POPE Methodology Manual

Post-opening project evaluation for major projects

March 2024

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1. Introduction

This document provides an overview of the current methodologies, processes, and technical assumptions that we employ in the post-opening project evaluations (POPE) of our major improvement projects. We will review it as required to incorporate process improvements, new data sources, and appraisal changes to ensure it remains an up-to-date and useful document.

Our approach to evaluation is proportionate. The method applied depends on individual project circumstances, such as the scale and complexity of the project, the opportunities for learning from evaluation findings, and the value of the investment being reviewed. We are not attempting to replicate the appraisal which informed the business case, but to give an indication of the likely outturn impacts of the investment and whether or not they are in line with our forecasts. The methods outlined in this document have limitations but are felt to be proportionate. It is important to recognise that all evaluation activities will be influenced by the nature and availability of data.

1.1. What is evaluation?

In broad terms, evaluation is the systematic assessment of the design, implementation, and/or outcomes of an intervention. It involves understanding how an intervention is being, or has been, implemented and what effects it has, for whom and why. It identifies what can be improved and seeks to estimate the overall impacts and cost-effectiveness of an intervention. POPE is a specific methodology which has been developed to consistently monitor and evaluate the outcomes and benefits of our road projects.

1.2. Why do we undertake POPE?

At each key decision stage throughout the planning process, our projects are subject to rigorous appraisal[1] to provide justification for their continued development. All the expected impacts of the project, both positive and negative, are recorded in a Benefits Register.[2] They are also summarised in an Appraisal Summary Table (AST)[3] which is presented in the project's business case to allow judgements to be made about the overall value for money of the proposed investment.

We undertake POPE to compare the expected impacts of a project with the observed (outturn) impacts after construction has been completed and the project is open to road users. POPE goes beyond monitoring progress against targets. It also provides us with opportunities to explore which aspects of a project, and the tools used in its appraisal, are performing better or worse than expected, and how they can be improved. Applying a standardised methodology to evaluate our major

[1] Appraisal is a key tool in our decision-making process to help ensure success and realise our corporate and project objectives. It considers all aspects of potential investment options and assesses the relevant associated benefits, costs and risks, and presents them in a format appropriate for decision makers so that they can make informed judgements and choices.

[2] In line with our 'Benefits Management Manual' (2018).

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/427081/tag-worksheet-appraisal-summary-table.xlsx

projects enables us to review impacts across programmes and portfolios through meta- analysis.

Our objectives for POPE can be summarised as follows:

- To clearly communicate the benefits and impacts of our projects to our customers.
- To provide high quality analysis of our projects' impacts that are consistent with the Department for Transport's (DfT) Transport Analysis Guidance (TAG) the HM Treasury's Green and Magenta Books, and project specific objectives.
- To identify, describe and explain the differences between the forecast and outturn impacts.
- To provide evidence to verify or improve our appraisal methods and tools.
- To learn from evaluation insights to inform future investment decisions.
- To give stakeholders confidence in our ability to deliver projects that provide value for money.

The appraisals for major projects tend to assess impacts over long-term periods covering 30 to 60 years. We evaluate a project after it has opened (typically at three years after opening) to inform judgements about the likely benefits over the entire appraisal period.

POPE is a requirement of the Project Control Framework (PCF) which we use in the development and delivery of our Major Projects.[4] The current POPE method has two key timeframes for data collection and analysis:

- **Collection of pre-construction baseline data** – The collection of pre-construction data associated with a project to support a post-opening evaluation.
- **Three-year after study** – Refers to the completion of a three-year after evaluation which sets out a comparison of the forecast and outturn impacts of a project against each of the impacts considered in appraisal[5]. Where possible, the value for money is re-forecast based on the observed benefits[6].

1.3. What is the scope of POPE?

We assess a range of objectives covering traffic, safety, environment and economics in our projects' appraisals.[7] We adopt a proportionate approach in our POPE studies and focus on the core objectives, sufficient to provide accountability and enable us to learn as an organisation. As such, there are some aspects which currently are out of scope. We have an ongoing programme of methodological development to support

[4] The project control framework is a management approach to major projects drawn up jointly by Department for Transport (DfT) and National Highways to help us work together.

[5] The Department for Transport (DfT) Transport Analysis Guidance (TAG) defines a set of impacts that should be considered. https://www.gov.uk/government/publications/webtag-appraisal-tables

[6] Previously we undertook evaluations at one and five years after opening. We have moved to a single three years after evaluation as there is often insufficient data at one year after to draw significant conclusions. A three years after study addresses this and enables us and customers to access timelier results, rather than waiting until five years after.

[7] The full range of objectives are detailed in the DfT's appraisal summary table. (https://www.gov.uk/government/publications/webtag-appraisal-tables).

us in enhancing the coverage of our evaluation approach, for example, in assessing wider economic impacts, social value, and customer experience. As these methods are developed, tested, and refined they will be added to our suite of evaluation tools to deploy in major project evaluation where appropriate.

Typically, an evaluation will monitor trends in:

- traffic growth
- journey times and reliability
- safety (changes in personal injury collisions)
- environment (including a site visit and covering all relevant environment objectives)
- economic assessment of value for money

Other impacts, such as other social impacts, may be included, as required, by individual projects[8].

1.4. What is the 'counterfactual'?

A counterfactual is an estimate of what would have happened if the scheme hadn't been implemented. Generally, when undertaking a POPE it is better to compare the 'outturn' impacts (those observed after opening) with a counterfactual. Our road schemes often take a few years to construct and we then wait three years before undertaking our POPE evaluation. Comparing the outturn impacts after opening directly to observations taken before construction can be misleading as over the intervening years the before situation would have changed whether or not we had undertaken the scheme. Where possible and proportionate, we are moving towards using counterfactuals in our POPE comparisons. This is particularly relevant for traffic volumes (which tend to increase over time), journey times (which tend to decrease over time due to the increase in traffic volumes) and safety (which has tended to improve over time with improvements to road and vehicle design). Further detail is provided in the following sections.

[8] For further information on the social impacts included in transport appraisal refer to TAG guidance: https://www.gov.uk/government/publications/webtag-appraisal-tables

2. Traffic evaluation

In our traffic evaluations we look at whether a project has delivered road user impacts relating to changes in traffic volumes, average speeds, journey times and journey time reliability. The results of our traffic analysis feeds into our economic assessment of the project. We use our observations to re-forecast the expected monetised benefits and help us determine whether the project is delivering the anticipated value for money. The results also feed into our environmental analyses to determine the project's impacts on noise, air quality and greenhouse gases.

2.1. How do we define the traffic study area for POPE?

We initiate our traffic evaluations by planning and undertaking a thorough data collection exercise for both before and after the construction of the project. We review the appraisal forecasting data and consult with internal stakeholders to agree the definition of the evaluation study area, which will enable us to determine which impacts can be attributed to the project. We will focus on the project extent, and, depending on project type, we may also include local roads, where the appraisal forecasts substantial changes in flows or journey times.

2.2. What data sources do we use for analysis of traffic impacts?

We obtain traffic data for the strategic road network (SRN) from a network of permanent long-term counters accessed either via the public-facing WebTRIS tool[9] or via internally held databases.

We may also obtain traffic flow data for surrounding roads, including those managed by local authorities. We work with the relevant local authority to access reliable data, and if this is not available, we commission short-term traffic surveys on key routes.

We generally use satnav data to assess impacts on journey times and journey time reliability, but a range of other data sources[10] are used if this data is not available for a particular project.

2.3. How do we assess a project's impact on traffic volumes?

We assess a project's impact on traffic volumes and movements in a study area by looking at different aspects that have changed over time. These broadly come under the following:

- national, regional, and local trends in traffic volumes
- changes in average traffic volumes throughout the day on the sections of the road relating to the project
- changes in traffic volumes on the local road network (for projects where impacts were expected)

[9] https://webtris.highwaysengland.co.uk/

[10] Other sources could include journey time information held in databases by the Department for Transport or data held by National Highways from our network of traffic sensors and in-vehicle data.

- reassignment of traffic to the strategic road network from the surrounding road network impacted by the project

2.4. How do we assess the changes in background traffic levels?

To contextualise and isolate a project's impact on traffic volumes in its study area we look at changes in traffic trends at national, regional, and local levels from before and after its construction. To do this, we use data from the road traffic statistics in Great Britain produced annually by the Department for Transport (DfT).[11] These are estimates of total distances travelled on the country's roads each year, categorised by local authority and road type. We combine the trend observed on the relevant road type and region and use this to produce a counterfactual flow estimate. This is our estimate of what traffic conditions would have been had the scheme not been implemented[12].

2.5. How do we assess the impact on the project section?

To understand changes in the flow of traffic on relevant project sections, we compare average weekday traffic (AWT) flows using data sourced from sensors on our network.[13] We compare observations from before construction, adjusted to represent an estimate of the counterfactual (see section 2.4), to observations at three-years after. In addition to the whole day AWT we consider the traffic changes at peak times and interpeak periods.

We use data for a neutral month[14] in both pre-construction and post-opening periods. Some projects require us to also look at a specific non-neutral time period. For example, a project implemented on the route to a holiday destination may have been designed to accommodate high levels of traffic demand in summer months. We would therefore analyse changes in traffic trends during these key periods in addition to the neutral month.

2.6. How do we assess the impact on the surrounding road network?

To understand a project's impact on flows on the local road network, we can use data collected from local authorities and/or from counts commissioned from specialist companies. We look at changes in AWT in a neutral month in both the pre-construction and post-opening periods.

Additionally, to understand whether the project has impacted traffic movements within the study area, we can use the traffic count data to create 'screenlines'. These

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[11] https://www.gov.uk/government/collections/road-traffic-statistics

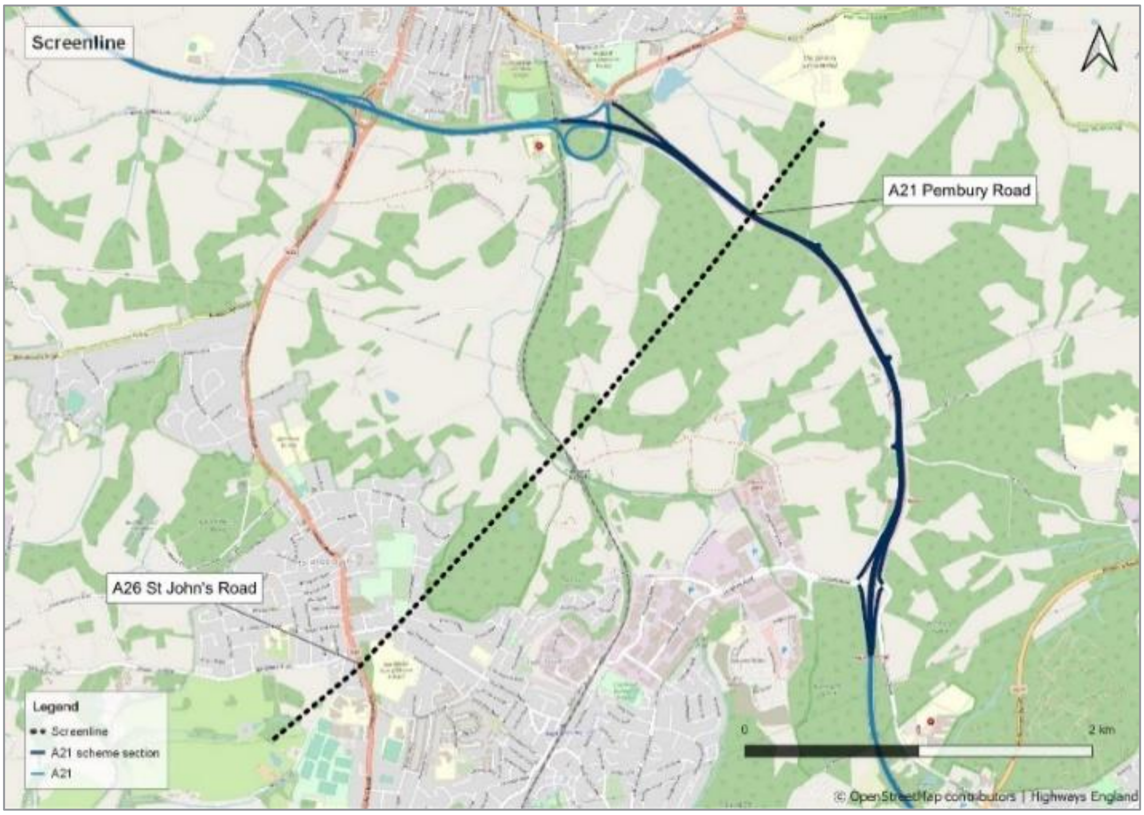
[12] Evaluations undertaken prior to 2024 would have presented a comparison of flows before versus after, with commentary to give context about the changes that could be expected to have occurred in the intervening time period if the project had not been implemented. We have now moved to explicitly presenting a counterfactual estimate.

[13] Historically, sensors have been embedded under the road surface, but more recently roadside RADAR sensors are being used instead.

[14] A 'neutral' month is defined as one least affected by seasonal effects and so best represents average traffic for a whole year.

are imaginary boundaries comprised of a set of traffic count points on a road network which define a broad traffic movement corridor, for example a project and several parallel routes. We use them to assess broader vehicle movements and identify whether any reassignment has occurred and, potentially, to determine whether there has been a change in rat-running near a project. Figure 1 shows a simple screenline comprised of two counts points.

Figure 1 Screenline created from points on two roads assess traffic pattern changes



2.7. How do we assess a project's performance compared to expectations?

Our investment decisions for road schemes are supported by a project appraisal which includes forecasts about the likely impact on traffic. Traffic forecasts are produced for its opening year, intermediate years, and a defined final assessment year.

In evaluation, we compare the appraisal traffic flow forecasts with outturn traffic flows to get a measure of their accuracy and of the uncertainties which may have been involved[15]. The time periods and metrics we look at are determined by those used in the appraisal.

Linear interpolation is used (assuming straight line growth between the opening year and the next closest year we have forecast for) to provide a forecast for the relevant year to match our observed data.

[15] For example, the Department for Transport's TAG guidance notes that a ±15% difference between modelled and observed flows can be an acceptable validation level of the traffic model.

2.8. How do we assess the impact on journey times?

To understand a project's impact on journey times we first make an estimate of counterfactual journey times. We do this using assumptions about growth of traffic flows (see section 2.4) and applying the theoretical change in speed that this growth would relate to, using standard speed-flow curves. We make a comparison between the counterfactual journey times and those observed after a project has been implemented, for each route/direction, and various time periods. Reductions are reported as a positive savings.

The analysis requires the definition of key routes within the study area, the key time periods[16] and the appropriate pre-construction and post-opening periods suitable for comparison. These are defined to align with those used in the pre-construction appraisal, as set out in the ComMA (combined modelling and appraisal) package and its related documentation. Journey time data is usually sourced from satnav datasets, although other sources will be explored if this is not available.

2.9. How do we assess speeds?

To better understand a project's impact on journey times we may also compare speeds along the defined routes, by direction and by time period, before and after a project has been implemented. It can be particularly helpful to understand where drops in speed are located to help identify reasons for changes in journey time. Changes are reported in miles per hour and we use harmonic averages[17] in our calculations.

2.10. How do we assess a project's journey time impacts compared to expectations?

We assess the accuracy of the forecasts by comparing them to observed data. If forecasts are not available for the same year as the observations, we use linear interpolation (assuming a straight line between the opening year and the next closest year we have forecast for) to provide a forecast for the relevant year to match our observed data[18].

We compare the 'do minimum' (or without project) forecasts with our estimate of the counterfactual based on pre-construction observed data[19]. We also compare the 'do something' (or with project) forecasts with post-opening observed data. We then compare the difference between the 'do minimum' and 'do something' forecasts with the difference between the counterfactual and post-opening observed data.

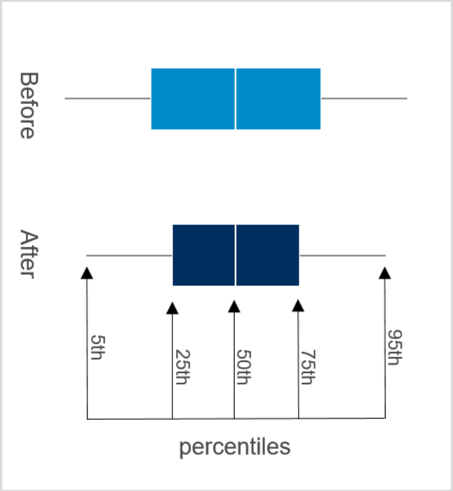
[16] Typical examples of time periods are the AM peak, interpeak, PM peak, overnight, and weekend.
[17] The harmonic mean is one of several kinds of average, typically it is appropriate for situations when the average rate is desired. The harmonic mean can be expressed as the reciprocal of the arithmetic mean of the reciprocals of the given set of observations.
[18] We previously compared the nearest forecast year to our evaluation year where we had observed data in order to avoid linear interpolation of speeds. Having undertaken research into the size of error linear interpolation could introduce to our results, we now understand that the impact of this assumption introduces in minimal.
[19] Evaluations undertaken prior to 2023 would not have calculated a counterfactual estimate, but rather just presented a comparison of before and after journey times.

2.11. How do we assess journey time reliability?

Journey time reliability refers to how consistent journey times are along a project extent or route. If the range of journey times has reduced, we interpret this as the journey times having become more reliable.

To understand a project's impact on journey time reliability, we look at the spread of journey times along the route, before and after a project has been implemented and illustrate change per quartile using box plots (see Figure 2). This is a way of representing the median average and the quartiles of the data and allows us to compare and illustrate the changes in the range of journey times along the project extent. We can assess how reliable journeys are by looking at the distance between each of the points plotted. The shorter the distance, the less variance and hence the more reliable a journey is likely to be.

Figure 2 Example box plot composition[20]



We can also assess reliability using other metrics:

- **Planning time index (PTI).** This is a reliability measure which represents the amount of additional travel time (over and above free-flow or normal conditions) that a motorist should expect to allow when planning their journeys to ensure they will arrive on time[21]. Comparison of the change in PTI on a project can give an indication of the impact of a project on journey time reliability and provides a metric that can be more easily used in meta-analysis.
- **Route stress**. This is the ratio of observed annual average daily traffic (AADT) to congestion reference flow (CRF).[22] We report it as a percentage

[20] A percentile is one of 100 equal groups into which the data has been divided, according to the distribution of values of a specific variable, in this case journey time. A quartile is one of four equal groups of the data. In Figure 2, the 5th percentile marks the point in the distribution of journey times along the project extent in a defined period where only 5% of journeys are longer than this journey time, and the 95th percentile marks the point in the distribution where 95% of journeys are shorter than this journey time. Any values lying outside these two points are deemed outliers.
[21] A PTI of 2 would mean the motorist should allow double the amount of time it would take to make the journey if the road was completely clear to be 95% confident of arriving on time. It is calculated as the 95th percentile journey time divided by the free flow journey time.
[22] CRF calculation is detailed in the Design Manual for Roads and Bridges (DMRB) and is a measure of the performance of a link between junctions. As stated in DMRB, "The Congestion Reference Flow

and assess whether it falls within the range of 75% to 125%. This allows us to comment on congestion even if no journey time data is available.

(CRF) of a link is an estimate of the Annual Average Daily Traffic (AADT) flow at which the carriageway is likely to be ‘congested’ in the peak periods on an average day”.

3. Safety evaluation

Safety on our network is one of our primary objectives. We aim to reduce the loss of life, injuries and damage to property which can result from collisions on our network. We assess the extent to which our projects achieve their safety objectives and contribute to the provision of a safe network for road users.

To evaluate a project's safety impact, we look at the changes in various aspects of safety on the project extent and on surrounding roads within a defined study area based on the appraisal. We monitor changes in personal injury collisions (PIC) over set periods of time. We also account for changes in traffic flows which may have impacted on collision rates, and at the changes in the severity of collisions.

Safety trends can be influenced by several factors. To help us understand the impacts of a project, we make comparisons of safety-related trends before and after the implementation of a project, and we make comparisons between the outcomes of a project and counterfactual scenarios. A counterfactual scenario estimates the safety trends that would likely have occurred had a project not been implemented. We also look at how a project's safety outcomes compare to what was expected from the appraisal forecasts. To ensure our analyses are robust, we undertake statistical significance tests using chi-squared tests[23] to give confidence that there has been a significant change between the counterfactual and observed trends.

3.1. How do we define the safety study area for POPE?

We define the study area for our safety evaluation based on the area that was considered in the pre-construction appraisal which supported the business case for the investment. As well as this 'wider area' we also highlight the impacts on the 'project extent'.

3.2. What data sources do we use for the evaluation of safety impacts?

A validated traffic incidents database produced annually by the Department for Transport is stored in National Highways' Road Information Framework.[24] It contains personal injury collision (PIC) information from 1994 to the present day. There are three datasets within it we use to inform our evaluations. These are:

- collisions database (records of all PIC including, collision severity, location, time of day, road conditions, etc.)
- vehicles database (records of the number and types of vehicles involved in PIC)

[23] A chi-squared test is a standard statistical tool we use to help us to determine whether those differences we find in our comparisons are due to chance or are significant and establish the degree of confidence we place in that significance. We employ the tests to ensure our analyses are robust. Note - changes that are not identified as significant can still be real.
[24] National Highways' Road Information Framework (RIF) is a collection of data tables relating to many aspects of the strategic road network. The data are used to inform day-to-day operations, performance monitoring, modelling, appraisal, economics and evaluation.

- casualty database (records of the number and severity of each casualty in PIC)

To ensure we can make appropriate comparative analysis across the strategic and local road network, we use collision data derived from the Road Safety Data in Great Britain. This dataset is validated and released annually by the Department for Transport (DfT)[25]. It comprises collision reports provided by the various police forces, local authorities, and transport bodies such as Transport for London. The reports are produced by police officers when they respond to personal injury collisions on public roads. Those collisions that result in injuries are recorded and categorised in the dataset by the severity as either fatal, severe, or slight. Those collisions that do not result in injury are not included in the dataset, so they are not available for analysis.

Police records of reported incidents on public roads are the primary source of road safety collision and casualty information in Great Britain. These records are collected using a data collection system known as STATS19. This dataset forms the basis of national statistics for road casualties and is used both nationally and locally for various road safety purposes. Since 2012, new data collection systems (called CRaSH[26] and COPA[27]) have been introduced by some police forces with the objective of eliminating the "uncertainty in determining severity that arises from an officer having to make their own judgement".[28]

The Department for Transport (DfT) and Office of National Statistics (ONS) have developed a methodology for collision and casualty severity adjustments when comparing timeseries analysis where a police force has transitioned to injury-based reporting mechanisms[29]. More detail on the methodology can be found here[30].

We review the forecasting data from the appraisal (Economic Appraisal Report) and use the observed data to check the accuracy of the modelling. We also undertake meetings with key stakeholders to help identify any impacts on roads which may not have been noted in the appraisal documentation.

3.3. How do we assess the impact of a project on road user safety?

We assess the impacts of a project on road user safety by looking at the changes in personal injury collisions (PICs) and collision rates between the pre-construction and the post-construction periods. We focus on collisions and not casualties because the number of casualties per collision are randomly variable and any change in the numbers is unlikely to be a response to the project.

[25] https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data
[26] Collision Reporting and SHaring system
[27] Case Overview Preparation Application
[28] 'Reported Road Casualties, Great Britain: 2018 Annual Report' (Department for Transport, 2018).
[29] As of September 2021, these reporting systems had been adopted by 26 out of 43 police forces in England
[30] 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

To reduce the influence of the random nature of collisions, we look at the trends in PICs over several years – a minimum of three years is required to provide robust results.

To determine the change in the number of PICs that occurred over the period being evaluated, we first compare the annual average number of collisions from the pre-construction and post-opening periods. A counterfactual estimated is calculated by adjusting the before data to provide the range of collisions likely to have occurred without the project taking place. The difference between the counterfactual and observed post opening data is then used to inform judgements on a project's likely safety impact.

Collision rates are used to consider changes in traffic flows, so we can determine if the change in observed collisions is representative. We observe before and after rates and calculate a counterfactual estimate to determine the likely rate without the project taking place.

3.4. How is the counterfactual estimated calculated?

Since the late 1990s collision numbers in the UK have declined despite increasing volumes of traffic. To account for this and to more accurately determine whether any change in collision numbers can be attributed to a project we pose the question: what is likely to have occurred had a project not been implemented? To answer the question, we create a counterfactual scenario in which we estimate the number of collisions which would likely have occurred over the evaluation timeframe had the project not been constructed. We can then calculate the net difference between the collision numbers of the observed post-construction period and those of the counterfactual scenario.

To create a counterfactual scenario, we adjust the observed pre-construction collision rate by applying changes seen in the background trends to it. We then estimate how the adjusted pre-construction collision rate might have changed over time[31].

In summary:

- We assume that traffic flow trends would follow the regional background traffic growth patterns had the project not been implemented.
- We calculate the collision rate for the appropriate type of road motorway (differentiating between conventional motorways, conventional motorways with high traffic flows, and smart motorways).
- We apply regional trends for collision rates.

[31] In previous POPE studies, national trends for the pre-construction road type were used to adjust the trend in personal injury collisions. In more recent POPE studies, we have adopted an updated methodology with improvements to enhance its accuracy. In applying the updated method, we compared the results using the previous method and this has confirmed that, whilst the detailed counterfactual estimate was slightly different, there was generally a good alignment in the conclusions being drawn by the two methods. The new approach provides increased accuracy in the counterfactual scenario and makes it more fit for the future.

- We use the chi-squared test to create a counterfactual range (rather than a single number estimate). This enables the counterfactual results to be interpreted with a greater appreciation of the levels of certainty

3.5. How do we assess the effects of traffic flows on collision severity?

To understand the impact of changes in the volumes of traffic on collision severity, we use casualty data published by the Department for Transport categorised by severity, that being ‘slight’, ‘serious’, and ‘fatal’. From this a measure called the fatal and weighted injuries (FWI) index is produced. It is a combined measure of casualties adjusted for severity, and expresses the numbers of fatal, serious, and slight incidents as weighted proportions. A fatal collision is 1.0, a serious collision is 0.1, and a slight collision is 0.01. The numbers are summed and a whole number is equivalent to a fatality.

The FWI index contributes to a metric which standardises the collision categories against traffic flow to show the likelihood of a fatality equivalent per hundred million vehicle miles travelled. This metric is expressed as FWI per hundred million vehicle miles travelled (FWI/hmvm). We calculate and compare FWI/ hmvm for equivalent periods of time before and after a project’s construction to see whether it has improved against the measure.[32]

We aim to use consistent data sources in our analysis on the effects of traffic flows on collision severity to ensure we make proper comparisons. The changes in the recording of incidents by police forces (see section 3.2) as noted above, can limit the scope of our analysis depending on when the new recording systems were adopted. Where a new recording system was adopted during the post-opening monitoring period, we would limit the time series assessed to that covered by the old system. However, where a new recording system was adopted while the project was being constructed, the data would not be consistent across the evaluation period, and limited comparison is possible. We are able to monitor fatal collisions as these are not impacted by the change in recording system. We will be reviewing this approach over time in line with changes in the Office for National Statistics’ guidance on adjustment factors.

3.6. How do we assess a project’s performance compared to expectations?

We assess the accuracy of the forecasts by comparing them to observed data. We compare the ‘do minimum’ (or without project) forecasts with our estimate of the counterfactual based on pre-construction observed data. We also compare the ‘do something’ (or with project) forecasts with post-opening observed data. This information is used when we monetise safety benefits.

[32] We use a tool called the FWI Calculator to determine the FWI Index. We input the aggregated number of casualties classed by severity, the total number of collisions and pre-construction and post-opening average annual daily traffic flows. A formula then calculates the FWI Index.

4. Environmental evaluation

We take a proportionate approach in our environment evaluations, with the level and focus of analysis determined by several factors. The key factors are:

- project type and complexity
- the availability of data and information to provide appropriate baselines for comparison
- the availability of post-opening data and any health and safety issues which could restrict the scope of our site visit

For most major projects, our evaluations consider the predicted impacts of the project and compare them against the outcomes observed three years after construction. Information on the predicted impacts is gathered from the original business case and supporting evidence including the environmental appraisal[33] and the environmental assessment[34]. Evidence on the observed impacts comes from a combination of a site visit to view the impacts in place and a review of any available supporting information. This usually includes any monitoring reports or surveys commissioned by the project and information on ongoing maintenance and inspections.

Our site visits seek to:

- observe the impacts of the project at a sample of locations along the project
- to confirm the degree to which the mitigation measures proposed have been implemented
- to assess the effectiveness of the mitigation measures at three years after and the prospect that they will deliver the desired design year[35] outcome

For some environmental topics[36] where changes in traffic characteristics influence the impact, observed traffic data will be obtained, and used to evaluate the project outcome.

The results of our analysis are recorded against each of the TAG environmental topics. We then report on whether we consider the observed outturn impacts to be 'as expected', 'worse than expected' or 'better than expected' as compared to the forecast impact reported in the Appraisal Summary Table (AST). Where insufficient evidence is available to determine the outcome, for example mitigation has yet to establish or monitoring data is unavailable, we record this as 'too early to say'. We also incorporate assessment of some social impacts[37] into the environmental evaluation. This is because the environmental site visit often provides an opportunity for us to observe the impacts that occurred and the mitigation put in place.

[33] https://www.gov.uk/government/publications/tag-unit-a3-environmental-impact-appraisal
[34] https://www.standardsforhighways.co.uk/search/54b0eb69-fd65-4fa5-a86b-7313f70b3649
[35] Usually 15 years after.
[36] Air quality, noise and greenhouse gases.
[37] https://www.gov.uk/government/publications/tag-unit-a4-1-social-impact-appraisal

4.1. What sources do we use for the evaluation of environmental impacts?

We collect both primary and secondary data to undertake evaluations. We obtain primary data from site visits and from the traffic surveys that support our traffic evaluation. The site visits include observations and photographs of the impacts of a project. It also considers various aspects of the design, the construction and the progress of embedding the project into the physical landscape. The data is geotagged for mapping and geospatial analysis.

We obtain our secondary data from documents and reports produced both during the project appraisal process and after construction during the aftercare period. Depending on the project, these documents can include: the Environmental Assessment Report, Environmental Scoping Report, Environmental Statement (ES), Environmental Management Plans (both construction phase and handover phase), Landscape Management and Maintenance Plans, as-built drawings, AST and TAG worksheets and post construction monitoring reports such as those for species surveys, and any relevant archaeological reports. This list is not exhaustive.

4.2. What environmental and social impacts sub-objectives do we evaluate?

We usually incorporate 11 environmental and three social impacts[38] topics into the scope of our environmental evaluations:

- Noise impacts
- Air quality impacts
- Greenhouse gases
- Impacts on landscape
- Impacts on townscape
- Impacts on the historic environment
- Impacts on biodiversity
- Impacts on water environment
- Physical activity impacts
- Journey quality impacts
- Severance impacts

4.3. How do we assess noise impacts?

We evaluate noise impacts of our projects by looking at the outturn traffic flows to see whether they are roughly as predicted. We don't currently undertake any new noise surveys.

[38] Physical activity, journey quality and severance

If we find that there have been changes in traffic beyond the following thresholds, then we assume that the traffic impacts for noise are either ‘worse than expected’ or ‘better than expected’. The thresholds are:

- where traffic flows (number of vehicles >1,000 per day) are 25% more or 20% less
- where average speeds differ by at least 10 kph
- where the percentage of Heavy Duty Vehicles (HDVs) differs by at least 10%

If we see changes in at least two of the above parameters, we then try to calculate whether the observed roadside noise level differs from that using the forecast traffic data. We calculate it using observed annual average traffic flows. Noise levels within 1dB of the forecast are deemed ‘as expected’.

We also consider existing noise survey/monitoring information where available.

If any noise mitigation is proposed by the environmental assessment, we would aim to confirm it was provided. During the site visit we check its location and physical characteristics. We check its technical properties by consulting as-built documentation. If the detailed mitigation specifications aren’t available in the as-built documentation, we will try to obtain further information from the project team covering:

- the noise insulation performance of barriers (usually confirmed by a certificate of conformity)
- the road surface type, including whether a low noise surface was laid

Environmental Statements and traffic forecast reports generally only contain traffic flow forecasts for the opening year and for the design year, which is, 15 years after opening. We therefore need to interpolate the forecasts to undertake the three-years after evaluations. We may have to consider the impact on the annual average traffic flows of any major developments which have subsequently been built.

4.4. How do we assess the impacts on local air quality?

We assess local air quality by looking at the outturn traffic flows, speeds and percentage of HDVs to see whether they are roughly as predicted.

If we find that there have been changes in observed traffic, beyond the following thresholds, we assume that concentrations of air pollutants are either ‘higher than expected’ or ‘lower than expected’. The thresholds are:

- where annual average daily traffic flows differ by more than 1,000 vehicles
- where average speeds differ by at least 10 kph
- where the annual average daily number of HDVs differ by more than 200 vehicles

As with noise impact evaluation, we need to interpolate traffic forecasts to be able to undertake three-years after evaluations and make comparisons with the observed traffic data. These are interpolated from the forecasts for the opening and design years. We will also consider any existing air quality monitoring data that may be available such as data included in Local Authority Air Quality Annual Status reports and, where possible, compare against predictions in the Environmental Statement.

4.5. How do we assess the impacts on greenhouse gases?

Changes in greenhouse gas emissions of a project are caused by changes in fuel consumption by vehicles. These changes will be related to all the different changes in traffic flows, speeds and composition across the road network affected by a project. We only have a limited amount of observed traffic data beyond the strategic road network, so we cannot evaluate with confidence the total change in emissions caused by a project. Instead, we base our evaluation on a comparison of forecast and observed traffic data along the project footprint. We use the emission factor toolkit published by DEFRA[39] to calculate total emissions to gain insight into the accuracy of the predicted emissions along the project footprint.

The DEFRA method requires the following inputs:

- link length (in kilometres)
- average daily traffic (ADT) flow
- average speed (in kilometres per hour)
- road type classification (for example, motorway, A road, etc.)
- percentage of HDV traffic

For the three-years after evaluation, we use interpolated forecast data. Where we have insufficient traffic data, we will attempt to qualitatively evaluate the outcome acknowledging any limitations involved.

4.6. How do we assess the impacts on landscape/townscape?

Planting and landscaping are usually important components of our road projects. They provide valuable landscape integration, screening, habitat protection and improved visual amenity and we can assess them during site visits. However, they need a minimum of three years to become established and usually 15 years before they fully mature and deliver the full mitigation benefits. Our evaluations will usually provide an overview of the forecast and observed impacts, confirm if mitigation measures have been implemented as planned, and record any substantial changes to design. We will take photographs of various key features taken from different viewpoints including a sample of locations predicted by the environmental assessment to be affected. Where the assessment included photomontages[40], we will attempt to replicate them. We will then use the evidence gathered during the site visit along with any information we have on the condition of the mitigation planting and proposed future maintenance to determine whether the forecast outcomes are likely to be met.

4.7. How do we assess biodiversity impacts?

Managing biodiversity impacts is an important element of our projects. To evaluate these impacts, we review as-built drawings, ecological monitoring reports and other

[39] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[40] These are locations where the assessment produced a visual representation of what the project would look like at different time periods. Usually, the winter opening year and the summer design year.

project documents and use the site visit to confirm the status of any pertinent mitigation measures (for example, ponds and new habitats, mammal underpasses).

4.8. How do we assess the impacts on the historic environment?

The management and preservation of our cultural heritage is an important part of our projects. To evaluate the effects of our projects, we gather information on the predicted impacts and proposed mitigation from the environmental assessment. We then undertake a site visit to identify if the impacts arose and whether the mitigation is in place and effective. For impacts on archaeology, we will review the findings of any published archaeology reports. We will use the report to assess the success of any mitigation measures employed.

4.9. How do we assess the impacts on the water environment?

Our new road projects normally require a range of relevant mitigation measures (highway drainage, balancing ponds, pollution control, road surface water treatment systems) and sometimes morphological enhancements to receiving watercourses (for example, meanders to offset culvert length), and measures to reduce flood risk. Our evaluations focus on confirming the mitigation measures have been implemented during a site visit and will seek to confirm that the mitigation measures are being maintained, operating effectively with no signs of pollution, sedimentation or erosion. We would use any water quality data if it were available in our assessment. If we found any pollution issues, we would notify the relevant project team/legacy team and relevant authorities.

4.10. How do we assess impacts on physical activity?

We look at whether any changes to the public rights of way network required by a project have been implemented to assess impacts on physical activity. We would review the as-built drawings and any copies of the audits for non-motorised users such as walkers, cyclists and horse riders (WCH) or vulnerable users. During site visits, we would try to qualitatively assess WCH usage, but we do not carry out any new surveys unless changes in physical activity was an objective of a project, and there was a specific need for data.

4.11. How do we assess the impacts on journey quality?

We look at the provision of facilities for drivers, for example, lay-bys, service areas, views from the road and new signage, and we consider the qualitative changes to driver stress using data on congestion, journey times and accidents. We use the site visit to qualitatively assess the success of any relevant measures.

4.12. How do we assess the impacts on severance?

We look at whether any changes to footpaths, rights of way, bridges, lighting or vegetation caused by the project have changed the level of severance experienced by local communities. This includes how a project may have affected access to community facilities and services. The site visit is used to qualitatively assess these impacts and they are then compared with the changes predicted in the project appraisal.

5. Value for money

5.1. What is ‘value for money’?

When we invest in a major road improvement project we must show that it will be a good use of public funds and will deliver ‘value for money’ (VfM). VfM is defined to be “the optimal use of resources to achieve the intended outcomes”.[41] It requires us to build a business case which demonstrates that objectives will be achieved, money will not be wasted, and that the expected benefits exceed the costs.

At each decision stage we assess how much VfM a project is likely to deliver and summarise it in a VfM statement. This statement considers the whole scheme-life (usually assumed to be 60 years) and will contain a project’s benefit-cost ratio (BCR) and allocate the project a VfM category[42]. The Benefit Cost Ratio (BCR) provides an indicative economic measure to decision makers that is calculated by dividing the value of the monetised impacts (or benefits) of a project by its costs.[43] The VfM category provides a more holistic measure to decision makers by accounting for the additional non-monetised benefits generated by the project, which can in some instances be substantial.

In our evaluations we undertake a combination of quantitative and qualitative approaches to understand the extent to which VfM has been achieved. For some impacts we are able to provide a reforecast estimate of the monetised value. For other impacts, or in situations where data is limited, we will undertake a qualitative analysis to reflect the project’s value for money[44].

Most of the economic benefits from a major highways project accrue from journey times savings and collision reductions. Our evaluation methodology assumes that the change in the observed traffic flows, journey times and collisions in the first three years of a project’s life can be associated to its predicted long-term economic benefits.

5.2. How do we monetise journey time benefits?

Our analysis of the traffic impacts of a project will usually provide information on the changes in journey times on the key routes at different times of day. Our analysis will also provide information on how many vehicles were using the route at those times of day before and after a project’s implementation. We use this information to calculate a ‘vehicle hours saving’ value.

We assume those road users already using the route gain the full journey time benefits of the project. For any additional road users present in the ‘after’ scenario,

[41] National Audit Office https://www.nao.org.uk/about-us/our-work/value-for-money-programme/
[42] The Department for Transport defines six ‘value for money’ categories ranging from ‘very poor’ to ‘very high’: https://www.gov.uk/government/publications/dft-value-for-money-framework
[43] As per HM Treasury’s Green book ‘Central Government Guidance on appraisal and evaluation’, a ‘present value’ is used for both benefits and costs. This means that all the monetary values are compared in the same price base (for example, 2010 prices) and are ‘discounted’ to the same year (for example, 2010).
[44] Refer to section 2 for further details and explanation of the counterfactual estimate.

we apply the ‘rule of a half’. This is a standard technique set out in DfT’s Transport Analysis Guidance (TAG)[45].

The project will usually have been appraised over a 60-year project life, so we estimate what the outturn benefits would have been over 60 years. We do this in one of three ways:

- **Capitalisation.** We monetise the vehicle hour benefits in the opening year using standard values of time issued by DfT and then apply a standard capitalisation factor. We use the same values that are used for the appraisal of small projects. These account for future traffic growth which will also benefit from the project. The value is then discounted. This is a standard procedure to enable benefits that happen at different points in time to be combined.
- **Discount**. This method is similar to capitalisation, but is used when evaluation evidence leads us to query the underlying relationship between traffic and benefits. If we are not able to judge what the impact of future traffic would be on the benefits, we assume that the observed benefits do not change over the lifetime of the scheme. The only calculation that is performed on the benefits stream is that it is discounted to provide a standard ‘present value of benefits’ that is comparable with the ‘present value of costs’.
- **Profile method.** The capitalisation and discounting methods don’t reflect the expected shape of the benefits profile over the project life. Some schemes are expected to deliver their maximum benefits, not in the opening year, but at some point in the future. The profile method considers what proportion of the vehicle hour benefits have materialised in the opening year. This proportion is then applied to the forecast opening year benefits. This difference is then applied to the forecast monetised saving in the future years. Discounting is applied to the calculation at each step allowing the total 60-year benefit to be estimated.

We use a decision tree to determine which of the three methods is used to re-forecast the monetised journey time benefits. This considers the observed data we have available as well as the information from appraisal and analyses the relationship between them to determine the most appropriate method to use.

5.3. How do we monetise reliability?

We use two tools in the appraisal of a project to estimate the journey time reliability benefits. These are INCA (incident cost-benefit analysis)[46] and MyRIAD (Motorway Reliability Incidents And Delays)[47]. For POPE, we monetise reliability by re-running INCA or MyRIAD with the outturn traffic flows to obtain an updated estimate of the monetised benefit.

45 https://assets.publishing.service.gov.uk/media/63174538d3bf7f792bcfb1a6/tag-unit-a1.3-user-and-provider-impacts.pdf
46 https://www.gov.uk/government/publications/inca-user-manuals-and-downloads
47 https://highways.sharepoint.com/sites/TPGInformationandResources/SitePages/Software-and-Tools.aspx

5.4. How do we monetise indirect tax revenues?

Indirect Tax Revenue (ITR) is the change in revenue to the government resulting from a project's implementation. For our projects, indirect tax is derived primarily from fuel consumption. A project may result in changed fuel consumption due to:

- changes in speeds (resulting in greater or lesser fuel efficiency)
- changes in the distance travelled
- increased road use

It is difficult to accurately calculate the fuel used in a study area, therefore we base our calculation method on the difference between forecast and observed estimated fuel consumption on the scheme extent. We apply the ratio of forecast:observed to the monetised ITR forecast to provide an outturn monetary value for ITR.

We use standard TAG vehicle category splits to estimate the composition of the traffic flow and apply standard TAG fuel consumption parameters to calculate the forecast and observed change in fuel consumption.

5.5. How do we monetise vehicle operating costs?

For most projects, the vehicle operating costs (VOC) and indirect tax revenues (ITR) are both very closely linked to changes in fuel consumption. Their impacts are of similar sizes but fall on opposite sides of the benefits balance. So that, if there is increased fuel consumption, VOC will increase too due to road users paying more for fuel (a disbenefit), but the increased fuel consumption will also generate more indirect tax in the form of fuel duty collected by the HM Treasury (a benefit, under current guidance).

We firstly calculate our estimate of outturn ITR and then apply the ratio of forecast:outturn change in ITR to the forecasts VOC estimate an outturn monetised value for VOC.

5.6. How do we monetise safety benefits?

We analyse monetised safety benefits by calculating the net difference between the average numbers of personal injury collisions per year in the counterfactual scenario (see section 3.4)and observed numbers in the post-project period. We then compare this with the net difference predicted between the 'do minimum' (without project) and 'do something' (with project) scenarios in the opening year. We adjust the observed data to account for the background trend in collision reduction. This difference between the predicted and observed impacts is then monetised using SAR guidance[48] for the appraisal period and by the primary road type of the improvement. The monetary value is then added to the forecast saving for the area over the appraisal period to give the outturn safety impact.

[48] SAR (Scheme Appraisal Report) is a spreadsheet-based tool which records the results of a TAG-based appraisal of a small highway improvement project (typically under £10 million).

5.7. How do we assess scheme costs?

We compare the outturn construction, operation, maintenance, and renewals costs against how much the project was expected to cost prior to construction.[49] The expected costs used in our post-opening project evaluations are the investment, operation, maintenance, and renewals costs that supported the Stage 5 Business Case.[50]

For major projects, we obtain outturn costs from colleagues in Commercial and Procurement Directorate to ensure consistency.[51]

For our post-opening project evaluations, we use present value costs (PVC) in a 2010 base year. Some older projects were appraised using a 2002 base year, in which case we convert it so that it is comparable with other projects.

[49] The scope of POPE methodology includes construction costs but does not monitor longer-term maintenance costs.

[50] National Highways projects follow a seven-stage lifecycle. Stage six refers to the construction period, therefore the estimate at the end of stage five is the cost that informed the decision to go ahead with construction.

[51] To account for inflation, we use a GDP deflator tool to estimate its impact.

Annex A – Glossary

Acronym	Definition	
AADT	Annual Average Daily Traffic	
	Appraisal	Appraisal is the assessment of the impacts of road project which informs our investment decision. It considers all aspects of potential investment options and assesses the relevant associated benefits, costs and risks, to enable decision makers to make informed choices.
	As-built documentation	Documentation supplied by our contractors confirming the technical specification of what has been constructed.
AST	Appraisal Summary Table	A summary of the outcomes of the appraisal process.
AWT	Average Weekday Traffic	
ComMA	Combined Modelling and Appraisal report	A report summarising how the evidence underpinning the business case has been developed. This includes the data which was collected, the production of the traffic modelling and its performance, the forecasts generated and the economic value of the forecast impacts.
COPA	Case Overview Preparation Application	A new data collection system introduced by some police forces for collecting road collision information.
	Counterfactual	An estimate of what would have happened if the scheme hadn’t been implemented.
CRaSH	Collision Reporting and SHaring system	A new data collection system introduced by some police forces for collecting road collision information.

CRF	Congestion Reference Flow	An estimate of the AADT flow at which the carriageway is likely to be congested in the peak periods on an average day.
DfT	Department for Transport	The government ministerial department responsible for the transport network.
DM	Do Minimum	The forecast of how the road network would perform if the scheme wasn't constructed.
DMRB	Design Manual for Roads and Bridges	The design standards relating to the design, assessment and operation of motorway and all-purpose trunk roads in the United Kingdom.
DS	Do Something	The forecast of how the road network would perform if the scheme is constructed.
FWI	Fatal Weighted Injuries	The FWI metric 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.
hmvm	Hundred million vehicle miles	
INCA	INcident Cost-benefit Analysis tool	A tool used in appraisal to estimate the journey time reliability benefits.
ITR	Indirect Tax Revenue	The change in revenue to the government resulting from a project's implementation.
	Meta-analysis	Periodically we undertake analysis considering the findings across a sample of projects.
MyRIAD	Motorway Reliability Incidents And Delays	A tool used in appraisal to estimate the journey time reliability benefits.
PIC	Personal Injury Collision	
POPE	Post-Opening Project Evaluation	National Highways' approach to evaluation of road schemes.
PTI	Planning Time Index	A reliability measure which represents how much additional time a motorist

		should allow to ensure they will arrive on time.
PVC	Present Value of Costs	The cost present in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented in appraisals and evaluations.
SRN	Strategic Road Network	The network managed by National Highways, comprising of motorways and some A roads in England.
STATS19		A data collection system of police records from incidents on public roads. It is the primary source of road safety collision and casualty information in Great Britain.
TAG	Transport Analysis Guidance	Published by DfT, this provides information on the role of transport modelling and appraisal.
VfM	Value for Money	This refers to the optimal use of resources to achieve the intended outcomes. Something which is ‘high’ value for money provides a better outcome for investment than an alternative which is ‘low’ value for money.
VOC	Vehicle Operating Costs	The fuel and other costs borne by the user (such as the wear and tear on vehicles).
webTRIS		National Highways’ public-facing website that provides traffic flow data at count sites on the Strategic Road Network.

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