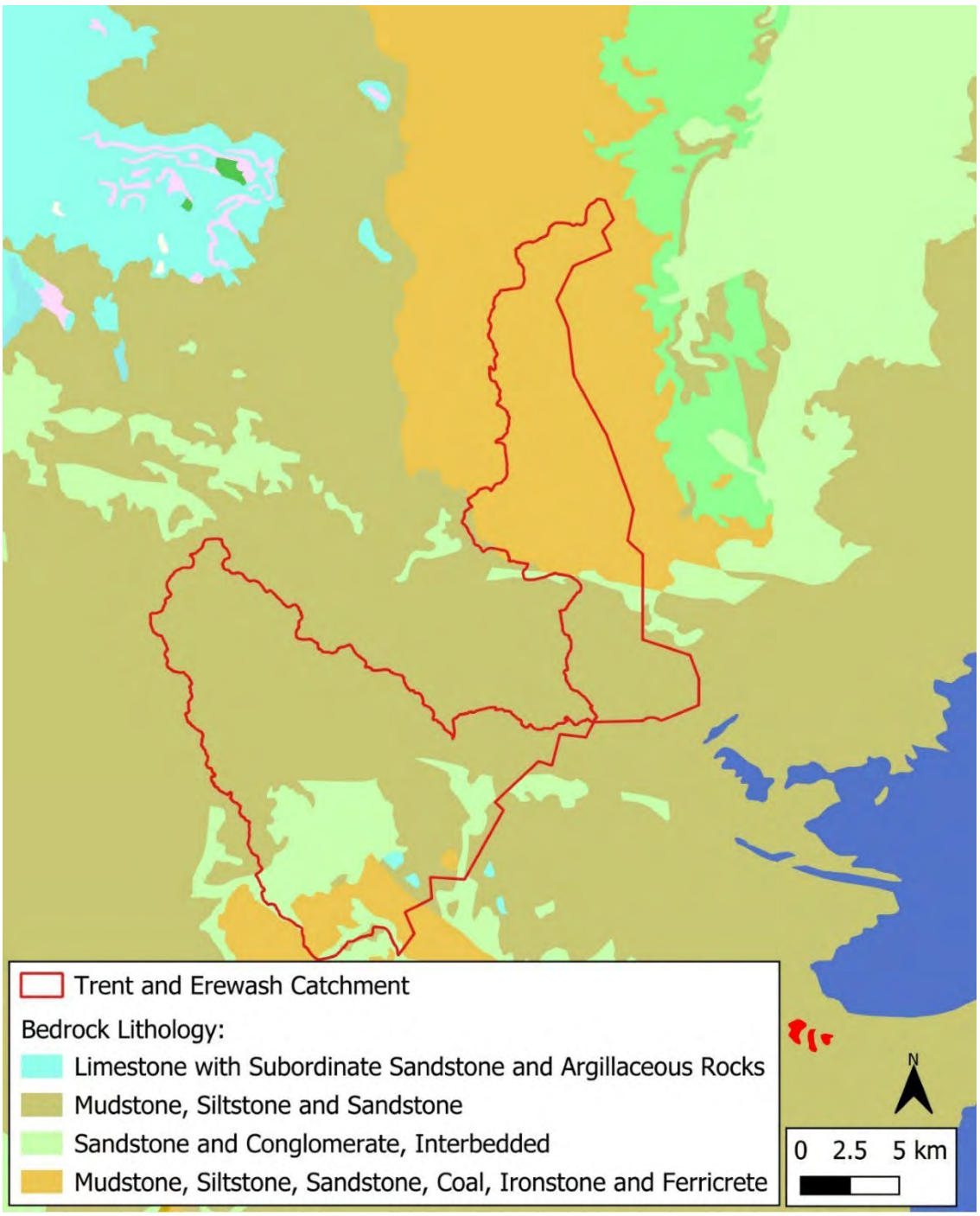

Figure 5-2: Bedrock lithology of the Don and Rother catchment (based on British Geological Survey 1:625000-scale geological map)

5.1.2 Rainfall Records

Eight Environment Agency rain gauges are within or near to the Trent and Erewash sub-catchment, as indicated in Figure 5-1. Recorded rainfall at 15-minute intervals from October 2023 at each station is indicated in Figure 5-3 to Figure 5-10.

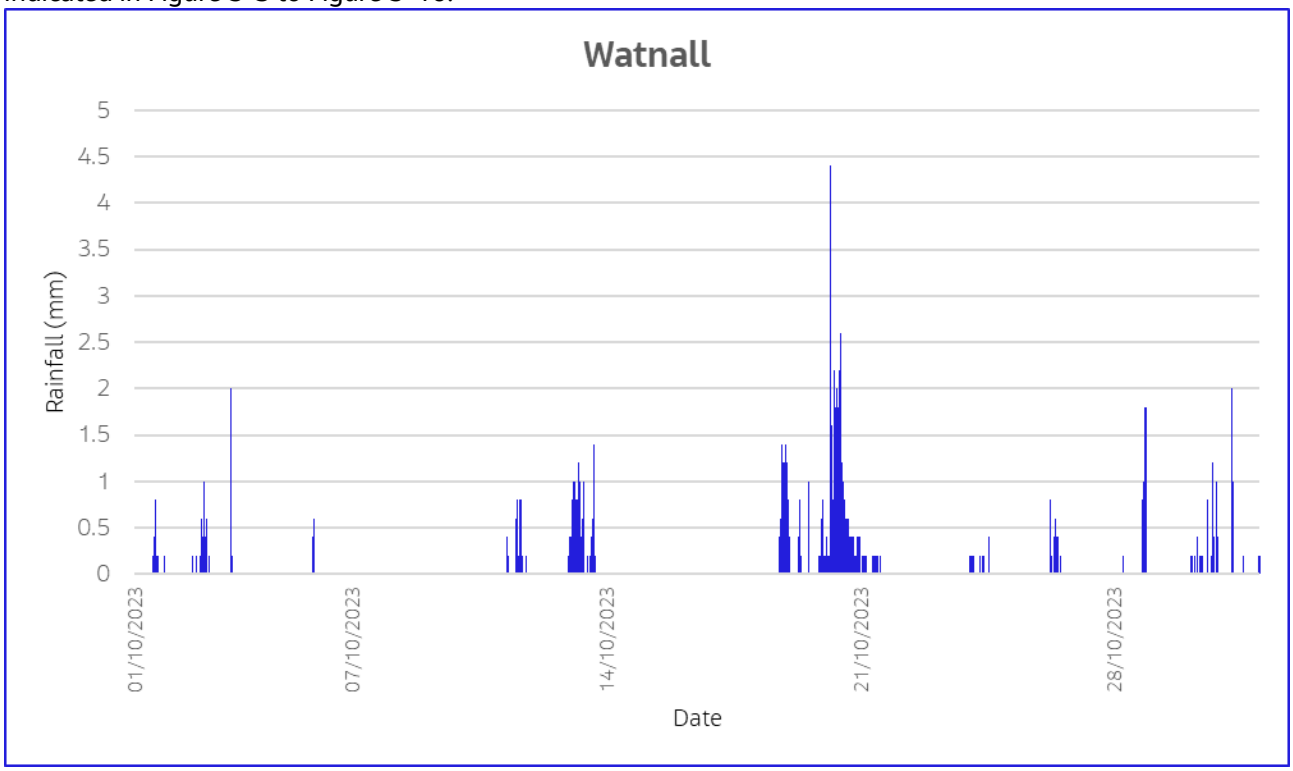

Figure 5-3: 15-minute rainfall data recorded in October 2023 at Watnall rain gauge

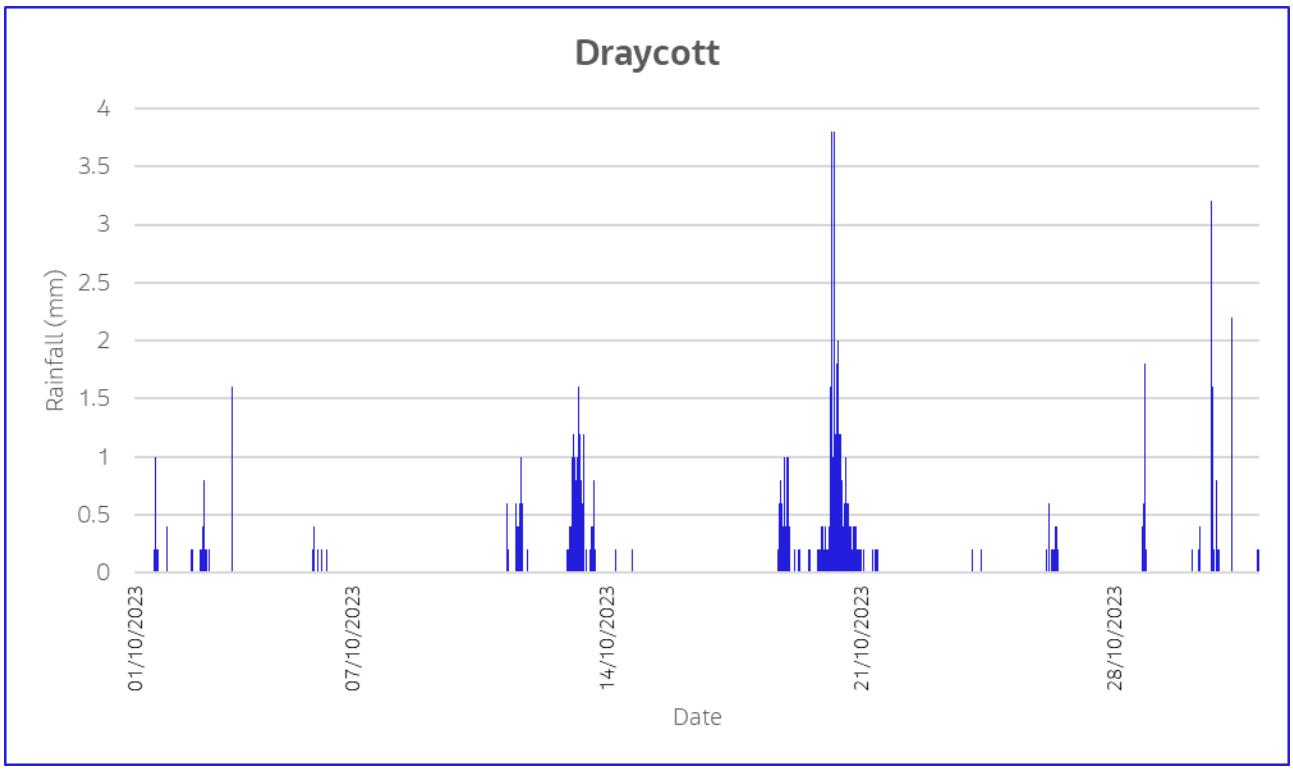

Figure 5-4: 15-minute rainfall data recorded in October 2023 at Draycott rain gauge

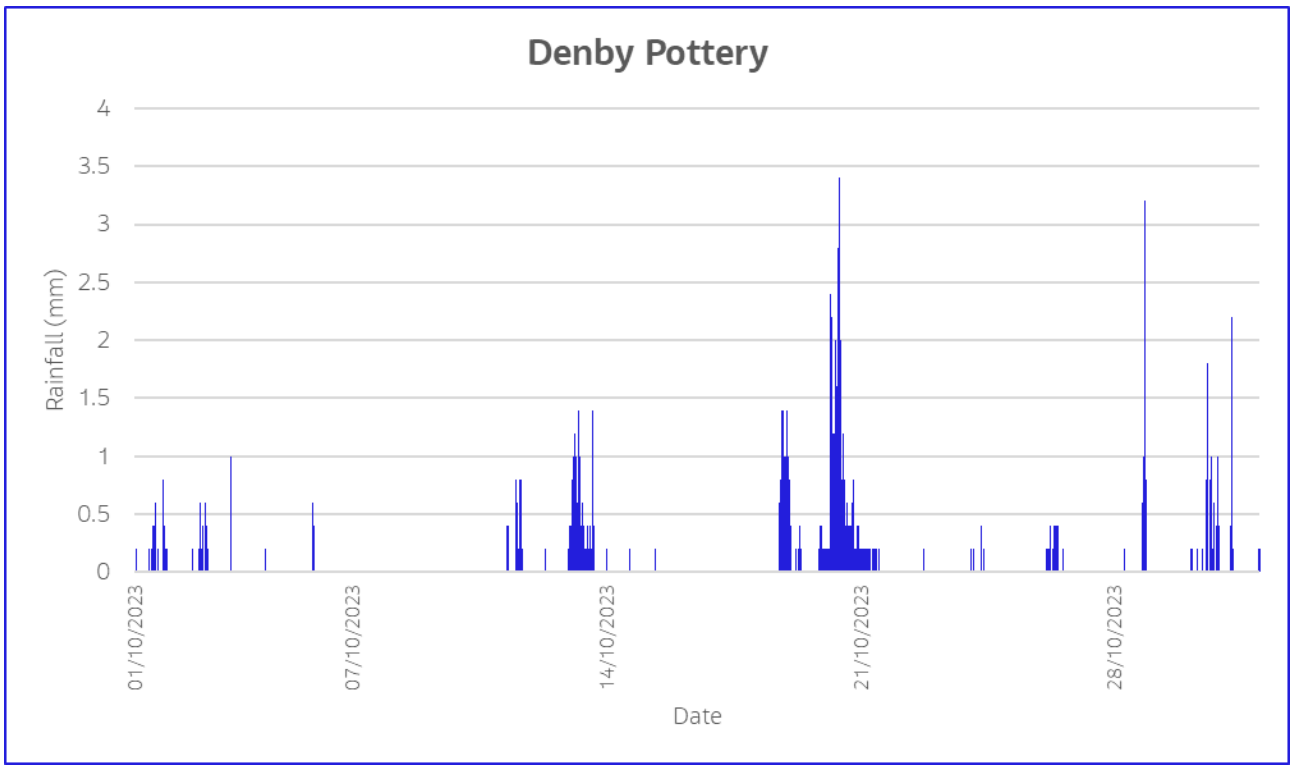

Figure 5-5: 15-minute rainfall data recorded in October 2023 at Denby Pottery rain gauge

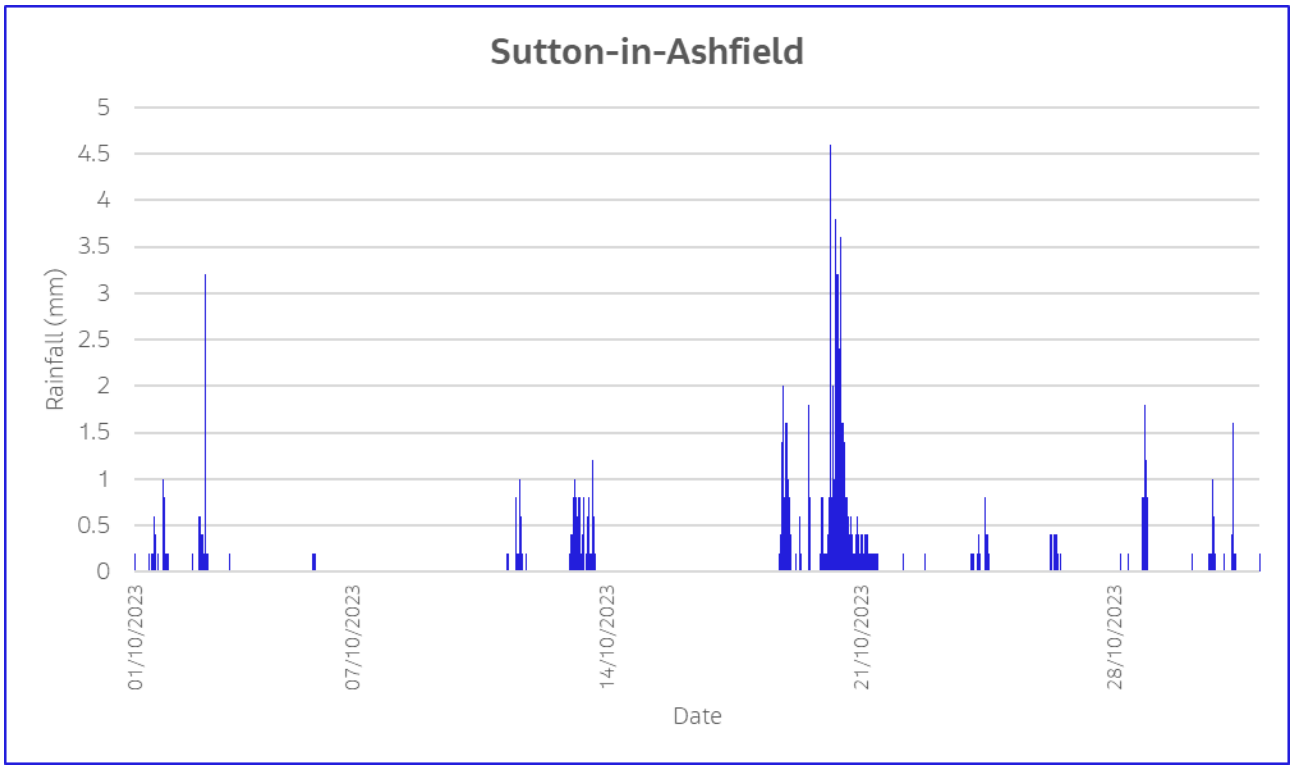

Figure 5-6: 15-minute rainfall data recorded in October 2023 at Sutton-in-Ashfield rain gauge

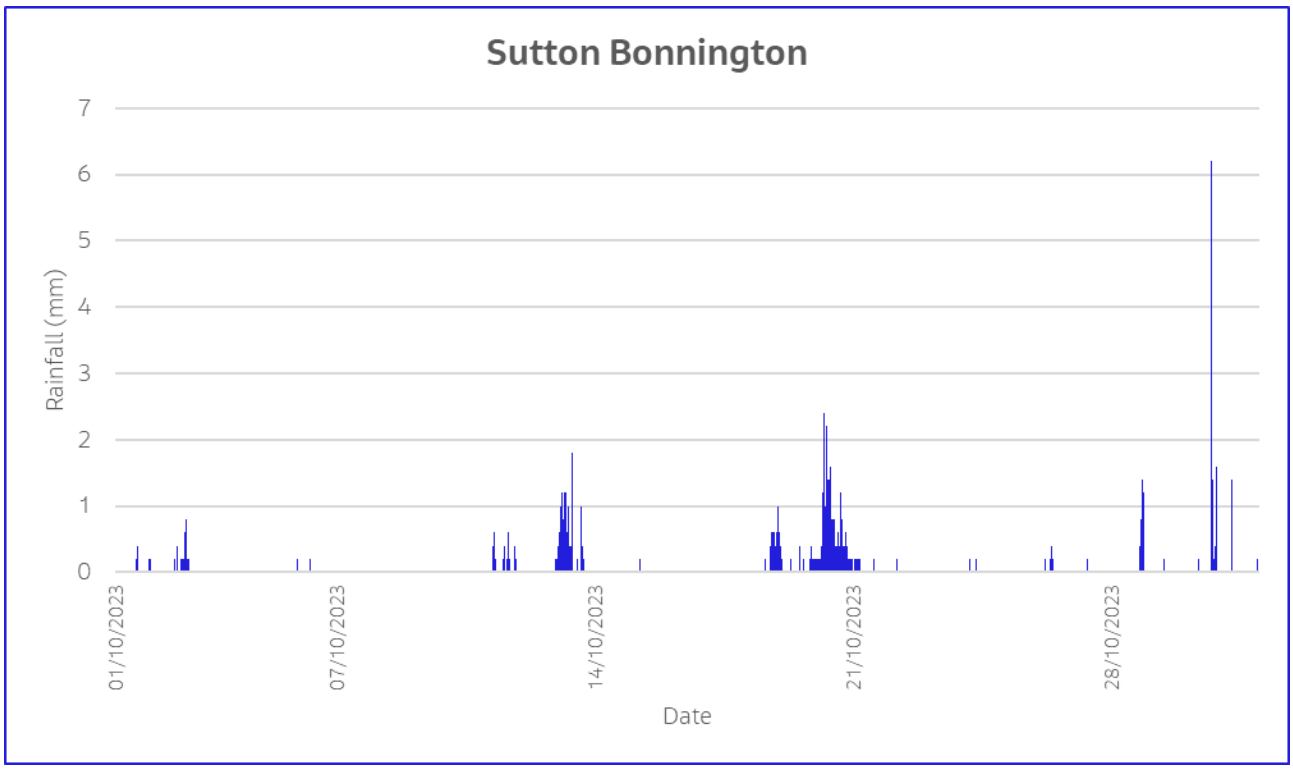

Figure 5-7: 15-minute rainfall data recorded in October 2023 at Sutton Bonnington rain gauge

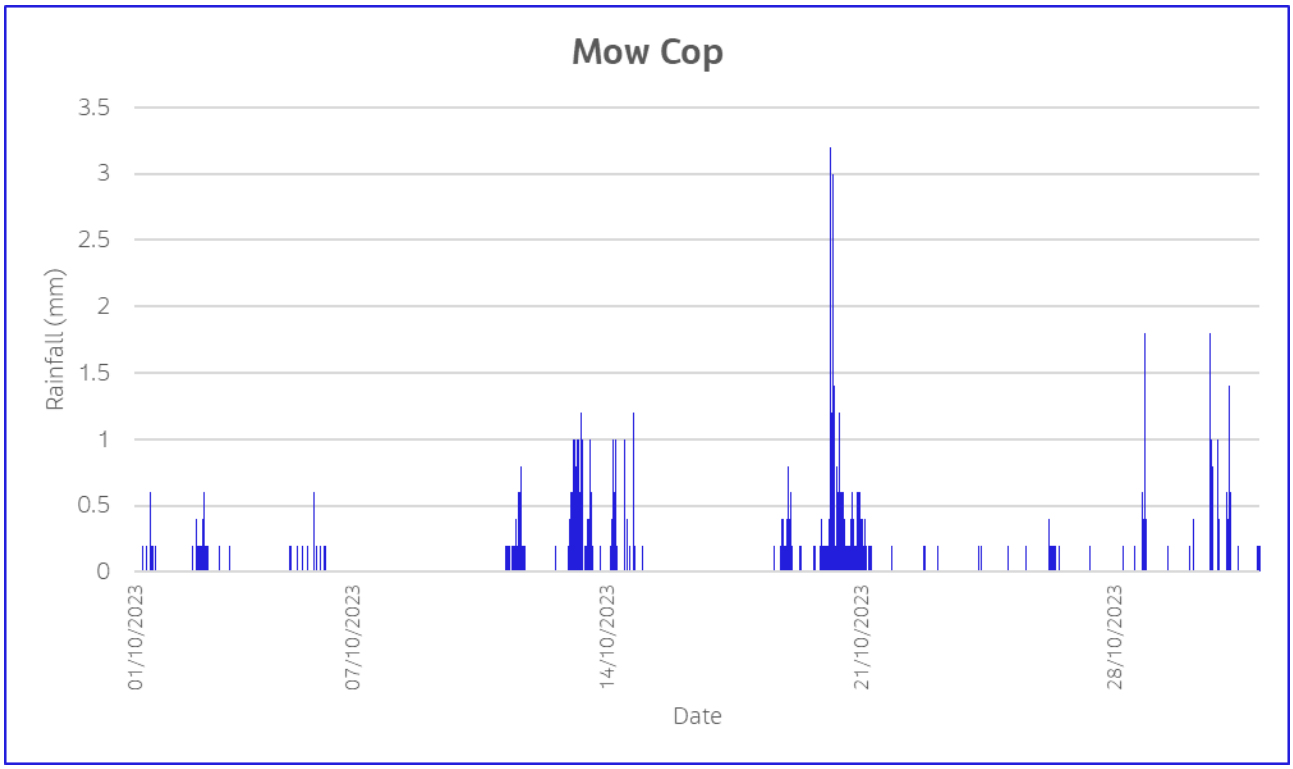

Figure 5-8: 15-minute rainfall data recorded in October 2023 at Mow Cop rain gauge

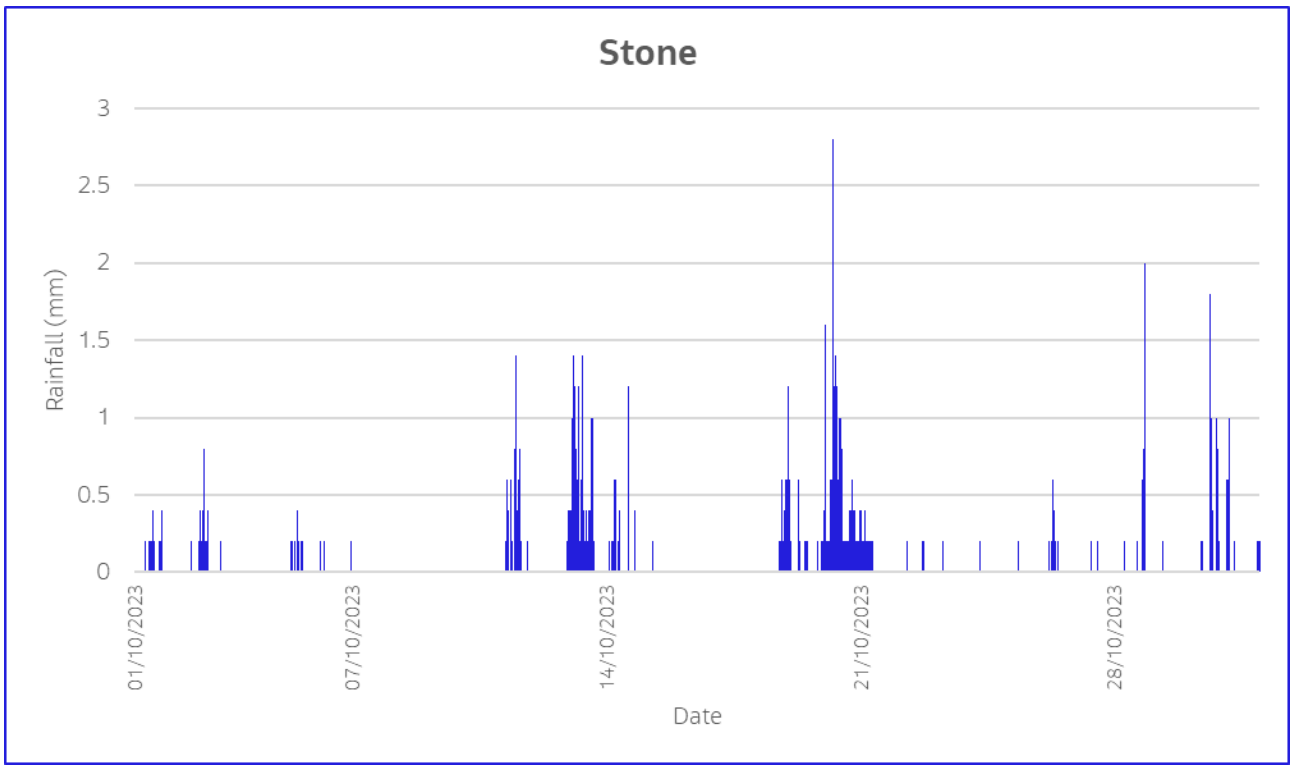

Figure 5-9: 15-minute rainfall data recorded in October 2023 at Stone rain gauge

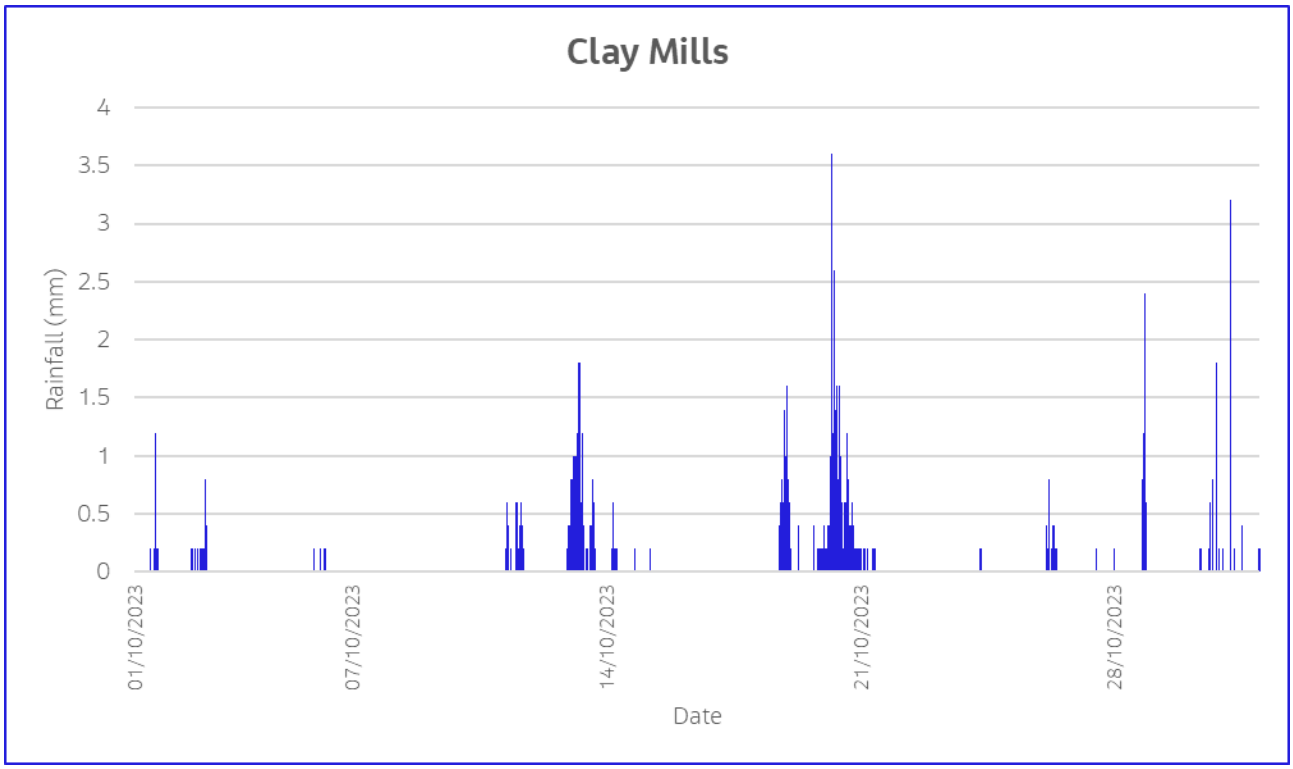

Figure 5-10: 15-minute rainfall data recorded in October 2023 at Clay Mills rain gauge

Figure 5-3 to Figure 5-10 indicate a prolonged heavy rainfall event from the 18th to the 21st of October. Table 5-1 indicates AEPs for the duration of Storm Babet and the most intense storm periods for rainfall recorded at each rainfall gauge. AEPs range from 25% at Stone, to the west of the sub-catchment, to 1% at Sutton-in-Ashfield, to the north of the sub catchment.

The most intense period of rainfall recorded at each station was from 3:00am-8:30pm on the 20th of October. Between 33-77mm of rainfall fell during this period equating to 64-88% of rainfall totals from Storm Babet. This corresponds to an AEP of between 44% at Stone and 1% at Sutton-in-Ashfield.

Table 5-1: Estimated Storm Babet AEPs: event totals and most intense rainfall period

Gauging Station	Rainfall total for Storm Babet (mm)	AEP (%)	Rainfall total recorded during peak of storm (mm)	Percentage of Storm Babet Rainfall (%)	AEP (%)
Watnall	92	1	59	64	4
Draycott	81	2	58	72	5
Denby Pottery	69	4	60	86	4
Sutton-in-Ashfield	94	1	77	82	1
Sutton Bonnington	48	15	42	88	20
Mow Cop	49	22	41	84	28
Stone	46	25	33	72	44
Clay Mills	54	10	41	77	16

Table 5-2 indicates 6-13% of annual average rainfall fell during Storm Babet. Rainfall totals for Storm Babet ranged from 54-121% of the LTA for October.

Table 5-2: Total event rainfall for Storm Babet compared to October 2023 and 2023 annual totals

Gauging Station	Rainfall total for Storm Babet (mm)	Percentage of LTA (%)	Percentage of Annual Average Rainfall[2] (%)
Watnall	92	111	13
Draycott	81	114	13
Denby Pottery	69	N/A	9
Sutton-in-Ashfield	94	121	7
Sutton Bonnington	48	73	8
Mow Cop	49	54	6
Stone	46	64	6
Clay Mills	54	75	8

Overall, heavier, more extreme rainfall was recorded to the east and north of the sub-catchment, within the River Erewash catchment (Sutton Ashfield, Watnall, Draycott, and Denby Pottery) compared to the south and west within the River Trent catchment (Sutton Bonnington, Mow Cop, Stone and Clay Mills). All stations within the River Erewash catchment recorded rainfall totals for Storm Babet exceeding the LTA for October and equating to AEPs <4%. Stations in the Lower Trent catchment recorded higher AEPs ranging from 10% at Clay Mills to 25% at Stone. The stations recording the lowest AEP were Sutton-in-Ashfield and Watnall (1%). These stations are both to the west of Derbyshire.

Peak rainfall was experienced at all stations at 3:45am-5:45am on the 20th of October except Denby Pottery, which experienced a later peak at 9:45am. Figure 5-3 to Figure 5-10 also indicate several rainfall events throughout October, prior to and after storm Babet. This correlates with the Environment Agency October 2023 water situation report from the Midlands.

5.1.3 River Gauge Records

Figure 5-1 illustrates there are three Environment Agency river flow gauges and one river level gauge within the Trent and Erewash catchment. Sandiacre, Pinxton and Shipley Gate gauges are located on the River Erewash in the upper, middle and lower reaches. Shardlow flow gauge is located on the River Trent near the confluence with the River Erewash. It is located upstream of the confluence with the River Derwent, which is a major Trent tributary. All flows at Sandiacre and Shardlow have been checked by the Environment Agency. It should be noted at Pinxton all flows are checked except from the 17th to the 20th of October. Levels at Shipley Gate have not been checked by Environment Agency.

Figure 5-11 to Figure 5-13 indicate a large increase in river flow or level from the 20th to the 21st of October.

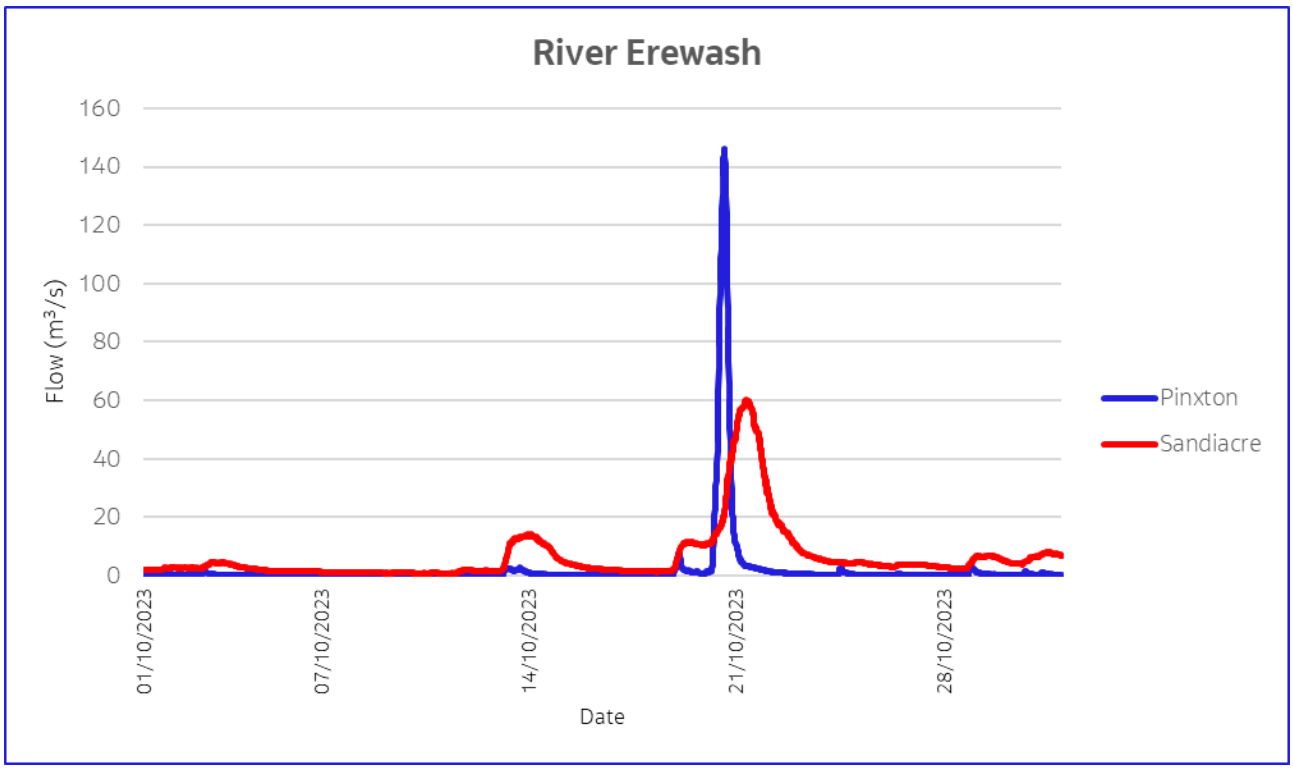

Figure 5-11: 15-minute river flow data recorded in October 2023 from Pinxton and Sandiacre gauging stations on the River Erewash

Figure 5-11 illustrates high flows were recorded at Sandiacre from 2:15pm on the 20th of October 2023 until 1:00pm on the 22nd. A peak flow of 60.1m³/s was recorded at 8:00am on 21st of October 2023. This is the highest flow recorded in the station's 57-year history.

High flows were recorded at Pinxton from 4:45am on the 20th of October2023 until 5:15am on the 21st. A peak flow of 146m3/s was recorded at 2:15pm on the 20th of October. This is the highest flow recorded in the station's 24-year history. However, it should be noted data was unchecked by the Environment Agency between 5:30am on the 20th of October until 1:30am on the 21st of October. This is where elevated flows over 100m3/s were recorded. This suggests flows were significantly higher during Storm Babet, but these results should be taken with caution.

Figure 5-11 indicates a shorter, later and flashier response was recorded at Pinxton in the upper reaches of the River Erewash compared to a more sustained increase in flow in the lower reaches at Sandiacre.

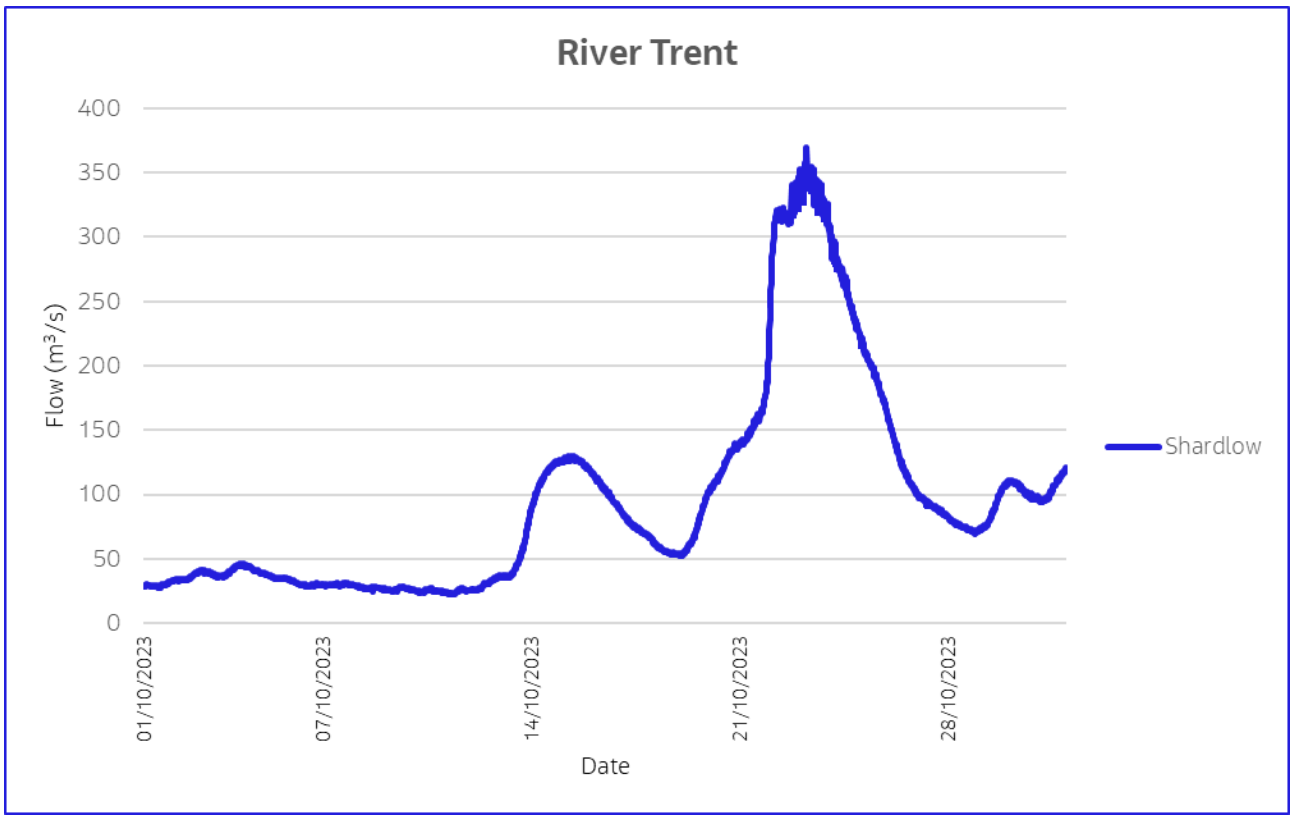

Figure 5-12: 15-minute river flow data recorded in October 2023 from Shardlow gauging station on the River Trent

Figure 5-12 illustrates multiple peaks in flow throughout October at Shardlow from 9:30am on 13th of October 2023 until 1:00pm on the 17th of October and from 8:45am on the 19th of October until the 27th of October. Two increases in flow were experienced during and after Storm Babet. An initial increase in flow from 52.9 to 157m3/s occurred from 8:45am on the 19th of October to the 21st of October at 4:15pm. A second increase in flow was recorded, peaking at 370m3/s on the 23rd of October. This is the 5th highest flow recorded at this station in its 33-year history. Shardlow is located upstream of the inflow from the River Derwent and the hydrograph illustrates the response time of the tributaries entering the Trent upstream.

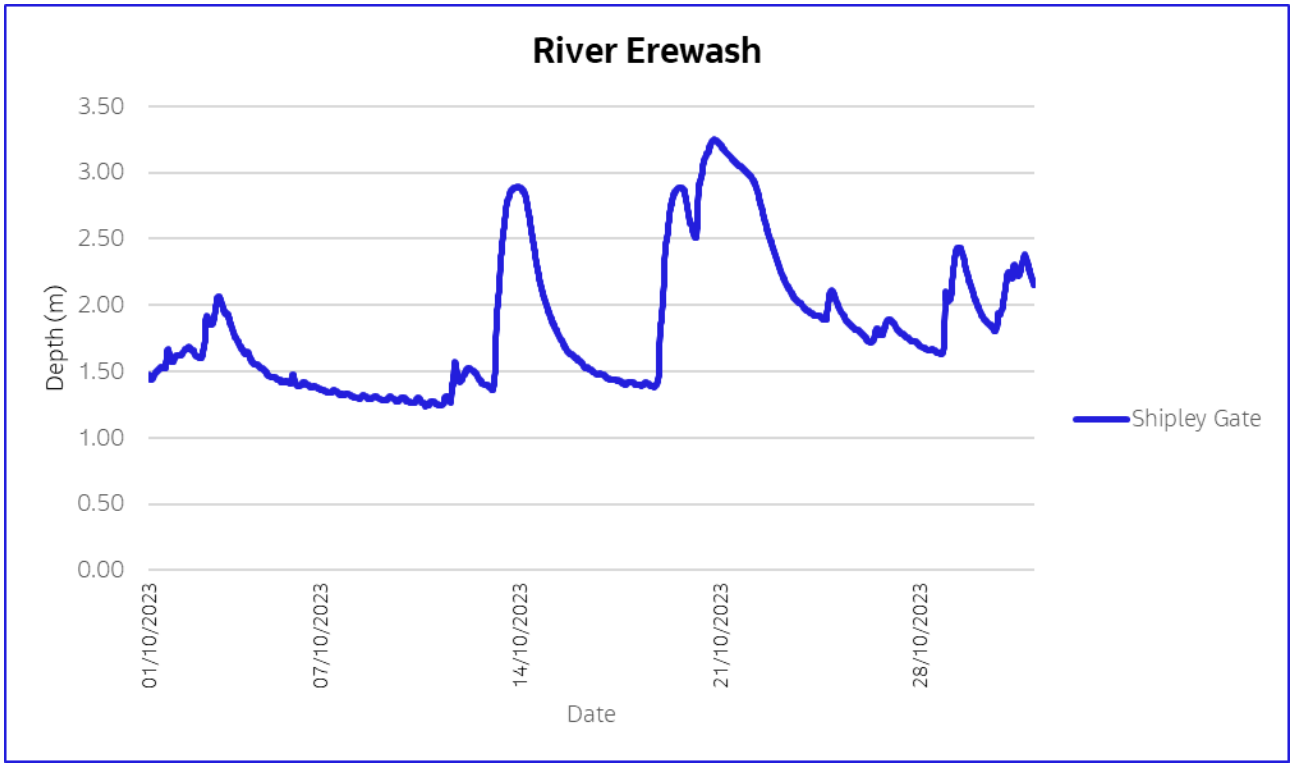

Figure 5-13: 15-minute river level data recorded in October 2023 from Shipley Gate gauging station on the River Erewash

Figure 5-13 illustrates high levels were recorded at Shipley Gate from the 12th to the 14th of October, prior to Storm Babet, and the 19th to the 22nd of October, during Storm Babet. A peak level of 3.25m was recorded at 7:30pm on the 20th of October 2023 with typical river levels ranging between 1.3-2.3m during October. The peak of 3.2m was the highest recorded level at this gauge in its 18-year history. Highs of 2.9m were recorded between 8:00pm on the 13th of October and midnight on the 14th of October. This elevated level was also recorded at Sandiacre station indicating high flows and levels were experienced during October, prior to Storm Babet.

Overall, river flows align with the Environment Agency's monthly water situation report for October 2023, which found all river flow monitoring sites recorded above normal river flows across the Midlands. Table 5-3 summarises peak flow, timing and ranking at each station indicating Storm Babet recorded the highest river flows and levels at each station except Shardlow. Shardlow is the only station on the River Trent used in this analysis, while the other stations are located on the River Erewash. This indicates the River Erewash responded more to high runoff produced by heavy rainfall during Storm Babet.

A shorter, flashier response to Storm Babet was recorded in the upper reaches of the River Erewash at Pinxton compared to the other stations located in the middle and lower reaches and the River Trent. The first stations to peak were Pinxton and Shipley Gate on the upper and middle reaches of the River Erewash. The latest station to peak was Shardlow on the River Trent.

Table 5-3: Peak flow, peak level, timing and ranking of each peak and station data record length recorded at each station within the Idle and Torne sub-catchment.

Station	Peak Flow (m^3/s)	Date and Time	Peak Flow Ranking	Station record length (years)
Sandiacre	60	21/10/2023 8:00am	1	57
Pinxton	146	20/10/2023 2:15pm	1	24
Shardlow	370	23/10/2023 6:00am	5	33
Station	**Peak Level (m)**	**Date and Time**	**Peak Flow Ranking**	**Station record length (years)**
Shipley Gate	3.3	20/10/2023 7:30pm	1	18

Figure 5-14 to Figure 5-18 summarise rainfall and river flow surrounding Storm Babet.

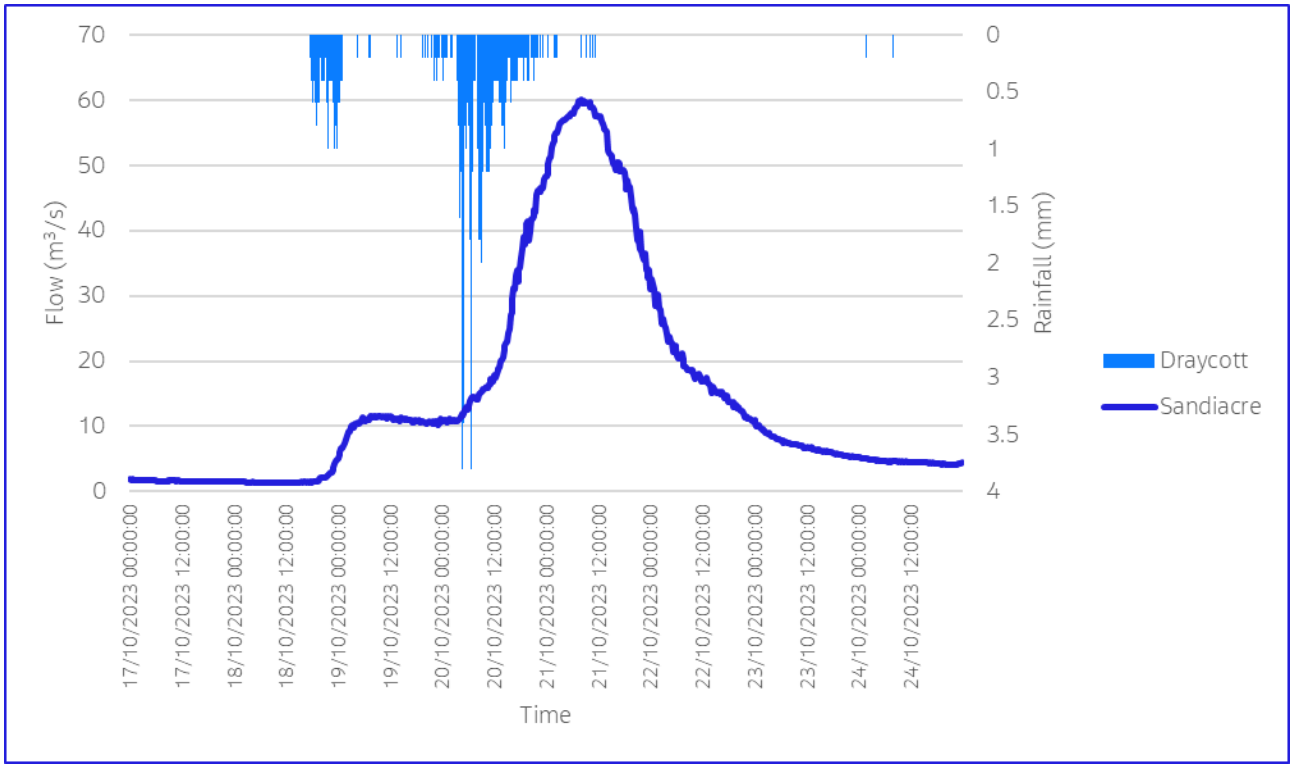

Figure 5-14: Hydrograph from the 17th to the 24th of October illustrating recorded river flow data from Sandiacre gauging station and recorded rainfall data from Draycott gauging station

Figure 5-14 suggests a lag of 26 hours was recorded between peak rainfall at Draycott (4mm in 15 minutes) and peak river flow at Sandiacre (60m3/s).

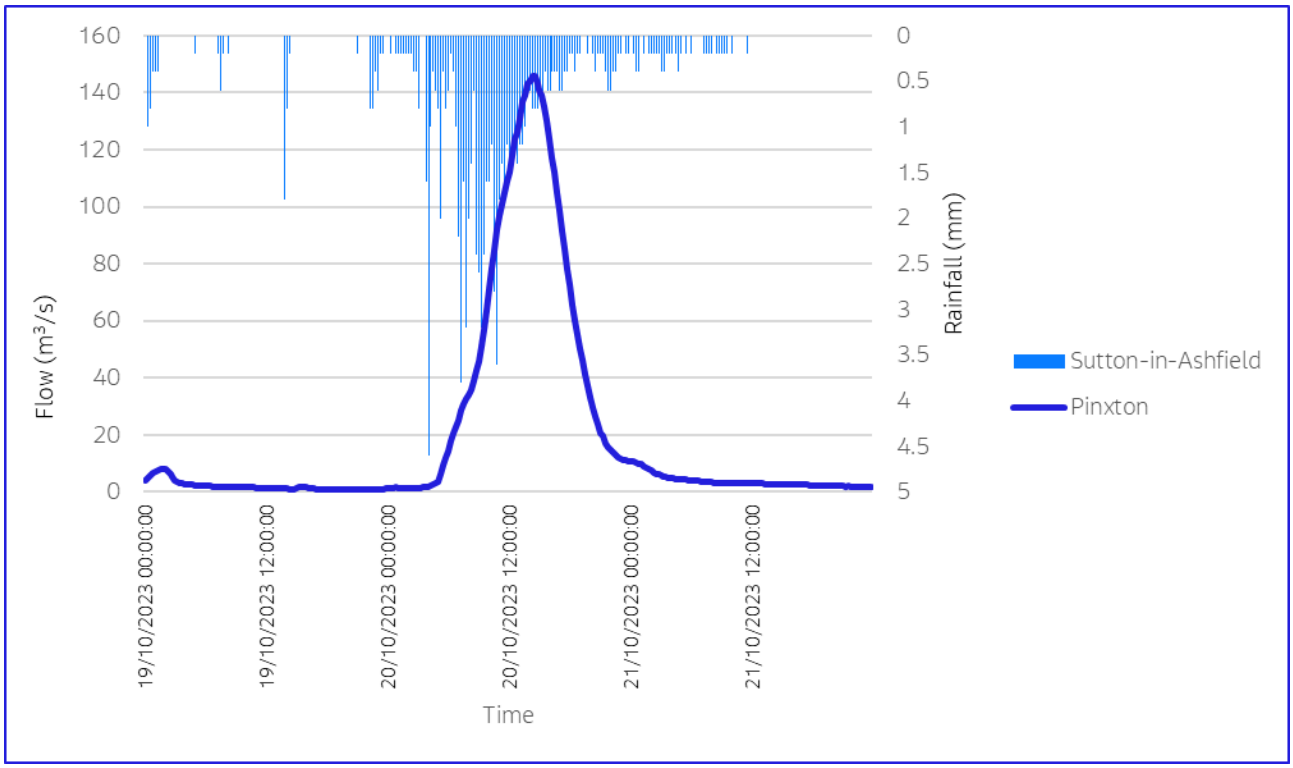

Figure 5-15: Hydrograph from the 19th to the 21st of October illustrating recorded river flow data from Pinxton gauging station and recorded rainfall from Sutton-in-Ashfield gauging station

Figure 5-15 suggests a lag of 13 hours between peak rainfall at Sutton-in-Ashfield (5mm in 15 minutes) and peak river flow at Pinxton (146m3/s).

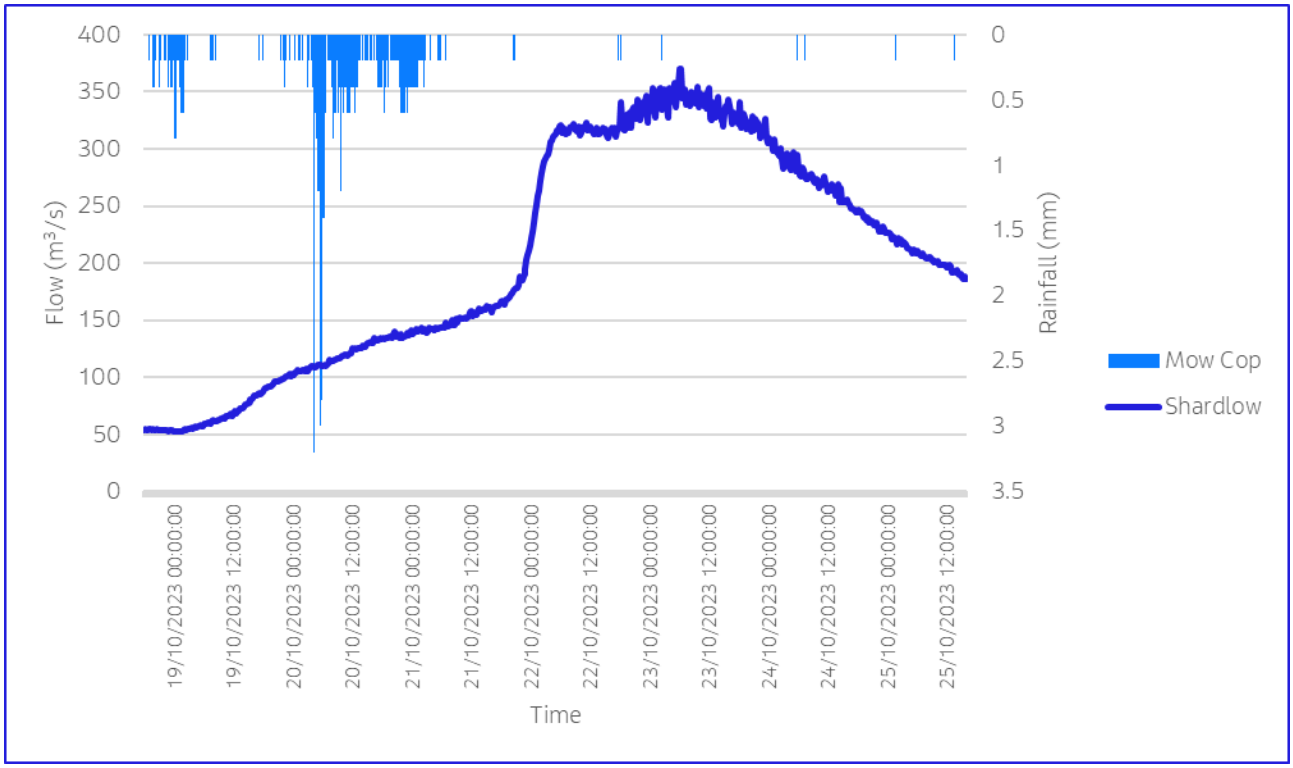

Figure 5-16: Hydrograph from the 19th to the 25th of October illustrating recorded river flow data from Shardlow gauging station and recorded rainfall from Mow Cop gauging station

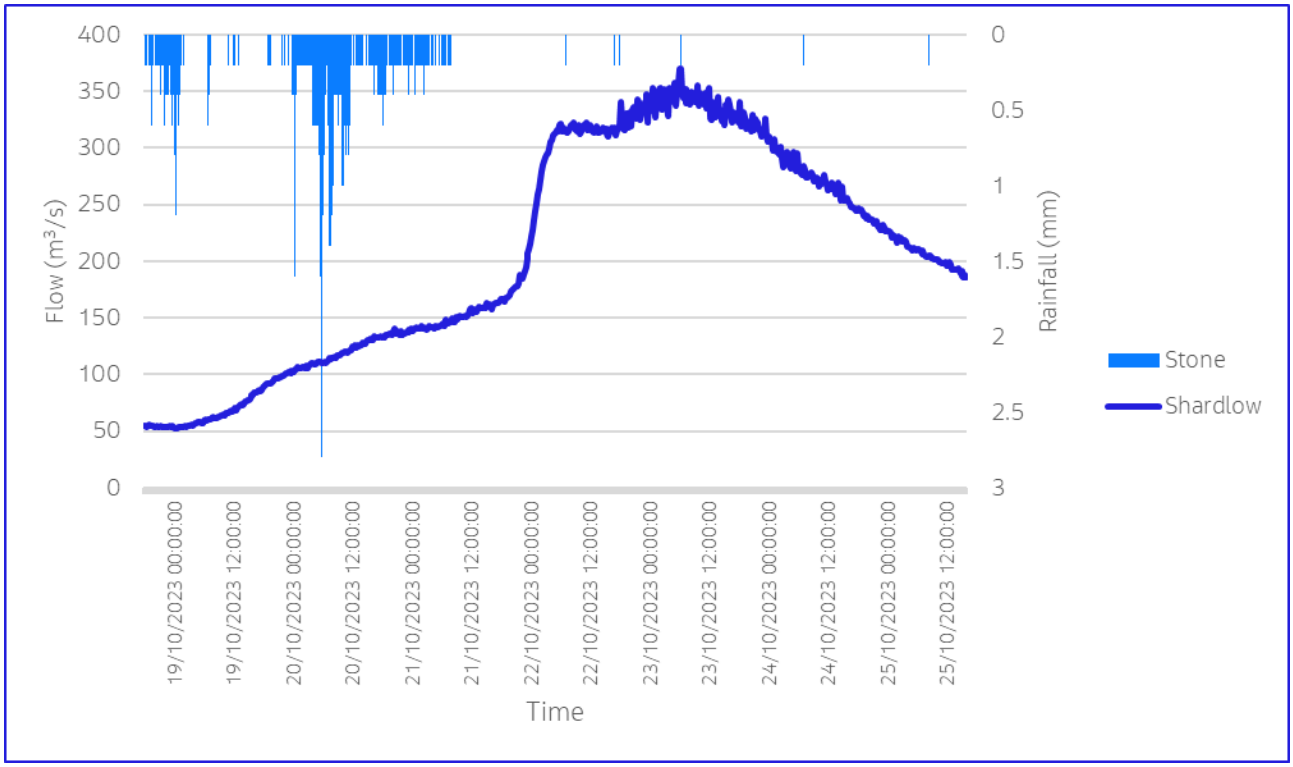

Figure 5-17: Hydrograph from the 18th to the 23rd of October illustrating recorded river flow data from Shardlow gauging station and recorded rainfall from Stone gauging station

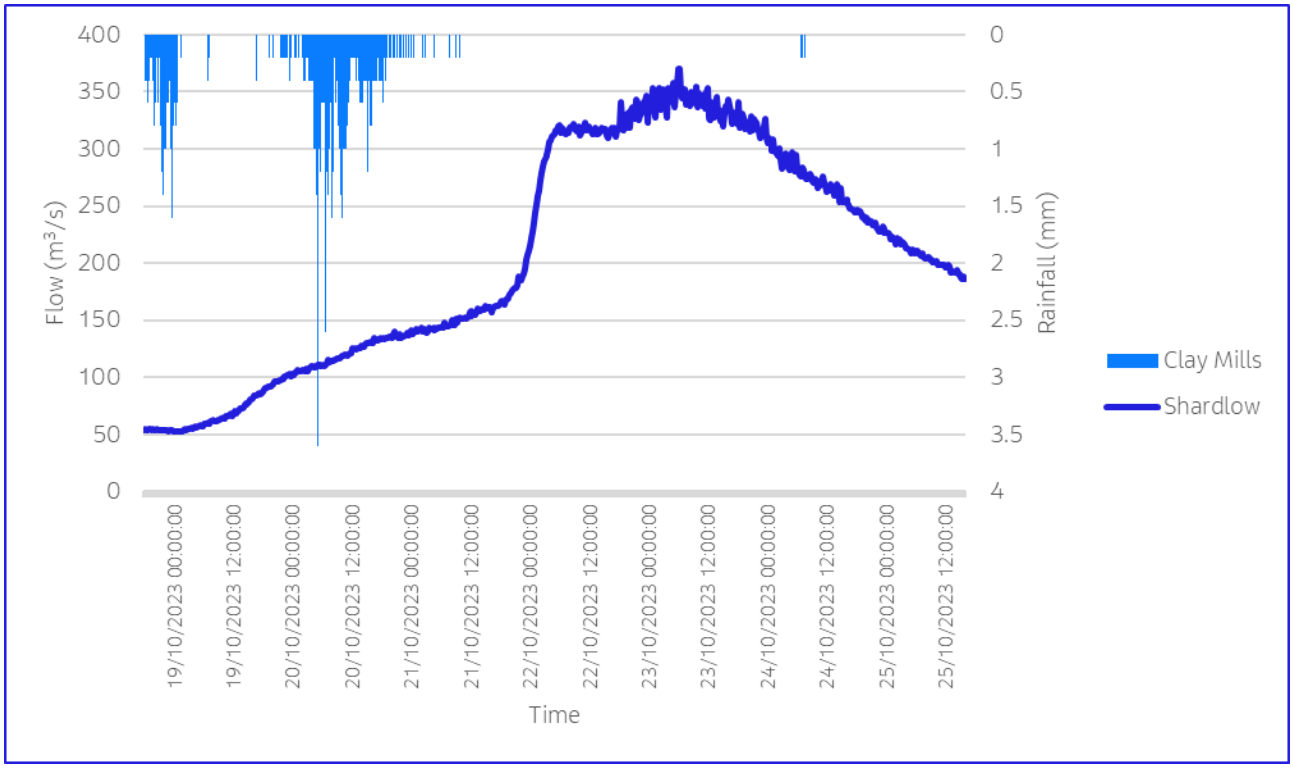

Figure 5-18: Hydrograph from the 18th to the 23rd of October illustrating recorded river flow data from Shardlow gauging station and recorded rainfall from Clay Mills gauging station

Figure 5-16 to Figure 5-18 suggest a lag of 73-74 hours between peak rainfall recorded at each station (3mm, 3mm and 4mm in 15 minutes at Mow Cop, Stone and Clay Mills respectively) and peak flow at Shardlow (370m3/s). This indicates there was a slower response to heavy rainfall and runoff by the River Trent compared to the River Erewash during Storm Babet.

5.1.4 Groundwater Records

Figure 5-1 illustrates one Environment Agency groundwater station is located proximal to the Trent and Erewash catchment. Hourly groundwater level data from October 2018 to March 2024 is indicated in Figure 5-19. The geology type at this station is permo Triassic sandstone and all data is checked by the Environment Agency.

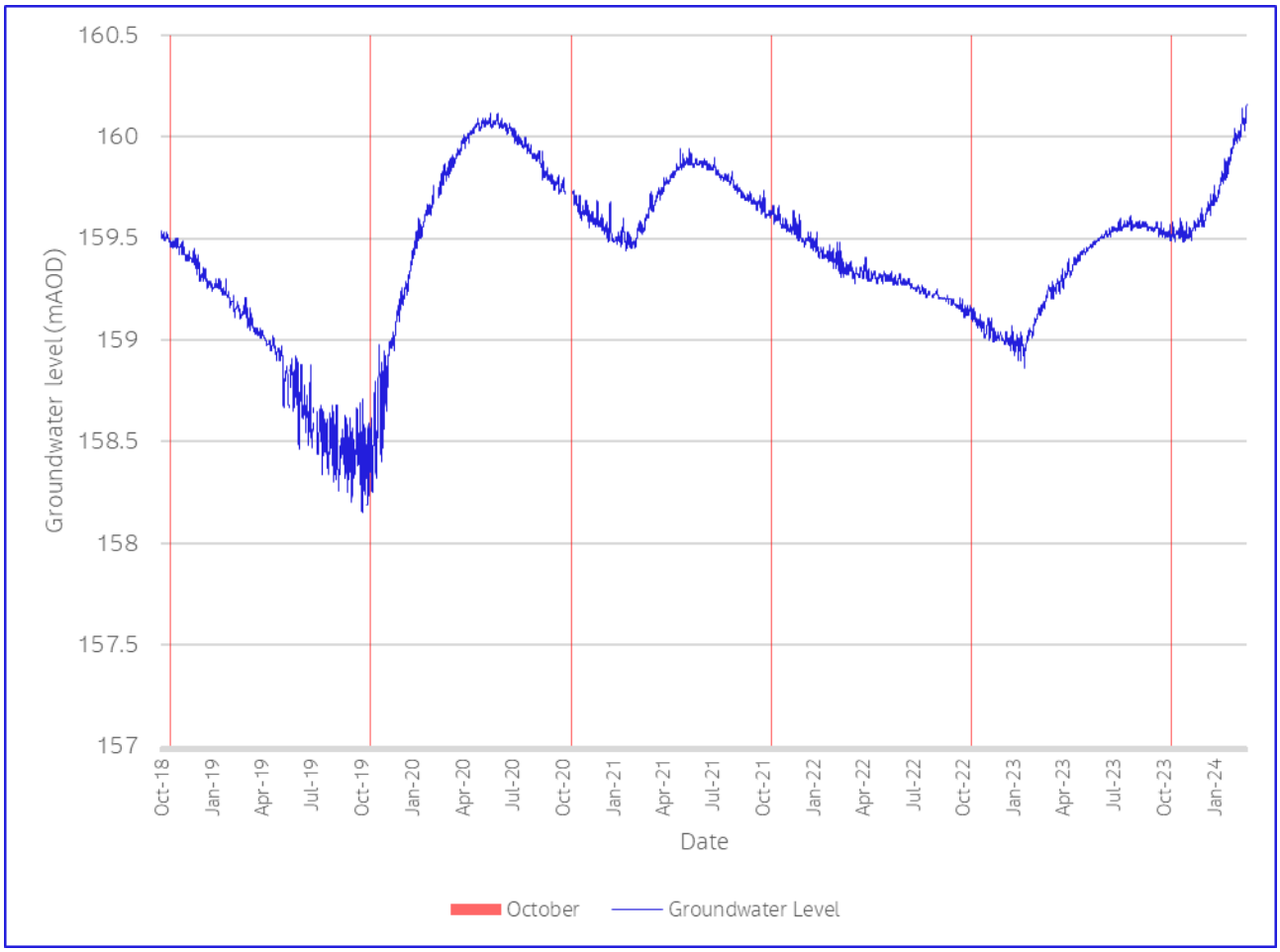

Figure 5-19: Coxmoor hourly groundwater levels October 2018 to March 2024. The red line indicates October

Figure 5-19 indicates groundwater levels recorded in October 2023 are higher than levels recorded in October 2018, 2019, and 2022. However, they are lower than October levels in 2020 and 2021. Groundwater levels rise from October 2023 to March 2024 which is a contrasting pattern to the fall in groundwater level experienced from October to March in 2018, 2020, 2021 and 2022. This could increase flood risk following Storm Babet due to reduced groundwater storage.

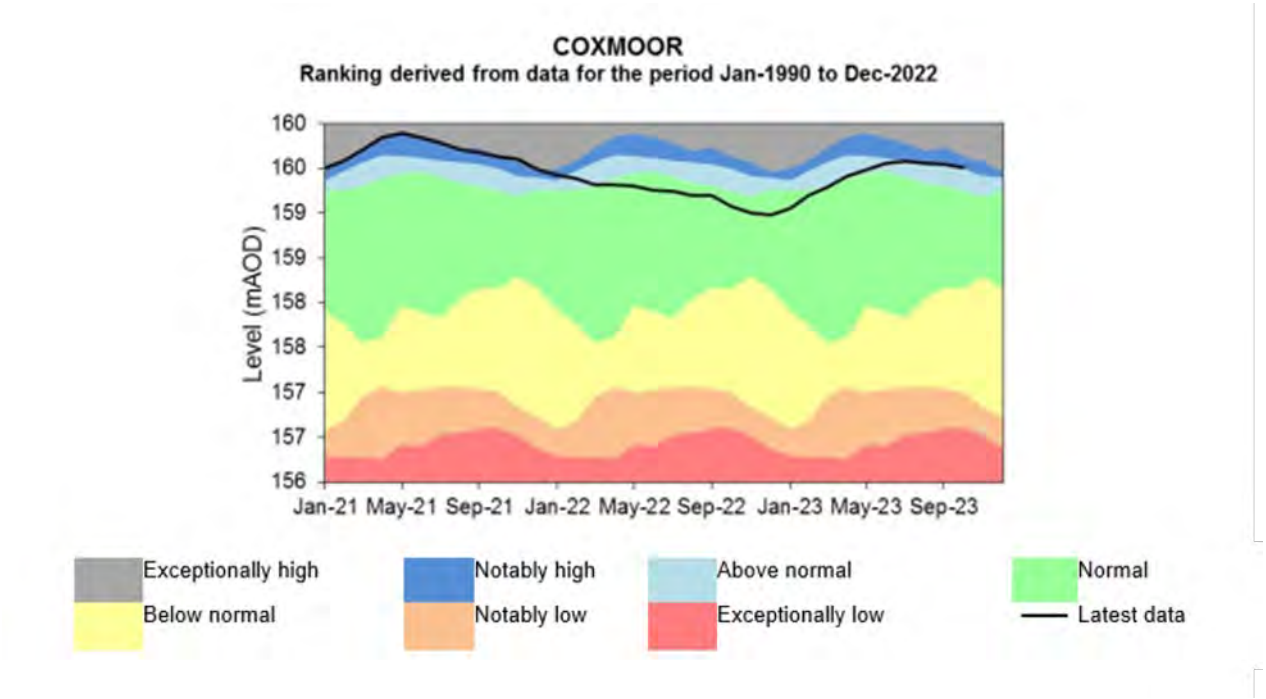

Figure 5-20: End of month groundwater levels at Coxmoor groundwater station from January 2021 to October 2023 compared to the long-term average. Taken from the Environment Agency's monthly water situation report for the Midlands from October 2023

Figure 5-20 indicates groundwater levels at the end of October were notably high compared to the LTA. Levels were exceptionally high by the end of December. This suggests at Coxmoor groundwater levels were raised considerably by Storm Babet.

5.1.5 Hydrological Summary

Overall, heavier rainfall was recorded in the south and east of the Trent and Erewash sub catchment, more proximal to the River Erewash. Rainfall peaked early on the 20th of October from 3:45am-9:45am. Total rainfall recorded equated to 0.9-3.6% AEP events at stations surrounding the River Erewash (Watnall, Draycott, Denby Pottery and Sutton-in-Ashfield) and 9.5-24.6% AEP events at stations surrounding the River Trent.

Flashier and earlier river responses to heavy rainfall was recorded in the upper reaches of the River Erewash at Pinxton compared to lower reaches and the River Trent. The shortest lag time between peak rainfall and peak flow was recorded at Pinxton (13 hours) while the longest was recorded at Shardlow (74 hours). This pattern corresponds with the duration of high flow recorded at each station. All stations on the River Erewash produced the highest ranked flow or level on record. Shardlow on the River Trent produced the fifth highest flow on record.

Groundwater levels by the end of October 2023 were notably high compared to the LTA. Levels continued to rise until March 2024 which is a contrasting pattern to the fall in groundwater level experienced from October to March since 2018.