LOWDHAM

FLOOD ACTION GROUP

Cause, Effect and Moving Forward

A comprehensive inside view of Lowdham flooding

December 2020

Contents

FOREWORD

I am very pleased to support the work of the Lowdham Flood Action Group who have prepared this comprehensive report on flooding in Lowdham. I would also like to pay tribute to the work of everyone involved over many years.

As the local MP I have seen at first hand the long-standing flooding issues in Lowdham.

I am delighted to have been able to help The Environment Agency obtain the additional £5m needed for the attenuation scheme which should prevent the Cocker Beck flooding in future.

This comprehensive report highlights the other issues that cause flooding, and makes recommendations including a new early warning system.

I hope that this comprehensive local analysis will help inform and develop an effective approach to preventing flooding in the future.

The Rt Hon Robert Jenrick
Member of Parliament for Newark

EXECUTIVE SUMMARY

1. Lowdham is a village with a significant flood risk and, like many other places in the UK, has experienced an increased frequency of severe incidents in recent years resulting in a large number of properties being flooded. Various schemes to prevent flooding have been promised over many years but none have materialised.

2. The Lowdham Flood Action Group (FLAG) was formed in February 2020 to
    - Build relationships with organisations and partners involved in mitigating Lowdham's flood risk.
    - Understand the causes of flooding in Lowdham
    - Support initiatives to address flood risks
    - Assist in the identification of maintenance issues that if unattended could increase flood risk.

3. Flood reporting. There has been insufficient identification of the causes and effects of flooding. Historically, had the reporting been more comprehensive in identifying the causes of flooding and made recommendations, action could have been taken sooner to avoid repeat events.

4. Recent improvements. It is recognised that a number of initiatives have been delivered to mitigate flood risk such as the flood lagoon on the cricket pitch, flood defences along the Cocker Beck, (that urgently needs to be repaired), and the increased soak away capacity recently delivered by Severn Trent Water. Despite these welcome improvements, and the efforts by partners over some 13 years to provide an as yet undelivered wider flood alleviation scheme, Lowdham remains at significant flood risk.

5. Lack of maintenance. The lack of maintenance of existing infrastructure has undoubtedly contributed to the scale of flooding endured on several occasions. It is unacceptable that 12 years should pass between inspections of key culverts. Routine inspections are required to prevent flooding, not occasionally in response to repeated floods. Detailed inspections of key assets should be conducted after each flood event to identify issues. Notwithstanding that, the recent efforts by VIA to inspect and clear key culverts are very much appreciated.

6. Creative thinking. There is an opportunity for creative thinking to adjust some of the current infrastructure to enhance the flow of the Cocker Beck through the village (Merevale parapet etc) and to better utilise the existing infrastructure to take water away from the Cocker Beck and the vulnerable centre of the village through the A6097 ditches (new spill weir and lagoon drain etc). This could be particularly helpful in the interim period prior to the attenuation reservoirs being completed in 2023.

7. Longstanding unresolved issues. Longstanding concerns remain about a number of specific high-risk issues which need to be addressed quickly such as the misaligned pipes in Willow Holt/Old Tannery Drive and the concerns about the double culvert downstream of Harrison's Garage.

8. Early warning. The current Environment Agency (EA) warning of Cocker Beck flooding is insufficient to allow householders to make preparations, especially for those living alone. A bespoke early warning system for Lowdham is being created with cooperation from the EA and Met Office, and FLAG is pairing volunteers with vulnerable households to provide support.

PURPOSE OF REPORT

9. Following each of the last 3 major flood events, the latest being in February 2020, Nottinghamshire County Council has been required the produce Section 19 reports. Their purpose is to seek to analyse the causes of flooding, summarise their impact, identify findings, allocate responsibilities and make recommendations.

10. While these reports obviously satisfy statutory requirements, following consideration of the content, review of section 19 reports produced by other Authorities, and conversations with a range of partners, Lowdham FLAG has produced this report to supplement the information provided in the Section 19 reports and provide improved insight regarding flooding in Lowdham and actions that can be taken to reduce risk.

SECTION 1 - BACKGROUND TO FLOOD EVENTS

FLOODING INCIDENTS AND EXTENT

11. Lowdham regularly experiences flooding; most recently in 1999, 2007, 2013, twice in 2019 and 2020.

a. 300 properties were flooded in 1999.
b. 150 properties were flooded in 2007
c. 70 properties were flooded in July 2013 (mainly pluvial)
d. 12 in June 2019 and 6 in November 2019
e. 93 properties flooded in February 2020.

12. There have been three identified sources of flooding

a. Fluvial (from the Cocker Beck)
b. Pluvial (surface water from surrounding fields and roads)
c. Sewer flooding (from public sewers at or exceeding operational capacity.)[1]

LOCATION CHARACTERISTICS

13. Lowdham is a village of 3,000+ inhabitants in Nottinghamshire, 3 kms north west of the River Trent. It has been the subject of three Section 19 investigations since 2013 (required under the Flood and Water Management Act 2010 when more than 5 properties have flooded). From the general area of Lowdham, the Trent is fed by two main sources; the Dover Beck and the Cocker Beck. (Figure 1). The Dover Beck approaches Lowdham from the north west but the village is largely protected by Barker Hill which directs the flow to the east towards Gonalston, and thence southwards to the Trent.

14. From the west, Lowdham is entered by the Cocker Beck, which rises some 8 kms away near Mapperley Top. The Cocker Beck flows into the north of the village from where it is directed southwards, through the settlement, by an open channel which passes under a number of culverts under roads. The flow of the Cocker Beck is increased by the smaller River Laybourn which also approaches from the west, joining it at Ton Lane.

[1] Section 19 Report Lowdham 23 July 2013.

Figure 1 Lowdham1:50,000 map

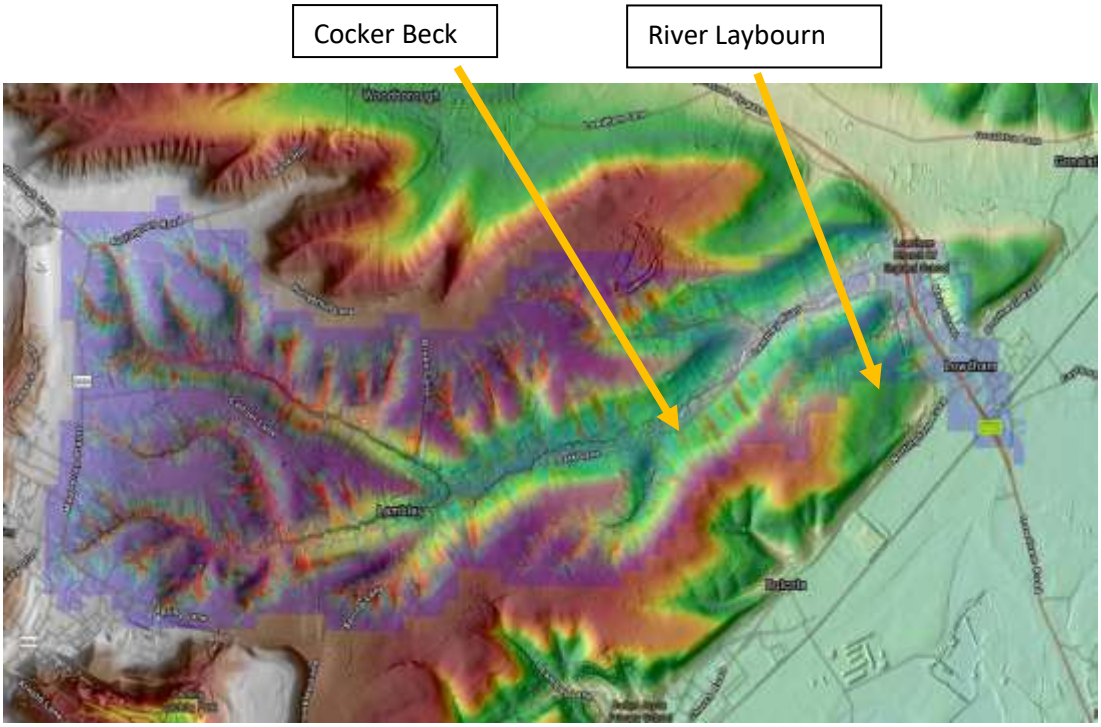


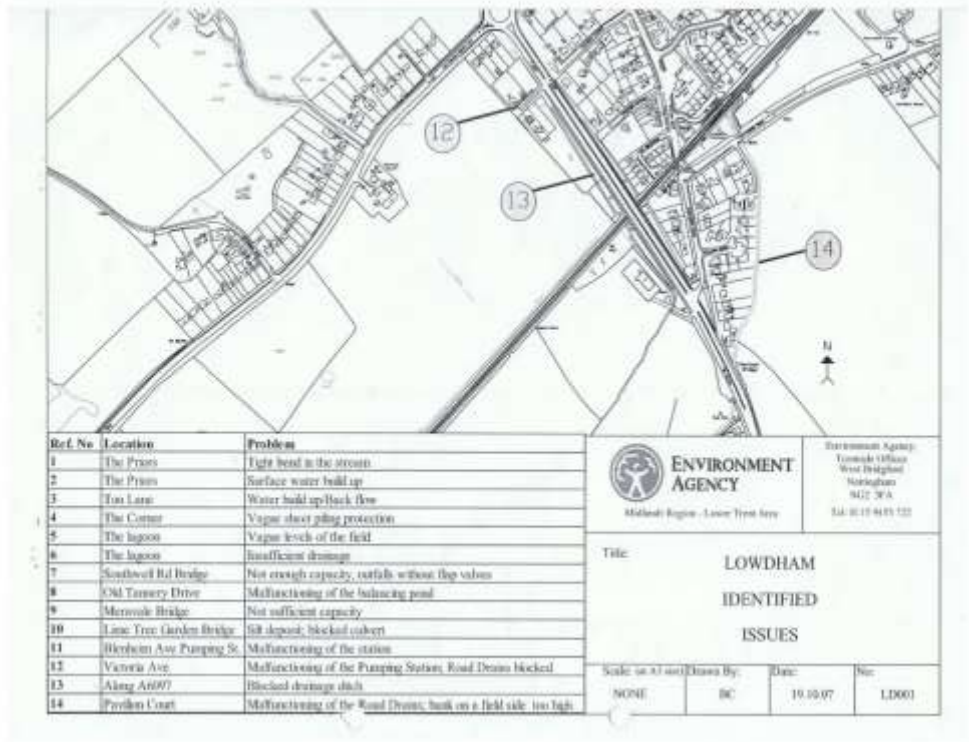
Figure 2 Lowdham Lidar map showing Cocker Beck and River Laybourn

15. The village has a recent history of flooding as a result of extreme rainfall events falling over a large catchment area of 12 km^2. Pinch points in the channel throughout the village constrict the flow of water during high river levels which causes the Cocker Beck to spill out of its bank causing fluvial (river) flooding of local infrastructure and surrounding properties. This fluvial flooding has previously combined with an overwhelmed surface water system increasing the flood risk.

16. The River Laybourn also enters the village from the west beside the World's End and flows into the Cocker Beck in the garden of a property on Ton Lane. Its catchment area is much smaller than the Cocker Beck. The Dover Beck affects some properties on the northern outskirts of Lowdham but is not responsible for flooding the village itself. During heavy rain, the village can also be vulnerable to surface run-offs from Barker Hill and, to a reduced extent, from the less steep

slopes to west; Lowdham Lodge and Hunter's Hill although surface water from these does not enter the village due to the camber of the A6097.

17. Following the flood in 2007, the EA identified the issues as shown on the following maps. A number of these issues remain unresolved to this day which is unacceptable and creates unnecessary risks which remain.



Ref. No	Location	Problem
1	The Priors	Tight bend in the stream
2	The Priors	Surface water build up
3	Top Lane	Water build up/Back flow
4	The Corner	Vague sheet piling protection
5	The lagoon	Vague levels of the field
6	The lagoon	Insufficient drainage
7	Southwell Rd Bridge	Not enough capacity, outfalls without flap valves
8	Old Tannery Drive	Malfunctioning of the balancing pond
9	Mereside Bridge	Not sufficient capacity
10	Lime Tree Garden Bridge	Silt deposit; blocked culvert
11	Blenheim Ave Pumping St.	Malfunctioning of the station
12	Victoria Ave	Malfunctioning of the Pumping Station; Road Drains blocked
13	Along A6097	Blocked drainage ditch
14	Pavilion Court	Malfunctioning of the Road Drains; bank on a field side too high

ENVIRONMENT AGENCY

Title: LOWDHAM IDENTIFIED ISSUES

Scale:	Drawn By:	Date:	No:
NONE	BC	19.10.07	LD001

Figures 3 and 4 Environment Agency Identified Issues 2007

18. Reference numbers 4, 5, 7, 8, 9, and 10 remain outstanding issues. Reference 14 requires regular maintenance. Reference 2 and 12 are resolved, and References 13 and 14 should be resolved in December 2020. There are new issues which are highlighted in Section 3 of the report.

SECTION 2 - CURRENT FLOOD DEFENCES

19. The sports fields (football and cricket pitches) in the centre of the village is used as a flood storage area. This storage area was constructed after the large flood event in 1999 and while this provided some protection the defences were overwhelmed in extreme flood events[2] as happened in 2007, 2019 and 2020.

20. A 200m stretch of shuttering was installed at the same time along the left bank of the Cocker Beck between Brookside and the Women's Institute building in 2000 in an attempt to raise and even out the bank height as well as creating a deeper storage channel for the Cocker Beck. This has proved to be ineffective as properties on the West flood before the lagoon is full and requires repair sue to general deterioration.

21. At the request of residents, three grips were cut in the east bank of the Cocker Beck in 2007 south of Caythorpe Road to permit water to escape quickly into the fields and prevent it backing up. A Trent Valley Internal Drainage Board scheme to divert water just before the A6097 at the south of the Village was put on hold when the previous Brakes Farm EA scheme was thought to be approved and implemented.

22. In 2020 the EA improved the ability of the lagoon to discharge water when safe to enable it to be ready more quickly for a subsequent event. The lagoon now drains automatically in 6 hours rather than by manual EA pumping in 36 hours.

23. In 2020 Severn Trent Water (STW) installed a sewerage holding tank which should prevent the public sewers being overwhelmed by having 24-hour sewerage holding capacity in a flood event. Work to replace the pumps and other work is currently being undertaken.

24. Trent Rivers Trust (TRT) have put in 54 preventative measures over the last three years in the catchment areas as part of their DEFRA funded Natural Flood Management schemes near Lambley. These include

a. Attenuation bunds
b. Leaky barriers
c. Tree planting
d. Flood plain reconnection
e. De-culverting.

RIVER GAUGE LEVELS AND RAINFALL

25. There is potentially a lot of information available to organisations and villagers which, if consolidated and made timelier would significantly increase the time available for a flood event.

26. There is a river gauge at Lowdham Grange which gives readings that are shown on the EA website and is used by the EA as part of their decision making when issuing alerts and warnings. The level of 0.6m is used as a Flood Alert level by the Environment Agency, alerting the public to the flooding of low-lying land and roads. It is not thought that flooding of property from the Cocker Beck occurs until at least 0.95m - though it may then be imminent.

[2] Environment Agency FAQs Lowdham

A new maximum level of 1.1m was set in 2019 and a new record level of 1.54m set in February 2020. Frequent updates of the gauge (e.g. 15 minutes), while not definitive, are key to giving residents an indication of how fast the river is rising.

27. There is a manual 'white ladder' gauge at the bridge by the Magna Charta pub. Due to its location in the village it cannot give advance warning of a flood but does give a quick indication of river level. The EA have recently provided access to the CCTV which points at this gauge and the cricket field. This will be useful to display to residents to see the situation from their home. If we get permission this will be available on the FLAG website.

28. There are rain gauges at Lambley and Calverton. The Lambley rain gauge is positioned in the catchment of the Cocker Beck and the Calverton gauge in the Dover Beck catchment. There are other rain gauges in a 10 mile radius but none are in the catchment area of the Cocker Beck.

29. The EA have provided historic data of rainfall as well as river levels and Lowdham FLAG has combined this data to see what level of correlation can be obtained. There is no definitive correlation between rainfall and a flood event although we have recognised a pattern whereby it appears that flooding does not occur when under 5mm of rain per hour for two hours falls, whereas 5mm of rain falling for five hours has caused flooding. It is recognised that rain can fall anywhere in the 12 km^2 catchment area and the Lambley gauge is just at one point. Interestingly, in 2013, 18mm falling in 2 hours did not cause the Cocker Beck to flood whereas there was surface water flooding. With the help of the EA, Lowdham FLAG plans to look at rainfall from other nearby gauges to see if a better correlation can be obtained and if so to obtain 'real time' information to display in its dashboard on the FLAG website.

30. The Met Office, via the EA, have provided Lowdham FLAG with access to the Met Office Hazard Manager software. This shows predicted rain levels in small time increments which give an indication of the amount of rain likely to fall. The plan is to record these and build them into a predictive model. We will be looking to provide simple ways to identify the types clouds (e.g. cumulonimbus) that have the ability to discharge more than 5mm of rain for more than 3 hours.

31. Longer term, using input from TRT, Lowdham FLAG plans to build a rain gauge and soil moisture content system in the village based on the Freestation program developed by King's College, London. This will provide information to be displayed on the dashboard to help residents decide what action to take as possible flood events develop.

32. Lowdham suffers from flash flooding so monthly rainfall figures do not tell the whole story. Daily rainfall levels at the Lambley gauge are similarly not in enough detail but by way of approximate correlation they are shown together with Lowdham Grange Beck levels in Figure 5.

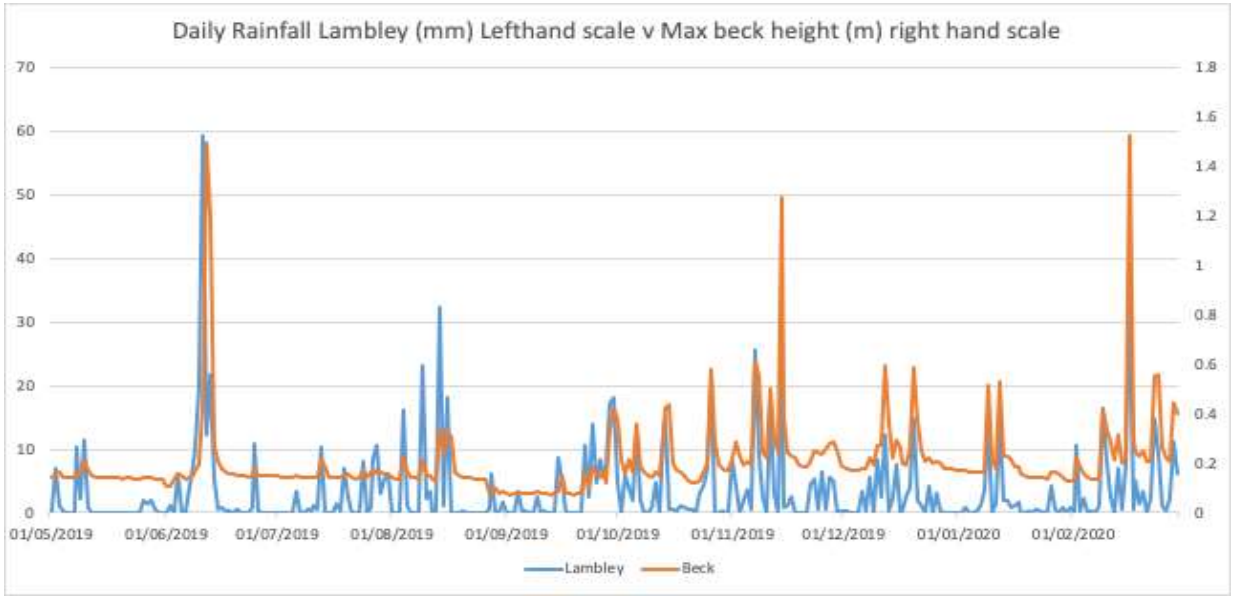


Figure 5 Graph showing relationship between Lambley rainfall gauge and Cocker Beck level gauge

FLOOD FLOW ROUTES

33. The diagram below shows the route that flood water takes. This information has been gleaned from surveys of those flooded and volunteers observing flood events. The EA has confirmed that these reports would support their modelling.

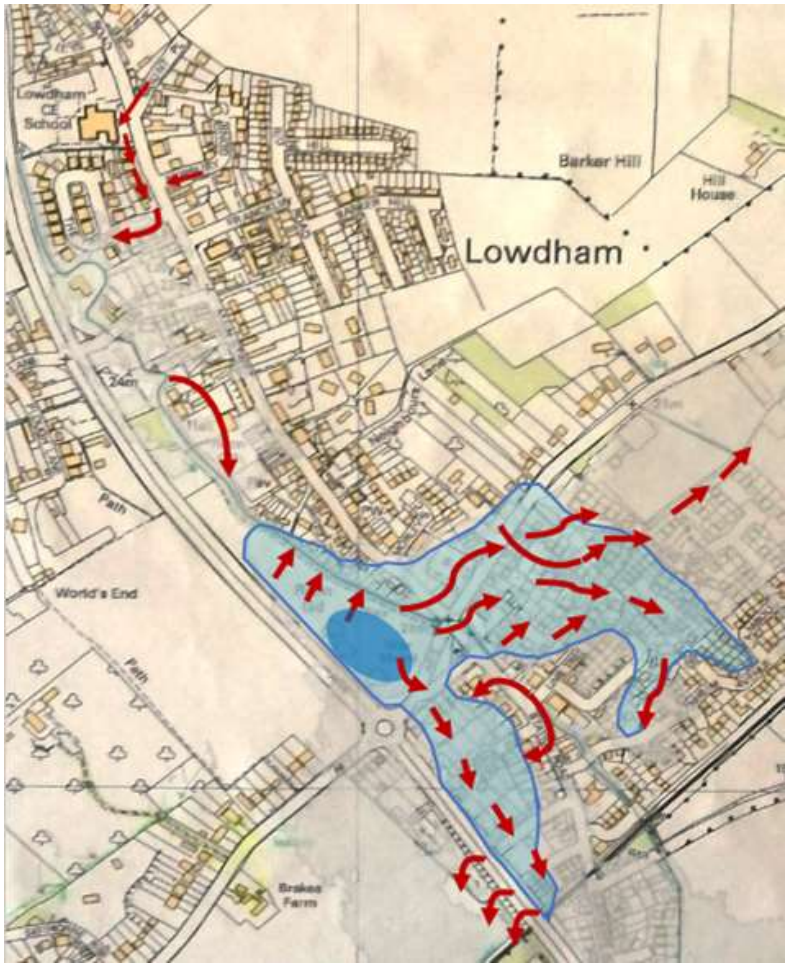


Figure 6 River flow routes. The blue symbol is the lagoon. We wish to be clear that not every house inside the blue area flooded internally but this is an illustraive map.

SECTION 3 - LIKELY CAUSES OF FLOODING

CAUSE BY LOCATION

34. Flooding at specific locations should have been identified by previous Section 19 reports. Some contributing issues have been identified, some of which were some time ago, but not addressed and that lack of maintenance in general has contributed to the degree of flooding.

35. **The Priors:** The Priors, a close in the north of the village, is flooded by surface water running down Main Street. This was identified in the three Section 19 reports but no action suggested, recommended or taken. There were only three gulleys between the Priors and the A6097, a distance of some 300m. This was inadequate to take the volume of water running off the hills to the east and the road itself. Subsequently in October 2020, at the insistence of Lowdham FLAG and championed by County Councillor Roger Jackson, two additional gulleys were installed while resurfacing work was being done. FLAG is grateful to VIA and Councillor Roger Jackson for this.

36. **Main Street/The Corner:** This area floods fluvially from the Cocker Beck overtopping the EA shuttering erected in 2000 before the cricket pitch lagoon is filled. Critically, this water then floods Southwell Road and beyond. The shuttering defences built in 2000 are inadequate. This issue was identified to CEO EA, Sir James Bevan, in March 2020 when he visited Lowdham. It should have been identified and addressed sooner had comprehensive post flood reporting been conducted and the issue treated as a repair rather than part of a 'planned capital' project.

37. **Southwell Road:** Southwell Road has flooded from water leaving the Cocker Beck in the vicinity of the WI building, entering the Magna Charta, and then running east down Southwell Road. The surface water drains in Southwell Road were completely blocked during the November 2019 and February 2020 flood events. They should have been properly inspected after the November 2019 flood event with cameras to identify the issue. Thankfully, they have since being maintained and re-lined in March 2020 and have taken water in recent downpours without any issue arising. This water flows into culverts leading under Old Tannery Drive.

Figure 7 Main Street by WI Hut flooded from Cocker Beck

38. **Willow Holt/Old Tannery Drive/Lime Tree Gardens:** This area is flooded by surface water originating from the Cocker Beck that comes down Southwell Road and then through The Cottages. Water does not escape quickly enough via Tannery Dyke and there is an issue with the culvert between 19 Willow Holt and 8 Old Tannery Drive of misaligned pipes and partial collapse which has been know about since 2013.

39. **Station Road/Victoria Avenue/Longmoor Avenue/The Orchards:** This area has three sources of flooding:

a. As the Cocker Beck rises, the water enters an upstream facing surface water drain pipe near Lime Tree Gardens that lacks a non-return valve. Water is pushed back up the gulley onto Station Road.

b. The bridge at Merevale is the first to have the rising Cocker Beck hit its parapet and spill out sideways onto Station Road. This is surprising, because at 9600 square inches of aperture, it is larger than other downstream apertures and we do not understand why this always floods first. A culvert adjacent to the Cocker Beck next to Lime Tree Gardens entrance is currently blocked and could increase the flow of the Beck if this was opened up.

c. When the lagoon wall overtops, water flows onto Nottingham Road and through gardens towards Victoria Avenue. Blocked culverts under Victoria Avenue were unable to take water away underground in February 2020 and the water moved over ground towards and into The Orchards. The culvert running alongside the east side of the A6097 into the Orchards was blocked, as were the three culverts running under the A6097 and the ditch on the A6097 west was partially blocked preventing the water reaching the main culvert under the Railway. The latter two were last inspected and cleared in 2008 despite being identified as critical assets to prevent Lowdham flooding.

FAILURE OF DRAINAGE SYSTEMS

40. **Epperstone Road/Main Street/The Priors:** The number of gulleys on this section of road was inadequate, with two new ones being built in October 2020.

Figure 8 Location of 3 Gulleys on Epperstone Road/Main Street prior to October 2020

41. **Southwell Road:** Contractors found the culverts to be completely blocked in March 2020 after the February flooding. The gulleys had been cleaned in the month before the November 2019 flood and were reported as functioning. This means that the VIA maintenance system is in need of review because it must ensure that water passes between gulleys down clear culverts and not merely out of the chamber.

Figure 9 Southwell Road with blocked drains, road closure, and severe flooding to The Cottages

42. **Victoria Road/Station Road/The Orchards:** The culverts running parallel to, and under the A6097 (CP1 CP2 CP3) were found in September 2020 to be completely blocked and incapable of taking water underground. These key assets had not been inspected in a number of years to identify that they were inoperable. There is a VIA workplan to ensure they are clear by the end of November 2020.

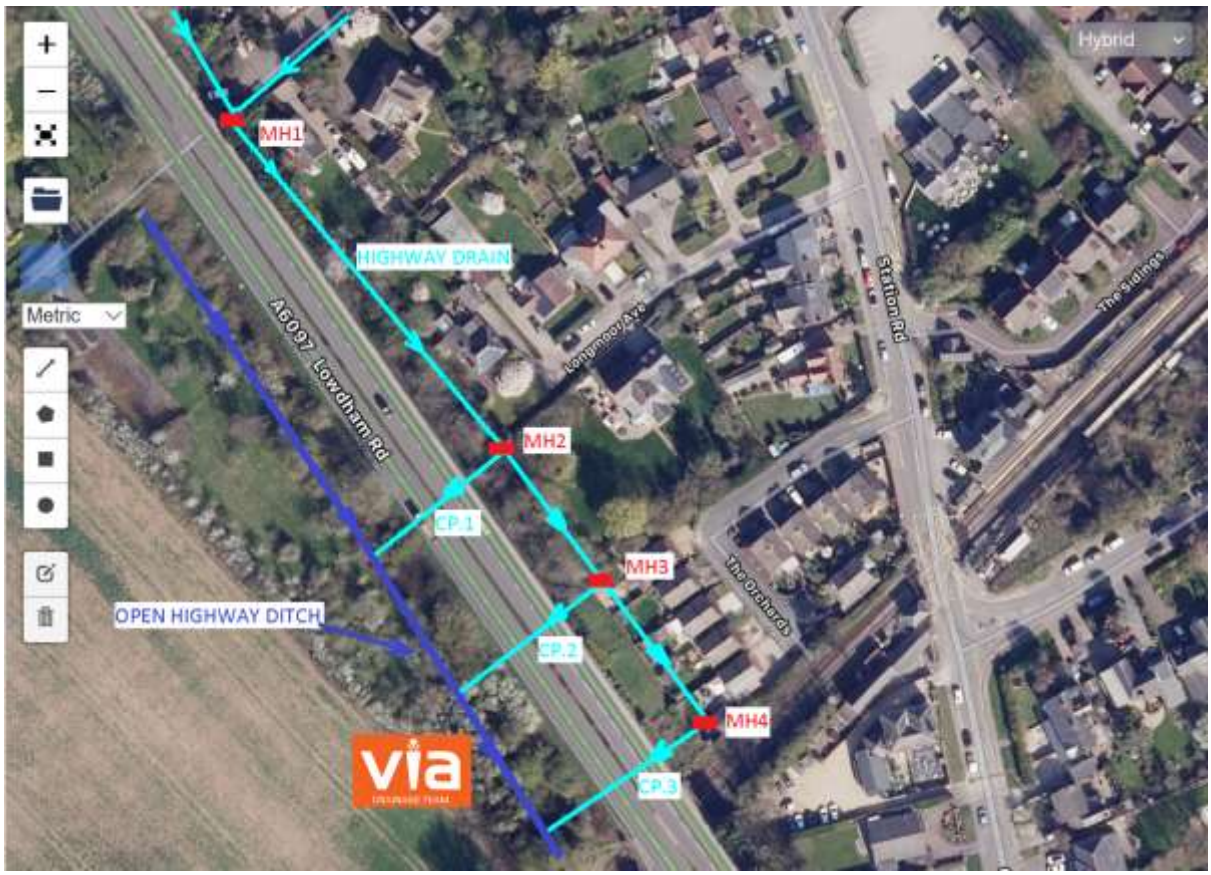


Figure 10 Map of key culverts and ditches which were all inoperable in February 2020

43. **A6097 ditches:** The ditches and culverts along both sides of the A6097 from Ton Lane to the roundabout are blocked and incapable of taking water.

Figure 11 Culvert on A6097 on east side completely buried preventing water passing under the roundabout. Fixed November 2020 thanks to VIA East Midlands

44. **West ditch A6097:** The ditch on the west of the A6097 from the roundabout to the railway bridge has not been maintained since 2008. It is full of silt and there is no fall from the culverts running under the A6097 which inhibits the flow of water under the railway (large clean culvert) and into the Bypass Feeder/Boundary Dyke towards the River Trent. There is a VIA workplan to ensure it is clear by mid December 2020.

Figure 12 Outfall of MH3 in Fig 9 in A6097 western ditch

45. **Misaligned pipes:** The culverts that run into chambers in 19 Willow Holt and 8 Old Tannery Drive have misaligned pipes and are partially collapsed following camera work in March 2014. These lead directly to Tannery Dyke. This issue was identified 7 years ago. FLAG has reminded Nottinghamshire County Council (NCC) of this issue repeatedly since formation early in 2020. Action needs to be taken urgently to obtain access to these chambers because, with the culverts on Southwell Road cleared, more water will flow here.

Figure 13 Map and camera images of misaligned pipes and partial collapse area Willow Holt/Old Tannery Drive

46. **Tannery Dyke (Carr Dyke):** The Tannery Dyke readily fills and water does not flow freely away causing a backing up of water in the culverts from Old Tannery and along the Carr Dyke. The main problem is that the Carr Dyke flows within a flood plain and this is exacerbated by a pair of culverts downstream of Harrison's Garage appearing to be both too small and too low so that they are part full even when there is minimal water in the Dyke. The dimensions of the double culvert are the smallest along the dyke even though other water courses join the Dyke after it leaves Old Tannery Drive.

47. The issue with moving water away from the houses within the flood plain has been known since Old Tannery Drive estate was built in the late 90's. It is not known what arrangements were made for flood water at the time. However, since the new estate was completed it has compounded the problem and it is now critical to address and will need capital investment.

48. In the meantime, ongoing maintenance is key to clear 'bad' weeds and stop cattle destroying the banks of the Dyke. This maintenance is carried out by the Trent Valley Internal Drainage Board (TVIDB).

Figure 14 Double culvert far side Harrison's Garage too small and too high to be effective

49. Bypass Feeder/Boundary Dyke. Bypass Feeder/Boundary Dyke takes water passing under the railway line west of the A6097. There is inadequate flow and it is going to be dug out and cleaned.

Figure 15 2Exit from Railway culvert into Bypass Feeder showing no flow after culvert cleaning by A6097

SECTION 4 - OPTIONS TO CONSIDER TO REDUCE THE COCKER BECK FLOODING

50. FLAG would like Risk Management Authorities (RMAs) to evaluate a number of options which, although relatively small in impact individually, if taken collectively could make a meaningful difference. In particular, we feel that they could provide welcome security from fluvial flooding in the interim period while the main EA scheme is built. The coloured arrows refer to those shown in the figure below.

a. The ditches alongside the A6097 north of the roundabout should be capable of taking water safely to the railway line culvert without ever entering the village and could be utilised to take water via a new spill weir as the Cocker Beck passes under the A6097 before it becomes a main river. NCC is asked to consider this option. See

b. Divert River Laybourn into one of two A6097 ditches. See

c. The cricket pitch lagoon could have a drain into the A6097 ditch would slow the rate of rise of the level in a flood situation. EA / NCC are asked to consider this option. See

d. The Merevale bridge parapet could be adapted to allow water to pass more quickly through it. EA is asked to report on whether the flow of water through this aperture can be improved. See

e. The culvert under Lime Tree Gardens bridge is blocked. EA is asked to have this unblocked to increase capacity. See

f. The grips south of Caythorpe Road could be deepened to take effect sooner. EA is asked to model this. See

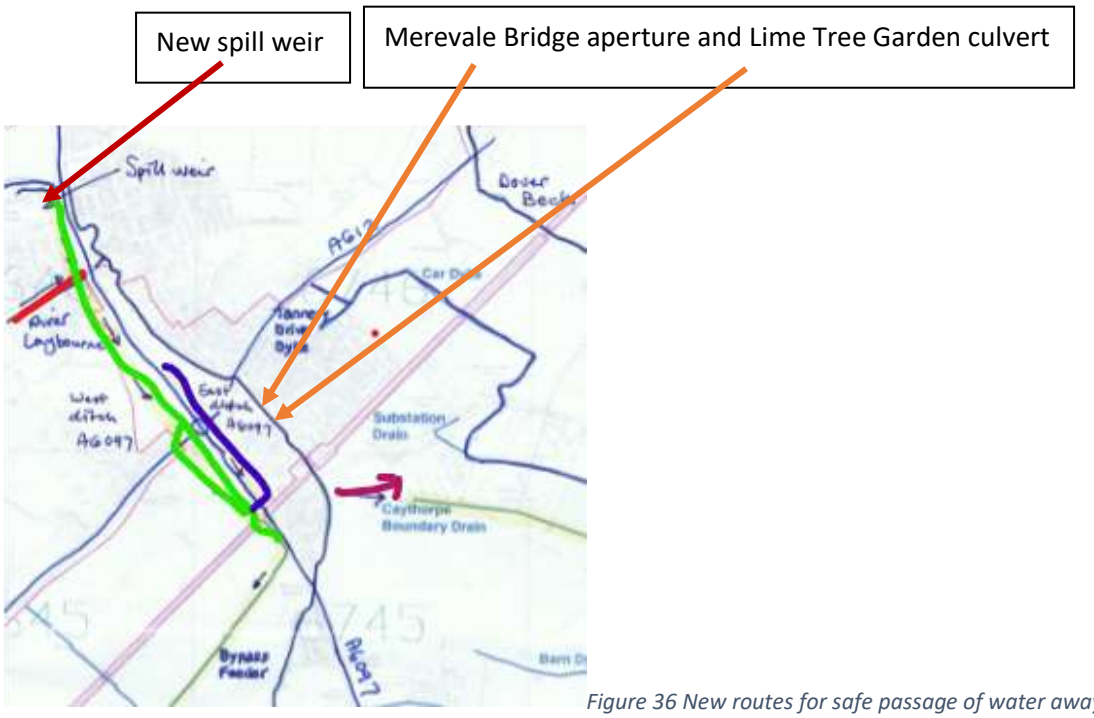


Figure 36 New routes for safe passage of water away

SECTION 5 - SUMMARY OF IMPACT AND FINDINGS

51. The majority of flood events have been caused by the Cocker Beck over topping its left bank. Only in the 23 July 2013 flood was surface water flooding the main source.[3] Recovery work by the Environment Agency to replace the shuttering on the left bank of the Cocker Beck is expected to be complete in Spring 2021. This should have some impact in preventing water leaving the Cocker Beck near the WI building and progressing towards the Tannery Dyke via Willow Holt, Lime Tree Gardens and Old Tannery Drive. It will not, however, prevent the water hitting the Merevale parapet and spilling over into Station Road, and it will also see the lagoon, which already overtops, fill more quickly.

52. Reducing those risks requires the new EA Lowdham Flood Alleviation Scheme (FAS) which has the aim of protecting up to 200 residential properties as well as several local businesses from the Cocker Beck overflowing by storing water in a reservoir upstream of the village; data the Environment Agency has gathered shows this option has great potential. The reservoir will remain dry for the majority of the year, only filling with water when a high rainfall event occurs. This scheme should be in place by the end of 2023.

53. The new scheme will not address surface water flooding which remains a clear and enduring threat.

54. Maintenance of the existing infrastructure is key. Failure by NCC/VIA to have the current infrastructure maintained properly is a major contributory factor in the recent flooding. In particular, key culverts under Southwell Road, Main Street and alongside the A6097 need occasional but scheduled camera work to identify their status.

55. The Trent Valley Internal Drainage Board does maintain the Carr Dyke, Bypass Feeder/Boundary Dyke and the EA stretch of the Cocker Beck on a regular basis but often after residents have provided feedback on silt or weeds. A more frequent schedule would alleviate the concern.

56. There is an opportunity to review the Section 19 reports and see them contain more detail about the causes of flooding with recommendations, cognisant of the British Standards Institute (BSI) on flood reporting and the Defra 2015 report on Section 19 reports. This would provide additional information rather than just meeting a statutory requirement.

[3] Section 19 Report Lowdham 23 July 2013 para 13.

SECTION 6 CONCLUSIONS

57. The provision of a new EA storage facility upstream should remove the threat of fluvial flooding by the Cocker Beck from 2023. In the interim, there is a continued threat of fluvial and pluvial flooding.

58. During the interim period, the left bank wall repair will prevent flooding to the properties on the west of Main Street but also see the lagoon come in to play more quickly. It is therefore essential that culverts and drains providing an escape route for surface water via Victoria Avenue/Longmoor Avenue and The Orchards are kept clear and are regularly monitored and maintained.

59. It is worth considering ways to reduce the volume of water entering the Cocker Beck by using existing infrastructure that has the water avoid passing through the village and slows the speed at which the lagoon fills.

60. Maintenance of existing infrastructure needs to be more comprehensive and include regular inspection of key culverts.

APPENDIX 1: SUMMARY OF TASKS AND RESPONSIBILITIES

Ser	Task	Responsibility	Status
1	Increase gulleys on Epperstone Road/Main Street	VIA EM (Shaun Brown)	**Complete**
2	Review and publish revised culvert / drain maintenance schedule including periodic Camera work and extra visits after floods	NCC/VIA EM (Martin Carnaffin)	Ongoing
3	Consider ways to reduce water entering the Cocker Beck (spill weir at Village entrance by A6097, River Laybourne divert into A6097 ditches etc, new culvert by Worlds End).	EA EM (Emily Mayle)	Awaiting result of discussion/modelling
4	Conduct a hydraulic analysis of Merevale Bridge in order to improve its ability to have water pass through.	EA EM (Emily Mayle)	Awaiting feedback
5	Critical review of hydraulic analysis on whether increasing depth of grips on Cocker Beck bank south of Caythorpe Road reduces backing up of the Beck notably at Merevale bridge. (model says no, residents say yes). Alternatively resurrect scheme to allow Cocker Beck to flow into Dover Beck nr bridge on A6097	EA EM (Emily Mayle)	Awaiting feedback
6	Consider a valve in the wall of the lagoon to have water enter the A6097 ditch to slow the rise of water levels and compensate to some degree for the effect of the left bank repair.	EA EM (Emily Mayle)	Awaiting feedback
7	Open all ditches and culverts along A6097 to take water.	VIA EM (Mike Keeling)	Date awaited
8	Investigate and fix misaligned pipes 19 Willow Holt/8 Old Tannery Drive.	LLFA Sue Jacques)	Ongoing

9	Fit non return valve to pipe into Beck near Lime Tree Gardens and by Womens Institute and under Magna Bridge	VIA EM (Matt Duckworth)	Ongoing
10	Clear culverts alongside A6097	VIA EM (Andy Clifford)	**Completed**
11	Clear ditch alongside A6097 south of roundabout	VIA EM (Matt Duckworth)	**Planned completion by mid Dec 20**
12	Improve Section 19 reports	LLFA (Sue Jacques)	To be agreed
13	Repair left bank shuttering	EA EM (Emily Mayle)	Ongoing (by March 2021)
14	Conduct a hydraulic analysis of the Tannery and Carr Dykes.	EA EM (Emily Mayle)	To be agreed
15	Create sewage storage facility to prevent backing up	Severn Trent Water	**Complete**
16	Create upstream attenuation facility	EA EM (Emily Mayle)	By 2023
17	Determine if needed and, if necessary, unblock the culvert under Lime Tree Gardens bridge	EA EM (Emily Mayle)	To be agreed
18	Assist with the rainfall analysis to help create a more effective early warning system	EA EM Adam Falkener Emily Mayle) LLFA (Sue Jacques)	To be agreed
19	Regrade Tannery Dyke from OTD to Dover Beck including make slopes < 45%, increasing capacity, review/fix 2nd double culvert	TVIDB (Mat Everett)	April 2021
20	Maintain Boundary Dyke from Railway Culvert to Trent	TVIDB (Mat Everett)	To be agreed
21	Complete and publish list of Lowdham critical assets including possible input from FLAG	NCC (Sue Jacques, Deniz)	Mid 2021
22	Finalise whether contractors building OTD fulfilled anti-flooding conditions properly	N&SDC, NHBC	Ongoing

APPENDIX 2: RAINFALL AND RIVER LEVEL DATA

This Appendix lays out current thinking by Lowdham FLAG to enable residents to form their own view of likely outcomes of a rainfall event. FLAG is seeking input from stakeholders, notably EA, to help 'sense check' this work.

The major factor in water levels in the Cocker Beck rising is clearly the amount of rain falling although this is not the only factor and must also include the condition of the ground after periods of rain / drought. Therefore, given there are other factors, looking at data can only inform rather than accurately predict what the Beck will do. Indeed rainfall, especially predicted rainfall, is one of the factors the EA consider when issuing flood alerts and warnings.

The EA have provided data going back to 2012 to find a link; and then use that link to help predict what may happen.

The following data is available:

a. River level of the Cocker Beck at Lowdham Grange from January 2012 (300,000+ data points).
b. Rain gauge at Lambley which is situated in the 12 km^{2} Cocker Beck catchment area (75,000+ data points).
c. Rain gauge levels at Calverton - which is outside the catchment area (Dover Beck is informed) (75,000+ data points).

The data on rainfall has been examined in several ways. The process is described below with shortcomings identified and possible ways forward examined. The analysis started with the hourly rainfall and determined the maximum downfall in the month and compared that to the months in which Lowdham flooded. This is shown in Table 1.

It is recognised that a heavy downpour could lead to flash flooding but unless the soil was baked and the rain quickly flowed into the Beck, then one hour's heavy rain is unlikely to cause a flood. Recognising that, longer periods of rainfall from 3 hours as shown in Table 2 were examined. This does show a greater correlation with the flood events. However, there are months when heavy downpours do not lead to flooding. The duration of rainfall was then extended to cover all periods from one hour's rainfall to 10 hours rainfall. This shows better correlation but, again, is not conclusive.

A comparison was then made between rainfall and river levels on an hourly basis in these high rainfall events. Examples are in Tables 3a and 3b. This highlights several issues to understand and then discuss:

a. The Beck is filled by rain falling in the catchment area other than just at the Lambley gauge, and there is a lag between rainfall and river level at Lambley and the flooding in Lowdham. To begin to address this the rainfall at Calverton has been shown.

b. When interpreting the information we need further data. For instance, in February 2020 the Beck rose but didn't flood around midnight and then over topped circa 3am. One interpretation could be that the total rainfall from 11pm to 1am of 10.4mm wouldn't have caused a flood but the extra 9.6 at 2am to make a total of 20mm which is what caused the flooding.

c. In terms of understanding the time lag we need accurate knowledge of when the flood occurred, possibly more granular detail on time of rainfall (if the lag is measured in minutes) and the condition of the ground.

d. Ultimately the objective is not to fully explain each event but to gain an insight into the cause so that different measures (such as predicted rainfall and approximate soil condition) can be used to predict if a flood event is likely to happen.

An analysis (which is yet to be completed) of 7 near flood events is shown in Table 4. The tentative working conclusion / hypothesis from the tabular data is that at rainfall over a 7-hour period of 30mm, there is a 50+% chance of leading to a flood. The conclusion from February 2020 is that heavy rainfall (over 8mm/hr) after persistent rainfall (10mm in 3 hrs) will lead to a flood.

Access to forecast data from the Met Office which shows the forecast rain levels is available. There is further work to be done to ensure that we are measuring the same thing (e.g. rain in mm that fell into the Gauge at Lambley being the same as forecast rainfall in mm/hour over the geographical area of Lambley). If these are the same, then the Met Office maps may give a good indication. We then need to adjust the 30mm figure to take account of ground conditions (see below)

Ground conditions. Ground conditions are reported by the EA on a weekly basis. In some parts of the country they are monitored more frequently. In terms of 'sodden' ground then the previous week's rainfall may be a good proxy. In terms of 'baked' ground, a low previous month's figure may be an appropriate measure. The EA will have more accurate information but one crude indicator is the average amount of monthly rain that has fallen in the last three months. This is shown in Table 5.

Monitoring. If additional monitoring is the answer, then the suggestion by TRT is that we could purchase the parts (at cost) to build our own measuring station to be sited at an appropriate location. Lowdham C of E Primary school has already said they would be interested in hosting the project.

Availability of Information. The Pang Valley Flood Forum has a dashboard that is automatically updated from the data available on the EA websites. Once we know what data we want it should be possible to have a similar system if we can access the expertise to build such a site.

When does heavy rain/flooding occur and is it getting more frequent? There is no pattern. Table 6 shows the data we have from our rain gauges since 2012. It is difficult to draw firm conclusions but the wettest months are June, October and November followed by December and August. February was the lowest until Feb 2020!

Tables 1 and 2 - Maximum rainfall in one hour (or 3 hourly) period in each month/year. Yellow shows when river flooding occurs, orange when surface water flooding occurs.

Table 1

Hourly rainfall rate in mm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	3	2	4	6	3	7	11	11	8	6	5	4
2013	4	2	3	5	5	6	18	4	3	10	4	4
2014	7	4	7	4	5	4	8	18	2	4	6	3
2015	4	3	3	2	5	3	7	7	8	10	4	5
2016	3	4	5	3	2	11	6	4	5	6	8	4
2017	2	4	3	2	4	5	7	6	7	4	3	4
2018	4	4	3	5	8	8	1	7	3	4	3	5
2019	2	3	3	4	6	9	4	12	6	5	6	4
2020	4	10	3	3	2	12	6	12				
Total	**7**	**10**	**7**	**6**	**8**	**12**	**18**	**18**	**8**	**10**	**8**	**5**

Table 2

3 Hourly rainfall rate in mm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	5	4	8	13	7	13	24	12	16	11	11	9
2013	10	6	5	6	12	7	31	5	4	16	6	8
2014	14	9	7	5	11	5	9	31	2	10	8	8
2015	5	7	8	3	10	8	10	11	8	17	6	8
2016	7	6	11	8	6	18	12	8	6	13	18	7
2017	4	7	5	3	8	9	14	12	16	5	7	10
2018	6	8	7	8	16	12	3	14	6	8	4	9
2019	3	7	8	8	11	14	10	16	14	9	15	7
2020	**10**	**19**	**5**	**3**	**2**	**12**	**10**	**20**				
Total	**14**	**19**	**11**	**13**	**16**	**18**	**31**	**31**	**16**	**17**	**18**	**10**

Table 3a

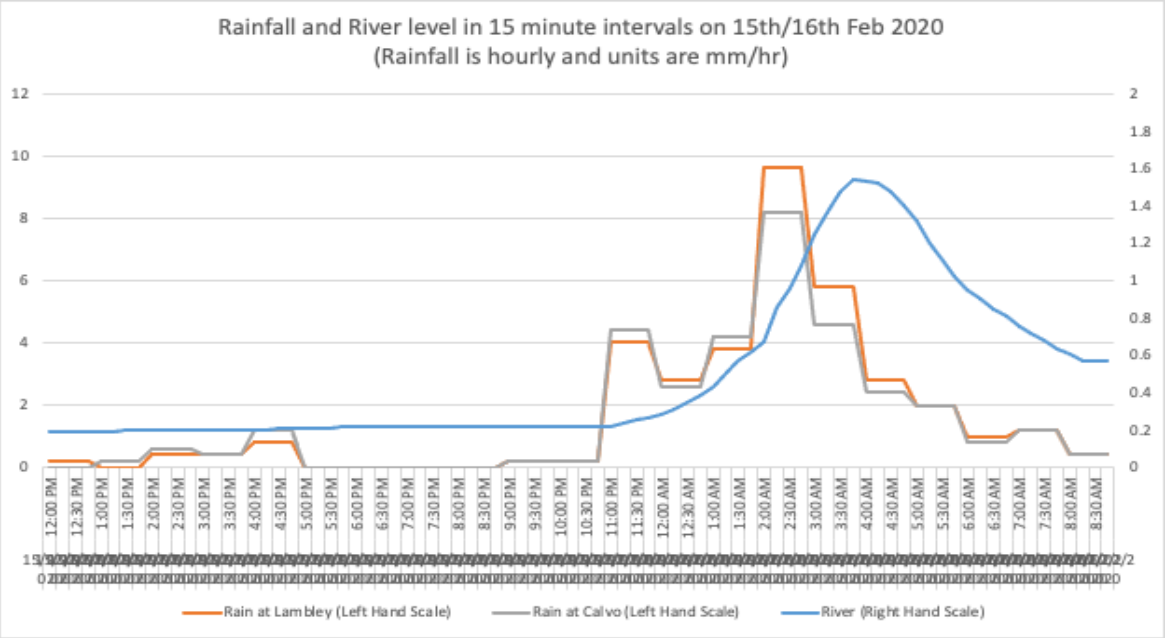


Table 3b

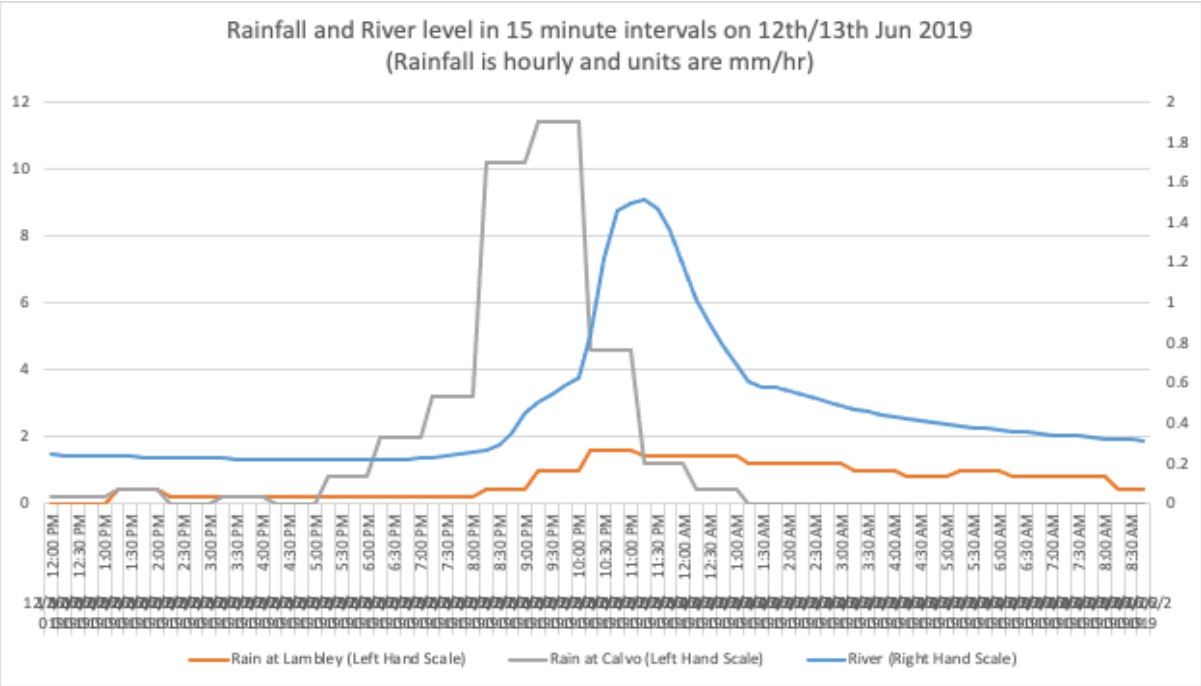


Table 4

During 7 recent flooding events, the rainfall per hour and river levels have been compared to identify when flooding occurs. The table below shows this

Av Rainfall (mm/hour)	Duration (hrs)	Beck height (m)	Date	Results in a Flood Y/N	Lag (mins) heavy rain to river peak	Annual Exceedance Probability (to be completed)
3	5	0.6	Dec 19	N	300	
Initially 2 then further 7 - 8	3 2	0.208	Aug 18	N	No change	
6	2	0.831	Jan 14	N	150	
5	5	1.261	Nov 19	Y	300	1 in 5-10 years rainfall
Initially 4 then further 8	3 2	1.539	Feb 20	Y	300	1 in 20-30 river level
1.6 (Lambley) 10 – 11 (Calverton)	4	1.508	Jun 19	Y (minimal)	180	
Initially 18 then further 13	1 1	0.546	Jul 13	Y (surface)	Concurrent	1 in 5 year river level

Table 5

Average Rainfall in last three months

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012			31	66	74	109	116	129	104	74	81	101
2013	90	65	43	34	55	51	72	54	46	68	68	75
2014	68	71	69	39	55	52	58	58	51	64	56	76
2015	60	48	42	36	47	49	60	56	52	61	66	79
2016	71	64	64	66	60	80	72	75	43	44	53	47
2017	47	37	47	37	41	48	76	79	85	61	52	42
2018	57	55	59	65	70	52	29	31	37	48	39	54
2019	47	47	41	41	44	75	89	112	94	106	116	105
2020	87	91	74	64	16	38	55	83				

Table 6

Monthly Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
2012	41	20	33	146	43	139	165	84	64	74	106	123	1037
2013	42	31	57	14	95	45	75	41	22	140	41	45	648
2014	117	51	38	29	100	29	45	100	7	85	78	64	741
2015	38	40	47	20	74	53	53	61	41	82	76	78	664
2016	58	57	77	63	41	135	38	51	40	40	80	20	701
2017	42	49	52	10	60	74	94	68	94	21	39	65	669
2018	66	34	77	83	50	24	12	58	40	45	31	87	607
2019	23	31	69	25	39	161	69	106	108	104	136	75	945
2020	50	148	25	18	4	90	70	88					494
2012-19	**427**	**314**	**449**	**388**	**502**	**660**	**551**	**569**	**415**	**592**	**588**	**555**	**6011**