M1 junctions 19 to 16 all lane running

Three-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 from 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 19 to 16 all lane running (ALR) smart motorway scheme three year after its opening in 2018 following conversion from a conventional three lane motorway.

This report will be followed by a five years after report which will provide 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.

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 2024

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1. Executive summary

The M1 junctions 19 to 16 smart motorway project covers a 16-mile stretch of the M1 between Northampton and Rugby. The M1 between junctions 19 and 16 is not only a strategic north-south route but provides east-west connectivity, linking with the M6, A14 and M45. Prior to the upgrade to all lane running[2], the motorway was a three-lane conventional motorway which experienced congestion and unreliable journey times.

The smart motorway sections on our network have provided additional road capacity, creating more road space on congested sections of motorway. Typically, this has provided more reliable journeys for road users at the busiest periods of the day. This has allowed people to travel as conveniently, reliably and safely as possible. This means more traffic can use the strategic road network rather than divert on to the local road network causing further congestion.

Without the smart motorway, these issues were expected to be exacerbated by predicted growth in traffic volumes. The project aimed to reduce congestion, reduce journey times, improve journey reliability, reduce the effects of traffic on the surrounding road network, improve the quality of information given to drivers, support local development plans and maintain safety performance.

During the first three years since the smart motorway opened, the annual number of personal injury collisions decreased from an average of 29 before construction to 10 after opening. This falls below the range of what would have been expected if the road were to remain a conventional motorway, and therefore considered statistically significant and could be as a result of the project. The annual average rate of personal injury collisions per hundred million vehicle miles has also improved.

Three-years after the upgrade to smart motorway, there has been less growth in traffic volumes than forecast. This impact is in line with national and regional trends[3].

Since the conversion, the smart motorway has improved the journey time reliability across the studied time periods for most road users. Journey times have also reduced in both directions during all time periods considered in this evaluation. The slowest journeys are quicker in most time periods. Average speeds along the route have increased resulting in improvements in journey times in both directions and all time periods.

At this stage we cannot be confident that the three-year after evaluation findings are a result of the project itself and not part due to the lower observed traffic volumes following Covid. Traffic levels could increase in later years, and so results at the five-year after opening evaluation will be essential to check if the evaluation trends continue.

[2] All lane running (ALR) motorways 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.
[3] The COVID-19 pandemic and associated restrictions that spanned from March 2020, until February 2022.

2. Introduction

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

The M1 junctions 19 to 16 smart motorway covers a 16-mile stretch of the M1 between Northampton and Rugby. The project started construction in December 2015 and opened for traffic two years later in January 2018.

Prior to construction, the section of motorway experienced congestion and unreliable journey times. This reflected the strategic importance of this section of the M1 as a north-south route and also one that provides east-west connectivity via the M6 and A14 and M1 junction 19 and the M45 at M1 junction 17.

The project aimed to reduce congestion, reduce journey times, improve journey reliability and maintain safety performance. Without the smart motorway, these issues were expected to be exacerbated by predicted growth in traffic volumes.

The key features of the project were:

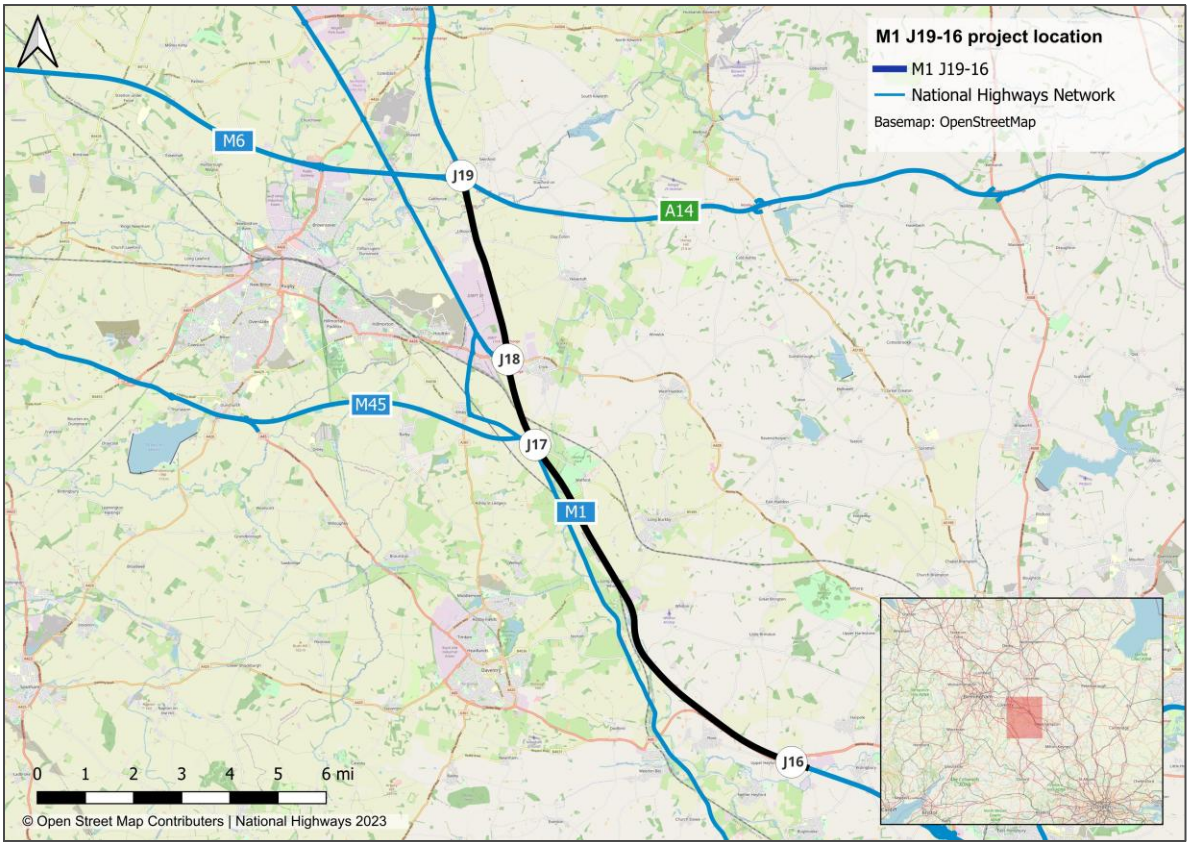
- Conversion of the northbound and southbound hard shoulder for use as a permanent traffic lane (all lane running) to provide additional capacity with four lanes in each direction.
- Introduction of smart motorway infrastructure, including variable mandatory speed limits (VMSL) to manage traffic flows and improve journey times.
- New emergency areas were constructed at regular intervals between junctions 19 and 16.

Project location

The M1 is a strategic route in England which extends from London to Leeds, passing through Midlands. The project extends for 16 miles between junctions 19 (Catthorpe Interchange) and 16 (Upper Heyford). Junction 19 is in the county of Leicestershire, to the northeast of Rugby, and forms the intersection between the M1 and M6, as well as the A14. Junctions 18 to 16 are in Northamptonshire, with junctions 18 and 17 located to the southeast of Rugby and junction 16 to the west of Northampton.

The location of the project in relation to the region and surrounding highway network is shown in Figure 1 below.

Figure 1 M1 Junction 19 - 16 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 provide opportunities to learn and improve future project appraisals and business cases too.

A post-opening project evaluation (POPE) compares changes in key impact areas[4] 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 methodology manual on our website[5].

[4] Key impact areas include safety, journey reliability and environmental impacts.
[5] https://nationalhighways.co.uk/media/exypgk11/pope-methodology-note-jan-2022.pdf

3. Delivering against objectives

How has the project performed against objectives?

All our 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. For this project, the three-year evaluation provides early indication of progress, followed by the five-years after evaluation which will give a more detailed insight. Table 1 summarises the project's performance against each of the objectives, using evidence gathered for this study.

Table 1 Objectives and Evaluation Summary – M1 junction 19 to 16

RIS Objective[6]	Scheme objective[7]	Three-year evaluation
Improving Safety for All We need to keep our customers, people and supplier safe, above all else.	To achieve a safety objective under which the "after" accident numbers (per annum) are no greater than those "before" and the severity ratio is not increased	The three-year analysis found that there has been a reduction in the number and rate of PICs. The severity of PICs is unchanged. The number of Fatal and Weighted Injuries remains unchanged. Therefore, at this evaluation point the project has met its objective.
Providing Fast and Reliable Journeys We want to help people and businesses have safe, reliable and efficient journeys.	Relieve congestion and smooth traffic flow, thus improve journey times	The three-year analysis has shown that along the project extent, there have been improvements in average journey times. Three years after the conversion to smart motorway, there has been less growth in traffic volumes than predicted. This impact is in line with national and regional trends. Average speeds along the route have increased resulting in improvements in journey times in both directions and all time periods.
	To improve journey time reliability, as measured by the average delay experienced in the worst 10% of journeys and to improve journey times	Three years after opening, the smart motorway has improved the journey time reliability for most road users in both directions. Across time periods, and in both directions, customers experienced a negligible change or improvement in journey time reliability. The slowest journeys are now quicker in most time periods. Average journey times along the project extent have improved in both directions during all periods of the day.

6 During the first Road Investment Strategy (RIS) from 2015 to 2020, and subsequent RIS2 (2020-2025), universal objectives were created to ensure consistency across the smart motorway programme.
7 The objectives as part of the original business case when the investment decision was made for the project.

RIS Objective[6]	Scheme objective[7]	Three-year evaluation
A Well Maintained and Resilient Network Our network is complex and varied and requires careful stewardship to keep it in good condition.	To minimise detrimental effects of traffic on the surrounding road network where possible	Routes have seen a reduction in traffic volume following the opening of the project. However, we cannot be confident that this is a result of the project itself and not part due to associated Covid impacts.
Delivering Better Environmental Outcomes We want our roads to work more harmoniously with the communities that live alongside them, and the environment that surrounds them.	To offset the detrimental environmental effects of the scheme by mitigation measures, taking into account costs, availability of funding and statutory obligations	This will be considered in a future POPE report for the project following an environmental site visit.
Meeting the Needs of All Users We want to meet and exceed the expectations of all those who use out network.	Aim to support local development plans and the Regional Spatial Strategy	This objective is not assessed within the POPE methodology. However, it is expected that at the early stage of the project, the smart motorway has helped to unlock opportunities for growth by improving traffic flow and making journeys more reliable for road users.
	To improve the currency and quality of information provided to drivers about the state of traffic flow on the motorway	Variable Messaging Signs (VMS) on gantries above the M1 provide improved driver information.
Delivering Even More Value for Our Customers We are setting out to deliver £2.23bn of efficiencies, which will mean that taxpayers will see even more investment for their money than in the past.	-	This will be considered in a future POPE report for the project following a value for money evaluation.

4. Customer journeys

Summary

For this three 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 March 2014 (before construction). For our three years after study, we have used data from November 2021 to avoid the period impacted by lockdown restrictions.

Our analysis has shown that there has been a reduction in traffic volumes using the route following the opening of the project. However, we cannot be confident that this is a result of the project itself and not part due to associated Covid impacts. The general trend of traffic volumes being lower than before is consistent with national and regional traffic growth trends (7.5% reduction in traffic volumes on National Highways motorways).

The project had an objective to improve journey time reliability and journey times. Three years after opening, the smart motorway has improved the journey time reliability for most road users. Across all time periods, and in both directions, customers experienced negligible change or improvement in journey time reliability.

Journey times have also reduced in both directions and in all time periods analysed for this evaluation. The longest journeys (90th percentile) are quicker in most time periods.

Average speeds across the route have increased following the implementation of the smart motorway. There is a slight fall in road users' speeds close to junction 16 in both directions. We believe that this is due to the construction works taking place as part of the M1 junctions 13 to 16 smart motorway project which commenced in August 2017.

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

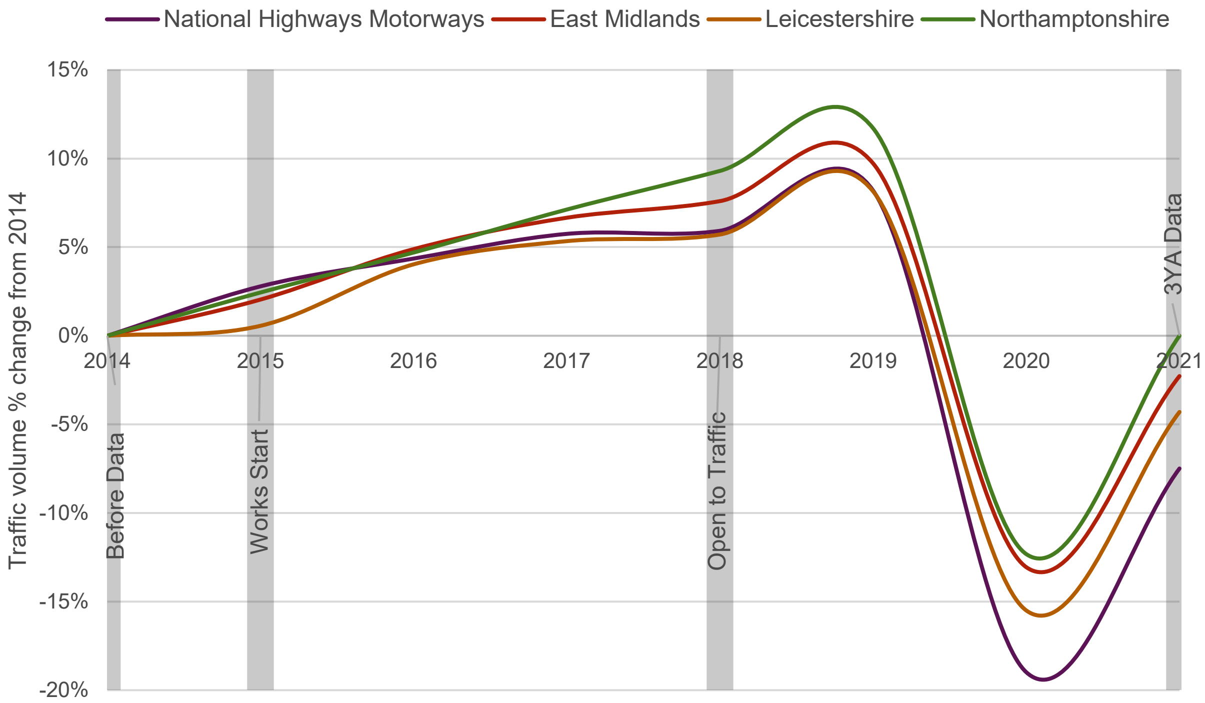
To assess the impact of the project on traffic levels, it is useful to understand the changes within the context of national and regional traffic. To do this, we use annual statistics from the Department for Transport, the data is reported by local authority and road type, recording the total number of million vehicle kilometres travelled[8]. 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 flow by year in the period from 2014 (which is our baseline in this study) to 2021. The project fully opened in January 2018. Due to Covid-19 impacts in 2020 and early 2021, the three years after study considers data from November 2021 (post Covid-19 pandemic and associated travel restrictions in England).

Trends over the study period are presented for roads in the regions within which the M1 junctions 19 to 16 are located (East Midlands, Leicestershire and Northamptonshire), and all motorways managed by National Highways.

[8] Motor vehicle traffic (vehicle kilometres) by region in Great Britain, annual from 1993 to 2021, Table TRA 8904, Department for Transport

Figure 2 Changes in National and Regional Background Levels of Traffic between 2014 and 2021 (M1 Junction 19 - 16)



Source: Department for Transport Road Traffic Statistics Table TRA8904.

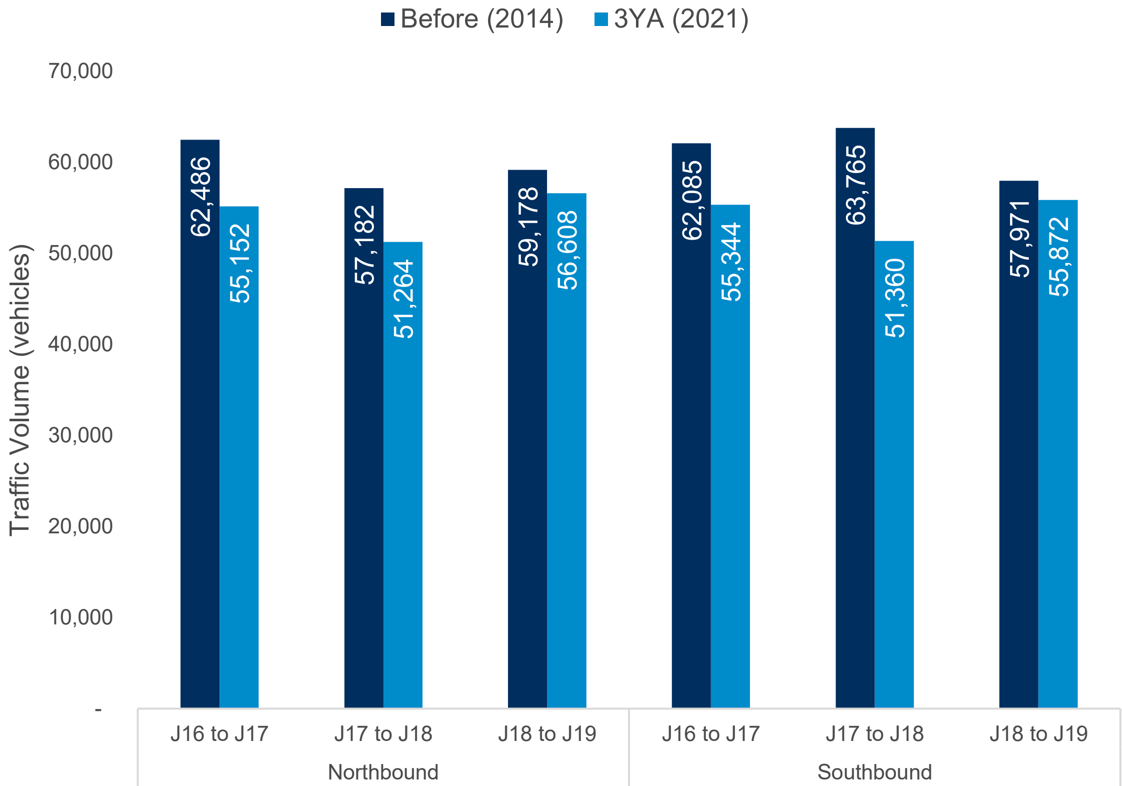
Traffic volumes in each region saw steady growth until 2018. There was a period of accelerated growth between 2018 and 2019 before a reduction in traffic levels across all regions, in line with the Covid-19 pandemic and associated travel restrictions. Traffic levels started to increase in 2021 as the restrictions associated with Covid-19 began to ease at times during the year. The impact of Covid-19 has made it difficult to estimate what level of traffic growth we would expect to see, based on background national and regional trends, on the project extent three years after opening.

Growth in Northamptonshire constantly exceeded growth in comparison to all areas from 2014. Traffic growth on National Highways Motorways saw the greatest decline following the COVID-19 pandemic restrictions when compared to all other areas.

How did traffic volumes change?

Traffic volumes were analysed through the project area by comparing the average weekday traffic (AWT) data. The data was compared before (March 2014) and three years after (November 2021) project implementation and the changes in traffic volumes are shown in Figure 3.

Figure 3 Average Weekday Traffic Volumes - M1 J19-J16 (24hr AWT)



Source: National Highways (WebTRIS). Before March 2014, 3YA November 2021

Figure 3 shows that since the smart motorway opened, there was a reduction in traffic volumes between junctions 16 and 19 in both directions. The most notable reduction in traffic was seen southbound between Junctions 17 to 18, with a reduction of 19% three years after the smart motorway opening.

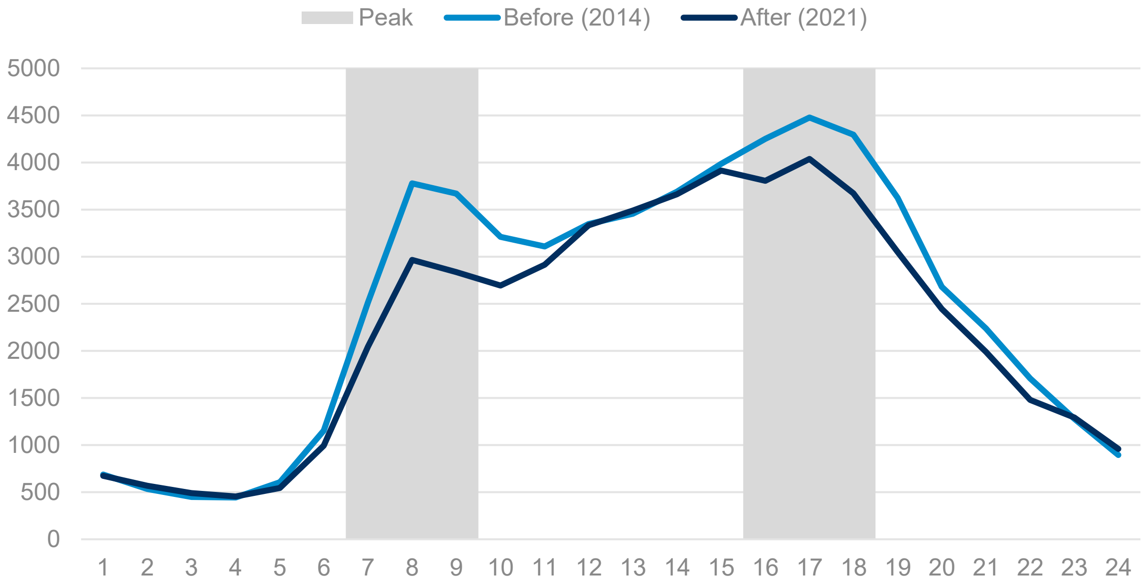
Analysis of hourly weekday traffic volumes (Figure 4 and Figure 5) also demonstrated that there was a lower traffic volume observed during the peak periods three years after opening.

Prior to construction of the smart motorway, the traffic flows followed a typical profile with peaks in both directions between 7-10am (AM Peak) and 4-6pm (PM Peak), and with lower traffic volumes in the inter-peak (10am-4pm) and overnight. In the northbound direction the PM peak was higher than the AM peak. In the southbound direction, the AM and PM peaks were of a similar magnitude.

In both directions, the largest variances in traffic volumes between before and three years after opening were evident in the peak periods. In both directions, the 2021 AM and PM peak hours were lower than 2014 levels, though the interpeak and overnight flow levels are similar. In the southbound direction, there is no distinct PM peak hour, with flow volumes in the PM period similar to those in the inter-peak period.

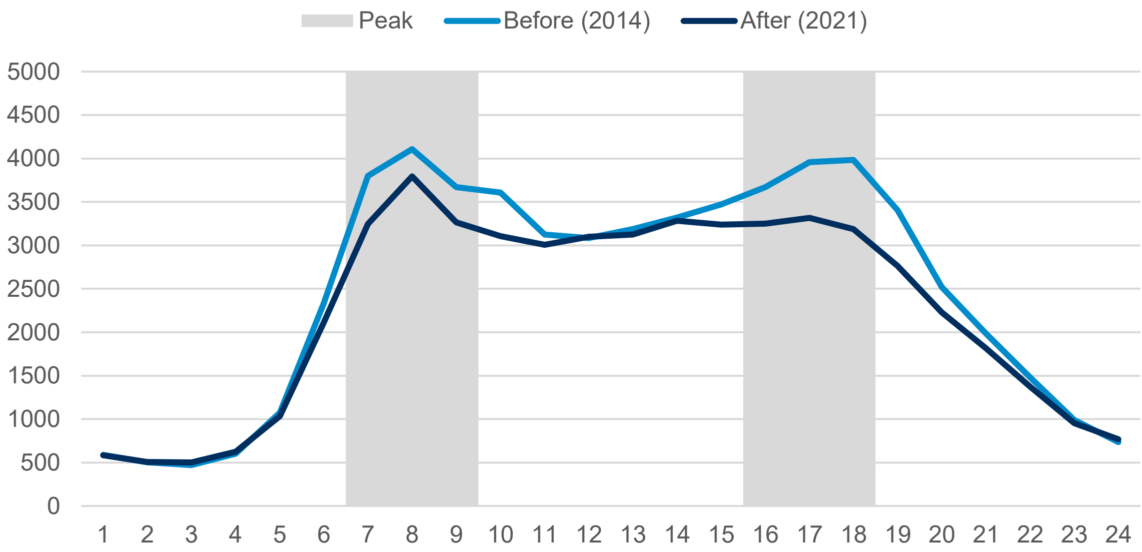
The general trend of traffic volumes along the project being lower than before is consistent with the findings presented in Figure 3 and the national and regional traffic growth presented in Figure 2.

Figure 4 Hourly Weekday Flow Profile (Northbound) M1 J19-J16 - Distance Weighted AWT)



Source: National Highways (WebTRIS). Before March 2014, 3YA November 2021

Figure 5 Hourly Weekday Flow Profile (Southbound) - M1 J19-J16 - Distance Weighted AWT)



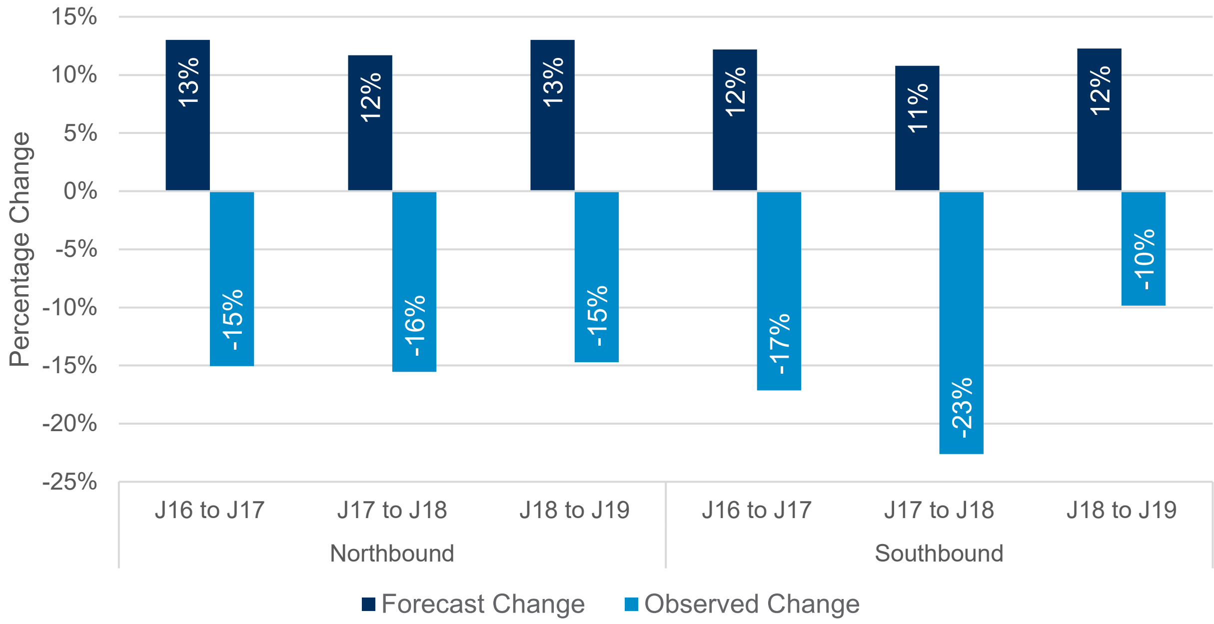
Source: National Highways (WebTRIS). Before March 2014, 3YA November 2021

Was traffic growth as expected?

Traffic growth forecasts were developed to support the business case for the project. The forecast changes in traffic volumes are shown in Figure 6. This compares the forecasts for 2014 without smart motorway and 2021 with smart motorway. The 2021 forecast was linearly interpolated from the 2017 and 2032 forecasts.

Figure 6 shows forecast and observed growth along the project extent, with forecast growth between 10-13% with the forecasts marginally higher northbound compared with southbound. The observed change in traffic volumes before (2014) and three years after (2021) the M1 junctions 19 to 16 project. Less growth was observed than forecast, with the trends showing a reduction in traffic levels. A reduction occurs between M1 junctions 16 and 19 in both directions. This impact is consistent with regional trends presented in Figure 3 and the decreases in flows are most likely due to the change in travel behaviours following the Covid-19 pandemic.

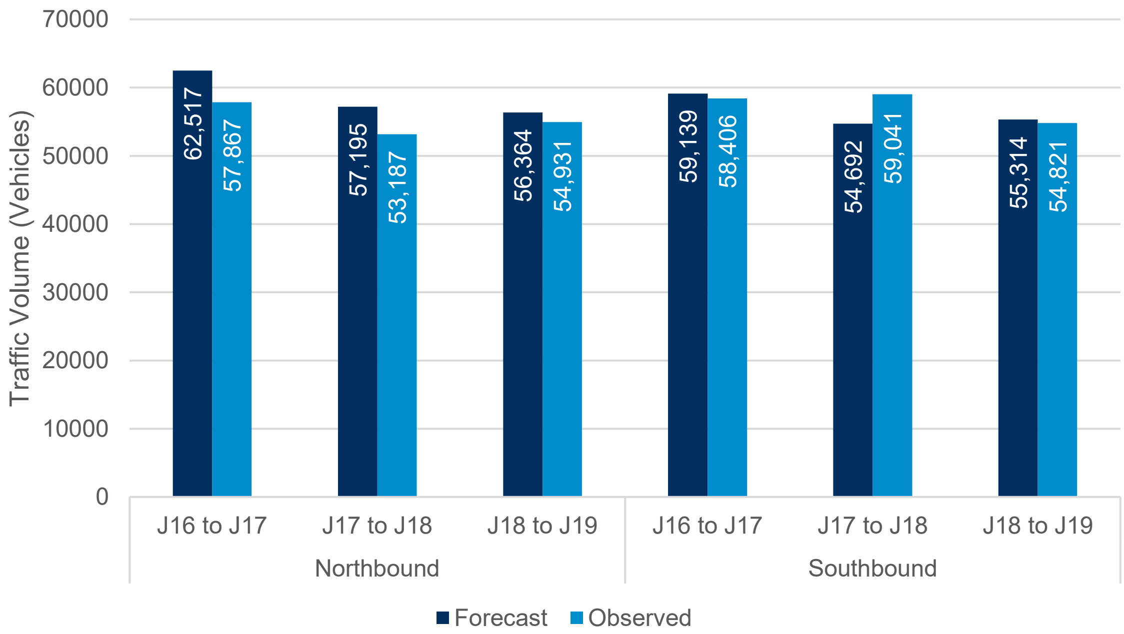
Figure 6 Forecasted vs Observed Change in Traffic Volume - AADT (2014 without project scenario vs 2021 with project scenario)



Source: National Highways (WebTRIS, Traffic and Economic Assessment Report) Before March 2014, 3YA November 2021

Figure 7 demonstrates the difference in volume between the 2014 Forecast (without the smart motorway) and 2014 observed flows. Forecast flows were higher than observed in all directions and sections with the exception of Junction 17 to 18 southbound.

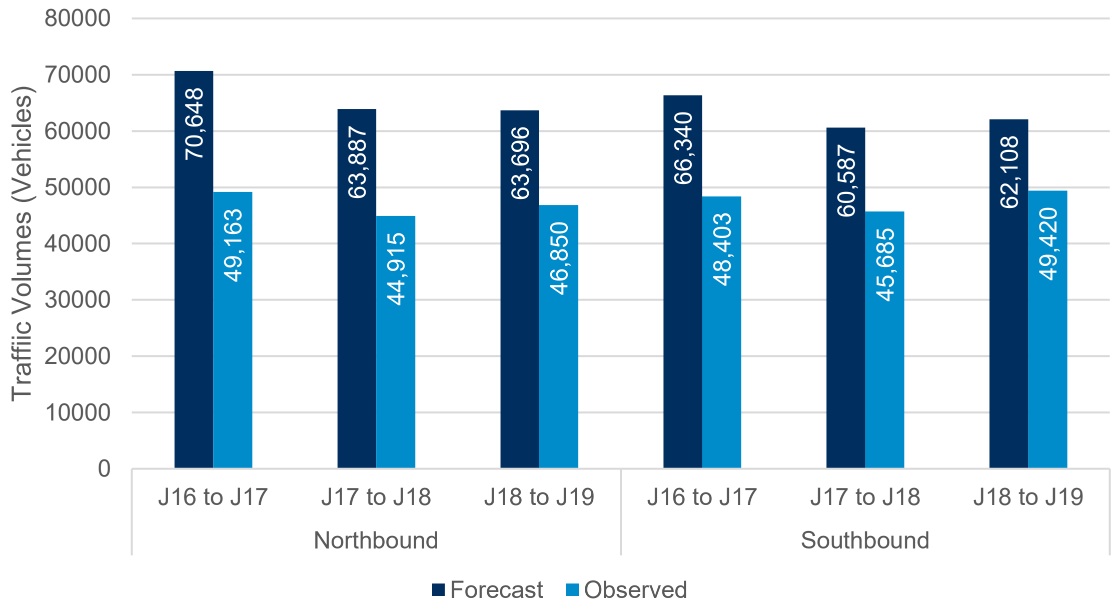
Figure 7 'Without project' Forecast vs Observed AADT Flows – 2014



Source: National Highways (WebTRIS and Traffic and Economic Assessment Report)

Figure 8 demonstrates that the 2021 observed flows are lower than the volumes expected in the 2021 forecast with the smart motorway, which is consistent with the after scenario being lower than before.

Figure 8 'With Project' Forecast vs Observed AADT Flows – 2021



Source: National Highways (WebTRIS and Traffic and Economic Assessment Report)

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.

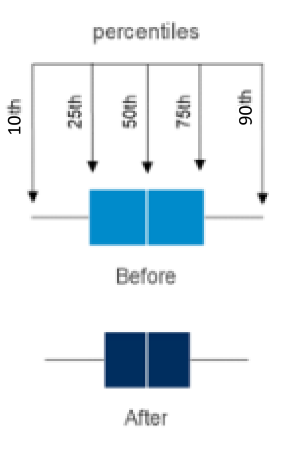
Did the project make journeys more reliable?

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. Where journeys are less variable, road users can allow a smaller window of time to travel through the stretch of smart motorway, when travelling at a similar time.

Four metrics of the distribution of journey times for the M1 junctions 16 to 19 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 9.

Figure 9 What does a box plot show?



The lowest point is the 10th percentile, this means 10% of journeys take less than this amount of time to complete. The highest point is the 90th percentile, this means 90% 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 more reliable a journey is.

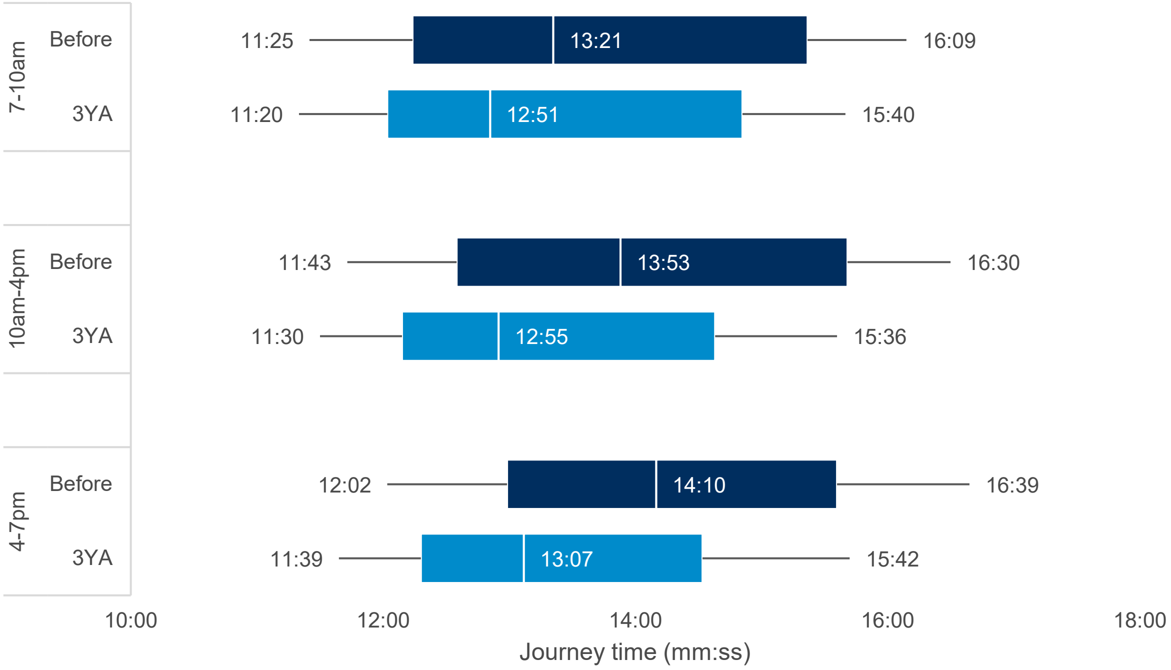
The journey time reliability is depicted by the 25th to 75th percentile boxes in Figure 10 and Figure 11, if the boxes get shorter, this indicates journeys become more reliable.

Journey time reliability has improved in all time periods and in both directions.

For northbound roads users (Figure 10), there has been an improvement in the reliability of journeys in all time periods. The average journey time improved the most during the PM peak with a 1 minute 3 second improvement three years after the smart motorway opening.

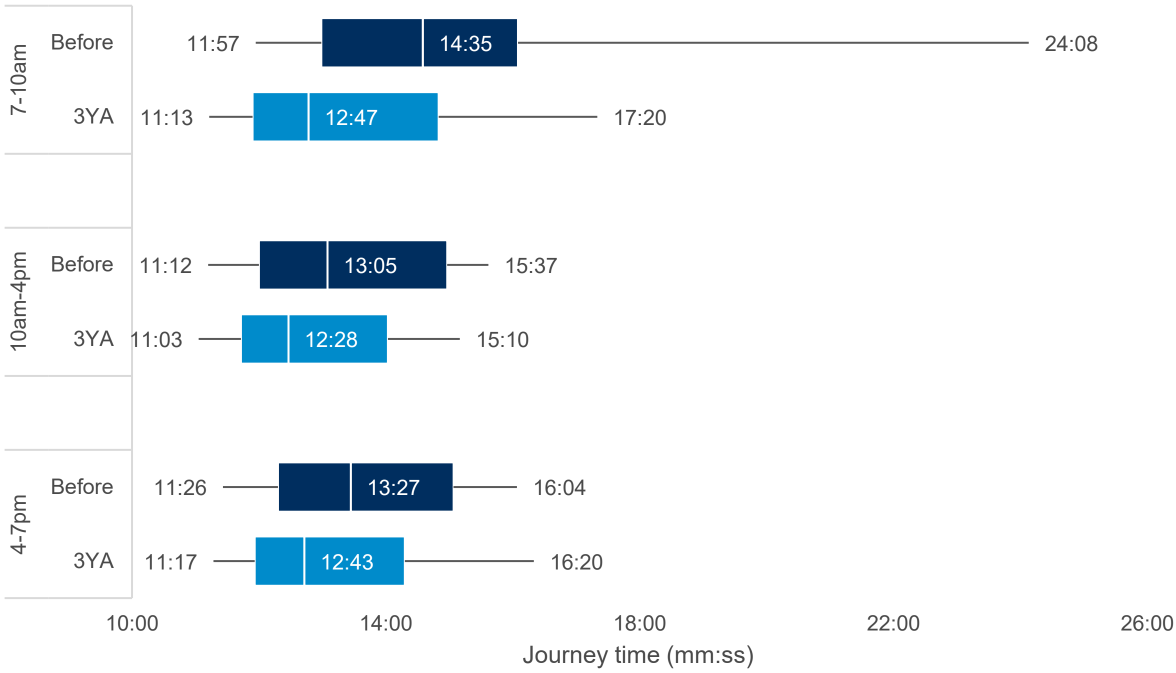
For southbound road users (Figure 11) there was also an improvement in the reliability of journeys in all time periods. The average journey time improved the most during the AM peak with a 1 minute 48 second improvement three years after the smart motorway opening.

Figure 10 Journey time reliability (northbound) (time taken to drive through the project, mm:ss)



Source: Observed journey times from TomTom satnav data. Before: March 2014, 3YA: November 2021.

Figure 11 Journey time reliability (southbound) (time taken to drive through the project, mm:ss)



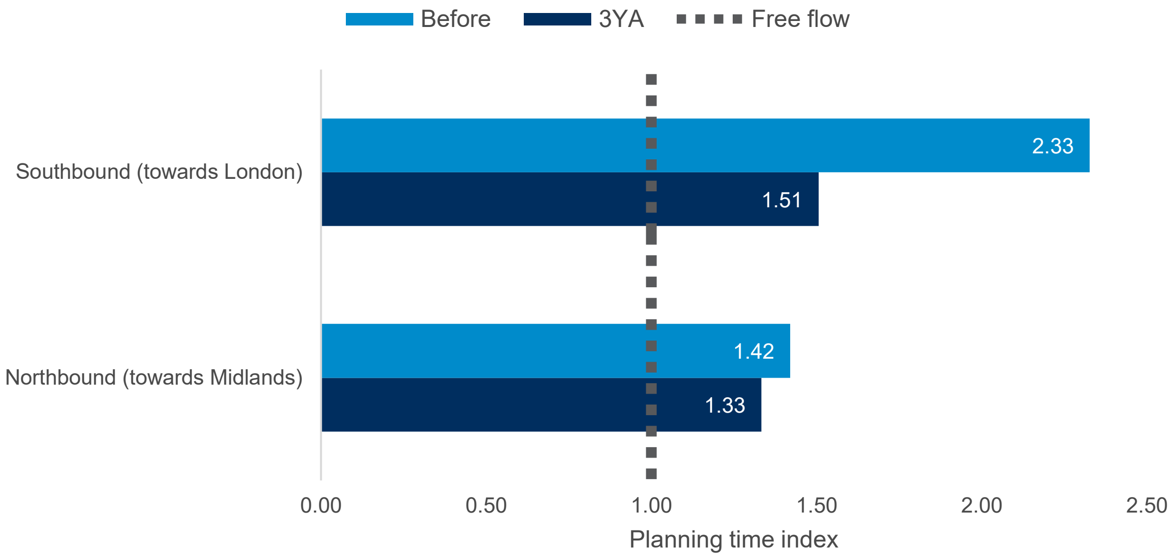
Source: Observed journey times from TomTom satnav data. Before: March 2014, 3YA: November 2021.

The longest journey times, depicted as the 90th percentile, for road users travelling northbound reduced in all time periods. The largest reduction (of 57 seconds) was observed during the PM Peak. In the southbound direction, the longest journey times increased in the PM peak by 16 seconds three years after the opening of the smart motorway compared with before construction. The AM and inter-peak longest journeys both reduced. The largest southbound reduction (of 6 minutes 48 seconds) was observed in during the AM peak.

Furthermore, in both directions and in all time periods, road users saw improved journey times for the shortest journeys as depicted by the 10th percentile (the line extending the left of the boxes).

We have also considered reliability through the Planning Time Index (PTI). The PTI is a reliability measure which represents how much time drivers must allow to ensure they arrive at their destination on time in 95% of cases. The PTI for the project is illustrated below in Figure 12, with the results showing that the 95th percentile journey would have taken 2.33 times longer before the project than the route in free flow, reducing to 1.51 three years after opening. In the northbound direction, the 95th percentile journey takes 1.42 times longer than free flow in the before, reducing to 1.33 time longer three years after.

Figure 12 Planning Time Index along the project extent



Source: Observed journey times from TomTom satnav data . Before: March 2014, 3YA: November 2021.

Three years after opening, the smart motorway has improved the journey time reliability for most road users in both directions. Across time periods, and in both directions, customers experienced an improvement in journey time reliability. The longest journeys (90th percentile) are quicker in most time periods. Average journey times along the project extent have improved in both directions during all periods of the day. However, we cannot be confident that this is a result of the project itself and not part due to the lower observed traffic volumes following Covid. Traffic levels could increase in later years, and so results at the five years after opening evaluation will be essential to check if this trend continues.

Did the project deliver journey time savings?

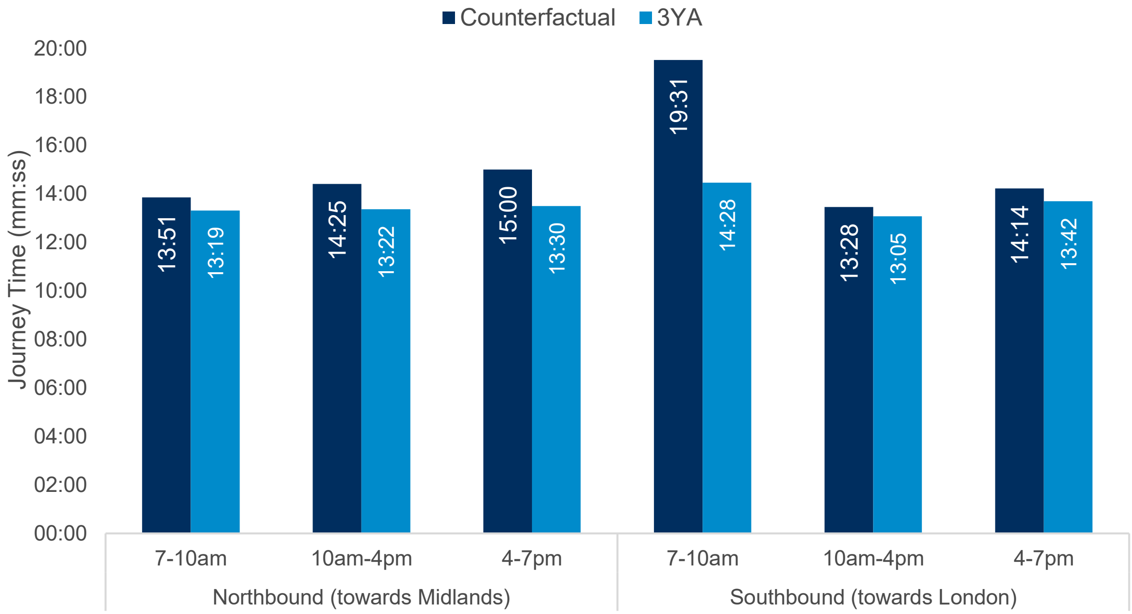
Improvements in journey times are an objective of this project and at three years after opening, results show that journey times have improved, with the smart motorway appearing to reduce delays along the route in both directions during all periods of the day as presented in Figure 13.

Figure 13 includes the counterfactual case, which demonstrates the expected journey times assuming the project was not implemented. The counterfactual is based on journey times before the project was implemented and factored using regional traffic trends. The project shows an improvement in journey times against the counterfactual case in both directions and during all periods of the day.

The evaluation observed an improvement in journey times northbound by over 30 seconds in the AM peak, and over 60 seconds in the inter-peak and PM peak. The largest improvement northbound occurred in the PM peak with a time saving of 1 minute and 14 seconds.

In the southbound direction, journey times have improved by over 5 minutes in the AM peak. The inter-peak and PM peak periods have improved by 23 seconds and 32 seconds respectively.

Figure 13 Change in average journey times comparison M1 J19 – J16



Source: Observed journey times from TomTom satnav data. Before: March 2014, 3YA: November 2021.

Were journey time savings in line with forecast?

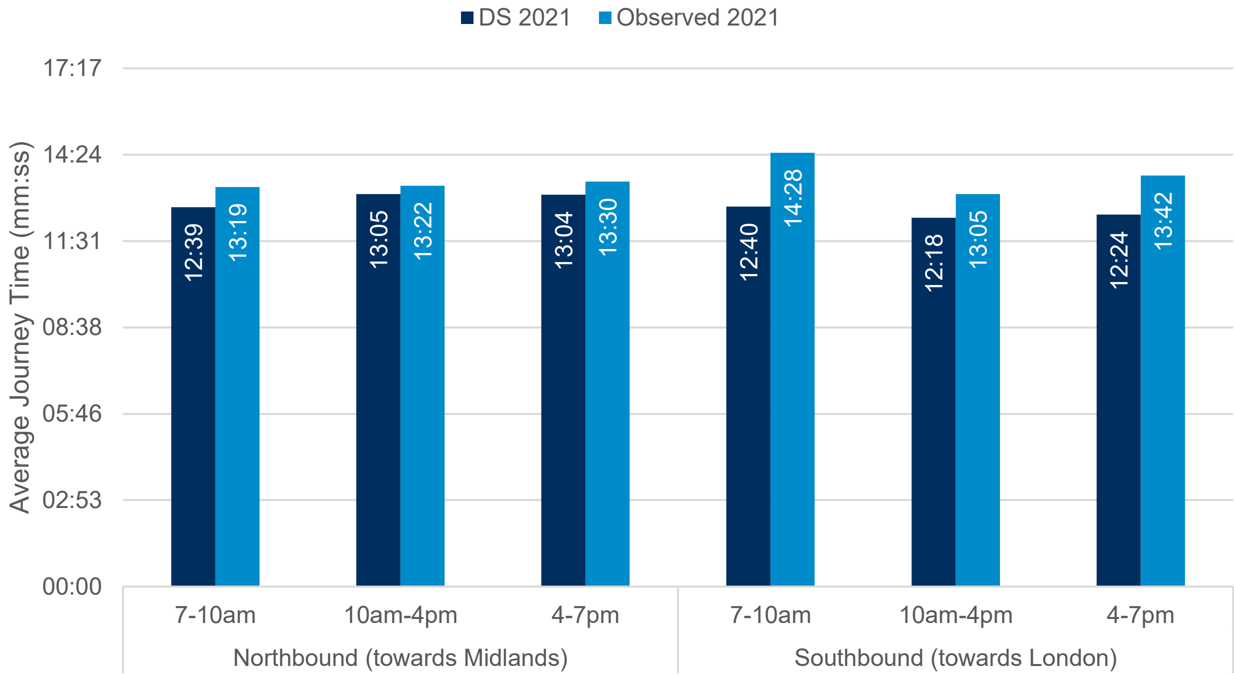
A comparison has been made between the observed journey times three years after, and the forecasted journey times[9], referenced as ‘expected’ in this section.

The expected journey times have been calculated by interpolating[10] the modelled ‘with project’ journey times, to present the same year as the observed after journey times, which for this project is 2021.

The evaluation found that the forecast journey times are quicker than observed in all time periods and in both directions. This is despite the traffic forecasts having higher AADT volumes than observed. We have noted that the forecast journey times are quicker than observed journey times in both the before and three years after comparisons. We believe this is likely to be a function of the traffic forecast model optimistically representing future year journey times.

[9] As presented in the TEAR
[10] Forecasted journey times have been interpolated using the 2017 and 2031 modelled journey time values.

Figure 14 Expected (DS 2021) Forecast versus Observed Journey Times



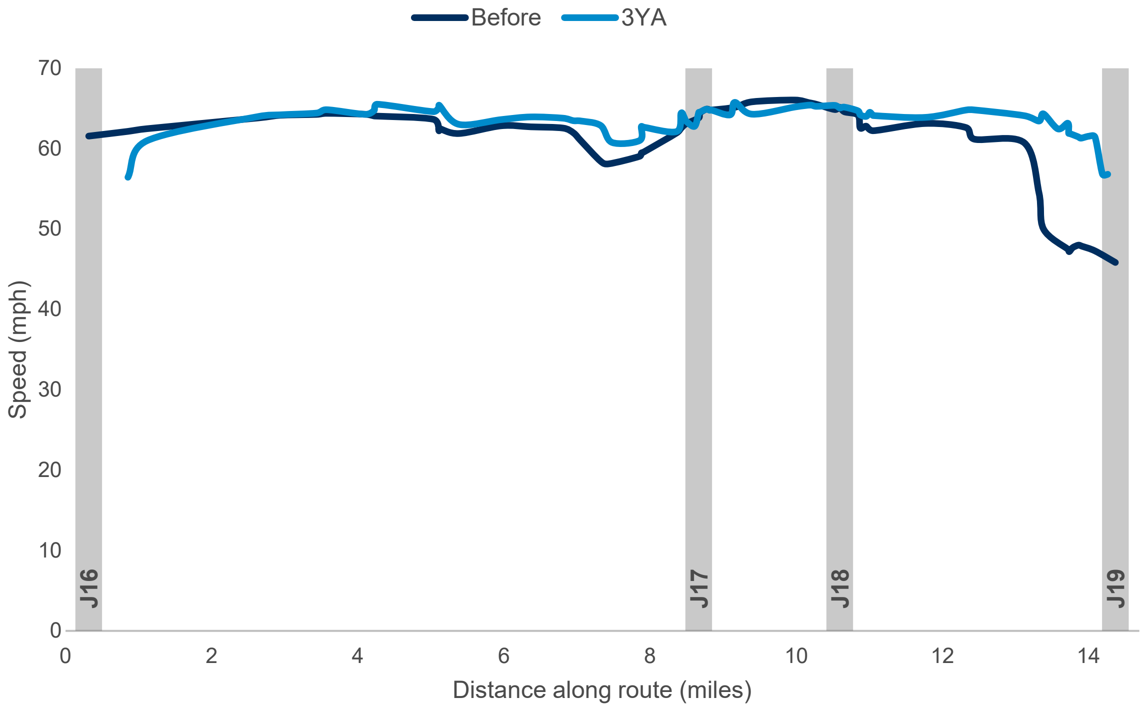
Source: Observed journey times from TomTom satnav data 3YA: November 2021.

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 has had on congestion. Smart motorways are often implemented where there is congestion, and/or an increase in traffic is expected in the coming years. Speeds are not necessarily quicker as a result of these projects. Instead, smart motorways aim 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. Figure 15 shows the average journey speeds northbound in the AM peak. The evaluation of average speed along the route was variable prior to the opening of the smart motorway, with speed reductions on the approaches to junction 17 and junction 19. The M1 junction 19 improvement project opened for traffic in 2018, which introduced grade-separated free flow links, reducing the queuing on the slip roads. This is likely to have helped improve motorway speeds approaching junction 19, as observed inFigure 15.

Average speeds across the route have increased following the implementation of the smart motorway. However, the three-year results show a reduction in speed after junction 16. This is likely due to the construction works between junctions 13 and 16 of the M1 which commenced in August 2017 (due to be completed in 2023).

Figure 15 Average speed over distance (Northbound) - AM Peak Period

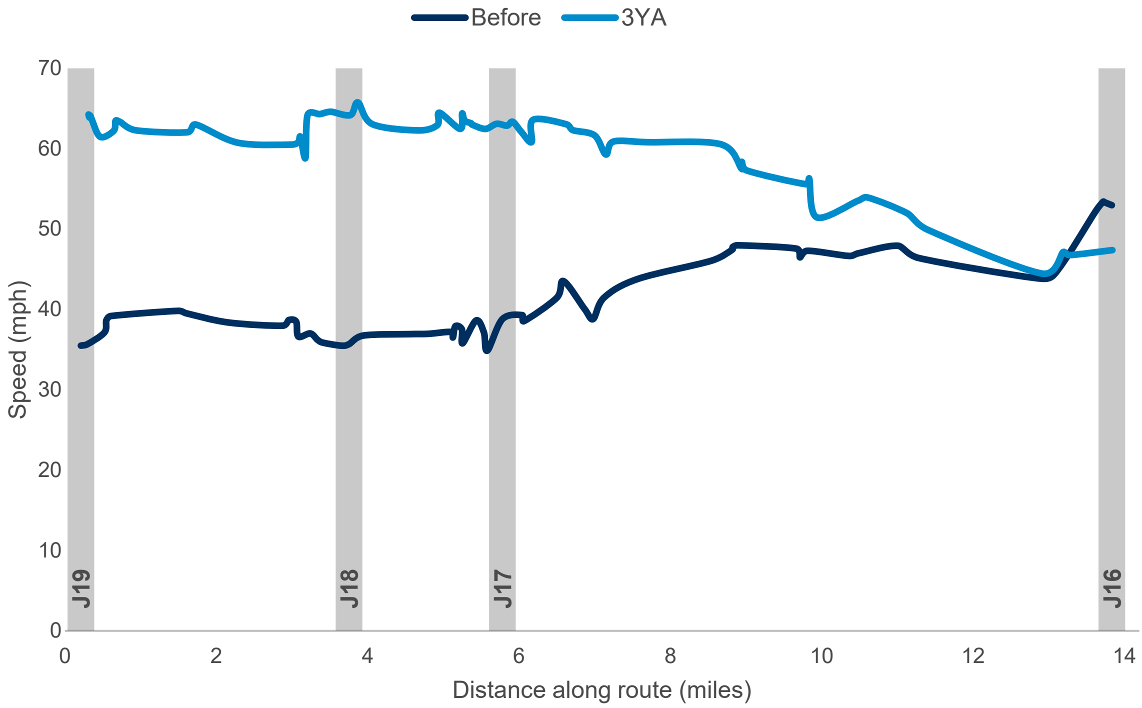


Source: Observed journey times from TomTom satnav data. Before: March 2014, 3YA: November 2021.

Figure 16 shows the average journey speeds southbound in the AM peak. In the southbound direction, average speed across the project extent was consistently lower prior to implementation of the project. In the southbound direction during the AM peak, prior to construction, reduced speed was evident on the approaches to junctions 18 and 17.

Three years after opening, speeds through the junctions improved. However, between junctions 17 and 16, the three years after results show a decline in average speeds on the approach to junction 16. This is likely to be an impact of the construction of the M1 junctions 13 to 16 smart motorway project with the reduced speeds in the southbound direction resulting from vehicles slowing to approach the construction works.

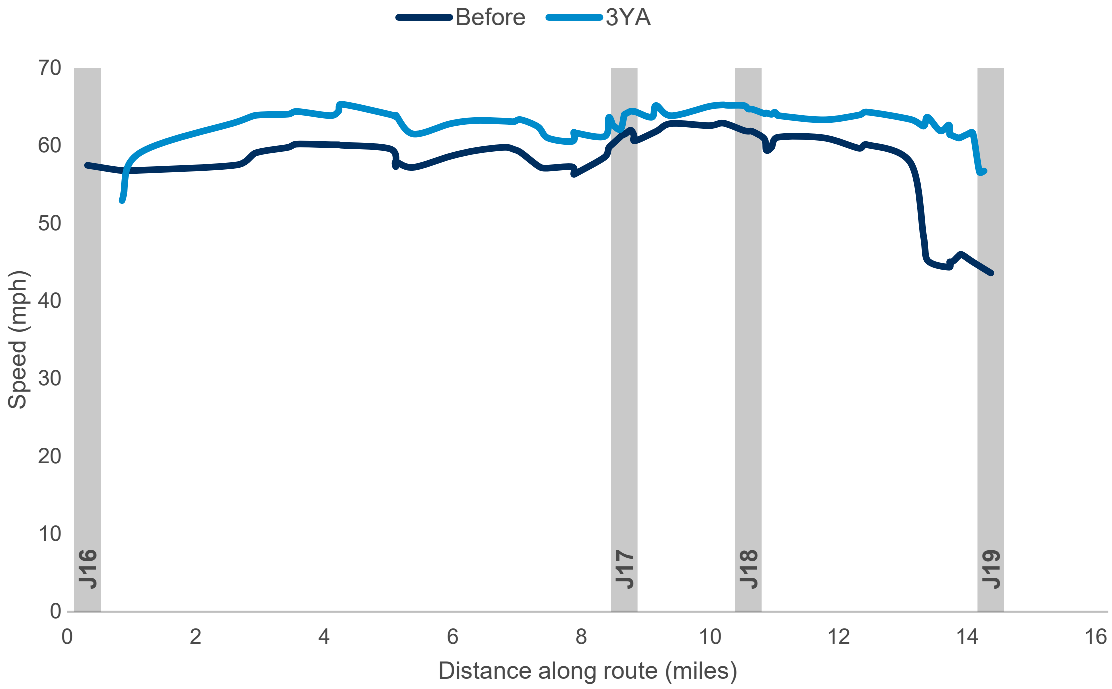
Figure 16 Average speed over distance (Southbound) - AM Peak Period



Source: Observed journey times from TomTom satnav data. Before: March 2014, 3YA: November 2021.

Figure 17 shows the average journey speeds northbound in the PM peak. Average speeds across the route have increased following the implementation of the smart motorway. However, the three years after results show a reduction in speed on the exit from junction 16. This is consistent with the findings in the AM peak period and we believe that this is also likely due to the construction taking place nearby.

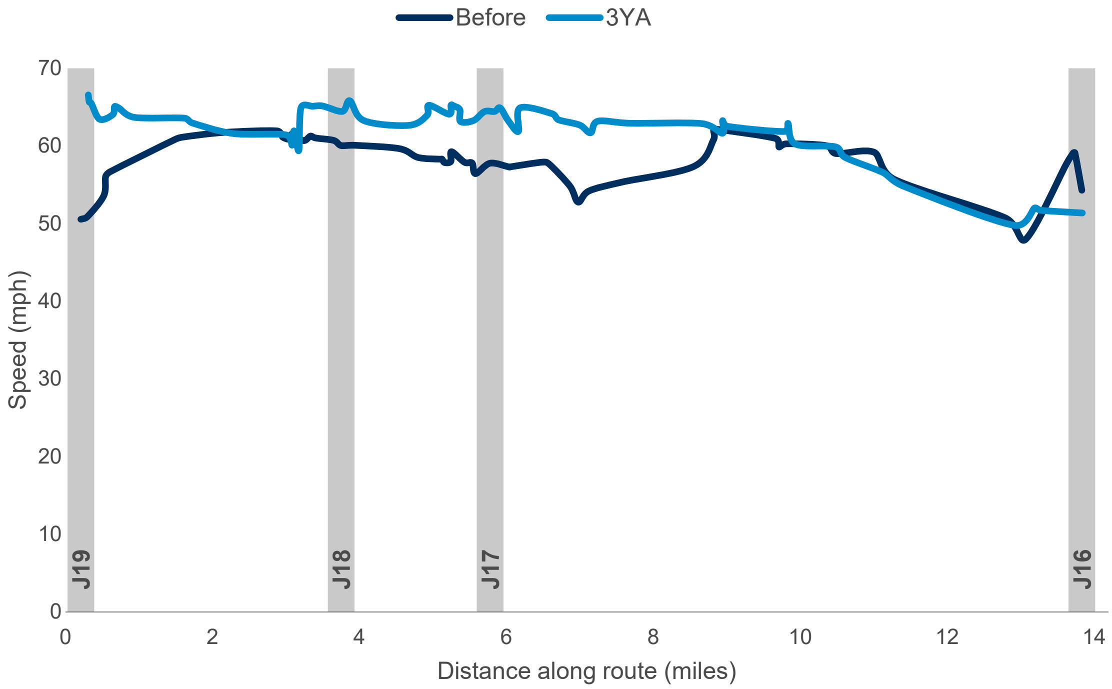
Figure 17 Average speed over distance (Northbound) - PM Peak Period



Source: Observed journey times from TomTom satnav data . Before: March 2014, 3YA: November 2021.

Figure 18 shows the average journey speeds southbound in the PM peak. Average speeds across the route have increased following the implementation of the smart motorway. However, between junctions 17 and 16, the three years after results show a decline in average speeds towards junction 16. This is a similar trend to the AM peak and is likely to be an impact of the M1 junctions 13 to 16 smart motorway project with the reduced speeds in the southbound direction resulting from vehicles slowing to approach the works.

Figure 18 Average speed over distance (Southbound) - PM Peak Period



Source: Observed journey times from TomTom satnav data . Before: March 2014, 3YA: November 2021.

The three-year analysis has shown that along the project extent, there have been improvements in journeys. Average speeds along the route have increased resulting in improvements in journey times in both directions and all time periods. However, we cannot be confident that this is a result of the project itself and not part due to the lower observed traffic volumes following Covid. Traffic levels could increase in later years, and so results at the five years after opening evaluation will be key to check if this trend continues.

5. Safety Evaluation

Summary

The project's safety objective was to achieve a safety scenario 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 collision[11] and the rate of these collisions per hundred million vehicle miles were analysed to track a change over time.

There has been a reduction in the rate and number of personal injury collisions on both the project extent and the surrounding network. This is based on comparing the first three years of the project being operational with the annual average for the five years before the project improvements[12].

During the first 3 years of the smart motorway being open there were an average of 10 personal injury collisions per year compared with an average of 29 per year before the project was constructed. The annual average reduction of 19 personal injury collisions is in line with the appraised business case for the project. If the road had not been converted to smart motorway, we estimate that the number of personal injury collisions would have been between 11 and 33.

The annual average rate of personal injury collisions per hundred million vehicle miles has also improved. The average collision rate decreased to two personal injury collisions per annual hundred million vehicle miles. This equates to travelling 50 million vehicle miles before a personal injury collision occurs. Prior to the project, there was an annual average of six personal injury collisions per annual hundred million vehicle miles. This equates to traveling 18 million vehicle miles before a personal injury collision occurs. We estimate that if the road had not been upgraded to a smart motorway, the collision rate would have been four collisions per annual hundred million vehicle miles. The reduction in collision rates suggest that safety has also improved[13].

The number of fatal collisions has not changed with a total of four before and after the project became operational.

The number of Fatal and Weighted Injuries (FWI)[14] has not changed annually. Before the project there was an annual average of 2 FWI per year. After the project became operational, this has remained at 2 FWI per year. When accounting for the change in the number of road users over this period, there is no change from 0.3 FWI per hundred million vehicle miles travelled observed.

On the surrounding network[15] there was an average decrease of 60 personal injury collisions per year (based on an annual average of 104 personal injury collisions observed after the project had opened compared with 164 before the project). If the

---

[11] A collision that involves at least one vehicle and results in an injury to at least one person

[12] We have tested the results at 95% confidence interval. The critical value at 95% confidence interval is 47, the observed collision savings for the project extent are close to this value of 47. We believe that the collisions savings observed for the project extent and wider safety area ensure that the project has met its safety objective

[13] We have tested the results at 95% confidence interval and believe the project has met its safety objective

[14] 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.

[15] 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

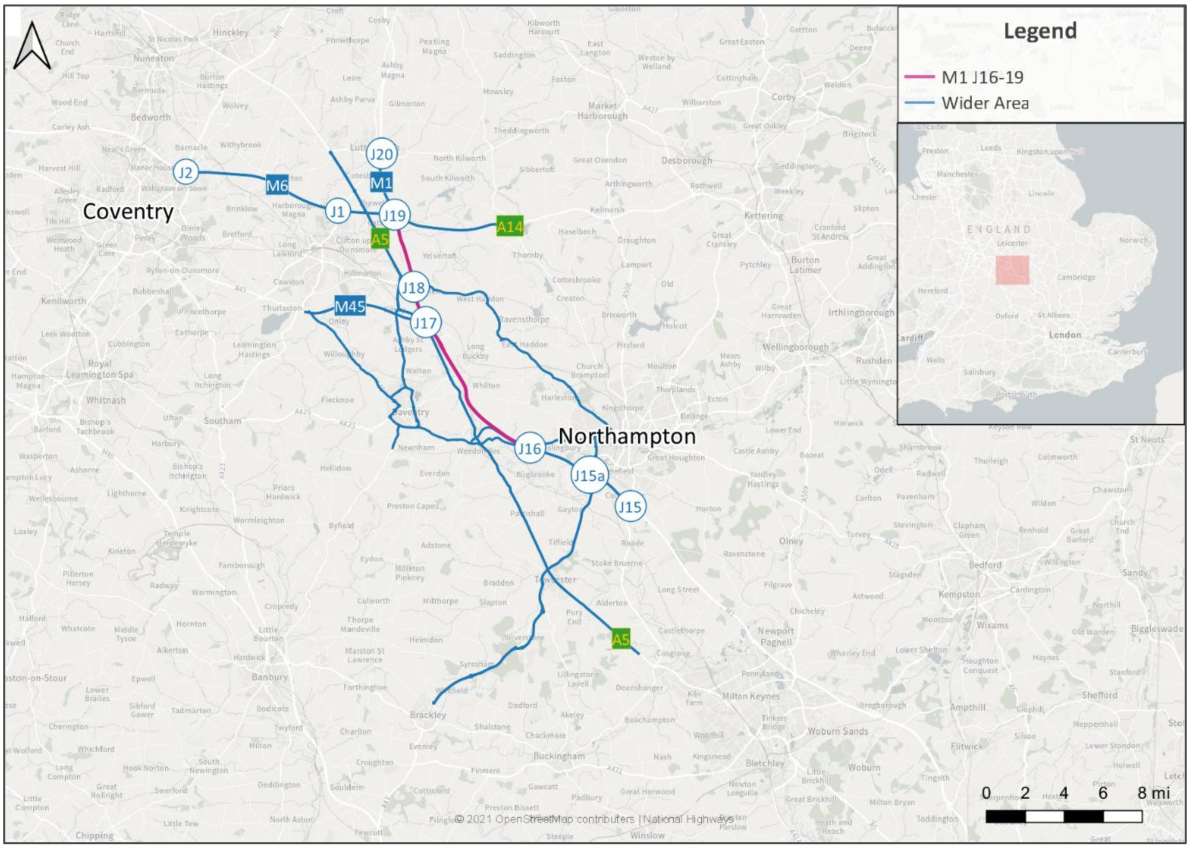
road had not been converted to a smart motorway, we estimate that the number of personal injury collisions would be between 119 to 177.

Based on this analysis the evaluation found there has been a reduction in the number, rate and severity of personal injury collisions. At this three-year evaluation the project has met its objective to reduce the number and severity of accidents[16].

Safety study area

The safety study area for the M1 junctions 19 to 16 is shown in Figure 19. These areas were assessed to check any potential wider 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 19 M1 junctions 19 to 16 safety study area



Source: National Highways and OpenStreetMap contributors

What impact did the project have on road user safety?

Safety data was obtained from the Department for Transport[17]. This data records incidents on public roads that are reported to the police. This evaluation considers only collisions that resulted in personal injury.

[16] Projects are appraised over a 60-year period. This conclusion is based on the findings at three years after the project opened for traffic.
[17] https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

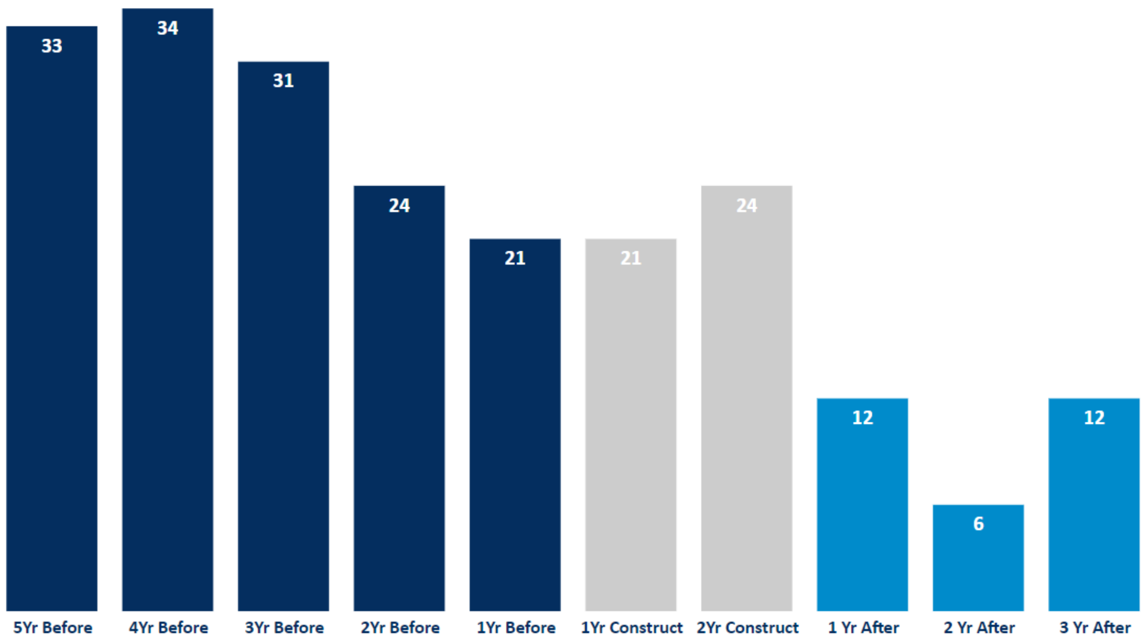
The safety analysis was undertaken to assess changes over time looking at the trends in the five years before the project was operational to provide an annual average. We have then assessed the trends three years after.

The analysis draws on the following data collection periods:

- Pre-construction: 30 November 2010 to 29 November 2015
- Construction: 30 November 2015 to 28 January 2018
- Post-opening: 29 January 2018 to 28 January 2021

The evaluation found the number of personal injury collisions within the project extent had decreased (impacts on the wider area are discussed later). Over the three years after the project was operational, there were an average of 10 personal injury collisions per year, this is 19 fewer than the annual average of 29 in the five years before construction commenced.

Figure 20 Annual personal injury collisions for M1 junction 19 to 16



Source: STATS19: 30th November 2010 to 28th January 2021

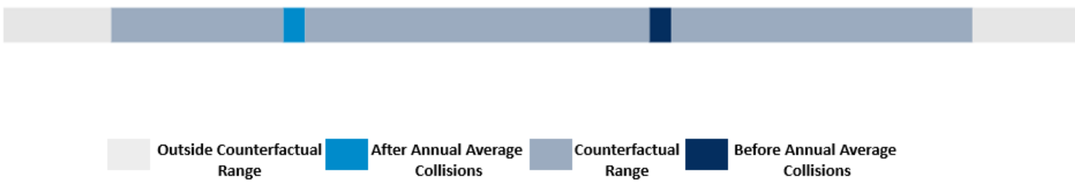
As part of the safety evaluation, we look to assess what changes in personal injury collisions might have occurred due to factors external to the project over this timeframe. To do this we estimate the trend in personal injury collisions which might have occurred if the road had remained a conventional motorway (this is referred to as a counterfactual - see Figure 21 and the POPE methodology manual[18]). This is based on changes in regional safety trends for conventional motorways with a high volume of roads users.

[18] https://nationalhighways.co.uk/media/exypgk11/pope-methodology-note-2024-v2.pdf

Figure 21 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 is developing new statistical methods to compare collision and casualty rates. We anticipate adopting these once the methods are finalised.

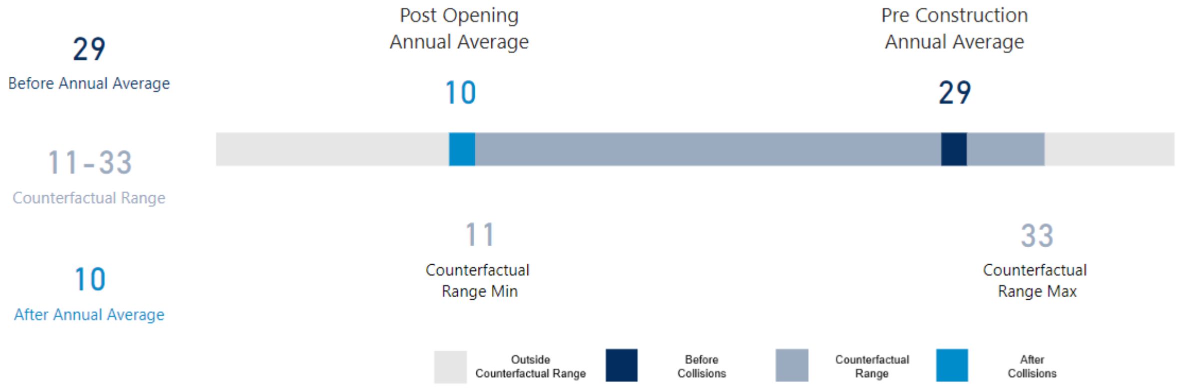


Based on this counterfactual test we estimate that if the road had not been widened, the trend in the number of personal injury collisions would likely have increased, and collision rates would remain stable.

A range of between 11 and 33 personal injury collisions during the three-year post project period would be expected. An annual average of 10 personal injury collisions were observed over the three-year post-opening period, this falls below the expected range, as shown in Figure 22, therefore this may be evidence to suggest that safety has improved[19], however we cannot be fully confident the Scheme is responsible for these results.

[19] We have tested the results at 95% confidence interval. The critical value at 95% confidence interval is 11, the observed collision savings for the project extent are close to this value of 11. We believe that the collisions savings observed for the project extent and wider safety area ensure that the project has met its safety objective

Figure 22 M1 junction 19 to 16 Observed and expected range of personal injury collisions (annual average)



Source: STATS19: 30th November 2010 to 28th January 2021

How has traffic flow impacted collision rates?

It is important to contextualise the number of incidents in the volume of traffic via a collision rate, the number of collisions per hundred million vehicle miles (hmvm).

The average collision rate after construction is two personal injury collisions per hmvm. This equates to travelling 50 million vehicle miles before seeing an accident.

Before the project the collision rate was six personal injury collisions per hundred million vehicle miles, this equates to traveling 18 million vehicle miles before seeing an accident.

A counterfactual test was undertaken. It found that the collision rate would likely have been four collisions per hmvm in the counterfactual scenario. The reduction in collision rates suggests that safety has improved[20].

What changes in the severity of collisions did we see?

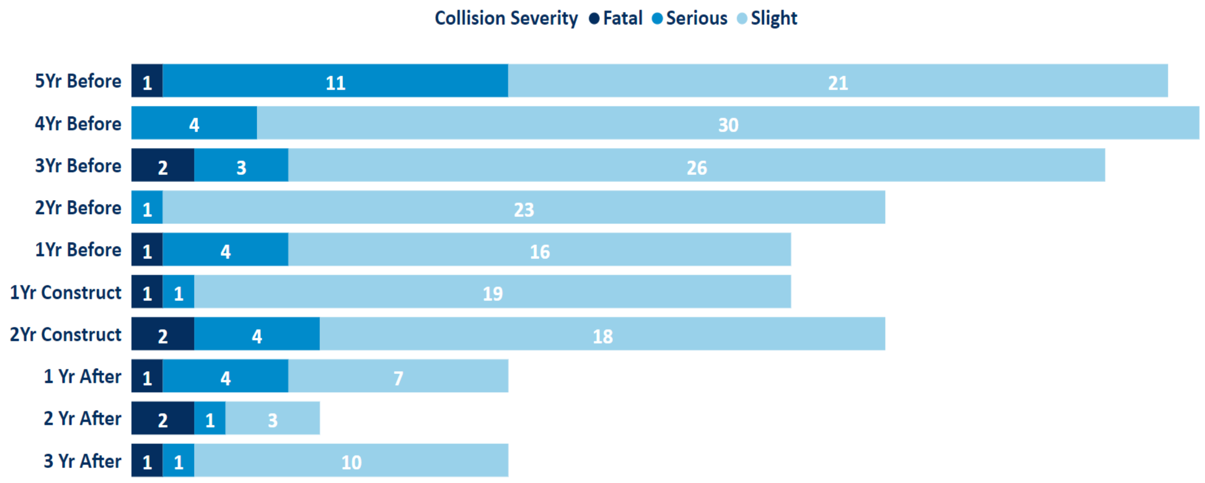
Collisions that result in injury are recorded by severity as either fatal, serious, or slight. The way the police record the severity of road safety collisions changed within the timeframes of the evaluation, following the introduction of a standardised reporting tool – Collision Recording and Sharing. This is an injury-based reporting system, whereby the severity of an incident is categorised automatically by the most severe injury. This has led to some disparity when comparing trends with the previous reporting method, where severity was categorised by the attending police officer[21]. As a consequence, the Department for Transport have developed a severity adjustment methodology[22] to enable robust comparisons to be made, (more information on this can be found in Appendix A.1).

[20] We have tested the results at 95% confidence interval and believe the project has met its safety objective
[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820588/severity-reporting-methodology-final-report.odt
[22] https://www.gov.uk/government/publications/guide-to-severity-adjustments-for-reported-road-casualty-statistics/guide-to-severity-adjustments-for-reported-road-casualties-great-britain#guidance-on-severity-adjustment-use

Figure 23 shows the severity of personal injury collisions on the M1 junction 19 to 16. After the project was constructed we have observed no change in collisions resulting in fatalities (the total before the project was four, compared to four after).

There was an average of three fewer collisions resulting in serious injuries per year (the annual average before the project was five, compared to two after). There was an average of 16 fewer collisions resulting in slight injuries per year (the annual average before the project was 23, compared to seven after).

Figure 23 Personal injury collisions by severity for M1 junctions 19 to 16



Source: STATS19: 30th November 2010 to 28th January 2021

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[23]. 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 no change in the FWI observed annually. Before the project an annual average of two FWI were observed. After the project this had remained at an annual average of two FWI.

The combined measure shows no change from 296 million vehicle miles travelled before a fatality[24]. The rate of FWI per hmvm has not changed.

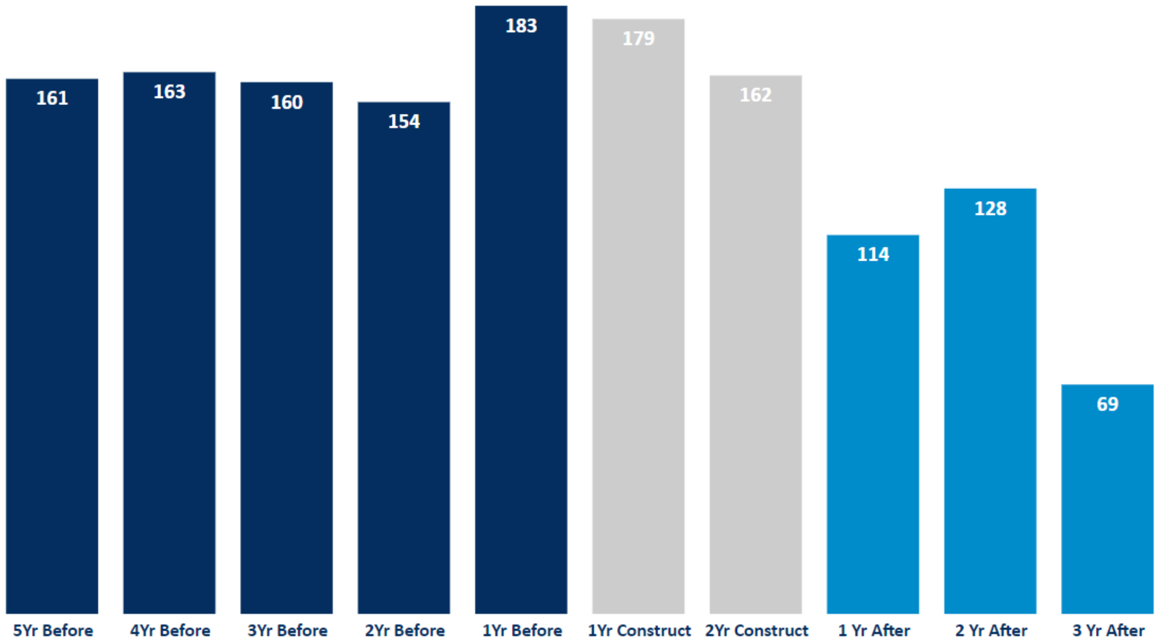
What changes in safety numbers did we see in the wider area?

Personal injury collisions were observed for a wider impact area, the extent of which is covered in Figure 1 (M1 junctions 19 to 16), to observe any potential wider impacts from the intervention. Three years of data after the smart motorway opened is available for the wider study area.

Figure 24 shows that before the project, an annual average of 164 collisions were observed within the wider area for the M1 junctions 19 to 16. After the project, the observed annual collisions had fallen to 104, a reduction of 60.

[24] Before the scheme, 296 million vehicle miles needed to be travelled before a fatality equivalent (0.3 FWI per hmvm). After the scheme this has remained at 296 million vehicle miles (0.3 FWI per hmvm).

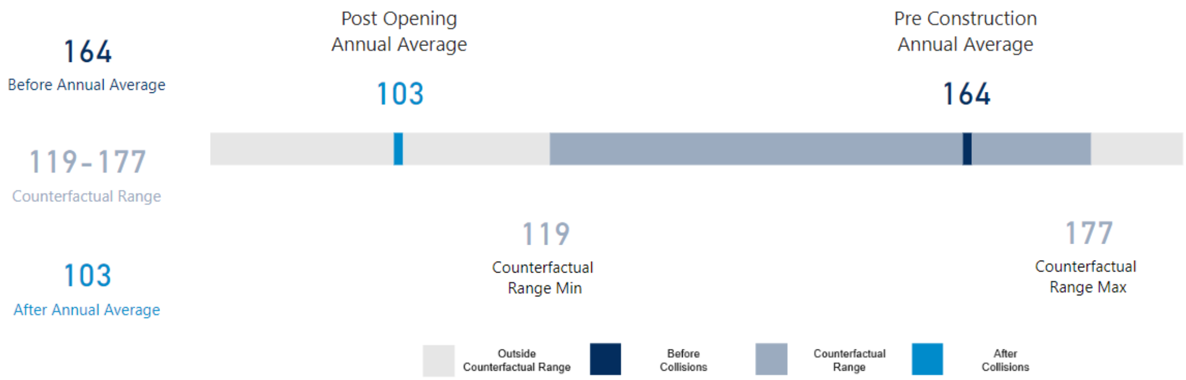
Figure 24 Annual personal injury collisions in wider area for M1 junctions 19 to 16



Source: STATS19: 30th November 2010 to 28th January 2021

If the motorway had remained a three-lane carriageway, the counterfactual estimated the number of personal injury collisions would have been between 119 and 177 (Figure 25). The observed annual average of 103 personal injury collisions falls below this range. Therefore, this may be evidence to suggest that safety has improved.

Figure 25 Observed and expected range of personal injury collisions in wider area for the M1 junctions 19 to 16 (annual average)



Source: STATS19: 30th November 2010 to 28th January 2021

What impact did traffic flows have on collision rates in the wider area?

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

Prior to the project, there was an annual average of 17 personal injury collisions per hmvm. After the improvements were made, there was a decrease to 11 personal injury collisions per hmvm. A decrease of six personal injury collisions per hmvm.

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

A counterfactual test was undertaken. It found that the collision rate would likely have been 15 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.

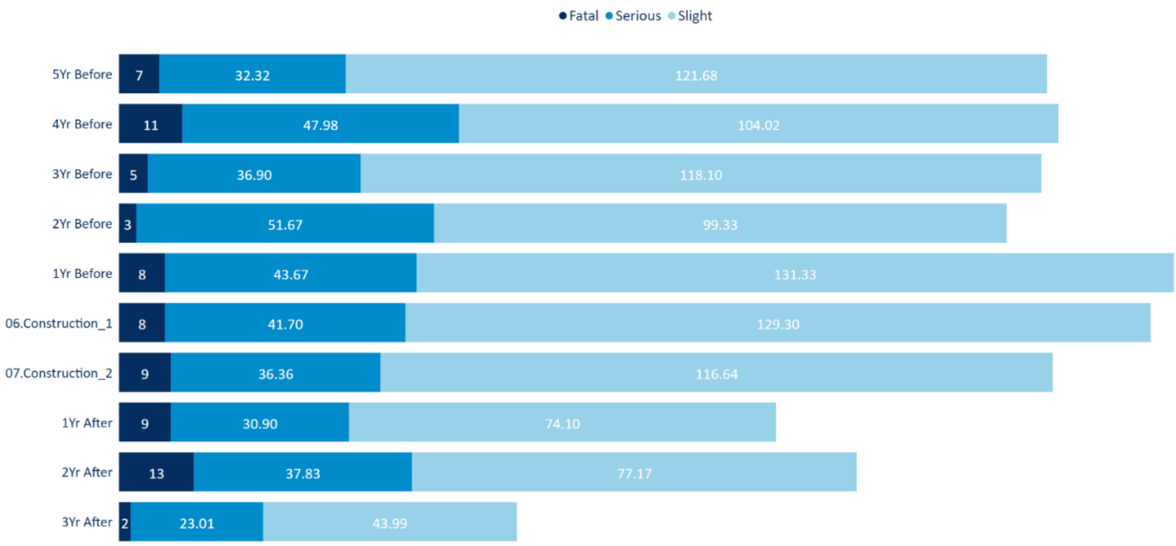
What changes did we see in the severity of collisions in the wider area?

As mentioned above and in Appendix A.1, the way the police record the severity of road safety collisions changed within the timeframes of the evaluation.

For this evaluation, one reporting mechanism was largely used prior to the smart motorway conversion and another afterwards. The pre-conversion collision severity has been adjusted, using the Department for Transport's severity adjustment factors, to enable comparability with the post-conversion safety trends.[25].

After the project was constructed, we have observed a decrease in collisions resulting in fatalities (the total before the project was 34, compared to 24 after). There was an average of 12 fewer collisions resulting in serious injuries per year (the annual average before the project was 43, compared to 31 after). There was an average of 44 fewer collisions resulting in slight injuries per year (the annual average before the project was 109, compared to 65 after). Figure 26 shows the severity of personal injury collisions.

Figure 26 Personal Injury Collisions by Severity in wider area for M1 junction 19-16



Source: STATS19: 30th November 2010 to 28th January 2021

[25] Collision Severities within this report use the 2020 adjustment factor

To understand the impact of collisions within the wider area, FWI was used. A decrease of one FWI has been observed. Before the project the average 14 FWI were observed. After the project this had decreased to 13.

The combined measure showed an increase of 1 million vehicle miles was travelled before an FWI. Before the project, 69 million vehicle miles needed to be travelled before an FWI (1.4 FWI per hmvm). After the project this increased to 70 million vehicle miles (1.4 FWI per hmvm).

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” collision numbers (per annum) are no greater than those in the “before” and the severity ratio has not increased.

The evaluation found personal injury collisions and rates have both decreased. This element of the safety objective has been met[26]. The severity of PICs is unchanged. Therefore, at this three-year evaluation the project has met its objective.

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

6. Environmental evaluation

The environmental impacts of projects are assessed during the development of projects and consider the environmental sub-objectives within Transport Analysis Guidance (TAG)[27]. he evaluation of environmental impacts compares the predicted impact from appraisal to observed impacts. 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 compares them with findings obtained three-years after the projects opened for traffic. The scope of this evaluation covers noise, air quality and greenhouse gases. The remainder of environmental topics will be evaluated at five years after opening. Impacts have been determined using observed traffic data. At this stage we cannot be confident that the three-year after evaluation findings are a result of the project itself and not part due to the lower observed traffic volumes following Covid. To avoid Covid impacts, timeframes for the five years after opening data collection and analysis have been delayed until seven years after opening.

Noise

The environmental assessment predicted that for the opening year there would be negligible noise increases and minor noise decreases predicted. For the design year, it was predicted that there would be negligible noise increases and decreases. No minor, moderate or major effects were predicted at any of the receptors within the study area. The relevant thresholds were predicted to be exceeded at three receptors in 2032. The environmental assessment predicted that 245 receptors would be exposed to night-time noise of above 55dB in 2032 with and without the project.

The environmental assessment assumed that the project provided for all carriageway running lanes, including the hard shoulders, to be surfaced with low noise surfacing which would be applied at the end of the construction phase. Low noise surfacing was lain on lanes 2 and 3 throughout the project.

In comparison with observed data, the forecasts predicted higher speeds and flow counts but a lower percentage of HGVs. The three-year analysis has shown that five of the six links fell within the expected range of plus or minus 1dB. M1 junction 18 to junction 19 southbound performed worse than expected with a 1.7dB increase from the forecast. This can be considered a ‘minor adverse’ effect.

Based on the available information, it was likely that the effects of the project on the noise climate along the M1 were as expected.

Air Quality

The environmental assessment predicted the project would cause a deterioration in local air quality and an increase in regional emissions as a result of forecast

[27] Transport Analysis Guidance (TAG) provides Department for Transport guidance on transport modelling and appraisal.

increases in flow and speed on the affected road network (principally M1 Junction 16 to Junction 17).

The environmental assessment anticipated that the project would not result in any new exceedances of EU limit values[28] or worsening of existing exceedances and therefore, mitigation for local air quality impacts was not required. Changes were anticipated to be below the UK Air Quality Strategy (AQS) objective and European Union (EU) limit value threshold, and it was anticipated the impact of the project on annual mean Nitrogen Dioxide[29] (NO_2)concentration would not be significant.

Overall, the evaluation has not determined whether the emissions are likely to be higher or lower than expected. This is due to the lower than forecast levels of observed traffic and the higher than forecast percentage of observed traffic that is made up of Heavy Duty Vehicles (HDV). Based on a comparison of available observed data to forecast data, it is not anticipated that the differences between the observed and forecast traffic would lead to a change in the overall evaluation of significance for air quality for the project.

Greenhouse gas emissions

The TAG appraisal predicted that the project was expected to cause an overall increase in carbon over a 60-year appraisal period. The non-traded carbon dioxide emissions in 2017 were 400 tonnes of carbon dioxide equivalent indicating an increase in carbon emissions in the Project's opening year. The change in emissions over the period from 2018 to 2022 was predicted to be 2400 tonnes and the change in emissions over the period from 2023 to 2027 was predicted to be 3200 tonnes.

Overall, based on a comparison of available observed data to forecast data, the observed data resulted in higher calculated greenhouse gas emissions than the forecast data. The evaluation demonstrated higher emissions with the observed data compared to the forecast data, mainly due to an increase in the proportion of HDVs that would be travelling through the project. The project has led to a small increase in carbon emissions than was predicted in the TAG appraisal for the subset of road links assessed.

Both approaches demonstrate higher emissions with the observed data compared to the forecast data. The total change in emissions caused by the project cannot be evaluated with confidence from the limited data. However, the evaluation suggests that the project may have led to a slightly larger increase in carbon emissions than was predicted in the AST for the subset of road links evaluated.

Overview

The results of the evaluation are summarised against each of the Transport Appraisal Guidance environmental sub-objectives and presented in Table 2. In the table we report the evaluation 'as expected' if we believe that the observed impacts

[28] Limit values are legally binding parameters that must not be exceeded. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year, if any and a date by which it must be achieved. [UK Air Quality Limits - Defra, UK]

[29] Nitrogen dioxide (NO_2 is a gas that is mainly produced during the combustion of fossil fuels, along with nitric oxide (NO). Short term exposure to concentrations of NO_2 can cause inflammation of the airways and increase susceptibility to respiratory infections and to allergens. [Nitrogen dioxide (NO2) - GOV.UK (www.gov.uk)]

at three years after are as predicted in the appraisal. We report them as better or worse than expected if we feel the observed impacts are better or worse than expected. Finally, we report impacts as too soon to say if we feel that at three years after there is insufficient evidence to draw firm conclusions.

Table 2: Summary of environmental findings

Environmental Sub-Objective	Appraisal Summary Table Score	Three Years After Evaluation Outcome	3YA Three Years After Evaluation Summary
Noise	Estimated number of people annoyed without the Scheme in 2032 = 440 Estimated number of people annoyed with the Scheme in 2032 = 443 Net increase of 4 people annoyed in the long term with the Scheme.	As expected	Forecast data predicted higher speeds and flow counts but a lower percentage of HGVs. The evaluation shows that the effects of the project were likely to be as expect.
Air Quality	PM_{10}: +0.4 µg/m^3 NO_2: +10.9 µg/m^3	As expected	Forecast data predicted higher traffic levels and lower percentage of HDV. The comparison of available traffic data has shown that local air quality would be broadly as expected, however further study would be required to understand observed concentrations.
Greenhouse Gases	NPV -£14.4 m Change in non-traded carbon over 60y: 334,000 (tCO2e)Change in traded carbon over 60y: 400 (tCO_2e)	Worse than expected	Greenhouse gases were not assessed as part of the EAR. The AST predicted that there would be an overall increase in carbon emissions. The evaluation suggests found that the project may have led to a slightly larger increase in carbon emissions than was predicted in the AST forecast for the subset of road links evaluated.

Appendix A

A.1 Incident reporting methodology

Police forces choose how they collect STATS19 data. Some police forces do this electronically, for example using mobile devices, while others complete paper forms which are later digitised. In addition, some collisions are reported by members of the public after the event. Since 2016, new data collection systems (called CRaSH and COPA) have been introduced by some police forces.

Before these new systems, reporting police officers categorised the severity of non-killed casualties as either serious or slight according to their own judgment of the injuries sustained. This was based on information available within a short time of the collision, and often did not reflect the results of medical examination. This sometimes led to casualties being incorrectly classified as slight injuries when they were serious, or vice versa.

In November 2015 Warwickshire police constabulary transferred from Stats19 to CRaSH (Collision Recording and Sharing) system for reporting personal injury collisions. In CRaSH reporting, police officers record the types of injuries suffered by the casualty rather than the severity. In previous systems the determination of severity was at the discretion of the reporting police officer. CRaSH automatically converted the injury type to a severity classification. This led to implications for reporting on collision severity as there had been an increase in the number of serious collisions recorded.

These changes make it difficult to monitor trends in the number of KSI casualties over time or between different police forces. To help with this, the Office for National Statistics (ONS) has undertaken research to identify methods of estimating and adjusting for the increased recording of serious injuries in the new systems. Based on this work, DfT have published an adjusted time series of KSIs at the national level and statistical adjustments at the record level. These adjustments are based on estimates of how casualty severities may have been recorded had injury-based severity reporting systems always been used.

The adjustments will be reviewed by the ONS and DfT as more data becomes available, and it is possible that further refinements will be made to the adjustment methodology in the future. Currently it is not possible to reliably adjust collision severity information at the granular level required for this project.

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