M1 junctions 39 to 42 all lane running

Five-year post-opening project evaluation

The methodology used to generate the data in this document should only be considered in the context of this publication. This methodology, and its subsequent outputs may differ to methodologies used in different analyses at different points in time. This is due to continuous improvements of data mapping, capture, and quality. As these factors evolve over time any comparison with earlier data or data from other sources, should be interpreted with caution.

Foreword

As Chief Customer and Strategy Officer, I want to know whether developments on our network are meeting their objectives and making a difference for our customers – the four million people that use the Strategic Road Network every day. Evaluation is a key function in the safe running of the Strategic Road Network (SRN) and we carry out POPE[1] evaluations at set points during a major enhancement scheme's lifetime to enable us to take stock and make any necessary interventions. POPEs provide an early indication if the scheme is on track to deliver the benefits over 60 years as set out in the business case appraisal.

This report evaluates the M1 junctions 39 to 42 all lane running (ALR) smart motorway scheme within five years of operation following its conversion from a conventional three lane motorway.

An initial study was conducted one year after the M1 junctions 39 to 42 project which opened in 2015, followed by this report after five years which provides more robust data and analysis. The report includes an understanding of the safety and environmental impacts of a scheme, as well as how traffic has changed due to a scheme being in place and how the scheme supports the economy.

There are three types of smart motorway, all lane running (ALR), dynamic hard shoulder (DHS) and controlled motorway. ALR and DHS motorways create more space on some of the most congested sections of the SRN by using hard shoulder as a running lane either permanently or only at busy times. They create extra capacity with less disruption to road users and fewer environmental impacts than physically widening the road, along with reduced carbon emissions associated with construction.

Although the performance of individual scheme is important at a local level, drawing together findings at a programme level helps us to understand patterns and trends across our network.

Safety remains our number one priority and the five-year POPEs published to date (representing approximately a quarter of those in operation) demonstrate that smart motorways are delivering safety benefits in line with or above those originally forecast, with most schemes evaluated having lower collision rates than would have been expected on the conventional motorways they replaced. Where it has been possible to assess changes to the severity of such collisions, the evidence shows those collisions have been less severe.

The published five-year POPEs show that smart motorways are broadly on track to realise their envisaged environmental objectives. With further planned mitigation these will be fully met.

The five-year ALR and DHS POPEs published to date for smart motorways also show that the schemes are delivering much needed capacity with schemes accommodating up to almost a quarter (22%) more traffic than before they were converted into smart motorways. The reports indicate that many of the motorway sections would have been unable to cater for today's traffic (at the busiest times) if they had not been converted into smart motorways.

[1] Post Opening Project Evaluation (POPE)

According the to the reports, the schemes are currently on course to deliver benefits, but will not deliver all the originally expected benefits within the 60-year appraisal period. There has been lower traffic growth than was expected when these schemes were appraised, due to the 2008 financial crisis and lower population growth than originally forecast (this will impact all transport schemes, built around this time). This means fewer drivers are benefiting today from smart motorway schemes than original anticipated. Five-year POPEs also show that traffic on some smart motorway sections is not travelling as quickly as was forecast at the appraisal stage. Together these factors have resulted in the value for money for all schemes with five-year appraisals, over the 60-year appraisal period, currently being lower than anticipated at this stage when compared with the original appraisal. This is, however, a forecast and there is the opportunity to take further action to improve benefits.

We have therefore examined these results in detail and have identified specific actions to further improve the performance of schemes, including:

- Standardised operating procedures for DHS schemes
- Technology improvements
- Optimisation of the algorithms that set speed limits
- Investigating physical constraints off the network that impact performance

We will continue to monitor schemes in operation, enabling us to track their benefits and take further action if required to ensure these schemes deliver an improved experience for our customers.

Elliot Shaw

Chief Customer and Strategy Officer

September 2023

Table of contents

1. Executive summary

The M1 junctions 39 to 42 smart motorway was a major project to improve seven miles of the M1 by providing additional capacity through the implementation of a smart motorway and widening between junctions 41 and 42 (northbound). The project opened in two stages: junctions 39 to 41 opened in December 2015, and junctions 41 to 42 opened in January 2016.

This scheme aimed to provide additional capacity to reduce congestion, better manage traffic conditions and improve journey time reliability while maintaining safety for road users and minimising adverse environmental effects of the project.

There was a slight improvement in safety; the number of personal injury collisions increased slightly but after accounting for higher traffic growth the rate of injury decreased. This lower rate still falls within the range of what could have been expected had the road remained a conventional motorway. There was a slight increase in the annual average number of collisions resulting in serious injuries however the FWI[2] rate improved. Overall, the safety objectives for the scheme were met.

The evaluation of traffic speeds found that for most time periods, there has been a very marginal reduction in road users' average speed, but reliability was maintained even with an increase in the volume of traffic (9% more road users). However, journeys taking place between 7-9am travelling northbound continued to be the most congested journeys with these being slower than before and less reliable.

The five years after evaluation highlighted that the environmental impacts of the project were largely on track to be realised as expected. While the impact on noise was as expected for part of the project, the impact was found to be worse than expected between junctions 40 and 41. This was due to the higher proportion than predicted of heavy-duty vehicles (HDV).

Based on the evidence from the first five years, at this stage the M1 junctions 39 to 42 ALR scheme is not yet fully realising its anticipated value for money over the 60-year life of the project, and we are exploring what further action can be taken to improve benefits. The primary reason for the overall reduced level of benefits is lower than expected traffic growth due to the 2008 financial crisis and lower population growth than originally forecast (this will impact all transport schemes, built around this time) as well as slower journey times. It is nevertheless delivering benefits - construction of the project was delivered under budget - it is delivering safety benefits to road users and most of the environmental benefits are as expected, or better, with the additional capacity being able to accommodate more traffic now and on into the future.

[2] The Fatal Weighted Injuries (FWI) is the key measure used to assess the safety of roads. The measure gives a fatality 10 times the weight of a serious casualty, and a serious casualty 10 times the weight of a slight casualty. It takes all the non-fatal injuries and adds them up using a weighting factor to give a total number of 'fatality equivalents'.

2. Introduction

What is the project and what was it designed to achieve?

The M1 junctions 39 to 42 smart motorway covers a seven-mile stretch of the M1, near Wakefield. The project opened in two stages: junctions 39 to 41 opened in December 2015, and junctions 41 to 42 opened in January 2016.

Prior to construction, congestion was a frequent problem on this section of the network, with daily traffic flows between junctions 39 and 42 in excess of 109,000 in 2008[3]. The route was one of the most congested trunk roads in the north of England, with levels of congestion in the top twenty percent nationally[4].

The project aimed to deliver capacity improvements, improve reliability, improve information to drivers, and achieve ‘after’ accident numbers which are no greater than those ‘before’ the project.

This section was converted to an all lane running (ALR) motorways. ALRs apply technology to control speeds and permanently convert the hard shoulder to a running lane. Emergency areas are available at regular intervals, providing places to stop in an emergency. There was also widening of the northbound section between junctions 41 to 42 to incorporate five lanes.

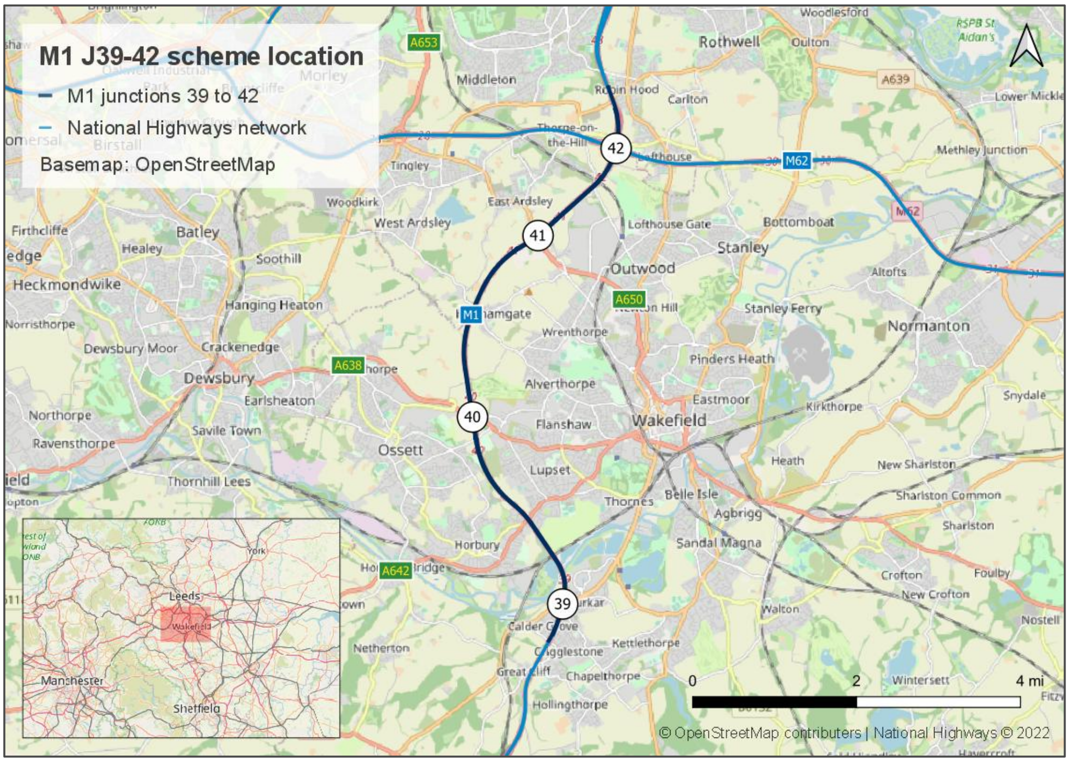
Project location

The M1 is a strategic route in England, linking London with the Midlands and the North. The project is seven miles of the M1 between junctions 39 (Durkar Interchange) and 42 (Lofthouse Interchange). This is located to the west of Wakefield and is within West Yorkshire. Junction 42 is an interchange between the M1 and M62 which is a strategic east-west route in the north of England. The location of the project, in relation to the region and surrounding highway network, is shown in Figure 1.

[3] Client Scheme Requirements, referred to in M1 Junction 39 to Junction 42 Smart Motorway All Lane Running – One Year After POPE Report.

[4] Client Scheme Requirements, referred to in M1 Junction 39 to Junction 42 Smart Motorway All Lane Running – One Year After POPE Report.

Figure 1 M1 junctions 39 to 42 project location



Source: National Highways and OpenStreetMap contributors.

How has the project been evaluated?

Post-opening project evaluations are carried out for major projects to validate the accuracy of expected project impacts which were agreed as part of the business case for investment. They seek to determine whether the expected project benefits are likely to be realised and are important for providing transparency and accountability for public expenditure, by assessing whether projects are on track to deliver value for money. They also provide opportunities to learn and improve future project appraisals and business cases.

A post-opening project evaluation compares changes in key impact areas[5] by observing trends on a route before a project is constructed (baseline) and tracking these after it has opened to traffic. The outturn impacts are evaluated against the expected impacts (presented in the forecasts made during the appraisal) to review the project’s performance. For more details of the evaluation methods used in this study please refer to the post-opening project evaluation (POPE) methodology manual on our website[6].

For this five years after study we have needed to take account of the impact of the COVID-19 pandemic and national lockdowns on traffic volumes. For our traffic analysis, our baseline is April 2013 (before construction). For our one year after study we used data from April 2016, but in this study we have used data from February 2020 rather than April to avoid the period impacted by lockdown restrictions[7].

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[5] Key impact areas include safety, journey reliability and environmental impacts.
[6] https://nationalhighways.co.uk/media/exypgk11/pope-methodology-note-jan-2022.pdf
[7] Timeline of UK government coronavirus lockdowns and measures, https://www.instituteforgovernment.org.uk/sites/default/files/timeline-coronavirus-lockdown-december-2021.pdf

3. Delivering against objectives

How has the project performed against objectives?

All National Highways major projects have specific objectives which are defined early in the business case when project options are being identified. These benefits are appraised to be realised over 60 years. The one-year evaluation provides early indication of progress, followed by the five-years after evaluation which gives a more detailed insight. The objectives for the M1 junctions 39 to 42 smart motorway included the following:

Table 1 Objectives and evaluation summary

Objective	Five-year evaluation
To support and enhance the role of the current M1 as a major national and interurban regional transport artery	The project delivered capacity improvement with the operation of the hard shoulder as a fourth traffic lane. There has also been widening of the northbound section between junctions 41 and 42 to create five lanes. This section of the M1 supports movements through Yorkshire, with junction 42 providing a connection to the M62 with east-west connectivity across the north of England.
To deliver the scheme in a way which supports the delivery of the Government's transport policy objectives	Completion of this smart motorway supported the Government's objective to increase capacity on the existing road network.
To achieve a safety objective under which the "after" accident numbers (per annum) are no greater than those in the "before" and the severity ratio is not increased	The evaluation found the number of personal injury collisions increased, however given the upgraded motorway carried larger flows, the rate of collisions decreased. This element of the safety objective has been met[8]. There has been an increase in the number of collisions resulting in serious injury. This element of the safety objective has not been met. In the wider area, a reduction in the number and rate of personal injury collisions has been observed. This is in line with the initial expectations that most of the safety benefits would be seen on local roads within the wider area.
The scheme should improve journey time reliability, by improving and better managing traffic flow conditions	During commuter times (northbound morning peak, southbound evening peak) the route experiences more variable journey times. At other times of the day, there have been marginal improvements in journey time reliability, and this was consistent with the one year after evaluation.
The scheme should aim to improve the currency and	Gantries provided by the project have improved the quality of information provision to drivers.

[8] Projects are appraised over a 60-year period. This conclusion is based on the findings at five years after the project opened for traffic.

Objective	Five-year evaluation
quality of information provided to drivers about the state of traffic flow on the motorway	
To minimise the detrimental environmental effects of the scheme and offset by mitigation measures where technically feasible and economic to do so, taking account of costs, availability of funding and statutory obligations.	The five year after evaluation found the environmental effects were generally on track to those predicted in the appraisal. The exception was a worse than anticipated impact on noise between junctions 40 and 41 owing to the higher proportion of heavy duty vehicles.

4. Customer journeys

Summary

The project had an objective to improve journey time reliability and better manage traffic flow conditions.

Since the conversion, the route has supported more road users and led to more reliable or no worsening of journeys for most times of day, however these benefits have not been observed during the busiest times of day. For the majority of road users, the reliability of northbound journeys made in the morning peak (7-9am) had deteriorated five years after the project opened compared with before construction. There was also a slight deterioration southbound in the evening peak (5-7pm). The route stress metric of reliability showed there is likely to have been a slight improvement in reliability overall, due to the additional capacity.

For road users travelling during the commuter peaks, average journey times were taking longer in the northbound morning peak (approximately 2 minutes longer) and southbound evening peak (approximately 45 seconds longer). This was accompanied by a reduction in speeds of journeys observed in the morning and evening peaks, though it is important to note speeds on smart motorways are regulated using the variable mandatory speed limits (VMSL). In all other time periods, there were marginal increases in the average journey time[9].

Five years after opening, the route was supporting an increased number of road users. Traffic growth on the route has increased by an average of 9%[10] since the smart motorway opened. The greatest level of growth was observed to the northern part of the project from junctions 41 to 42 in the southbound direction. Junction 42 (Lofthouse Interchange) is where traffic joins the M1 from the M62. Overall, the forecast traffic growth was found to be overly optimistic compared with the observed growth.

How have traffic levels changed?

Smart motorways are built on stretches of motorway which experience high levels of congestion and/or are expected to see traffic levels increase in future years. The following sections examine how the traffic levels changed over the evaluation period and to what extent the forecast traffic levels were realised.

National and regional

To assess the impact of the project on traffic levels, it is helpful to understand the changes within the context of national and regional traffic. To do this, we use the Department for Transport annual statistics, the data is reported by local authority and road type, recording the total number of million vehicle kilometres travelled[11].

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[9] In this section we are presenting before and after journey times unadjusted. For section 7 (value for money) we have compared outturn journey times against a counterfactual estimate of what journey times are likely to have been without the scheme. This allows for the deterioration in journey times that we would have expected to have happened due to growth in background traffic levels causing additional congestion. The counterfactual calculation estimated an overall disbenefit of 171,000 vehicle hours in the fifth year after opening.

[10] Comparing average weekday traffic (AWT).

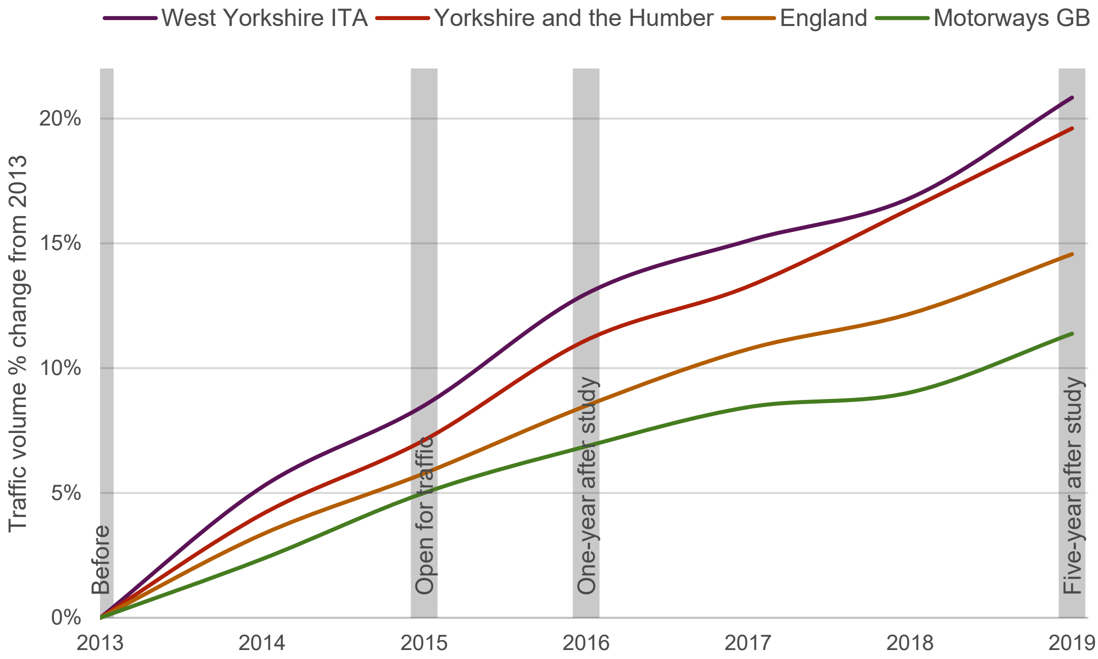
[11] Motor vehicle traffic (vehicle kilometres) by region in Great Britain, annual from 1993 to 2019, Table TRA 8904, Department for Transport

This data is used as a baseline, and we attribute any growth observed on roads in the project area which is above national and regional trends to the project.

Figure 2 shows the changes in traffic by year in the period between 2013 and 2019[12] for roads in the region (West Yorkshire), wider region of Yorkshire and the Humber, all motorways managed by National Highways and for England as a whole.

Considering local, regional and motorway traffic trends, growth of 11-20% might be expected to have occurred between 2013 and 2019 regardless of the project being implemented. The analysis in the following sections should be considered in this context as no adjustments have been made to take account of background traffic growth.

Figure 2 Changes in national and regional background levels of traffic



Source: Department for Transport Road Traffic Statistics Table TRA8904.

How did traffic volumes change?

Traffic volumes were analysed for the M1 through the project area by comparing the average weekday traffic (AWT) data. The data was analysed for before and after project implementation and the changes in traffic volumes are shown in Figure 3. It is important to note that seasonality may influence the observed results as the before and one year after opening data was from April in the respective years, while the data for five years after opening was from February.

The results highlight that the flows are not evenly distributed across the project extent, with greater flows evident to the north of the project and lowest to the south of the project. There is variation of approximately 10,000 vehicles between junctions 39 to 40 and junctions 41 to 42.

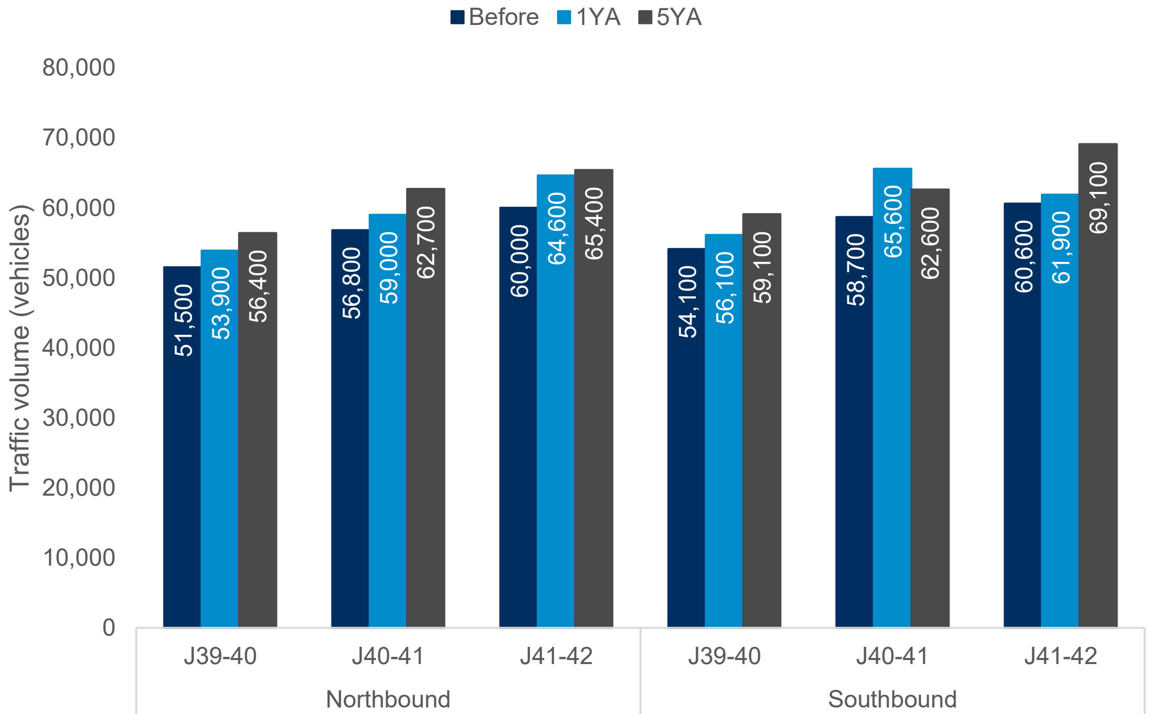
[12] 2013 is the baseline for this study. We have used February 2020 as our after year, but 2019 was the latest year for which this data was available.

The evaluation found that traffic growth on the M1 junctions 39 to 42 increased by 9% since the project opened[13], with this reasonably consistent across the project extent. However, this level of increase is lower than the national and regional trends seen in Figure 2.

Figure 3 shows increases in traffic flows from April 2013 (before construction), April 2016 (one year after opening) and February 2020[14] (proxy for five years after opening) between the junctions in both directions. The exception to this trend is southbound junctions 40 to 41, where traffic volumes increased by 12% one year after but subsequently fell by 5% at five years after. In 2015, work was completed on widening the approaches and circulatory carriageway at the junction 41 pinch point, which likely contributed to the traffic volume increase observed one year after at junctions 40 to 41.

The largest increase in growth since 2013 was seen southbound between junctions 41 and 42, with an increase of 14%. Widening increased the capacity to four lanes on this section, albeit the same section northbound also included the introduction of a fifth traffic lane but experienced a smaller increase of 9% over the same period.

Figure 3 Average weekday traffic volume (24hr AWT, average day in month)



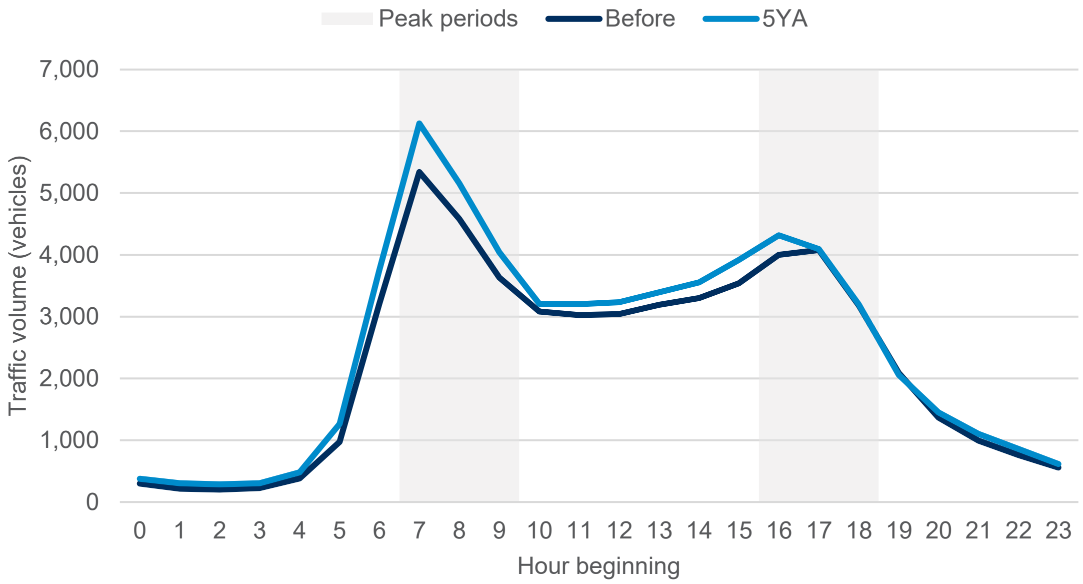
Source: National Highways Traffic Count Data. Before: April 2013, 1YA: April 2016, 5YA: February 2020.

Analysis of hourly weekday traffic volumes (Figure 4 and Figure 5) demonstrated that traffic volumes have grown throughout the entire day between 2013 and five

[13] April 2013 to February 2020.
[14] February data used rather than April data owing to the impact of the COVID-19 pandemic and national lockdowns on traffic volumes. Timeline of UK government coronavirus lockdowns and measures, https://www.instituteforgovernment.org.uk/sites/default/files/timeline-coronavirus-lockdown-december-2021.pdf

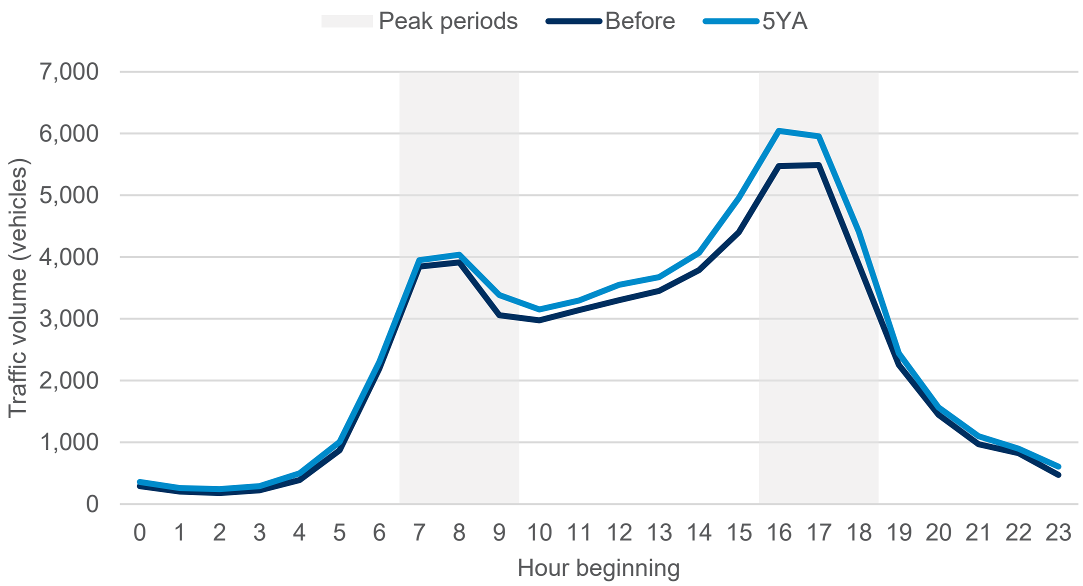
years after opening. The largest increases were seen in the pronounced peaks of the morning peak northbound and evening peak southbound.

Figure 4 Hourly weekday flow profile northbound (distance weighted AWT)



Source: National Highways Traffic Count Data. Before: April 2013, 5YA: February 2020.

Figure 5 Hourly weekday flow profile southbound (distance weighted AWT)



Source: National Highways Traffic Count Data. Before: April 2013, 5YA: February 2020.

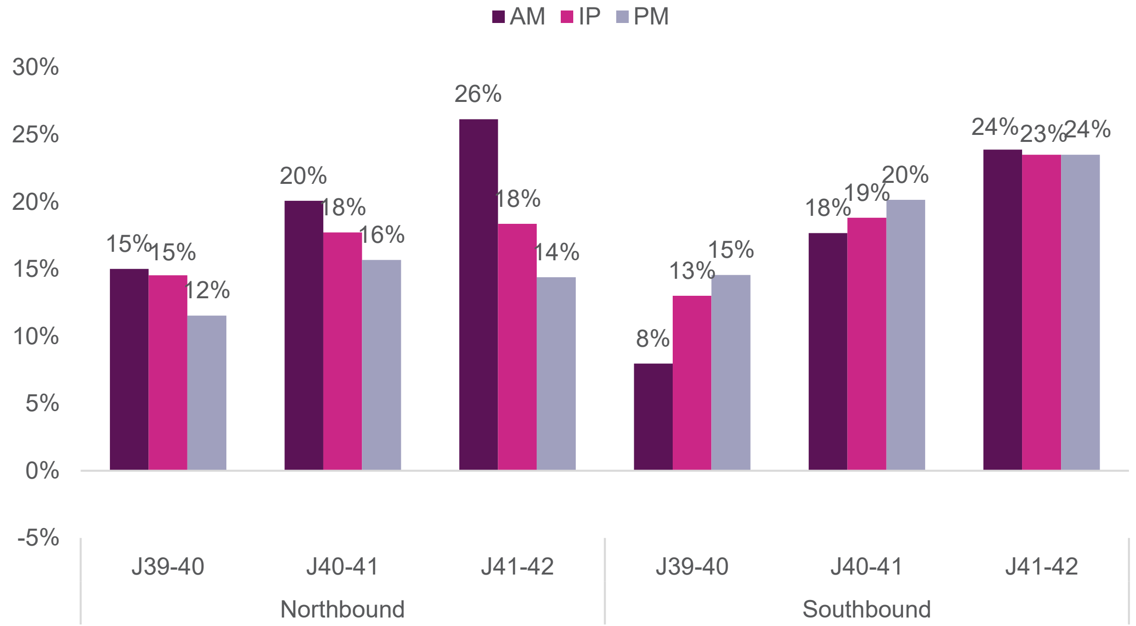
Was traffic growth as expected?

The forecast traffic growth and observed traffic growth for junctions 39 to 42 are shown in Figure 6 and Figure 7. Overall, the results highlight traffic growth forecasts were found to be overly optimistic with less growth observed between April 2013 and February 2020. The exception to this was between junctions 39 and 40 in the morning peak which were broadly in line with the forecast.

The forecasts did capture the predicted pattern of higher flow growth rates in the morning peak for northbound and evening peak for southbound, although this was not as pronounced in the observed data. Junctions 41 to 42 northbound was the only route section which experienced a reduction in flow after project opening, despite this section having the greatest additional capacity provided by the project. The 2% drop in the evening peak was a notable contrast to the 14% growth forecast for this section of the project.

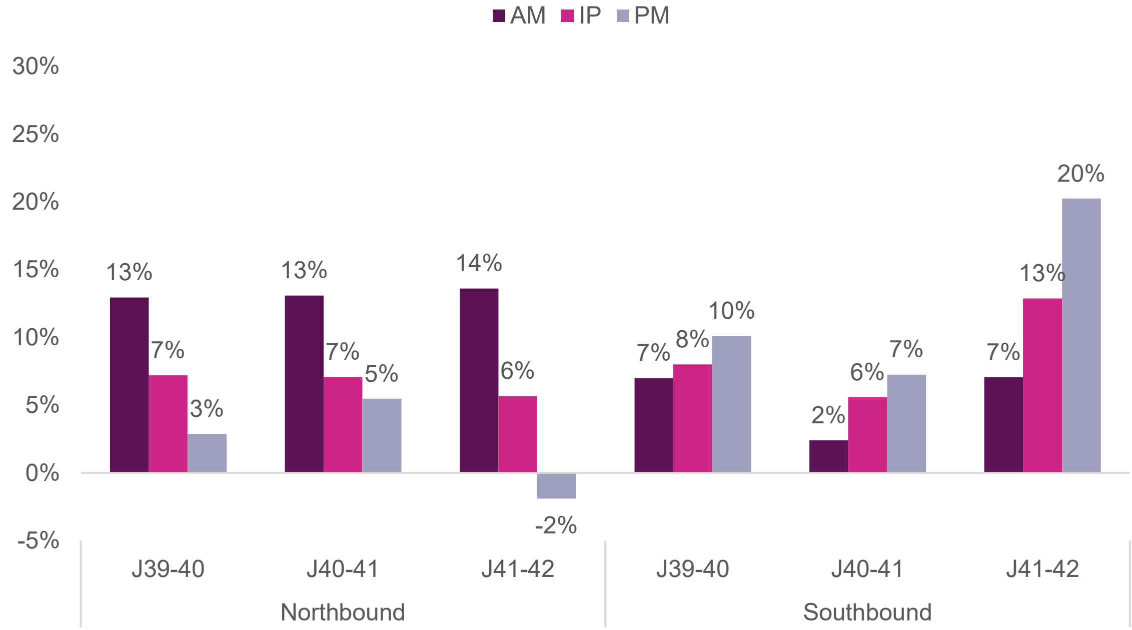
The observed change in northbound traffic flows was consistent in the morning peak (13-14% growth) in each section of the corridor. While this level of growth was expected for junctions 39 to 40, the forecasts north of junction 40 were notably higher.

Figure 6 Forecasted change in traffic volume without the smart motorway (2013) and with (2020)



Source: Forecasts from Traffic Forecast Report.

Figure 7 Observed change in traffic volume (before vs five years after)



Source: National Highways Traffic Count Data. Before: April 2013, 5YA: February 2020.

Relieving congestion and making journeys more reliable

We implement smart motorways on the busiest routes to ease congestion and ensure journey times are more predictable. Often these routes are where we anticipate congestion will increase in the future and our actions seek to limit this.

Analysis of journey times and speeds can indicate the impact of the smart motorway on congestion. The extent to which journey times vary from the expected average journey time indicates how reliable a journey is.

Did the project deliver journey time savings?

Improvements in journey time were not set out as an objective for this project. The objective however was to improve journey time reliability, by improving and better managing traffic flow conditions. For context we have included analysis on the change in journey times as time savings were a substantial element of the forecast monetised benefits (see section 7)[15].

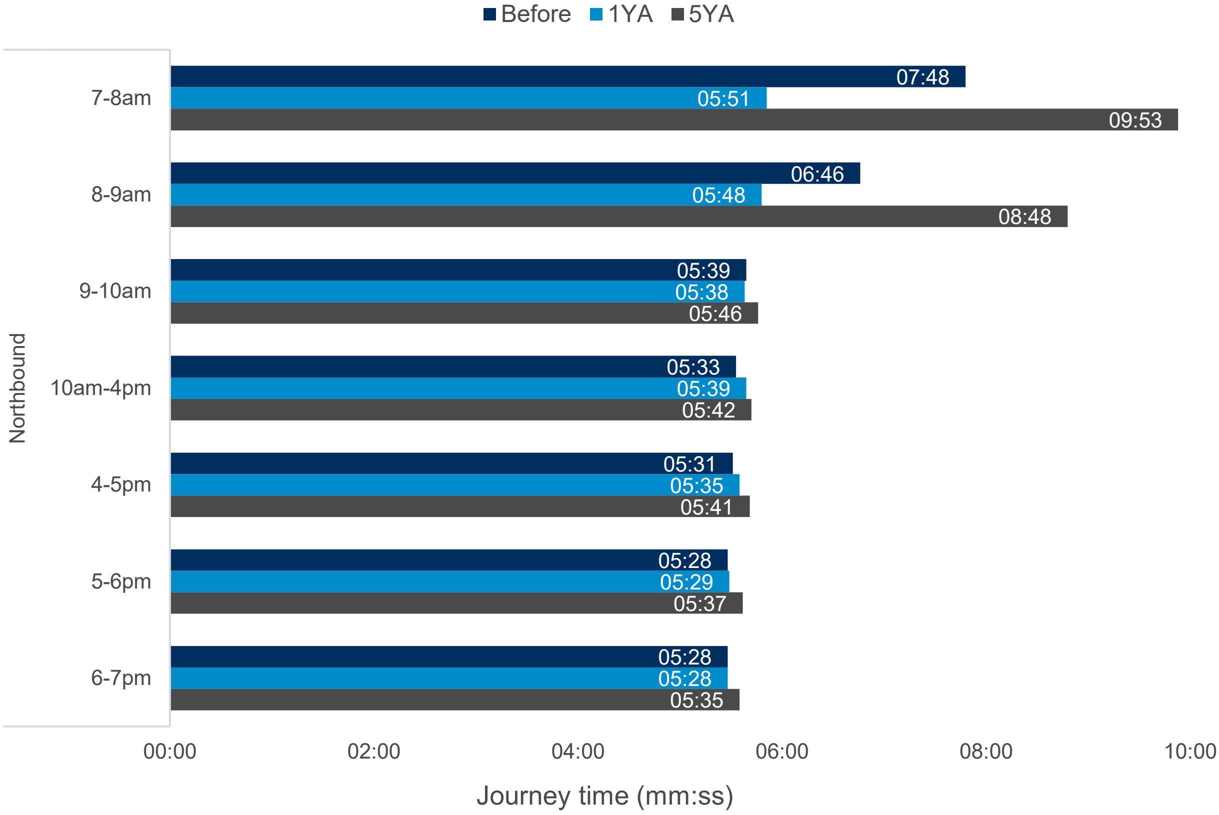
The change in average journey times for northbound journeys is presented in Figure 8, where the evaluation observed a notable increase in journey times for road users travelling northbound in the morning peak. Meanwhile, there were marginal increases in average journey time in all other time periods.

The five year after opening average journey times northbound in the morning peak was approximately one minute longer than before the project. The one year after results show there were initially improvements in the average journey time of approximately one minute compared with before the project. Figure 4 showed the

[15] In this section we are presenting before and after journey times unadjusted. For section 7 (value for money) we have compared outturn journey times against a counterfactual estimate of what journey times are likely to have been without the scheme. This allows for the deterioration in journey times that we would have expected to have happened due to growth in background traffic levels causing additional congestion. The counterfactual calculation estimated a disbenefit of 171,000 vehicle hours in the fifth year after opening.

highest northbound flows occurred in the same hourly periods as those with the largest increases in journey time.

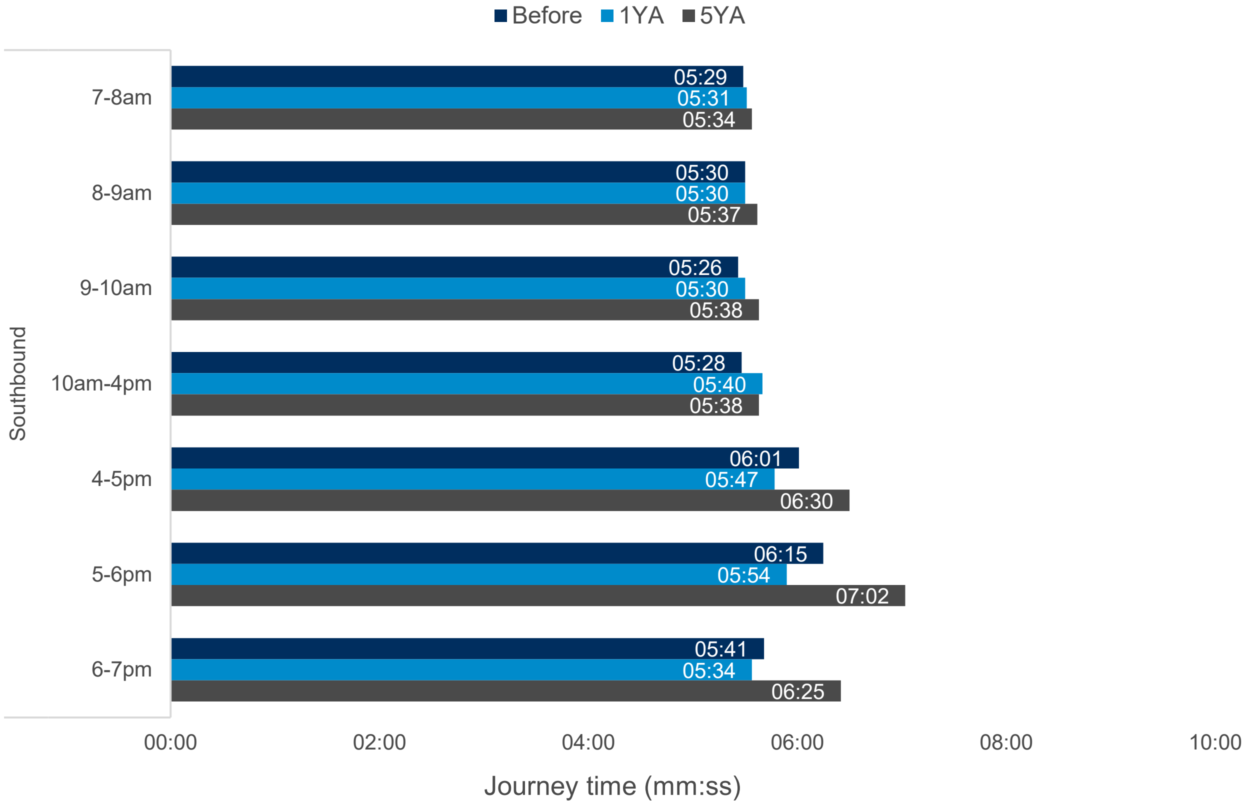
Figure 8 Average journey times northbound



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

Figure 9 reveals that southbound journey times were observed to have moderately increased during the evening peak, with journeys taking approximately 30 to 45 seconds longer compared to before the project. In a similar pattern to the northbound morning peak results, the southbound evening peak also experienced journey time savings in the one year after, however these have been lost five years after. During the morning peak and inter-peak there were also small increases in journey times at both one year after and five years after compared with before the project. Figure 5 showed the highest southbound flows occurred in the same hourly periods as those with the largest increases in journey time.

Figure 9 Average journey times southbound



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

The increase in journey times is potentially the result of increases of traffic flow, although as discussed previously in section 4 the observed traffic flows five years after were less than forecasted, suggesting that the increase in journey times cannot be solely justified by higher traffic flows. Another factor likely to have affected journey times was speed restrictions applied as part of the VMSL technology to smooth the flow of traffic, reducing stop-start movements. When accounting for the observed traffic growth seen at five years after, if the section of road had remained as a 3-lane motorway they would have been unable to support the additional road users, without experiencing a reduction in speed[16].

How did the project impact road user's speeds?

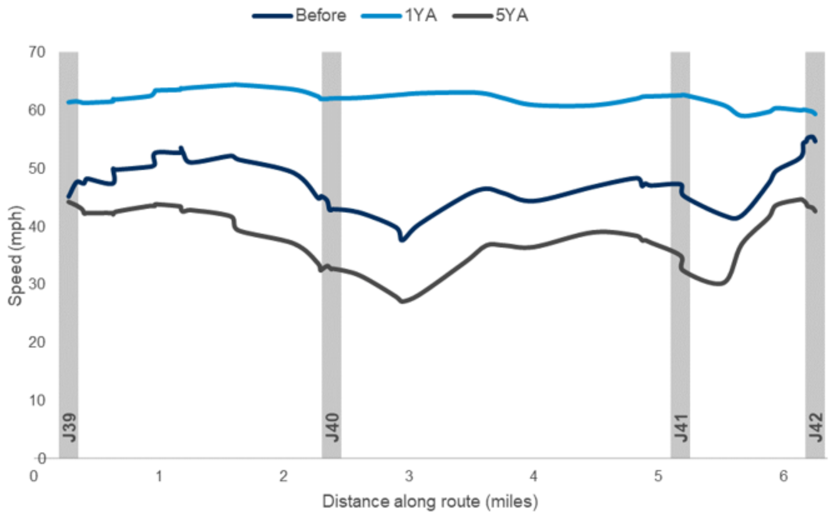
In combination with journey time analysis, speed can help to determine the impact the smart motorway had on congestion. Road users' average speeds are not necessarily quicker because of a smart motorway. Smart motorways are often implemented where there is congestion, and/or an increase in traffic is expected in the coming years. The aim is to make journeys smoother, and therefore speeds should be more consistent, with road users less likely to be accelerating and braking leading to unnecessary queuing.

The evaluation of junctions 39 to 42 found that for most time periods, there has been a very marginal reduction in road users' average speed. However, there are trends in the peak periods consistent with the earlier journey time results.

[16] Analysis has shown that with observed increased in traffic at five years after, a 3-lane motorway would not be able to support these additional road users without experiencing a reduction in speed, in at least one peak time period.

Figure 10 shows the average journey speeds northbound along the route in the morning peak. The average speed observed for journeys made between 7am and 8am at five years after opening mirrored the pattern of before the project, albeit the average speed being lower and typically between 30mph and 40mph. In comparison, the one year after average speeds increased and became smoother, suggesting the project was easing some of the fluctuations in speeds seen before the project.

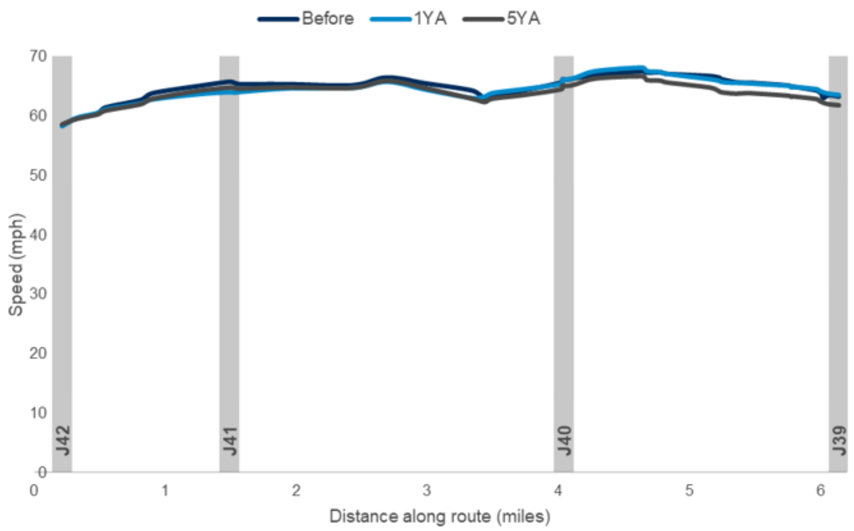
Figure 10 Speed over distance (northbound 7am to 8am)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

As with journey time, southbound in the morning peak experienced fewer changes since the project was implemented, with average speed remaining consistent and above 60mph, showed in Figure 11.

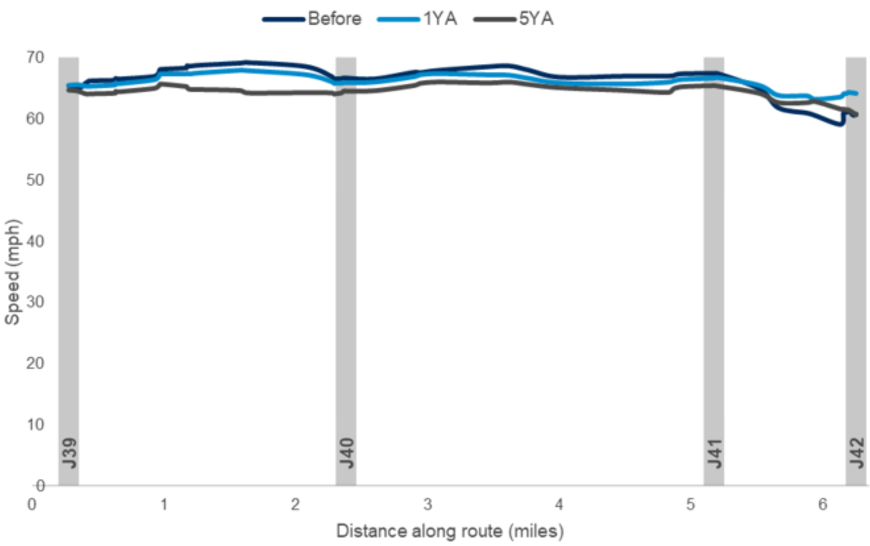
Figure 11 Speed over distance (southbound 7am to 8am)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

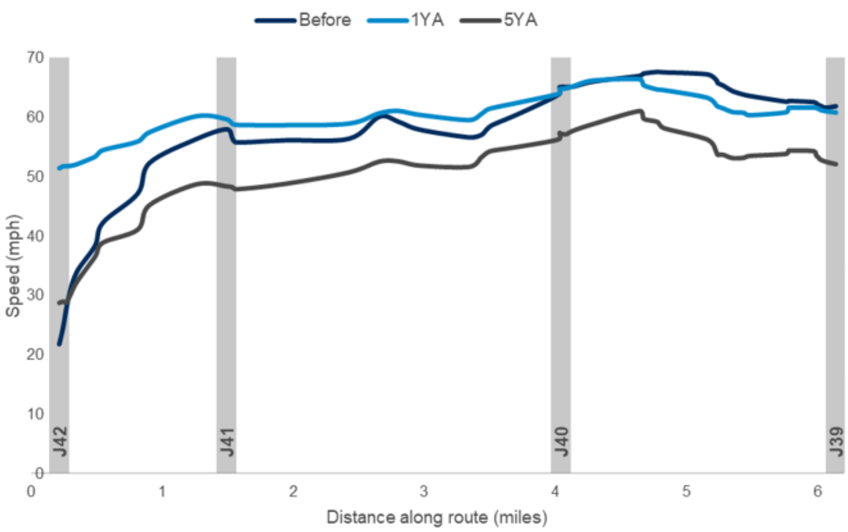
There was little change for road users' average speeds northbound in the evening peak, but in the southbound direction times reduced when compared to before the project (Figure Figure 12 and Figure 13). This matches the shape of the traffic flow curves presented earlier. The main difference between five years after and before is that the average speed was around 10mph lower across the junctions, explaining the worsening journey time seen. in each direction as shown in Figure 12 and Figure 13 where southbound has a stronger evening peak than morning peak, the inverse is true for northbound.

Figure 12 Speed over distance (northbound 5pm to 6pm)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

Figure 13 Speed over distance (southbound 5pm to 6pm)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

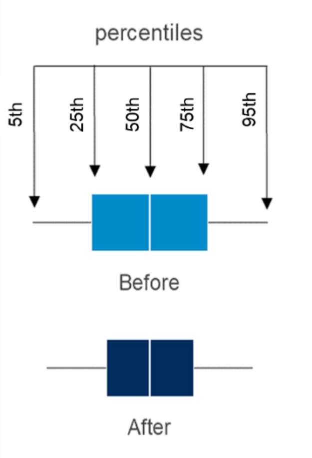
Did the project make journeys more reliable?

Congestion can make journey times unreliable. If the time taken to travel the same journey each day varies, journey times are unreliable and the road user is less confident in planning how long their journey will take them. If journey times do not vary, the road user can be more confident in the time their journey will take and allow a smaller window of time to make that journey.

To measure journey time reliability, we examine how much journey times vary from the average journey time, on any day or time-period. The distribution of journey times is a good indication of how much journey times vary.

Four metrics of the distribution of journey times for the M1 junctions 39 to 42 route have been used and presented as box-and-whiskers diagrams for northbound and southbound journeys. An explanation of the metrics shown in the box-and-whiskers diagrams is provided in Figure 14.

Figure 14 What does a box plot show?



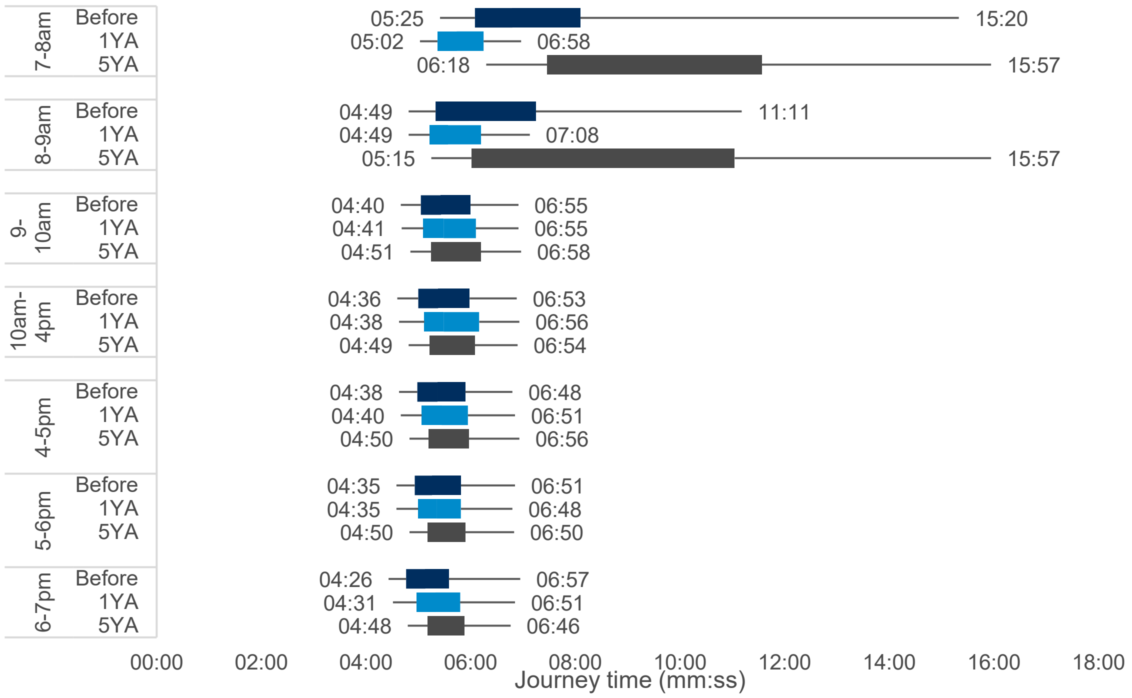
The lowest point is the 5th percentile, this means 5% of journeys take less than this amount of time to complete. The highest point is the 95th percentile, this means 95% of journeys take less time than this to complete. This shows the difference between the longest and the shortest journey times observed.

The length of the box shows how the journey times vary between the 25th and 75th percentile (the journey time 25% and 75% of journeys are faster than). The narrower the box the less variable, and hence reliable the journey.

Half of all journeys, are represented by the box between the 25th to 75th percentile in Figure 15 and Figure 16, if the boxes get shorter, this indicates journeys become more reliable. For the majority of road users, the reliability of northbound journeys made in the morning peak (7-9am) had deteriorated five years after the project opened compared with before construction. During the other time periods, there was a neutral change or small improvement in journey time reliability. For southbound road users, the reliability of journeys has seen more stability. There has been a marginal deterioration in journey time reliability in the evening peak (5-7pm), and neutral change or small improvement in other time periods.

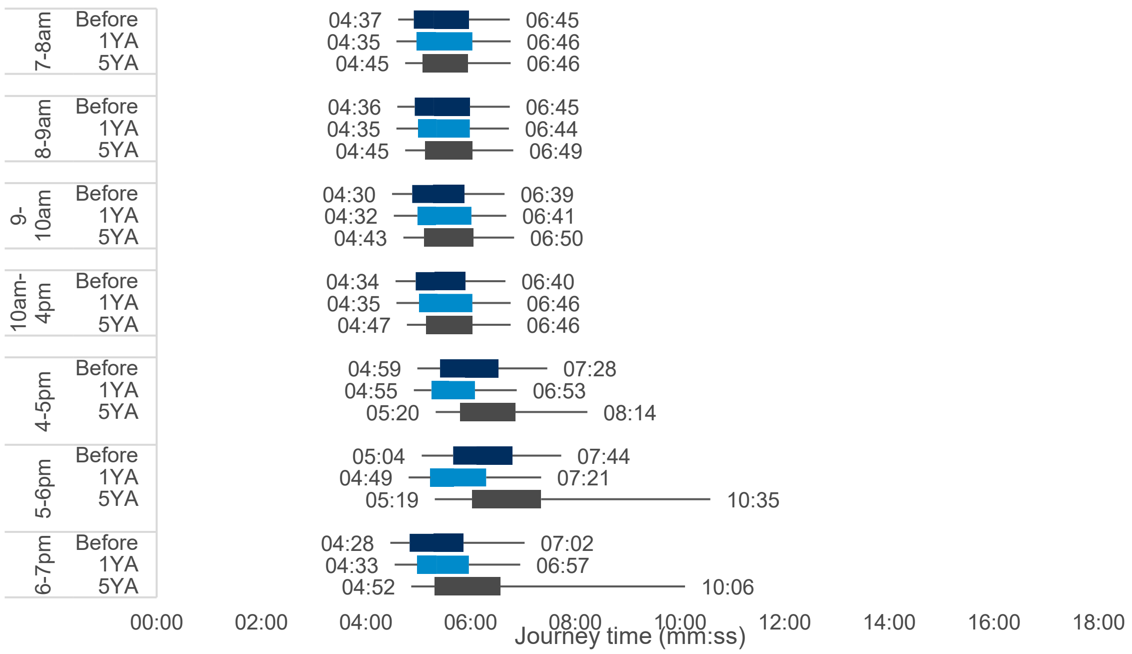
Analysis of the longest journeys times depicted as the 95th percentile (the line extending to the right of the boxes) found for road users travelling northbound during the morning peak, the journey time for the longest journeys have increased. Between 8am and 9am they had increased by 4 minutes and 46 seconds. This was the opposite of the trend seen one year after where the longest journey times had decreased. Southbound, the longest journeys took up to 3 minutes longer during the evening peak (5-7pm) five years after.

Figure 15 Journey time reliability northbound (time taken to drive through the project mm:ss)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

Figure 16 Journey time reliability southbound (time taken to drive through the project mm:ss)



Source: Satellite Navigation (TomTom). Before: April 2013, 1YA: April 2016, 5YA: February 2020.

An alternative measure of reliability is the route stress metric. This uses the percentage of road capacity that is being used to assess whether congestion is likely to impact on journey time reliability. A value of 100% means that the road is at full capacity.

The route stress results in Table 2 suggest that the road was not yet at capacity, either before or five years after the smart motorway was implemented, but that there has been an improvement. The route stress results were lower five years after despite traffic volume increasing between 2013 and 2020. Increases in traffic would typically apply additional stress to a road, but significant capacity increases have been made as part of this project with the hard shoulder converted to a fourth live lane, and a fifth lane being added between junctions 41 and 42 northbound, adding even more capacity. This has offset the increase in flow, enabling route stress to see small improvements.

Table 2 Route stress results for M1 J39-42 (before and 5YA)

Route	Route stress	
	Before	Five Years After
J39-40	**81%**	**75%**
J40-41	**91%**	**75%**
J41-42	**85%**	**75%**

5. Safety evaluation

Summary

The project's safety objective was to achieve a safety objective under which the "after" accident numbers (per annum) are no greater than those in the "before" and the severity ratio is not increased. The number of personal injury collisions[17] and the rate of these collisions per hundred million vehicle miles have been analysed to track changes over time.

There has been an increase in the average number of personal injury collisions, which is in line with the appraised business case for the project. Before the project became operational, there was an average of 16 personal injury collisions per year. After the project became operational, an average of 17 personal injury collisions per year has been observed. If the road had not converted to all lane running, it is estimated that the number of personal injury collisions would have been between 7 and 22.

When accounting for the increased volume of road users over this period, the annual average rate of personal injury collisions per hundred million vehicle miles improved over time. The average collision rate had decreased to 7.7 personal injury collisions per hundred million vehicle miles, this equates to travelling 13 million vehicle miles before a personal injury collision occurs. Before the project, the collision rate was 8.2 per hundred million vehicle miles[18], this equates to travelling 12 million vehicle miles before a personal injury collision occurs. If the road had not been converted to all lane running, it is estimated that the collision rate would reduce to 7 personal injury collisions per hundred million vehicle miles.

The number of fatal collisions has reduced to a total of one after the project was operational compared to a total of three before. When accounting for the increased number of road users over this period, there had been a reduction from 0.5 to 0.4 FWI[19] per hundred million vehicle miles travelled. Reducing the risk of a fatality equivalent by 0.1 for every hundred million vehicle miles travelled.

On the surrounding network[20] there was an average reduction of 264 personal injury collisions per year (based on an annual average of 565 personal injury collisions observed after the project had opened compared with 829 before the project). If the road had not been converted to a smart motorway, we estimate that the number of personal injury collisions would be between 629 to 741. The rate of personal injury collisions has also reduced from 43 to 28 per hundred million vehicle miles.

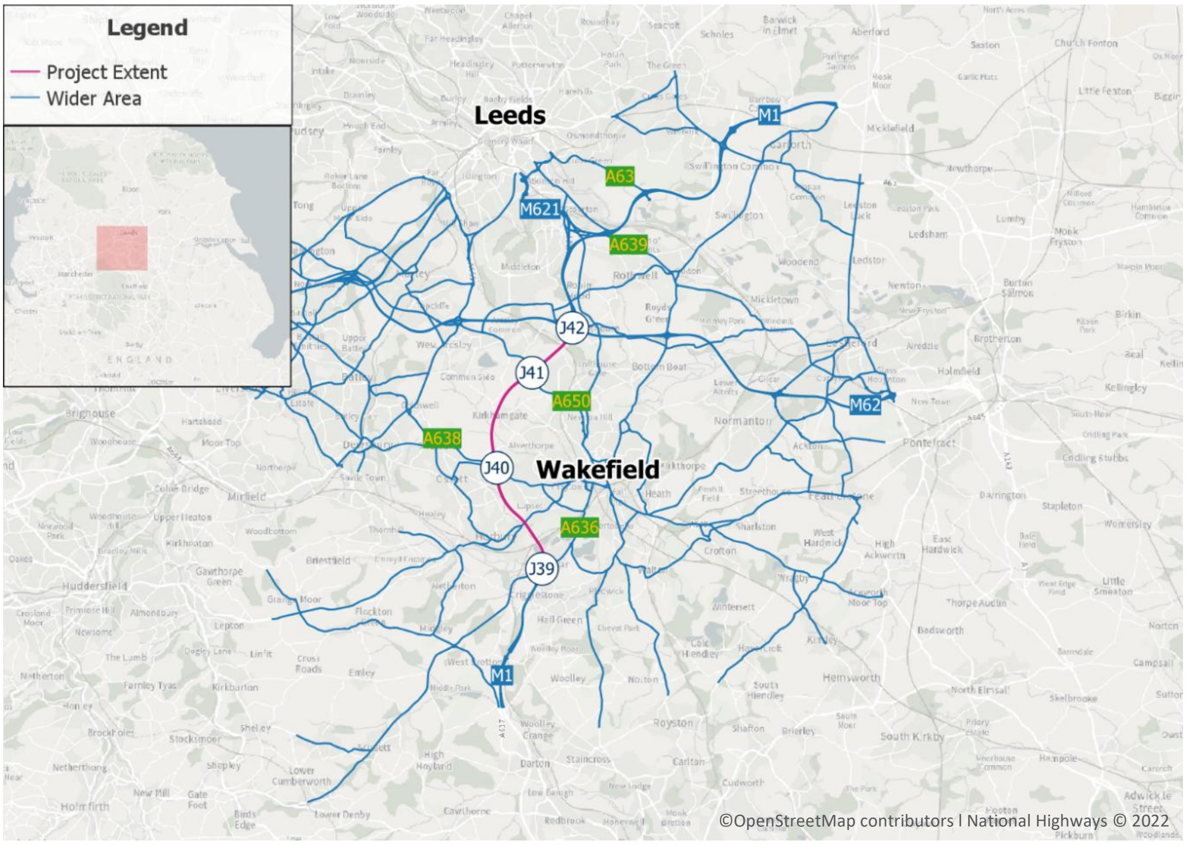
Safety study area

The safety study area is shown in Figure 17. This area was assessed in the appraisal supporting the business case for the project to check any potential wider

[17] A collision that involves at least one vehicle and results in an injury to at least one person
[18] 8.2 personal injury collisions per hundred million vehicle miles (PIC per hmvm) before the project, reduced to 7.7 PIC per hmvm.
[19] The FWI weights Collisions based on their severity. A fatal collision is 1, a serious collision is 0.1 and a slight collision is 0.01. The combined measure is added up. A full number is the equivalent to a fatality.
[20] The road network is determined as part of the appraisal process to understand changes to road safety on the project extent and roads which the project may have an impact.

implications of the intervention. This information was then used with other predictions around the potential impact of the project such as by how much traffic may grow. We have therefore replicated the appraisal study area to understand the emerging safety trends.

Figure 17 Safety study area



Source: National Highways and OpenStreetMap contributors.

Road user safety on the project extent

What impact did the project have on road user safety?

Safety data was obtained from the Department for Transport road safety data[21]. This records incidents on public roads that are reported to the police. This evaluation considers only collisions that resulted in personal injury via this dataset.

The safety analysis was undertaken to assess changes over time looking at the trends in the five years before the project was operational to provide an annual average. We have then assessed the trends five years after.

The analysis draws on the following data collection periods:

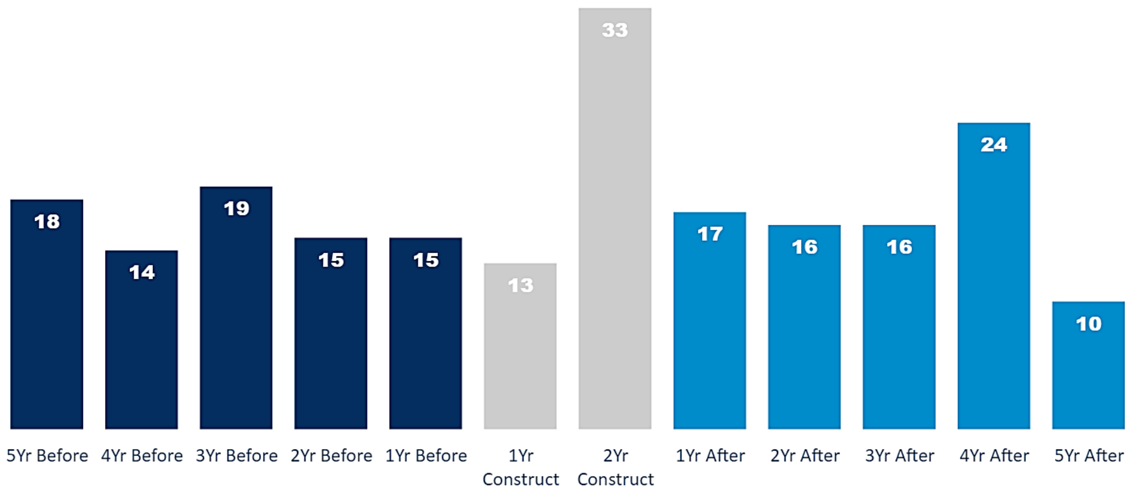
- Pre-construction: 25 November 2008 to 24 November 2013
- Construction: 25 November 2013 to 30 December 2015
- Post opening: 31 December 2015 to 30 December 2020

The evaluation found the number of personal injury collisions on the project extent, had increased (impacts on the wider area are discussed later). As Figure 18 illustrates over the five years after the project was operational, there were an

[21] https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

average of 17 personal injury collisions per year, one more than the average 16 per year over the five years before the project was constructed.

Figure 18 Annual personal injury collisions



Source: STATS19: 25th November 2008 to 30th December 2020.

As part of the safety evaluation, we look to assess what changes in personal injury collisions might have occurred due to factors external to the project over this timeframe. To do this we estimate the trend in personal injury collisions which might have occurred if the road had remained a conventional motorway (this is referred to as a counterfactual - see Appendix A.1: Safety Counterfactual Methodology). This is based on changes in regional safety trends for conventional motorways with a high volume of roads users. Based on this assessment we estimate that if the road had not been converted to a smart motorway, the trend in the number of personal injury collisions would likely have increased, and collision rates would remain stable as shown in Figure 19.

Figure 19 What does the counterfactual show?

The counterfactual is an estimation of what we think would occur without the project taking place. We estimate a range of collisions that follow regional trends. The chart shows:

1. Annual average number of collisions from before the project
2. Annual average number of collisions after the project
3. Estimated counterfactual range, which comes from a X^2 hypothesis test on one degree of freedom using a significance level of 0.05. More details can be found in the POPE Methodology Manual.
4. National Highways are developing new statistical methods to compare collision and casualty rates. We anticipate adopting these once the methods are finalised.

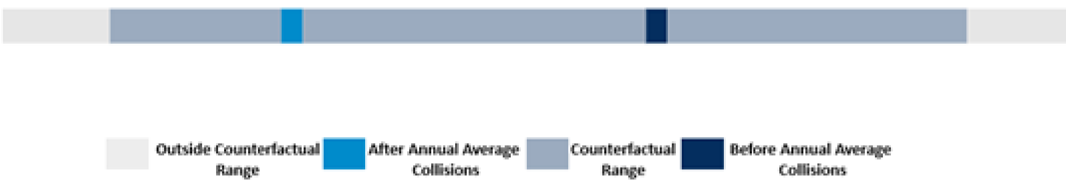
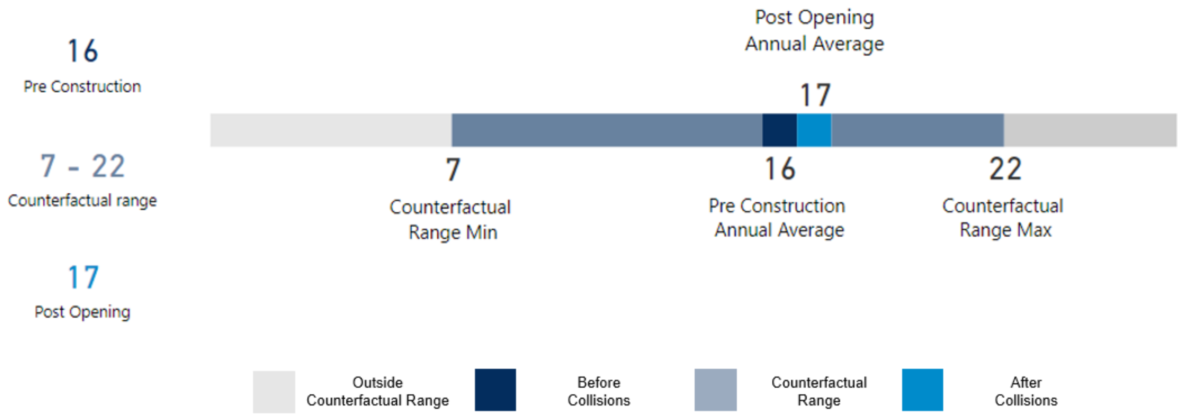


Figure 20 shows the counterfactual range expected personal injury collisions[22] in a range of between 7 and 22 during the five-year post project period. An annual average of 17 personal injury collisions were observed over the five-year post opening period and this falls within the expected range. Therefore, the observed changes fall within what was expected if the project remained as conventional motorway.

Figure 20 Observed and expected range of personal injury collisions (annual average)



Source: STATS19: 25th November 2008 to 30th December 2020.

[22] The safety methodology is different from one-year to five-year evaluation. We still have confidence in the accuracy of the previous methodology but have made suitable changes that will ensure a methodology fit for purpose for the future.

How has traffic flow impacted collision rates?

Smart motorways are implemented on some of England's busiest routes. It is, therefore, important to contextualise any incidents in the volume of traffic seen on this stretch via a collision rate, the number of collisions per hundred million vehicle miles (hmvm).

The evaluation has identified a slight decrease in the rate of collisions per hmvm. Prior to the project, there was an annual average of 8 personal injury collisions per hmvm. After the improvements was a decrease of 0.5 personal injury collisions per hmvm[23].

The distance travelled before a personal injury collision occurred increased from 12 to 13 million vehicle miles per personal injury collision.

A counterfactual test was undertaken to estimate what the impact would have been without the project taking place. This found that the collision rate would likely have been 7 collisions per hmvm in the counterfactual scenario. Statistical testing indicates the difference between the counterfactual and observed collision rate is not significant and the changes are in line with regional trends.

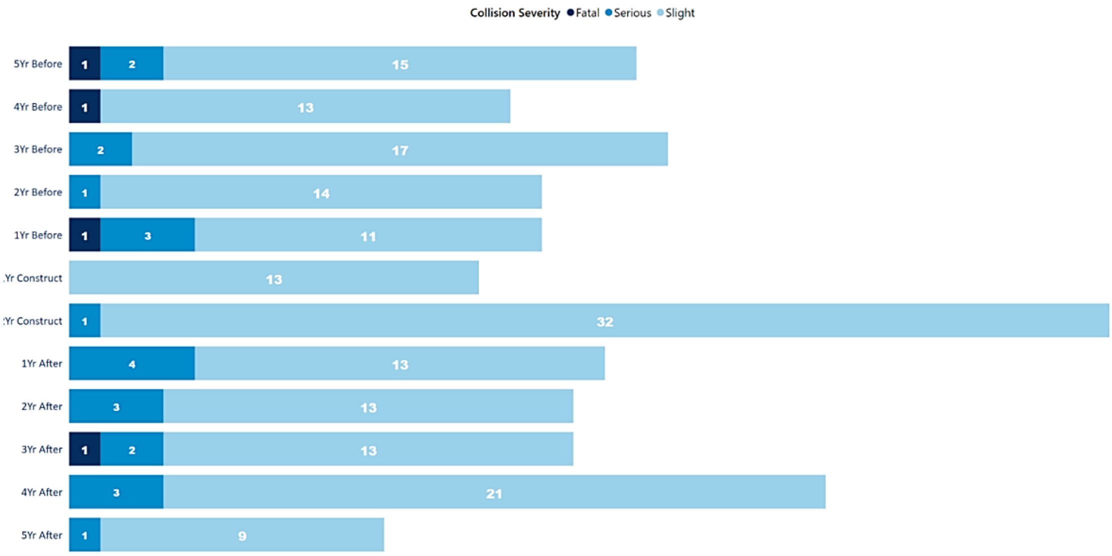
What changes in the severity of collisions did we see?

Collisions which result in injury are recorded by severity as either fatal, severe or slight. During 2016, there was a transition in how severity of incidents were recorded.

Figure 21 shows the severity of personal injury collisions within the project extent. After the project there was no change in the average number of personal injury collisions resulting in slight injuries per year (the annual average before construction was 14, compared to 14 after). There has been an increase in the average number of personal injury collisions that result in killed or serious injuries (the annual average before the project was 2, compared to 3 after). Further analysis highlights there has been an increase in serious injuries per year (annual average before construction was 2, compared to 3 after) but a reduction in fatal collisions. In the five years before construction, there were three fatal collisions compared with one fatal collision in the five years after the project opened.

[23] Prior to the project, there was an annual average of 8.2 personal injury collisions per hmvm. After the improvements were made there was a decrease to 7.7 personal injury collisions per hmvm, which is a decrease of 0.5 personal injury collisions per hmvm.

Figure 21 Severity of personal injury collisions within the project extent



Source: STATS19: 25th November 2008 to 30th December 2020.

How has traffic flow impacted casualty severity?

Like other transport authorities across the UK the key measure we use to assess the safety of roads, is Fatal and Weighted Injuries (FWI). This gives a fatality 10 times the weight of a serious casualty, and a serious casualty 10 times the weight of a slight casualty[24]. In effect, it takes all non-fatal injuries and adds them up using a weighting factor to give a total number of fatality equivalents. This is represented by an annual average and a rate that standardise casualty severities against flow to show the likelihood of a fatality equivalent occurring per distance travelled.

There has been a decrease in the average number of fatality equivalents observed. Before the project an average of 1.1 FWI were observed. After the project this had decreased to 0.8.

The combined metric showed an extra 88 million vehicle miles was travelled before an FWI. Before the project, 182 million vehicle miles needed to be travelled before an FWI (0.5 FWI per hmvm[25]). After the project this increased to 270 million vehicle miles (0.4 FWI per hmvm).

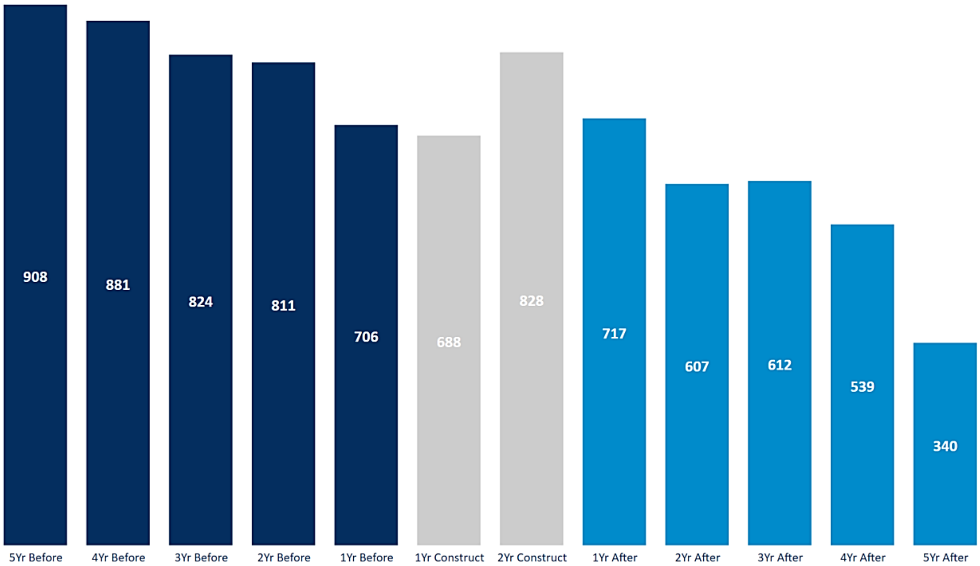
Road user safety in the wider area

What impact did the project have on safety for the wider area?

Personal injury collisions were observed for a wider impact area, which is derived from the safety appraisal for the project. The appraised wider area is shown in Figure 22. The results show that before the project an annual average of 829 collisions were observed and, after the project, this had fallen to 565 collisions which is a reduction of 264 collisions.

[24] The FWI weights Collisions based on their severity. A fatal collision is 1, a serious collision is 0.1 and a slight collision is 0.01. So 10 serious collisions, or 100 slight collisions are taken as being statistically equivalent to one fatality.
[25] Hundred Million Vehicle Miles

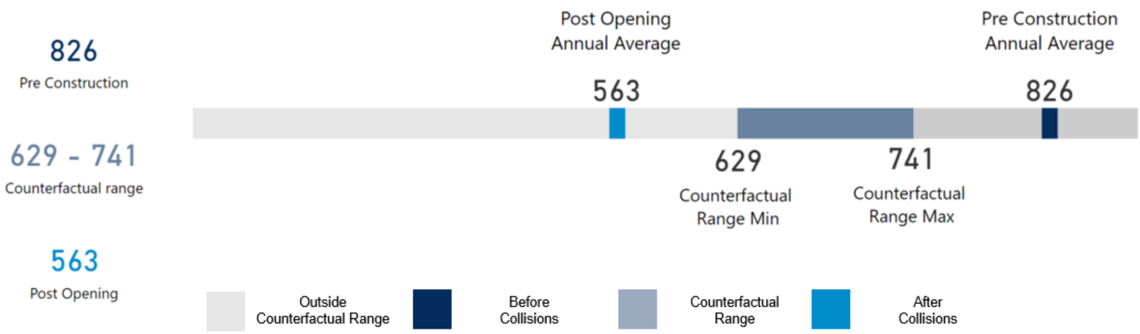
Figure 22 Annual personal injury collisions in wider area



Source: STATS19: 25th November 2008 to 30th December 2020.

The counterfactual analysis (Figure 23) indicated that it is likely that an annual average of between 629 and 741 personal injury collisions would have occurred. The observed annual average of 565 personal injury collisions falls below the range. We can be confident that the observed reduction is significant. This suggests that the project may be having a positive impact on safety in the wider area.

Figure 23 Observed and expected range of personal injury collisions in wider area (annual average)



Source: STATS19: 25th November 2008 to 30th December 2020.

How had traffic flows impacted collision rates in the wider area?

The evaluation has identified a decrease in the rate of collisions per hundred million vehicle miles (hmvm).

Prior to the project, there was an annual average of 43 personal injury collisions per hmvm. After the improvements were made there was a decrease to 28 personal injury collisions per hmvm. A decrease of 15 personal injury collisions per hmvm.

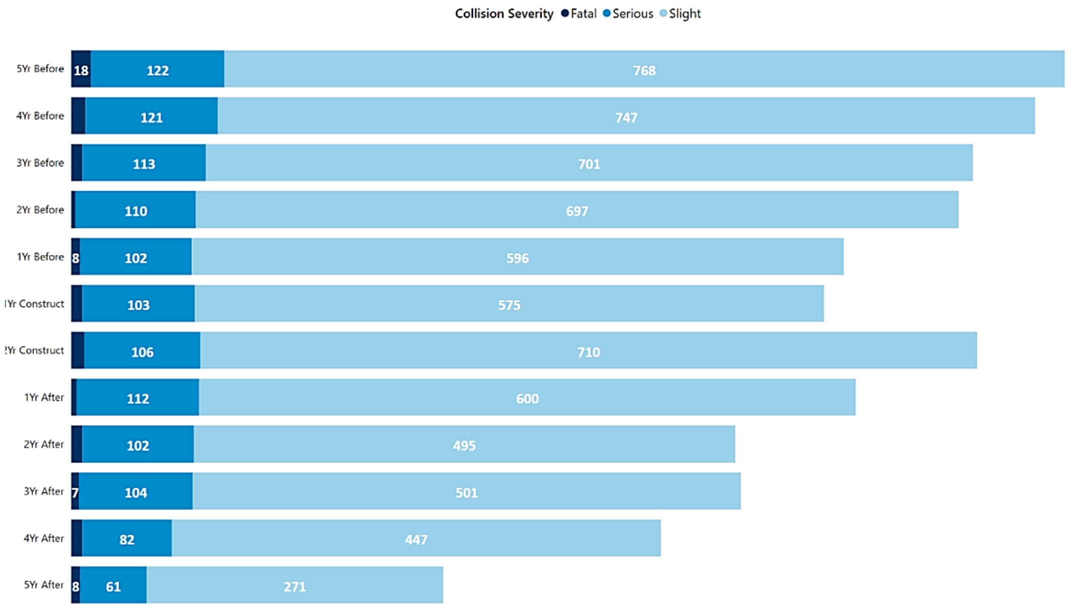
The distance travelled before a personal injury collision occurred increased from two to four million vehicle miles per personal injury collision.

A counterfactual test was undertaken. It found that the collision rate would likely have been 32 collisions per hmvm in the counterfactual scenario. This indicates we have observed a larger reduction in the rate that personal injury collisions occur than predicted. Statistical testing indicates this reduction is significant suggesting that the project could be having a positive impact on the wider area.

What impact did the project have on the severity of collisions in wider area?

Figure 24 shows that after the project there was a reduction in the average number of personal injury collisions resulting in slight injuries per year (the annual average before construction was 705, compared to 465 after). There has been a decrease in the average number of personal injury collisions that result in serious injuries (the annual average before construction was 114, compared to 93 after). The number of fatal collisions has reduced from a total of 52 before to 40 after.

Figure 24 Personal injury collisions by severity in wider area



Source: STATS19: 25th November 2008 to 30th December 2020.

How had traffic flows impacted casualty severity in the wider area?

To understand the impact of the increased traffic flow on collision severity, the measure we use is FWI.

A reduction of 10 FWI has been observed. Before the project, an average of 36 FWI were observed. After the project, this had reduced to 26.

The combined measure showed an extra 25 million vehicle miles was travelled before an FWI. Before the project, 54 million vehicle miles needed to be travelled before an FWI (1.8 FWI per hmvm). After the project this increased to 79 million vehicle miles (1.3 FWI per hmvm).

This indicates that we are observing a reduction in the severity of injuries occurring after the project was completed.

Is the project on track to achieve its safety objective?

The project's safety objective was to achieve a safety objective under which the "after" accident numbers (per annum) are no greater than those in the "before" and the severity ratio is not increased.

The evaluation found the number of personal injury collisions increased, however given the upgraded motorway carried larger flows, the rate of collisions decreased. This element of the safety objective has been met[26]. There has been an increase in the number of collisions resulting in serious injury. This element of the safety objective has not been met.

Within the wider area, there has been a reduction in both the number and rate of collisions. There has also been a reduction in the killed or serious injury collisions. The analysis suggests the project could be having a positive impact on the wider area.

The appraisal for the project expected that most of benefits would be seen on local roads within the wider area. This is due to lower traffic flows on local roads as vehicles rerouted to the project. In total, the appraisal estimated a reduction of 133 personal injury collisions (an average of two per year) over the project lifespan. The observed results also support this finding with a reduction in the number, rate and severity of collisions in the wider extent.

[26] Projects are appraised over a 60-year period. This conclusion is based on the findings at five years after the project opened for traffic.

6. Environmental evaluation

The evaluation of environmental impacts compares the predicted impacts from the appraisal to observed impacts determined during a site visit. Post opening evaluations provide an opportunity for such findings to be captured early and ensure improvements are made, so the design outcome can be achieved.

The evaluation of environmental impacts used information on the predicted impacts gathered from the environmental appraisal within the business case, the environmental assessment report (EAR) and in consideration of the findings of the one year after opening evaluation, compares them with findings obtained five years after the project opened for traffic.

Observed impacts have been determined during a site visit, supported by desktop research. The site visit was undertaken in August 2020.

Summary

The environmental assessment for the project predicted that there would be some adverse impacts on the environment, primarily due to the introduction of all lane running smart motorway on this section of the M1. The use of the hard shoulder as a running lane and widening between junctions 41 and 42 northbound results in traffic being closer to properties, as well as changes in traffic flows and speeds owing to a smart motorway being in place. This was expected to have adverse effects on air quality, but these would not be significant, and it was also predicted to increase greenhouse gas emissions.

The design considered mitigation for the anticipated adverse impact on the landscape owing to the visual impact of the infrastructure required for a smart motorway to operate (particularly gantries) with new planting proposed alongside the existing vegetation. The assessment predicted that the impact on noise would not be significant, so mitigation was not considered to be necessary.

Impacts to townscape, heritage and historic resources, biodiversity and to the water environment were predicted to be neutral.

The five year after evaluation highlighted that the environmental impacts of the project were largely on track to be realised as expected. While the impact on noise was as expected for part of the project, the impact was found to be worse than expected between junctions 40 and 41. This was due to the higher proportion than predicted of heavy duty vehicles (HDV).

The following environmental impacts were scoped out for the five years after evaluation:

- Physical activity: This was scoped out as there are no outstanding issues following the one year after evaluation.
- Journey quality: This was scoped out as there are no outstanding issues following the one year after evaluation.
- Severance: This was scoped out as there are no outstanding issues following the one year after evaluation.
- Water environment: The environmental assessment scoped out impacts on the water environment and the one year after evaluation confirmed the

drainage design had been implemented as proposed and there were no new drainage features or outstanding issues. Due to dry weather during the five years after site visit, there was no opportunity to inspect the drainage systems and no further evidence on the performance of the drainage system has been observed. The outcome five years after was assumed to be the same as at one year after.

- Heritage and historic resources: The environmental assessment considered there would be no direct impacts on cultural heritage assets and minimal impacts on their settings. This was confirmed during the one year after evaluation, so no further evaluation was considered necessary.

Noise

The environmental appraisal in the business case reported that more people would experience increases in noise due to the changes in traffic flow and the use of the hard shoulder (which is closer to the receptor). The overall result expected that there would be slight adverse impacts. Due to the appraisal not predicting any significant changes in noise levels, the project did not propose any new mitigation measures.

At five years after, observed traffic flows (AADT, February 2020) were between 16% and 20% lower than the forecast. However, where the HDV data was available for the project (junctions 39 to 41) the difference in % HDV was between 9% and 12% higher. In the POPE methodology, a 10% difference in % HDV indicates a potential noticeable change[27]. Using the forecast and observed traffic data, basic noise level[28] calculations were done.

The results from the calculations found that the noise impacts were likely to be broadly as expected between junctions 39 to 40. However, between junctions 40 to 41 the noise impacts were slightly worse than expected, this was due to the observed % HDV in 2020 being higher than forecast.

During the five years after site visit, it was noted that a noise barrier had been installed at junction 39, but this was part of the National Highways noise action planning work and was not part of the studied project. Any benefits associated with this cannot be attributed to the project so have not been considered in the five years after evaluation.

Air quality

The project was predicted to not cause any significant local air quality impacts. The appraisal noted that there were three air quality management areas (AQMAs) within 200m of the project; ‘Wakefield City’, ‘Wakefield 1’ and ‘Barnsley No.1’. It was predicted that the project would result in four new exceedances of the Air Quality Strategy Objective, however the change in annual mean NO_2[29] concentrations was small at most of the receptors[30]. In those areas where the air quality objectives for NO_2 were not being met, the changes due to the project were

[27] Changes of more than 1 decibel (A-weighted) are noticeable by a typical person.
[28] A calculation that predicts the noise level at 10m from the road.
[29] Oxides of nitrogen which includes nitrogen dioxide – one of the principal pollutants from road traffic.
[30] Locations sensitive to changes in air quality such as domestic properties.

expected to be small and unlikely to be observable within normal year-to-year variations.

According to the comparison of the observed traffic flows along the M1 between junctions 39 to 42 against the equivalent forecasts, the two-way (AADT) flows show a reduction of between 20,000 and 30,000. The reduction in flows indicate that air quality may be better than expected. However, the observed HDV flows were between 8,000 and 12,000 higher than forecast. To quantify what the combined effect of the lower total flows but higher HDVs would have on receptors across the study area would require further air quality modelling and assessment that is outside the scope of POPE. However, a simple air quality emissions calculation was undertaken to compare the effect on emissions caused by changes in the forecast and observed traffic data. This suggested that, despite the higher % HDVs, observed NOx emissions were still likely to be lower than forecast as overall traffic flows were lower[31].

Data from the project environmental assessment was also studied. This confirmed that in the opening year of the project, which was considered to be the worst year in the first 15 years after opening, air quality at most of the receptors would be either below the annual average air quality objective or would experience very small changes in NO_2 concentrations.

The 2020 Air Quality Annual Status Report from Barnsley Metropolitan Borough Council[32] reported that at the 'Barnsley No.1' AQMA, for the last nine years of monitoring, NO_2 concentrations have been within the UK air quality standard. Similarly, the Wakefield Metropolitan Borough Council 2020 Air Quality Annual Status Report[33] highlighted improvements within the Wakefield 1 AQMA such that the air quality standard was being achieved. For the 'Wakefield City AQMA' there was a trend of slightly declining concentrations of NO_2, however exceedances of the standard were reported at two locations. These locations are approximately 1.9 miles (3km) from the M1 and outside of the network of roads predicted to be affected by the project in its air quality environmental assessment.

The analysis suggests there was a low risk that the traffic changes observed at five years after would have led to a significant air quality effect or changed the outcome of the air quality assessment. The outcome at five years after was likely to be not significant and so as expected by the original environmental assessment.

Greenhouse gases

The appraisal reported that there would be an increase of 28,638 tonnes of CO_2 in the opening year due to the project. At five years after, HDV observed data was not available along the full project extent, with data unavailable for junctions 41 to 42, so it was not possible to quantify the difference in forecast and observed greenhouse gas emissions. As detailed in section 4, traffic flows were lower along the project extent than the forecast which, like the outcome at one year after, may suggest that the emissions were lower than forecast. However, without quantifying the emissions, it is not possible to determine what impact the higher HDV flows may have had so there is uncertainty with this outcome.

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[31] National Highways' Speed Band emissions tool which is derived from Defra's emission factor toolkit v11 was used to compare emissions.
[32] https://www.barnsley.gov.uk/media/16804/air-quality-status-report-2020.pdf
[33] https://www.wakefield.gov.uk/Documents/bins-environment/environmental-health/pollution/air-quality-management-annual-status-report.pdf

Landscape

The appraisal noted that there would be no change to the existing urban fringe / agricultural landscape character. The appraisal did report that the proposed gantries were expected to have an adverse visual impact on nearby residential receptors. Overall, the landscape impact was predicted to be slight adverse. Landscape mitigation measures included the retention of the existing vegetation where possible and restoration of areas used temporarily, including replanting trees, hedgerows, shrubs and grass. New planting would be used, as appropriate, to screen structures and to help integrate the project into the existing landscape. This mitigation was expected to reduce the landscape / visual impact as the vegetation matured.

The five years after opening site visit and analysis confirmed that the project had added new infrastructure to the local landscape and, in some locations, there were open views towards them. The M1, however, was already a dominant feature, and the new infrastructure did not significantly change the landscape character. Some gantries were within cuttings or screened by retained vegetation and, at other locations, mitigation planting had been provided to help filter views.

New planting was establishing across the project (example in Figure 25); however, failed planting was identified in some plots. This included some planting that had been dead for some time. This suggested the requirements to replace dead plants during the 36-month aftercare period were not implemented (Figure 26), which was outlined in the Handover Environmental Management Plan (HEMP). It was noted that at some of the locations where new mitigation planting had failed, existing retained vegetation was still helping to minimise landscape and visual impacts. Despite the failed planning, including near properties, sufficient retained vegetation and new screen planting was in place. The outcome at five years after confirmed the one-year after findings that the impact was considered to be as expected.

Figure 25 Example of mitigation planting and failed planting

Close up of gantry from Woodhouse Lane. Shows mitigation planting in place on embankment slope at one year after.

North east towards M1 from Woodhouse Lane, with open views to gantry and filtered views to top of VMS at five years after.

Planting beneath the gantry opposite Woodhouse Lane was establishing slowly but should still help filter views by the design year. Planting on right of picture within oval appears to have failed five years later.

Source: One year after site visit (May 2017) and five years after site visit (August 2020).

Figure 26 Example of failed planting at one-year after not replaced

Source: Planting at foot of new gantry near junction 41. Planting dead however adjacent retained vegetation likely to be filtering views from nearby properties. Five years after site visit (August 2020).

Townscape

The appraisal predicted that there would be no townscape impacts as the surrounding area is urban fringe or agricultural landscape. The one year after evaluation found that there were no direct impacts on townscape by the project.

Analysis at the time of the five years after evaluation supported the findings of the one-year after evaluation. Overall, the additional infrastructure had not had a noticeable effect on the townscape, although there had been some localised vegetation loss and new gantries installed. There had been unexpected changes at

M1 junction 39 because of the construction of a new noise barrier[34]. To install the noise barrier some vegetation had been removed which had affected views for properties in the immediate vicinity but this was, in part, be due to the construction of the noise barrier and not the project itself. The outcome at five years after was considered to be as expected.

Biodiversity

The appraisal predicted that the project would cause a very minor loss of roadside habitats. No adverse impacts on designated species (such as great crested newts and breeding birds) were predicted. Overall, with mitigation, the impacts to biodiversity were anticipated to be neutral by 15 years after project opening.

At the five years after evaluation the impacts to biodiversity were broadly as expected. A minor loss of roadside habitats of local value was lost to accommodate the new emergency refuge areas and gantries. However, mitigation planting had been provided and areas temporarily disturbed during the construction had been restored. Overtime, it was expected that the new planting should replace lost habitats for species (such as breeding birds).

Asset data provided evidence that some grassland enhancement works were undertaken but there was limited information on the wildflower mixes used. Site observations suggested there had been limited success in developing a diverse wildflower sward along the soil nailed slopes (Figure 27), compared to one-year after (Figure 28). As no specific wildflower management regime was in place, it is unlikely that significant further progress will be made. Evidence from the Handover Environmental Management Plan confirmed that protected species were not adversely affected by the works.

Figure 27 One year after evaluation of seeded slope south of Park Mill Lane (between Junctions 40 and 41)

Source: One-year after site visit (May 2017).

[34] After the M1 Junction 39 to 42 was completed, and part of National Highways' noise action planning work.

Figure 28 Five year after evaluation of seeded slope South of Park Mill Lane (between Junctions 40 and 41), including a close-up view of the slope

Source: Five year after site visit (August 2020).

Overview

The results of the evaluation are summarised against each of the Transport Analysis Guidance (TAG)[35] environmental sub-objectives and presented in Table 3. In the table we report the evaluation as expected if we believe that the observed impacts at one-year after were as predicted in the appraisal. We report them as better or worse than expected if we feel the observed impacts were better or worse than expected.

Table 3 Summary of environmental findings – M1 junctions 39-42

Sub Objective	Appraisal Summary Table Score	Five-Year Evaluation Outcome	Five-Year Evaluation Summary
Noise	Slight adverse	As expected and worse than expected	The use of the hard shoulder as a running lane has, as expected, brought traffic closer to properties. Analysis of available traffic data suggested impacts were as expected between junctions 39 and 40 but, due to higher % of HDVs, worse between junctions 40 and 41.
Air Quality	NO_2 2168 improve, 696 worsen, 437 no change	Not significant, as expected	Observed traffic flows were different to the forecast. However, the analysis suggested that the differences would not change the outcome of the original assessment.
Greenhouse Gases	There is an increase in CO_2 of 28,638 tonnes in the opening year as a result of the project.	-	It was not possible to quantify the change in greenhouse gas emissions due to the absence of all the required HDV data.

[35] **TAG** provides guidance on appraising transport options against the Government's objective for transport.

Landscape	Slight adverse	As expected	The new infrastructure had not significantly altered the landscape character and new mitigation planting along with retained woodland was helping to screen and filter views. Dead planting identified in some plots suggested not all maintenance works had been undertaken. However, sufficient retained vegetation remains so it was expected that design outcomes will be met.
Townscape	Neutral	As expected	There had been some localised vegetation loss within the highway boundary and new gantries installed. However, overall, the corridor and local townscape remained broadly unchanged.
Biodiversity	Neutral	As expected	The evaluation confirmed that habitat loss had been minor, and mitigation and restoration planting had taken place. There was no evidence that protected species were adversely affected during construction and, overtime, the new planting should replace lost habitats for species such as breeding birds.

7. Value for money

Summary

As part of the business case, an economic appraisal was conducted to determine the project's value for money. This assessment was based on an estimation of costs and benefits over a 60-year period.

The project was delivered at a cost of £117million[36], slightly under the forecast cost. The road provided additional capacity to support more road users (an increase of around 9% between April 2013 and February 2020).

Overall, the evaluation indicated that in the first five years this investment is not on track to deliver the value for money anticipated over the 60-year life of the project. If the journey time trends observed within the first five years continue, the project is expected to deliver 'poor' value for money[37].

Forecast value for money

An economic assessment is undertaken prior to construction to determine a project's value for money and inform the business case. The assessment is based on an estimation of costs and benefits. The impacts of the project such as journey time savings, changes to user costs, safety impacts and some environmental impacts are able to be monetised. This is undertaken using standard values which are consistent across government. The positive and negative impacts over the life of the project[38] are summed together and compared against the investment cost to produce a benefit cost ratio (BCR). The monetised impacts are considered alongside additional impacts which are not able to be monetised to allocate the project a 'value for money' category.

The monetised benefits forecast by the appraisal which supported the M1 junctions 39 to 42 smart motorway business case are set out in Table 4. We have also included an indication of what proportion of the monetised benefits each impact accounted for and a summary of how we have treated the monetisation of each impact in this evaluation.

[36] Present value of costs in 2010 prices and values.
[37] The value for money categories referenced are defined by the Department for Transport https://www.gov.uk/government/publications/dft-value-for-money-framework
[38] Typically project life is taken to be 60 years.

Table 4 Monetised benefits of the project (£ million)

	Forecast (£M)	% forecast monetised benefits[39]	Evaluation approach
Journey times	419	102%	Reforecast for the project area (not the wider area) using observed and counterfactual[40] traffic flow and journey time data
Vehicle operating costs (VOC)	-23	-6%	Reforecast using observed and forecast traffic flow and journey time data
Journey time & VOC during construction and maintenance	-58	-14%	Not evaluated (assumed as forecast)
Journey time reliability	106	26%	Re-forecast using observed traffic flow data
Safety	10	2%	Reforecast using observed and counterfactual[41] safety data for the project extent and wider area
Carbon	-51	-12%	Monetised benefits assumed as forecast
Air quality	-2	<0%	Monetised benefits assumed as forecast
Noise	-3	-1%	Monetised benefits assumed as forecast
Indirect tax revenues	13	3%	Reforecast using observed and forecast traffic flow and journey time data
Total present value benefits	**411**		

Note: 2010 prices discounted to 2010. Due to rounding the numbers and percentages may not always add up exactly to the presented totals.

The costs anticipated in the appraisal are set out in Table 5. The appraisal expected that the project would result in an increase in maintenance costs over the life of the project. As the vast majority of this maintenance is still in the future, the evaluation uses the maintenance costs forecast within the business case.

Based on this information in Table 4 and Table 5, the project was anticipated to deliver 'high' value for money over the 60-year appraisal period.

Table 5 Cost of the project (£ million)

	Forecast (£M)	% forecast costs	Evaluation approach
Construction costs	117.5	82%	Current estimate of project cost
Maintenance costs	25.0	18%	Not evaluated (assumed as forecast)
Total present value costs	**142.5**		

Note: 2010 prices discounted to 2010. Due to rounding the numbers and percentages may not always add up exactly to the presented totals.

[39] Disbenefits are presented as negative numbers and percentages. The total of the positive and negative contributions total to 100%.
[40] We calculated the vehicle hours saved by comparing outturn journey times with an estimate of how journey times would have continued to deteriorate had the project not been implemented (i.e. a 'counterfactual').
[41] We compared observed trends with an estimation of the trends if the road had remained a conventional motorway (i.e. a 'counterfactual').

Evaluation of costs

The project was delivered at a cost of £117 million[42], very close to the anticipated cost (see Table 5).

The appraisal expected that the project would result in an increase in maintenance costs over the life of the project. As the vast majority of this maintenance is still in the future, we did not have any information with which to update the estimate for this part of the cost and therefore the forecast from the appraisal remains our best estimate.

Evaluation of monetised benefits

Once a project has been operating for five-years, the evaluation monitors the construction costs and the trajectory of benefits to reforecast these for the 60-year project life. Appraisal of these major investments takes many years of complex and expensive analysis. Our evaluation methods are much simpler, so consequently there is a degree of uncertainty around these numbers.

Monetised journey time benefits

As can be seen in Table 4, journey time benefits comprised the majority of the justification for investing in this smart motorway. As previously noted, within the first five years journey times have marginally increased. This is likely to be due to a combination of reasons including the increases of traffic flow, and the speed restrictions applied as part of the VMSL technology to smooth the flow of traffic.

The forecasts generally overstated traffic increase[43]. The observed before traffic flows were higher than the forecast, as well as the five-year after observed and forecast flows which are presented in Figure 6 and Figure 7.

The overall impact on vehicle hours on the project section in the fifth year was estimated to be negative[44]. Without the detail of the original forecasts to compare to it is difficult to draw conclusions, but given the lifetime positive monetised impact presented in the pre-construction appraisal, this is unlikely to be in line with what was anticipated.

Without further intervention, journey time benefits are unlikely to be on track to be realised. The appraisal assumed the project would deliver journey time savings for those using the smart motorway, where congestion would be eased by the additional capacity. It is worth noting the evaluation has not monitored the journey time impact on the surrounding roads.

If the trends observed at the fifth year continue over the 60-year period, without any further action to optimise benefits, the monetised impact on journey times, for those using the road, would be -£66 million[45]. This figure only reflects journey time

[42] This is the PVC (present value cost) of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[43] Refer to section 4 for further details.
[44] A disbenefit of 171,000 vehicle hours in the fifth year.
[45] This is against a counterfactual where we have estimated what the journey time is likely to have been if the road had remained a conventional motorway.

trends observed on the project area, not the surrounding road network which would have been considered in the appraisal[46].

Other reforecast impacts

We reforecast total safety benefits to be £197 million. This figure relates to the benefit on the project extent and wider area, as described in section 5. Within the project extent, there was an improvement in the rate of personal injury collisions although the number of collisions did increase and within the wider area there was an improvement in the rate and number of collisions [47].

There are two further impacts associated with the changes in numbers and speeds of vehicles – indirect tax revenues and vehicle operating costs. Indirect tax revenues are the benefit to the government (and therefore society) of the additional tax income from the additional fuel consumed due to increased speeds and distances travelled. This was forecast to be positive because more vehicles were forecast and they were forecast to be travelling at higher speeds, and therefore using more fuel and paying more tax. We have reforecast that the impact would be smaller than expected, an increase in tax revenues (£4 million[48]). The impact is smaller because our evaluation has shown that there was not as much traffic growth as forecast. Vehicle operating costs refer to the fuel and other costs borne by the user (such as the wear and tear on vehicles). This generally increases with increased distance travelled. There was a disbenefit forecast and, based off the changes we have seen in our estimate of fuel consumption and indirect tax revenue, we estimate the outturn impact to be a small disbenefit of £6 million[49].

We reforecast journey time reliability benefits by reusing the INCA[50] file used in the appraisal. This found the monetised reliability benefit to be similar to that identified in the appraisal at £116 million[51]. Our analysis of journey times found that for most time periods, there was a neutral change or small improvement in journey time reliability, with the exception of the morning peak northbound and evening peak southbound. The route stress metric suggested an overall improvement.

Impacts assumed as forecast

The evaluation has not been able to reforecast the monetary value of noise, air quality and carbon benefits[52], and instead these were reported as forecast. For air quality and carbon impacts, this assumption is reasonable, based on the analysis in section 6. Analysis of available traffic data suggested noise impacts were as

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[46] Our findings relating to the project area are very different from those forecast for that area. We therefore did not feel we had sufficient confidence in the forecasts to use them as the basis of an estimate of the outturn impact in the wider area.
[47] Refer to section 5 for further detail on safety.
[48] This is the contribution to the PVB (present value benefit) of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[49] This is the contribution to the PVB of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[50] INCA (INcident Cost-benefit Assessment) is a Department for Transport tool for estimating the expected impact of an intervention on journey time reliability and calculating the value of this benefit.
[51] This is the contribution to the PVB of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[52] We do not have a method for reforecasting the monetised impact of noise, air quality and carbon impacts. These generally have a small contribution to the monetised benefits and therefore the impact of assuming as forecast is unlikely to impact on the value for money rating of the project.

expected between junctions 39 and 40, but our evaluation found that the higher proportion of HDVs between junctions 40 and 41 meant that this section was likely to be worse than expected, albeit this was only one section within the project extent. As noise is a small contribution to the total benefits, we do not believe this uncertainty would alter the value for money rating of the project.

Journey times and vehicle operating costs during future construction and maintenance have been assumed as forecast. As the vast majority of this maintenance is still in the future, the evaluation uses the impacts forecast within the business case.

Overall value for money

The main reason for the overall reduced level of benefits from this project is the lack of journey time savings. The appraisal forecast a significant traffic growth and improving journey times; the observed data suggested a more modest traffic growth accompanied by slightly slower journey times in most time periods and considerably slower average journey times in the northbound morning peak. This has affected the project's value for money.

When considering an investment's value for money we also consider benefits which we are not able to monetise. For this project, the following might be relevant considerations:

- Journey quality[53] was appraised to be large beneficial owing to the information provided and no substantial change in the views for road users. The project has provided increased information for drivers via the gantries and improved signage. The new gantries increase the visual presence of motorway infrastructure and, together with the new vertical concrete barriers in the central reserve, add to the feeling of urbanisation within the route corridor. As set out in section 5, although the number of personal injury collisions increased slightly, when taking into account the additional traffic the collision rate has decreased slightly. However, driver stress benefits have not been as realised to extent anticipated, with slower and less reliable journey times in the busiest time periods. As the journey quality benefits may not have fully been realised, it is unlikely this impact would alter the value for money rating of the project.
- Although not included in the appraisal, wider economic benefits might be relevant given the project's proximity to a functional urban region and the strategic M62 east-west route, but these are usually dependent on delivering journey time savings. As the journey time savings have not been realised, there are unlikely to be additional benefits in this area.

With few non-monetised benefits to take into consideration, it is likely that this project has offered 'poor' value for money.

Based on the evidence from the first five years, this project is not on track to realise the anticipated value for money. However, there have been benefits delivered - construction of the project was delivered within budget, it is delivering safety benefits to road users and most of the environmental benefits are as expected, or better.

[53] Journey quality is a measure of the experience of travelling. This includes traveller care (for example information and facilities), travellers' views; and traveller stress factors (for example perceptions of safety, congestion and reliability). Refer to TAG unit A4.1

Appendix A

A.1 Safety counterfactual methodology

Personal injury collisions (hereafter referred to as collisions) on the strategic road network are rare and can be caused by many factors. Due to their unpredictable nature, we monitor trends over many years before we can be confident that a real change has occurred as result of the project.

To establish whether any change in collision numbers is due to the project or part of wider regional trends we have established a test we call the Counterfactual. The Counterfactual answers the question: What would have likely occurred without the project being implemented? To answer this question, we estimate the range of collisions that could have occurred without the project in place. Previous Post Opening Project Evaluations answered this question by looking at national trends in collisions. Adjustments have been made to the methodology for estimating the Counterfactual. These have been made to address the following areas:

Amended Data Collection Method

- Revised method for identifying collisions that occurred on the network.
- Only validated STATS19 information is used for reporting purposes.

Adjusting for Traffic Flows

- Baseline traffic flows are an important factor when determining the counterfactual. We now assume that without the changes made to the network, the trends would follow regional background traffic growth patterns.
- We can now calculate the collision rate for the busiest stretches of conventional motorways.

Better Differentiation between different types of motorway

- The existing methodology only had one definition of motorway.
- The new method allows us to differentiate between conventional motorways, conventional motorways with high traffic flows and smart motorways.

Assessing Regional Trends

- The new method uses regional rather than national trends for collision rates and background traffic growth, which provides greater granularity and makes the hypotheses more realistic.

We have found that the adjustments have resulted in a slight change from the previous methodology. We still have confidence in the accuracy of the previous methodology but believe we have made suitable changes that will ensure a methodology fit for purpose for the future.

Since this project, smart motorways have evolved. More recent all lane running projects have demonstrated that they are making journeys more reliable for those travelling during congested periods, enabling us to operate the road at a higher speed limit for longer periods, whilst maintaining safety.

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