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DEVON AND CORNWALL

The November 2012 Railway Flooding in Devon:

Observations & Recommendations

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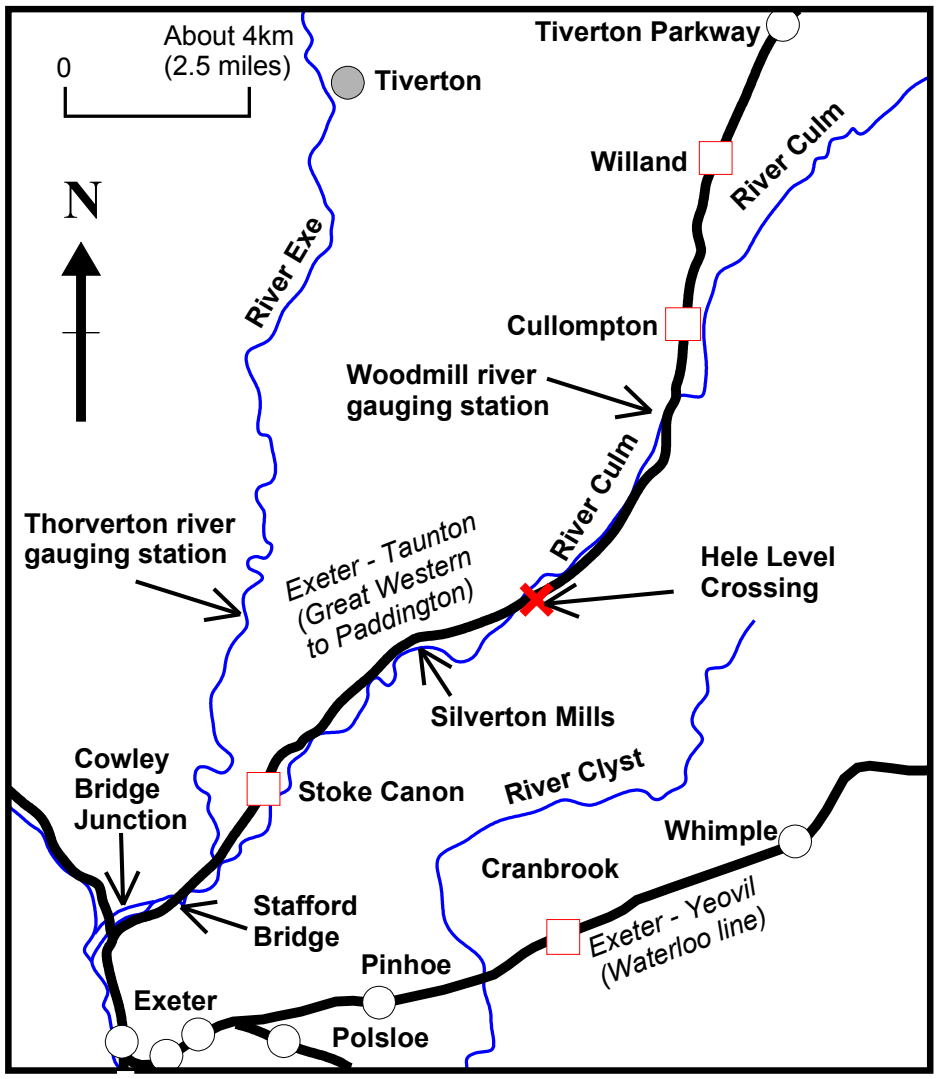

Figure 1. Location map showing the Great Western main line from Exeter to Taunton and its proximity to the River Culm. Red squares show suggested new stations.

Cover photo shows some of the flood water flowing south from Cowley Bridge Junction on 25/11/2012.

the independent campaign for rail users

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Summary

From Wednesday 21st November 2012 the Great Western main line was closed for a week between Tiverton Parkway and Exeter. This was mainly due to flooding at Hele Level crossing and Cowley Bridge Junction, plus associated track damage. The alternative route from Exeter via Yeovil was also closed by flooding.

High peak flow rates on the River Culm are primarily responsible for past and present flooding on this line, coupled with the railway having been built too low on the flood plain. Unlike the River Exe, the River Culm has no equivalent to the Wimbleball reservoir to take up and delay the release of excess water.

There is a high probability of flooding at Hele level crossing when the Cullompton Woodmill river gauging station records river levels above 3 m, high peak flow rates of around 150 m^3/s and average daily flows of around 40 m^3/s on two successive days. Under these conditions it is on the second day that flooding occurs. So the first day of high river flow levels can act as an amber warning for bus replacement services and track repair teams to be on standby.

The railway around Hele level crossing has flooded on several occasions in the past and consideration should be given to raising the level of the line at this point. This could either be by around 1 metre or with a bridge that would allow the level crossing to be removed and lines speeds increased.

At Cowley Bridge Junction a culvert needs to be widened beneath the 'V' of the diverging Barnstaple and Taunton lines. This would allow water which may build up on the east side of the railway to pass freely to the river channel on the west side.

The alternative Yeovil route from Exeter needs to be improved, so that it can act as a good quality backup line for diversions when the Taunton line is closed. Closure may be due to flooding or other reasons such as track engineering work. The Yeovil line has a low line capacity, because it is only single track. Two new double track passing loops need to be built, with one around Whimple and the other near Crewkerne. The low embankment across the River Axe flood plain should be made more permeable to flood water. Low bridges and culverts should be added to the flood plain sections to stop flood water building up and then washing away the track foundations.

Contents

Introduction

On Wednesday 21st November 2012 flooding closed the main line railway linking Penzance, Plymouth and Exeter with Taunton, Bristol and London Paddington for a week. Unfortunately the alternative route via Yeovil was also closed for similar reasons at Axminster. There were also landslips at various locations.

Flooding at Cowley Bridge Junction, Exeter

Between Exeter and Taunton the railway was flooded at Cowley Bridge Junction, on the edge of Exeter, by the combined flows of the River Exe and River Culm. A normally stagnant channel of water, running along the east side of the line, came to life and the extra volume overwhelmed its engineered normal escape route through a small culvert under the tracks (Figures 2 and 3).

The trapped water rose and flowed across the track, and scoured away the supporting track formation and ballast of both the Taunton line and the diverging Barnstaple line. Some water flowed south along the railway, as if following its old course to a mill, that had been there before the railway was built in the 1840s (Figure 1).

Figure 2. The River Exe at Cowley Bridge on 25th November 2012 after water levels had begun to drop at around midday. The view is to the north close to the railway junction and shows the trapped water on the east side of the railway.

Figure 3. The flooded railway at Cowley Bridge Junction on 25th November 2012.

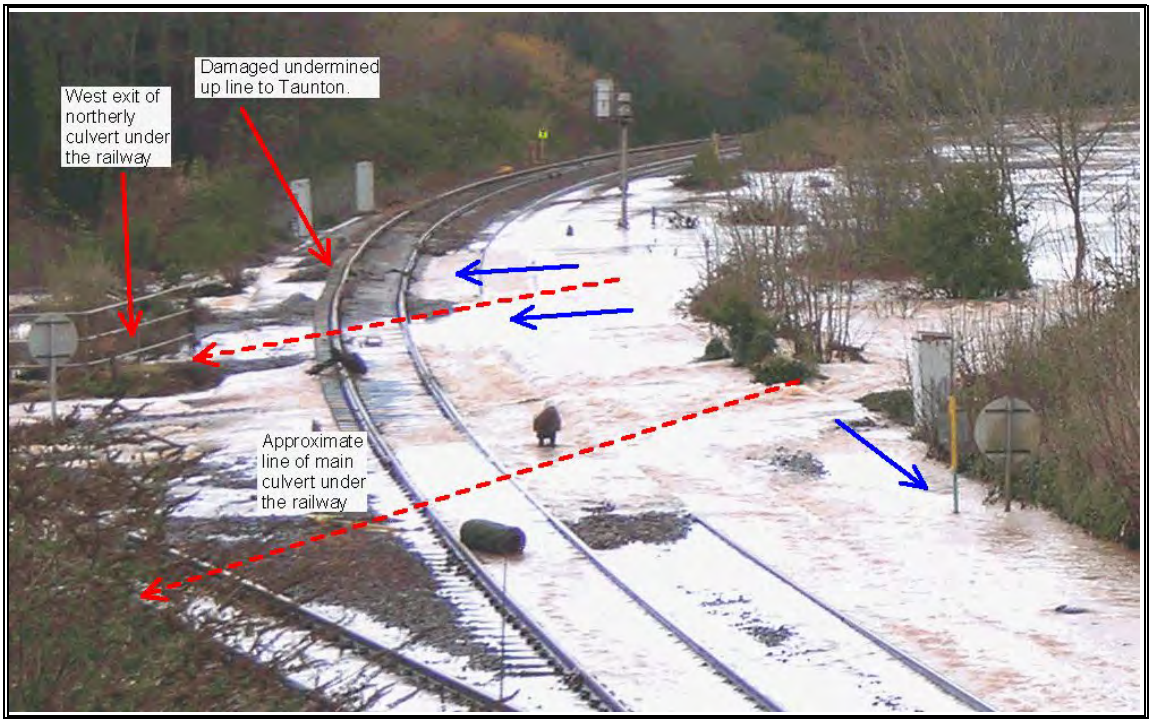

Figure 4. Enlarged section of photo to show where the water escaped over the tracks (blue arrows to left) and southward (arrow on right) once the culverts beneath were full. Red arrows indicate existing culverts.

Flooding at Hele

A few miles further towards London, flood water from the River Culm covered the tracks at the Hele level crossing near Bradninch on Sunday 25th November. This location has an intermittent history of flooding with notable dates being1st October 1960, 30th October 2000, 14th November 2002 (Figure 5) and 30th October 2008.

Figure 5. The Great Western main line during the past flooding event on 14th November 2002. The view on the left is looking south towards Exeter from the level crossing and at the site of the closed railway station. The right hand view shows the flooded line towards Taunton. Photos by kind permission of Warren Radmore, Warren's Weather Watch website - http://www.eclipse.co.uk/~sa3332/warrensweatherwatch/index.htm

Flooding at Axminster on the Yeovil route.

Exeter's alternative route out of the region via Yeovil was also flooded. Water from the River Axe washed away ballast and the supporting ground beneath the tracks near the Broom level crossing.

Overview of Weather Conditions

The amount of rain falling in the days leading up to 25th November 2012 was exceptionally large and reported worldwide. The American television channel CNN reported a figure of 72mm of rainfall, almost a month's normal rainfall in a few days. At Dunkeswell, close to the headwaters of the River Culm, 30.8 mm or rain was recorded by the Met Office between 6 pm on Saturday 24th November and 8 am on Sunday 25th November 2012.

Under these conditions the railway network cannot be expected to function normally, but total closure for a week is not acceptable. Measures need to be taken to make the railway more resilient and Railfuture suggests the following.

Proposed culvert widening at Cowley Bridge Junction

At Cowley Bridge Junction the main overflow culvert has clearly proved inadequate under peak flood conditions (Figure 2). This structure should be replaced with a wider structure that will release all the water that builds up on the east side of the railway line. A smaller culvert (Figure 4) should be widened and additional ones provided beneath the low main line embankment and under the Barnstaple line. This is an urgent measure, firstly as the time taken to repair the damaged track far exceeds the period when trains cannot run due to actual water on the tracks. Secondly, the Barnstaple line is also affected by the flooding, along with the Okehampton line with its potential as a second Exeter to Plymouth line.

However, a long term aspiration should be to run the Barnstaple and Okehampton lines parallel to the Great Western main line, so moving the physical junction closer to Exeter St. David's station. Therefore new bridges/culverts should be designed to take this future possibility into account.

River Culm hydrology

There is no simple solution to the flooding, because the railway has been built too low on the flood plain of the River Culm (Figure 6).

Figure 6. The railway on the low flood plain of the River Culm at Silverton Mills. View south towards Exeter. The River Culm is at the end of the first field on the left (east) side.

The River Culm has short periods of comparatively high flow rates (Figure 7), which follow prolonged rainfall. In contrast the River Exe has fewer exceptionally high peaks (Figure 8), probably due to its wider channel, upstream regulation by the Wimbleball reservoir on Exmoor and water abstraction for Tiverton.

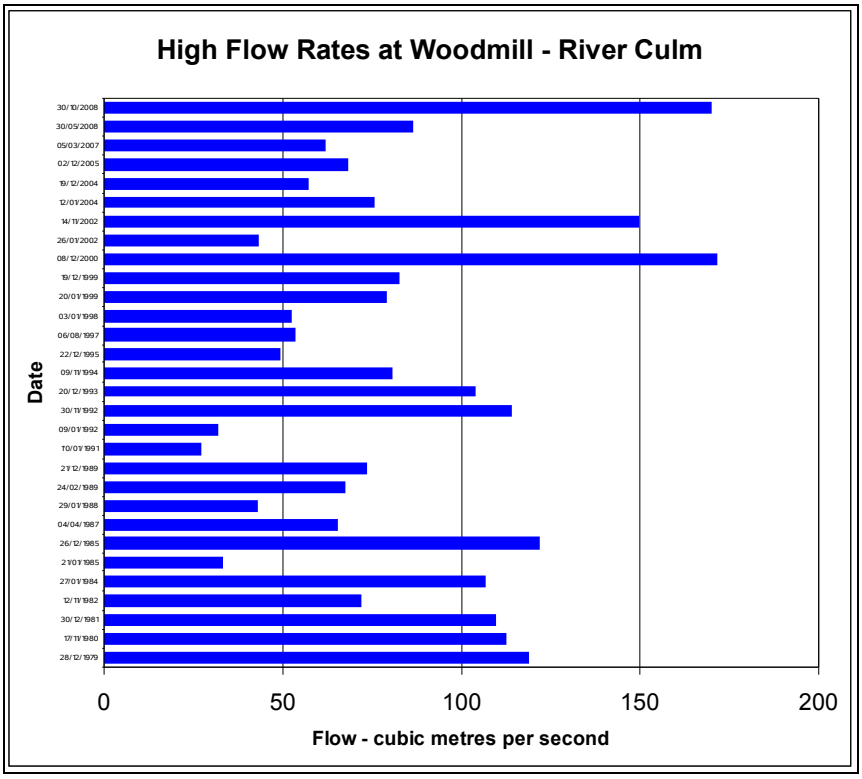

Figure 7. Graph of high flow rates on the River Culm 1978 to 2008 showing the wide range. The very highest flow values of around 150 m^3/s or more are double the average maximum flow rates of around 82 m^3/s (108% increase on average high flow). It is these really high flows that normally result in the flooding of the Great Western main line at Hele. Data from Environment Agency.

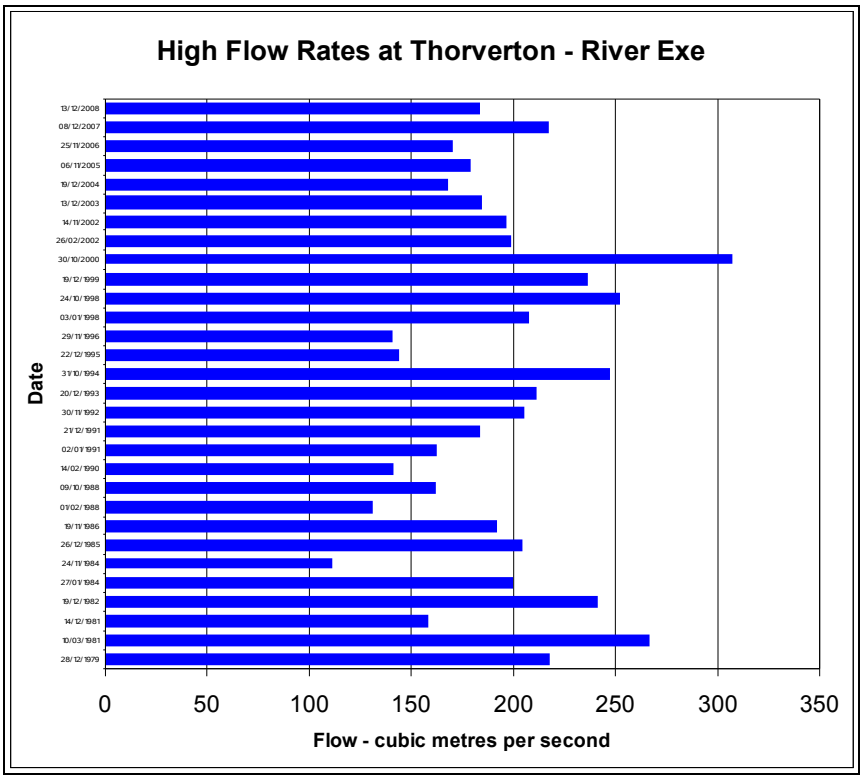

Figure 8. Graph of high flow rates on the River Exe at Thorverton showing the narrower range of high flow rates. Since opening of the Wimbleball reservoir on Exmoor, at the end of the 1970s, the maximum high flow has been no more than about 60% above the average maximum high flow. Prior to this there was a high flow of 395 m^3/s on 19th December 1965. Data from Environment Agency.

Upstream of Woodmill half of the River Culm catchment is within land between about 142 metres and 293 metres in altitude. Valley sides are steep leading to rapid runoff particularly if the water table is high. When the river level at the Woodmill river gauging station rises much above 3 metres and records high flows greater than 150 m^3/s, the railway is in danger of flooding. The 30th October 2008 flooding at Hele was associated with a 3.32 m level at Woodmill and a similar level for the November 2012 flooding.

Taking instead the daily average flows, the chart for October and November 2008 (Figure 9) shows the Culm flowing at an average 24.5 m^3/s on 29/10/2008 and 53.4 m^3/s on 30/10/2008 for each 24 hour period. The long term average flow for 30 years is just 3.85 m^3/s. The flow on 29th October 2008 was not sufficient to flood the railway from a one day peak, but did so on the second day of high flows. This is supported by the flow of 24.3 m^3/s on 19th November 2008 which being for one day only did not flood the railway, and the 14th November 2002 flooding that was also marked by flooding but only on the second day of high flows. On 12th November 2002 the Culm at Woodmill had a daily average of 10.2 m^3/s, then the next day 50.4 m^3/s and then 35.5 m^3/s which caused the railway to flood on the 14th November 2002. The next day (15th November 2002) the river was flowing at 16.9 m^3/s.

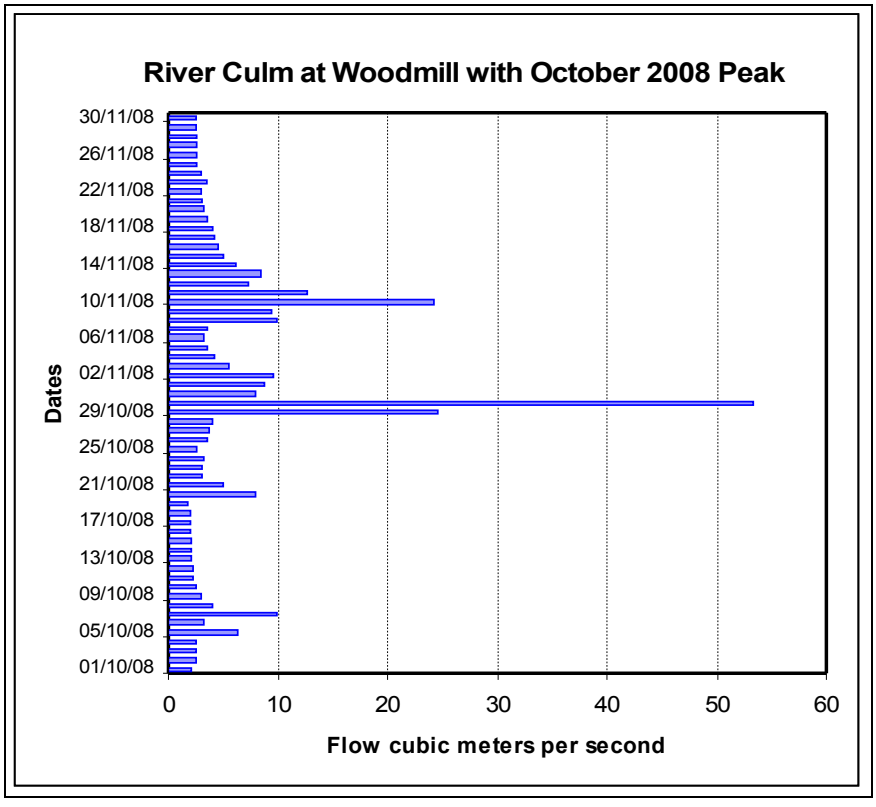

Figure 9. River Culm flow data from Woodmill showing the peak flows over a 2 day period, that resulted in the 30th October 2008 flooding of the railway at Hele level crossing. Flow data from Centre for Ecology and Hydrology website.

Early Warning of Flooding

The water levels at Woodmill should form the basis of a direct early warning system, not only for the railway but for their passenger information systems. A full day of 40 m^3/s river flow at Woodmill represents an amber warning for the railway and if this continues into a second day a red warning. At these flow rates a 3 m height is to be expected at Woodmill and this latter information is readily available on the Environment Agency's website. This is important so that emergency timetables are in place together with replacement road transport.

A Role for New Stations

Railfuture has previously proposed new stations within Devon (Figure 1) at Willand (former Tiverton Junction station), Cullompton (Figure 10) and Stoke Canon (on a new site to the north of the village). They would primarily be served by a new local rail service between Taunton and Exeter, but they could also be useful when parts of the line are closed due to flooding or planned engineering work on the route.

When trains are unable to travel through from Taunton to Exeter they should go as far as possible towards Exeter. Passengers driving from Exeter to Tiverton Parkway, to catch their trains and avoid a bus replacement service, would save 5½ miles on their journey if Cullompton station could be used as well. The station site is conveniently adjacent to Junction 28 of the M5 motorway. Bus replacement services could continue to use Tiverton Parkway or a reopened Cullompton station.

Figure 10. A new station at Cullompton would have a valuable role when the line southwards is closed. It is close to the motorway from Exeter which is just to the right of the service station and garage.

A new station at Stoke Canon would have an important role when there are just problems at Stafford Bridge or Cowley Bridge Junction. Stoke Canon is only 4¼ miles from Exeter St. David's station and a 10 minute bus journey away. The A396 can flood as it did on Sunday 25th November 2012, but this is much rarer than flooding of the railway line.

From Tiverton Parkway there is an hourly local bus service to Exeter bus station via Cullompton. From Cullompton town centre this becomes a 20 minute service (Stagecoach 1, 1A and 1B). On occasions these service may prove more convenient for passengers travelling to the east side of Exeter. Arrangements should be made to allow use of rail tickets on these services.

Raising the Line Level at Hele

Raising the level of the railway to either side of the Hele road level crossing is a possibility that should be evaluated. The trackbed could be raised by a height of about 1 metre along with the level crossing on the road to Bradninch. An alternative would be to raise the line sufficiently to allow a bridge to be put in place. This would allow the level crossing to be removed and the line speed to be increased on an improved track alignment to the north of the level crossing site.

From Cullompton the railway descends slightly to the Hele level crossing at 1 in 292 and then ascends at 1 in 534 towards Silverton Mills and Exeter (Figure 11). This slight dip in the trackbed would slightly reduce the length of raised new line on new approach embankments needed to either side of a new railway bridge at Hele.

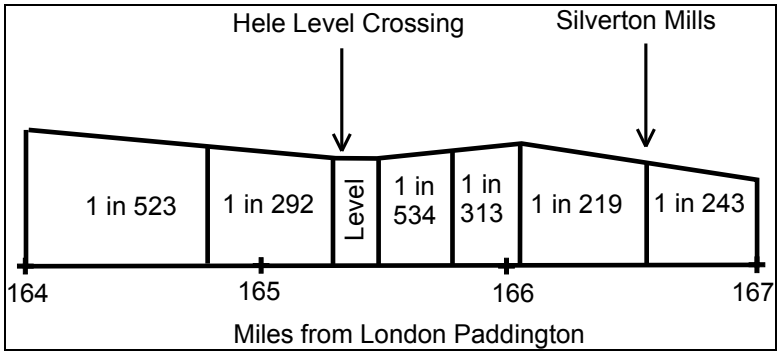

Figure 11. Sketch of gradient profile of the Taunton to Exeter line at Hele where it is following the valley of the River Culm. Although the flood water originates from the nearby River Culm the downward dip in gradients to the level crossing may delay dissipation of water at this point.

With either option the new line would be best constructed parallel to the existing trackbed so as not to close the railway for far longer than any future flooding.

Options for Flood Mitigation on the Railway

Raising the railway line at Hele still leaves the line potentially vulnerable to high flood levels south of Hele (Silverton Mills to Rewe). During a flood event large amounts of water are discharged. The November 2002 and October 2008 flooding saw 6.7 million cubic meters of water pass the Woodmill gauging station at Cullompton. If the downstream discharge at Stoke Canon is restricted, this amount of water was sufficient to flood the 5.5 km^2. flood plain between Cullompton and Stoke Canon to a depth of about 1.2 metres or 4 feet.

Improvements to the river channel alongside the railway might be a possibility, but there is a limit to what can be discharged south of Stoke Canon. The water level downstream from where the Culm joins the Exe can threaten the operation of the railway at Stafford Bridge and Cowley Bridge Junction.

Ideally the River Culm needs to be regulated upstream of Woodmill, so as to hold back about 2 million cubic metres of water. This would reduce the sharp peak flow rates that lead to inundation of the railway and also flooding of some streets in Cullompton. This could be in the form of an earth dam that allows an area of land to be temporarily flooded in a controlled way.

Developing the Exeter to Yeovil Line as a Second Route.

Although the November 2012 flooding closed both routes out of Exeter for a week, it is comparatively rare for both lines to be unusable for so long.

Railfuture suggests that the Yeovil route should be developed as a second high quality railway route to and from the South-West. With flood prevention work at Axminster, the Yeovil line would be better placed for this role and could act as a backup route for trains from Penzance, Plymouth and Exeter to London Paddington. However, the line remains largely single track with a low line capacity.

Proposed culverts for the Exeter to Yeovil line at Axminster

On the Exeter to Yeovil line work must to be done to minimise future trackbed damage from the River Axe in flood at locations such as Broom level crossing. Rather than turning the trackbed into a defensive structure against flooding, the low embankment should be made more permeable to the water with a series of low bridges and culverts. The aim must be to remove the resistance to flood water by providing pressure release points, so that floodwater is less likely to build up on one side of the railway line.. Then even if the track is inundated for a few hours, it is less likely to be from fast flowing destructive water that could close the line for days.

Proposed capacity improvements for the Exeter to Yeovil line

Railfuture suggests that more sections of the single track Exeter to Yeovil line should be restored to double track. Also track doubling on the Yeovil Pen Mill to Castle Cary line, which forms the diversionary link back to the Great Western London Paddington route. At minimum two new 3 mile passing loops should be built, at a possible cost of around £40 million, one in the vicinity of Whimple and the second near Crewkerne. This would enable the line to carry an average 5 trains each way every 2 hours compared to the current 3 trains each way every 2 hours. Further track doubling would increase the line capacity still further and reduce delays waiting at passing loops.

A secondary benefit from new loops on the Exeter to Yeovil line would be that it would provide the infrastructure needed to run daily additional hourly Exeter to Axminster trains (as supported by Devon County Council) and on to Yeovil Pen Mill to connect with trains to Dorchester and Weymouth.

Conclusions

The railway must be better prepared for flooding, by making full use of the monitored water flow on the River Culm at the Woodmill gauging station at Cullompton. Embankments must have more culverts to stop water building up on one side and then scouring away the trackbed.

Widening the main culvert under the ‘V’ of the diverging lines at Cowley Bridge Junction and raising the level of the line at Hele is recommended. This would enable the Exeter to Taunton railway to better cope and recover from flooding as experienced in November 2012.

Raising the entire line between Cullompton and Cowley Bridge Junction above all possible flood levels has not been suggested. This is due to the cost and the need to raise the level of all the road overbridges. The construction work would also close the line for far longer than that of any future flooding.

The backup Exeter to Yeovil line must also be improved to make it an effective diversionary route. Flood protection measures are needed around Axminster and new double track passing places to increase line capacity.

December 2012 Postscript

On Thursday 20th December 2012 prolonged rainfall returned to Devon and the River Culm reached 2.27 m at the Woodmill gauging station near Cullompton. The following day was dry and by the early hours of Saturday 22nd December the river level dropped to 0.81 m, before rising later in the day to 2.35 m at around 14:15. The intervening dry day was sufficient to keep the main line railway free of flooding at Hele and south towards Stoke Canon. Figure 12 shows the railway line free of any flooding at Silverton Mills and can be compared with Figure 6.

Figure 12. The Taunton to Exeter line at Silverton Mills in the afternoon on Saturday 22nd December.

On Saturday 22nd the main culvert under the railway line at Cowley Bridge Junction was still able to release flood water from the east side of the line (Figure 13). The orange barrage had been put across the line, to direct any rising water across the railway instead of it running south along the railway towards St. David's station.

Figure 13. The main culvert at Cowley Bridge Junction on Saturday 22nd December 2012.

On Sunday 23rd December at Thorverton, the River Exe reached a peak of around 3.25 m at 05:00 and downstream the railway was flooded. Track foundations were washed away as they had been in November. Figure 14 shows the main culvert overwhelmed by flood water and Figure 15 the protective barrage helping to protect the railway line to the south.

Figure 14. The main culvert at Cowley Bridge Junction overwhelmed by flood water on Sunday 23rd December 2012.

Figure 15. Cowley Bridge Junction overwhelmed by flood water on Sunday 23rd December 2012.

The following observations can be made –

Exeter to Yeovil Diversionary Route

During the December flooding the Exeter to Yeovil line remained operational with a near normal service to London Waterloo, but only a few London Paddington services used the line as a diversionary route. For example the 15:52 Penzance to Paddington on Saturday 22nd December. With Railfuture's suggested new passing loops around Whimple and Crewkerne, an hourly train service could have been run from Plymouth and Exeter to London Paddington, 2 hourly to Bristol and the north via Yeovil and Westbury, plus the normal hourly Exeter to London Waterloo service.

Flood Level Monitoring

The Exeter to Taunton line was closed on Saturday 22nd December and the protective barrage put in place at Cowley Bridge Junction. However, the line did not flood until Sunday 23rd. With careful monitoring of flood levels on the River Exe the line could have stayed open for much longer. The peak flood level that occurred on Sunday morning at Cowley Bridge can be traced from Exmoor. A peak was recorded on Saturday at Exford at around 18:00, reaching Brushford at about 21:30. Then continuing downstream early on Sunday morning, 00:30 at Stoodleigh, 02:30 at Tiverton and 05:00 at Thorverton.

Cowley Bridge Junction and a Station for Stoke Canon

The December 23rd flooding caused extensive flood damage to the Exeter to Taunton line track, just as severe as the November flooding that closed the line for many days even after the flood water had receded. However, the Culm did not flood the railway over the weekend of December 22nd –23rd. In this situation train services could run from Taunton to Stoke Canon, with a 4 mile bus link to Exeter, as soon as any flood water recedes from the main road. It also requires the station to be built.

Given the extent of damage to the trackbed at Cowley Bridge junction, twice in November and once in December, the widening of the culverts is very urgent. It may be more appropriate to consider these as a set of new bridges with track fully secured to the bridge structure. Just north of Stoke Canon a flood secure bridge is needed at Stafford Bridge.

The work at Cowley Bridge Junction will be disruptive to train services, so it would be useful to have a new station in place at Stoke Canon before anything is done, as well as the new passing places on the Exeter to Yeovil line.