Department for Transport

Benchmarking Minor Road Traffic Flows for Great Britain, 2018 and 2019: Methodology Report

In this publication

Definitions

Traffic

Traffic refers to the total distance travelled by all vehicles over the year, measured in vehicle miles. This combines the number of vehicles on the road, and how far they drive.

Minor Road

Roads classified as B roads, Classified Unnumbered and Unclassified.

Introduction

The Department for Transport publish estimates of minor road traffic in Great Britain on an annual and quarterly basis. These estimates are calculated using observations of the change in traffic at a fixed sample of locations.

For the minor road traffic estimates, the sample of minor road locations remains fixed for around 10 years. Change estimates from a fixed sample may drift over time and the sample may vary and become less representative of the changing minor road network. To account for any error incurred in the fixed sample, the sample is revised through the minor roads benchmarking exercise every decade.

The latest benchmarking exercise has been conducted over 2018 and 2019. The exercise comprises traffic counts undertaken, in parallel with the standard annual minor road counts, using a new large benchmark sample of minor road locations across Great Britain. An estimate of the 2019 minor road traffic level was calculated from these benchmark counts and compared with the existing estimate from the standard annual process. As a result of this benchmark exercise, minor road traffic estimates have been revised for 2010 to 2019, providing a new basis for future estimates.

A subset of the benchmark sample locations have been selected to be the fixed sample of locations that are counted for the annual minor road traffic estimates for the 2020s.

This document sets out the minor benchmark processes in detail, explaining the impact on minor road traffic estimates and the methods used to select the fixed annual sample for the 2020s.

Technical note

The annual traffic estimation methodology note can be found here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524848/annual-methodology-note.pdf

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1. Background Information

1.1 Current methodologies

- ► Road traffic estimates are currently published for Great Britain on an annual and quarterly basis, as well as an annual publication of street-level traffic data via the traffic counts website.

- ► The scale of the minor road network in Great Britain means it is not possible to count traffic on every stretch of road. Instead, a representative sample of road sites are counted each year.

- ► Quarterly estimates are calculated on a panel sample approach, with traffic data collected continuously from a fixed national network of around 300 Automatic Traffic Counters (ATCs) which count flows and classify by vehicle type.

- ► Annual estimates are currently based on around 8,000 manual counts, where trained enumerators count traffic by vehicle type over a 12 hour period. This data is combined with the ATC data and road length statistics to produce the number of vehicle miles travelled each year by vehicle type, road category, and region.

- ► For major roads (motorways and 'A' roads) a rolling-Census approach is taken to manual counts, which enables road-level traffic estimates to be produced for these road types.

- ► For minor roads a panel sample approach is taken, whereby the same roads across Great Britain are counted each year (over 4,000 locations). This enables robust national level minor road traffic estimates to be produced.

Current data sources

Manual counts, carried out by trained enumerators on the road side for 12 hours

+

Manual video counts, carried out where it is not safe to stand on the road side to carry out the count

+

Automatic Traffic Counter (ATC) data

+

Road Length Statistics

=

Total Vehicle Miles

- ► More detailed explanations of the current methods used to produce traffic estimates, from the above data sources, can be found in the guidance pages available at: www.gov.uk/government/publications/road-traffic-statistics-guidance

2. Benchmark Sample

Definitions and additional information

Count Point (CPs)

The location on a road link where a traffic count is performed.

Sample population

The population from which the sample is drawn.

Topographic Identifier (TOID)

A unique ID attributed to an OS Mastermap Highways Network Road Link Feature.

Stratification/ Stratum/Strata

Groups dividing the sample population for stratified sampling.

Road Classification

The categorisation of roads according to the hierarchy and function.

Urban/Rural Classification

Roads located in areas with a population of 10,000 or more are considered Urban. Those with less than 10,000 are Rural.

Due to the large number of minor roads in Great Britain it is not possible to count the traffic flows on all of them. Therefore, a representative sample of points (count points, CPs) on minor roads were selected in 2017 for traffic counts for the minor road traffic benchmarking exercise.

The sample CPs were selected from the sample population, which for this exercise was all carriageway road links of minor roads in Great Britain as at September 2017. These are contained in the Ordnance Survey Mastermap Highways Network product, where each road link is given a unique Topographic Identifier (TOID).

The sample was stratified by local authority, road classification and urban/rural classification.

2.1 The sample design

The total number of CPs for the benchmarking exercise was set at 10,000; the maximum number covered by the budget set for the project. Traffic counts at CPs can be cancelled, rescheduled or deemed unusable, so to account for this the sample was over allocated by 500 sites (n=10,500).

2.1.1 The Neyman Allocation

To optimise the precision of the allocation for the given sample size, the number of CPs in each strata was determined using the Neyman Allocation formula:

$$n_h = [n\ (N_h \times \sigma_h)] / \sum(N_i \times \sigma_i)$$

Where:

n_h = Sample size in stratum h

n = Total sample size (10,500 sites and assume will lose 500 sites over course of 2 years)

N_h = Road length in stratum h

σ_h = Standard deviation of the change in observed flows between 2015 and 2016 in stratum h

$\sum(N_i \times \sigma_i)$ = Sum of the road length multiplied by the standard deviation for each strata

The strata used were local authority, road classification and the urban or rural location. Following this initial allocation, a regional adjustment was applied to correct for low allocations and minimum/maximum allocations within the strata, as follows.

Definitions and additional information

Cul-de-sac

Defined, for this exercise, as any road with a dead-end. These roads are not limited to small residential cul-de-sacs but also include roads such as those leading to industrial estates and train stations.

2.1.2 Regional adjustments and minimum values

Wales and Scotland both had a maximum allocation; 500 counts in Wales and 730 in Scotland, the remainder were allocated to England (9,270). The regional adjustment was applied to firstly ensure that there was a minimum number of 50 CPs in each strata and secondly to ensure that this adjustment for minimum numbers within each strata would not result in exceeding the total allocation to each country.

2.1.3 Cul-de-sac allocation

Once the Neyman allocation and regional adjustments were applied, a total of 70 counts were initially allocated to cul-de-sacs. Cul-de-sacs tend to be very low flow roads and the behaviour of traffic flows on cul-de-sacs is very different to other roads. Therefore, it was important to include a sample of these roads in the benchmarking exercise.

2.2 Sample selection

To select the count point locations, TOIDs were systematically selected from the sample population database of TOIDs within each strata. TOIDs were ordered by length, to help control the length distribution of the selected TOIDs, and the cumulative length was calculated starting with the shortest TOID. The total length was used, alongside the number of TOIDs needed in the sample strata, to give a selection interval (*in*). The first TOID was selected at a random start point, the next TOID had a cumulative length equal to that of the start point plus *in*. This continued until the count allocation was filled and created a probability of selection proportional to TOID length.

1.2.1 Selection interval calculation

$$(\sum L_h) / C_h = in_h$$

Where:
L_h = TOID length within stratum h
C_h = Count of TOIDs in stratum h
in_h = Selection interval for stratum h

The mid-point of each selected TOID was given as the CP. Theoretically there are an infinite number of potential CPs on a TOID, but the mid-point is chosen to give an average level of traffic across all possible CPs. Where possible all counts were carried out at the mid-point, this was only moved due to lack of a suitable observation point or safety concerns.

The proximity of the CPs to other sampled CPs was assessed. CPs were replaced when they were within 100 metres of another sampled CP in the same strata. CPs were also replaced before and during the count season for various reasons, including: safety concerns, very short road links and incorrectly classified roads. In these cases, the next TOID in the same stratum was chosen as the replacement, aiming to select a replacement with similar characteristics.

2.3 The final sample

The total number of benchmark CPs scheduled to be counted during either the 2018 or the 2019 count seasons were 10,767. Of these, 567 CPs were not included in the final sample, 5% of the total, these CPs were excluded for reasons such as enumeration errors and safety concerns of manual enumeration. This level was approximately what had been expected, so the final achieved sample of 10,200 CPs was sufficient. Overall 1,229 of the CPs in the final sample were replacements of original CPs, 12% of the final sample. Of the final 10,200 counts 123 were carried out on cul-de-sacs, this was higher than the initial 70 counts allocated to this type of road.

As shown in Figure 1, the number of counts achieved varied by region, but the proportion of counts in each region was similar to he regional proportion of total minor road length. The South West had the highest proportion of counts at 13.6%, this is similar to the proportion of minor road length in the South West (13%). The North East had the smallest proportion of counts at 4.9%, and this was also similar to the proportion of minor road length that it accounts for (4.2%). The initial allocation aimed for 500 counts in Wales and 730 in Scotland, 511 count in Wales and 725 in Scotland were achieved. These numbers were sufficient for the benchmark traffic estimates to be calculated.

Figure 1: The number of benchmark minor road counts carried out in Great Britain, regionally, 2018 - 2019

Region / Country	Number achieved in sample	Percentage of total sample (%)
North East	502	*4.9*
North West	1155	*11.3*
Yorkshire and the Humber	976	*9.6*
East Midlands	882	*8.6*
West Midlands	906	*8.9*
East of England	1276	*12.5*
London	566	*5.5*
South East	1312	*12.9*
South West	1389	*13.6*
England	**8964**	***87.9***
Scotland	**725**	***7.1***
Wales	**511**	***5.0***
Great Britain	**10200**	***100.0***

3. Estimation Method

Definitions and additional information

AADF

Average Annual Daily Flow, this refers to the average number of vehicles travelling along a given stretch of the road network per day (24 hours).

ATC

Automatic Traffic Counters, these count and classify vehicles passing over them 24 hours a day, on every day of the year.

Expansion Factors

Used in the annual estimation process to attain estimated flows for a 24 hour period, an expansion factor derived from ATC data is applied. (See Appendix A)

Growth factors

Used in the annual estimation process where it is not possible to count at a CP in the current year. A growth factor derived from ATC data is applied to the previous year's AADF to get estimated flows for the current year (see Appendix B)

Traffic counts were conducted at the 10,200 minor road locations during 2018 and 2019.

3.1 Converting count data to daily flows

At each CP in the sample, a 12 hour traffic count was undertaken. These counts used the standard manual count methodology, as used for all manual counts undertaken by DfT. The results of these 12 hour count surveys were converted into an annual average day's 24 hour flow, the AADF. This conversion to an AADF used the standard process of applying expansion factors derived from automatic traffic counter (ATC) data. The expansion factor applied was dependant on the expansion factor strata and the date that the count was carried out on, as it adjusts for traffic variation across the year. See Appendix A for further information about expansion factors.

3.1.1 AADF calculation

$$a_{tx} = c_{tx} \times e_{dx}$$

Where:

a_{tx} = AADF of CP *t* within the expansion factor group *x*
c_{tx} = 12 hour count of CP *t* within expansion factor group *x*
e_{dx} = Expansion factor for the date of the count *d* in expansion factor group *x*

As traffic counts took place over 2018 and 2019, the relevant expansion factors for the year counted were applied.

Following the conversion to an AADF, growth factors were then applied to the 2018 AADFs. This process resulted in a set of AADFs all at 2019 levels, making the resulting traffic estimate more comparable to the 2019 annual traffic estimate. See Appendix B for further information about growth factors.

3.1.2 Growth factor application

$$a_{tz2019} = a_{tz2018} \times g_{dz}$$

Where:

a_{tz2018} = AADF of CP *t* within the growth factor group *z* in 2018
a_{tz2019} = Estimated 2019 AADF of CP *t* within the growth factor group *z*
g_{dz} = Growth factor for the date counted *d* in growth factor group *z*

3.2 Traffic estimation by vehicle type

DfT produce traffic estimates by vehicle type, but when assessing the variation in the AADFs by vehicle type within the benchmark strata, it was deemed inappropriate for traffic estimates using the benchmarking sample to be carried out by separate vehicle type. Specifically, the variance of bus and HGV counts were much higher than that for the 'all motor vehicle' total. As a result, the benchmark traffic estimate and the benchmark adjustment are on an 'all motor vehicle' basis, i.e. the same adjustment will be applied independent of vehicle type.

3.3 Design weighted initial traffic estimate

The initial traffic estimate for a given strata was calculated by aggregating for all CPs: the 2019 AADF multiplied by the 2019 length of the TOID that the CP is on, the number of days in the year and the design weight.

$T_h = \sum_h d_{hk} \, (Y_{2019} \;\; a_{hk} \;\; l_{hk})$

Where:

T_h = Initial traffic estimate for stratum h

d_{hk} = Design weight for CP k in stratum h

Y_{2019} = Number of days in 2019

a_{hk} = AADF for CP k in stratum h

l_{hk} = Length of the TOID at CP k in stratum h

The design weight was used to reverse the probability of selection for a given CP. It was calculated by dividing the total strata length at the point of selection (2017), by the original 2017 length of the TOID that the CP is on, multiplied by the number of CPs originally selected in 2017 in the strata.

$d_{hk} = \Lambda_h / (n_h \times Y_{hk})$

Where:

d_{hk} = The design weight for CP k in stratum h

Λ_h = Total road length as at 2017 in stratum h

n_h = The number of CPs selected in stratum h

Y_{hk} = Original TOID length at CP k in stratum h

3.4 Traffic calibration to full 2019 minor road network

Over time the total length of roads can vary, with new roads built or changes to road classifications. For the benchmark traffic estimate, the original sample was based on the road network as at September 2017, but the traffic estimation calculation was as at 2019 using the achieved sample. Therefore, a calibration factor was calculated to account for this change.

3.4.1 Calculation of road length calibration factors

Each CP's design weight was multiplied by the 2019 TOID length that the CP is on, and then when subsequently summed within the post-strata, this gave the road length estimated on. If road length had not changed between selection and estimation then this would equal the final 2019 road length within the strata. In many cases the TOID length will vary slightly, plus a few CPs were also lost, reducing the road length estimated on. Therefore, dividing this number by the final 2019 road length within the strata gave a calibration factor.

During the calibration steps, in addition to region, road classification and urban/rural classification, the post-strata took into account whether a road was a cul-de-sac. Below is how the calibration factors were calculated. This calculation was used to get calibration factors for both cul-de-sac and non-cul-de-sacs.

$cf_h = \sum_h (l_{hk} \times d_{hk}))/L_h$

Where:

cf_h = Calibration factor applied to traffic in post-stratum *h*
l_{hk} = Length of the TOID at CP *k* in post-stratum *h*
d_{hk} = Design weight for CP *k* in post-stratum *h*
L_h = Total length of road in 2019 in post-stratum *h*

Definitions and additional information

Post-strata/Post-stratum

The final groupings used for the traffic estimates and adjustments. This was by region, road and urban/rural classifications.

3.4.2 Regional cul-de-sac adjustment factors

The number of cul-de-sacs included in the sample was disproportionate to the total road length that they accounted for. As a result, to offset the impact of this under sampling, the traffic on cul-de-sacs within each post-strata was based on the national estimate with an additional regional factor applied. The regional factor was calculated by comparing regional traffic levels per meter road length for non-cul-de-sacs to the national levels.

$rf_{hc} = (T_{hn} / L_{hn}) \div (T_n / L_n)$

Where:

rf_{hc} = Regional factor for cul-de-sac traffic in post-stratum *h*
T_h = Traffic on non-cul-de-sac C and U roads in post-stratum *h*
L_h = Road length of non-cul-de-sac C and U roads in post-stratum *h*
T_n = Total Traffic on non-cul-de-sac C and U roads in Great Britain
L_n = Total Road length of non-cul-de-sac C and U roads in Great Britain

3.5 Final traffic estimate

To create the final traffic estimate, the initial traffic estimates the post-strata level were multiplied by the relevant calibration factors. Traffic on cul-de-sacs was halved to reflect the different pattern of traffic on dead-end roads, where vehicles are less likely to drive the full length of the road.

$T_{bh} = \sum_h [(T_{hn} \times cf_{hn}) + ((T_{hc} \times cf_{hc} \times rf_{hc})/2)]$

Where:

T_{bh} = Benchmark traffic estimate for post-stratum *h*
T_{hn} = Un-calibrated initial traffic estimate for non-cul-de-sacs in post-stratum *h*
cf_{hn} = Calibration factor for non-cul-de-sacs in post-stratum *h*
T_{hc} = Un-calibrated initial traffic estimate for cul-de-sacs in post-stratum *h*
cf_{hc} = Calibration factor for cul-de-sacs in post-stratum *h*
rf_{hc} = Regional factor for cul-de-sac traffic in post-stratum *h*

3.6 Benchmark adjustment

To attain the final benchmarking adjustment, the benchmark traffic estimate was compared to the 2019 annual estimate, which was created using the standard annual methods.

3.6.1 Adjustment factor calculation

$A_h = T_{bh} / T_{ah}$

Where:

A_h = Benchmark adjustment to be applied to post-stratum *h*
T_{bh} = Traffic estimate from the benchmark sample (*b*) in post-stratum *h*
T_{ah} = Traffic estimate from the 2019 annual sample (*a*) in post-stratum *h*

3.7 Providing a consistent back series

The application of the benchmark adjustment is intended to reduce the impact of accumulated error from having a fixed sample in the standard annual methodology. To give a consistent back series with viable year on year comparisons, the benchmark adjustment was applied to the published back series using annual factors. These annual adjustment factors are a geometric series, so the benchmark point adjustment is raised to the power of the factor described below to get each annual adjustment. The annual adjustments for Great Britain can be seen in Figure 2.

3.7.1 Annual adjustment factor calculation

$A_h^{(P-\rho)/P}$

Where:

A_h= Benchmark adjustment to be applied to post-stratum *h*
P = Number of years since the last Benchmark (10)
ρ = Number of years prior to the current benchmark year

Figure 2: Minor road traffic (billion vehicle miles) estimates for Great Britain benchmark adjustments, 2010 - 2019

Year	2019 Fixed annual sample estimate (bvm) [A]	Benchmark traffic estimate (bvm) [B]	Benchmark adjustment [B] / [A]
2010	106.6	108.4	1.02
2011	105.8	109.4	1.03
2012	105.4	110.8	1.05
2013	105.4	112.7	1.07
2014	109.2	118.9	1.09
2015	110.2	122.1	1.11
2016	111.4	125.6	1.13
2017	113.4	130.1	1.15
2018	112.9	131.9	1.17
2019	114.1	135.8	1.19

4. Impact of benchmark

4.1 Impact by region

Overall in Great Britain the benchmark adjustment was 1.19. This adjustment figure varied by both country and region, with Scotland having an overall figure of 1.00, Wales 1.23 and England 1.21. Within England, the level of adjustment varied between 1.09 in the East of England and 1.35 in Yorkshire and the Humber. In all regions the minor road traffic levels increased after benchmarking.

Figure 3: Estimated traffic (billion vehicle miles) by region for 2019 annual and benchmark samples, and regional benchmark adjustments

Region / Country	2019 Fixed annual sample estimate (bvm) [A]	Benchmark traffic estimate (bvm) [B]	Adjustment to benchmark [B]/[A]
North East	4.8	5.8	1.20
North West	11.8	15.4	1.31
Yorkshire and the Humber	9.6	12.9	1.35
East Midlands	9.1	10.7	1.18
West Midlands	10.7	13.2	1.23
East of England	14.1	15.3	1.09
London	7.9	10.4	1.32
South East	17.4	19.7	1.14
South West	12.3	14.5	1.18
England	**97.7**	**118.0**	**1.21**
Scotland	**10.1**	**10.1**	**1.23**
Wales	**6.3**	**7.8**	**1.00**
Great Britain	**114.1**	**135.8**	**1.19**

4.2 Impact by road type

The final adjustments took into account the road classification. The adjustment factors in Figure 4 show a larger adjustment for all ‘B roads’ compared to ‘C roads and other’. The benchmark figure for all ‘B roads’ in Great Britain was 1.25 times greater than the 2019 annual estimate, for ‘C roads and other’ this was 1.17.

Figure 4: Estimated traffic (billion vehicle miles) by road classification for 2019 annual and benchmark, and benchmark adjustments by road type

Region / Country	2019 Fixed annual sample estimate (bvm) [A]	Benchmark traffic estimate (bvm) [B]	Adjustment to benchmark [B]/[A]
B Roads	23.9	30.0	1.25
C roads & other	90.1	105.8	1.17
All minor roads	**114.1**	**135.8**	**1.19**

4.3 Impact by urban or rural location

The adjustments at Great Britain level for all urban and rural minor roads can be seen in Figure 5. Overall the adjustment for urban roads was 1.22, and for rural roads it was 1.15.

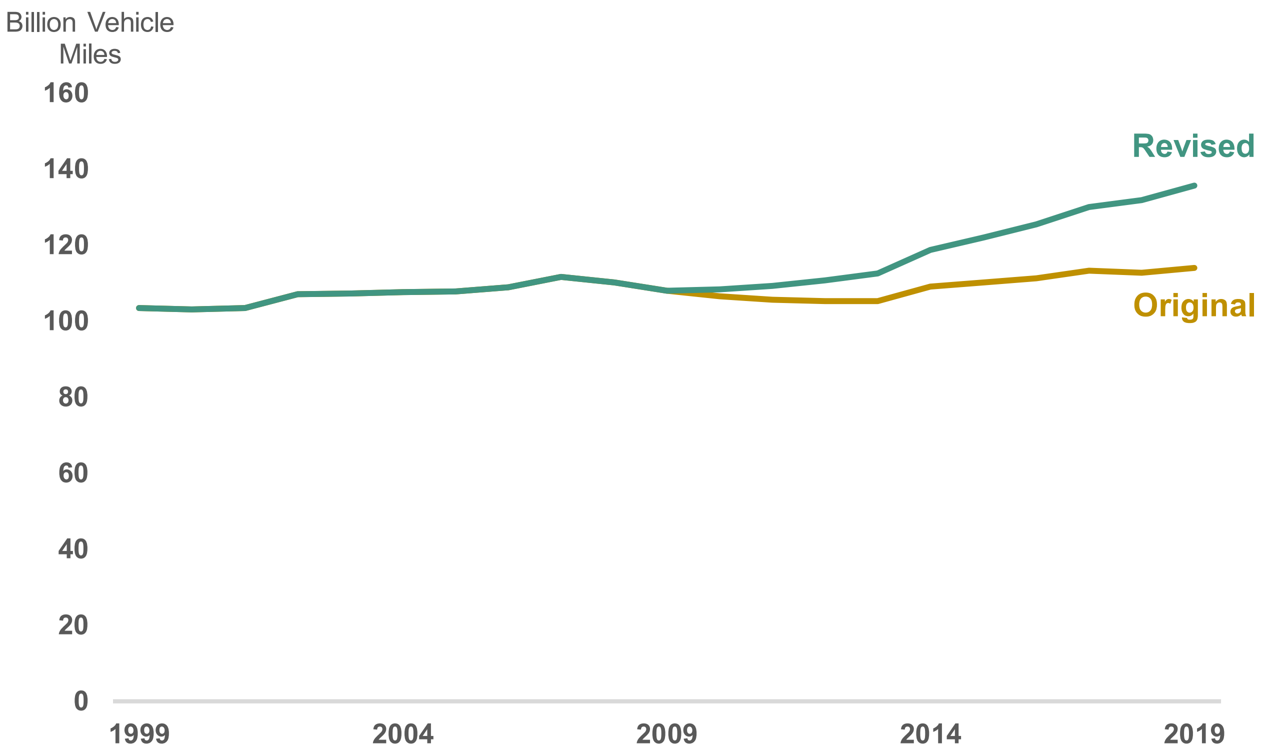
Figure 5: Estimated traffic (billion vehicle miles) by urban or rural location for 2019 annual and benchmark, and benchmark adjustments for urban and rural roads

Region / Country	2019 Fixed annual sample estimate (bvm) [A]	Benchmark traffic estimate (bvm) [B]	Adjustment to benchmark [B]/[A]
Urban	68.2	83.2	1.22
Rural	45.9	52.6	1.15
All minor roads	**114.1**	**135.8**	**1.19**

4.4 Impact on the back series

The overall impact of the adjustments applied over the last 10 years can be seen in Figure 6. The original series showed a 6% increase in traffic on minor roads between 2009 and 2019. The revised series, on which the benchmark adjustments have been applied, shows a 26% increase in traffic over the same time period.

Figure 6: Estimated minor road traffic (billion vehicle miles) in Great Britain before and after applying the benchmark adjustment, 1999 - 2019



Technical note

Historic and 2019 road traffic estimates can be found in 'Road traffic estimates in Great Britain: 2019': https://www.gov.uk/government/statistics/road-traffic-estimates-in-great-britain-2019

4.5 Strengths and Weaknesses

Strengths

- ► The benchmark traffic estimate for minor roads is calculated from a new larger sample. This will mitigate error accumulated in the rolled over and grown traffic estimate.
- ► The 2019 exercise includes Scotland, in the 2008/9 exercise Scotland was excluded, meaning Scotland's traffic estimates will be refreshed for the first time in 20 years. As a result, Scotland's traffic estimates for 2010-2019 are more comparable to the rest of Great Britain.
- ► Applying the benchmark adjustments over the last 10 years gives a more comparable back series and mitigates the chance of error accumulated from the fixed sample.
- ► In addition to region, the 2019 benchmark adjustments take into account road classification and urban or rural location. This more granular breakdown should allow for greater accuracy in the breakdowns presented in the published minor road estimates.

Weaknesses

- ► The benchmark traffic estimate has been produced from a sample. The sample was selected to best represent all minor roads in Great Britain, but this does not eliminate potential error. As such, the changes seen between the standard 2019 estimate and the benchmark estimate could partly be due to the different sample.
- ► Although Scotland's inclusion allows 2010-2019 traffic estimates to be comparable to the rest of Great Britain, this does leave the 2000-2009 Scotland figures unadjusted. As 2000-2009 figures remain unadjusted there is a greater risk of error from the fixed sample in these years.
- ► Applying the benchmark adjustments over the last 10 years gives a more comparable back series but does make some assumptions. The key assumption is that traffic growth is gradual over time and there are systematic increases year on year.
- ► Compared to the 2010-2019 fixed annual sample, the benchmark sample had a lower proportion of 'B' roads and a greater proportion of rural roads, both of which could have an impact on the overall estimate.
- ► The proportion of cul-de-sacs in the sample was not fully representative of the minor road network. Although additional adjustments have been used to give a more accurate level of traffic on cul-de-sacs, the small sample size does allow greater room for error.

5. New 2020 minor roads sample

As a result of the benchmarking exercise the minor road panel sample for 2020 has been revised, and will remain fixed for the next 10 years. This sample was chosen from the CPs used during the benchmark. The revision of the sample from the benchmark enables us to continue to use the standard annual methodologies and reduce any error incurred by having a fixed sample.

5.1 How was the new annual sample drawn

To select a new annual sample, a subset of count points were drawn from the benchmark sample. The sample was stratified by local authority, road classification and rural/urban classification.

The total number of CPs for the 2020 minor roads sample was 4,411. The final benchmark sample was 10,200 CPs. After adjusting for low flow and cul-de-sac CPs (see next section), the same proportion of CPs were systematically randomly selected from each strata.

5.1.1 Non-cul-de-sac selection for the counted 2020 sample

$N_h = n_h \times p$ *where* $p = ((N - N_c) / (n - n_c - l))$

Where:

- N_h = Sample size for 2020 minor traffic sample in stratum h
- n_h = Benchmark sample size in stratum h
- p = Proportion of each benchmark strata
- n_c = Benchmark cul-de-sac sample size
- N = Counted sample size for 2020 minor traffic sample
- N_c = Cul-de-sac sample size in 2020 minor traffic sample
- n = Total benchmark sample size
- l = Number of low flow sites in the benchmark sample

5.2 Low flow CPs and Cul-de-sacs in the annual sample

Very low flow and cul-de-sac CPs were selected separately, to ensure they were represented in the annual 2020 minor roads sample. To increase the representation of cul-de-sacs in the sample, approximately 170 additional cul-de-sac sites have been added to the 2020 sample. To avoid producing a biased sample, a proportion of these low flow CPs will be used in the traffic estimation process each year. The low flow CPs, along with a subset of cul-de-sacs, will not be counted on but their traffic levels will instead be estimated by applying growth factors.

5.2.1 Calculating the number of low flow sites grown year on year

$L = l \times (N / (n + c))$

Where:

- L = Number of low flow sites included in 2020 minor traffic sample
- N = Total sample size for 2020 minor traffic sample
- l = Number of low flow sites in the benchmark
- n = Total benchmark sample size
- c = Number of additional cul-de-sacs added to sample

Appendix A: Expansion Factors

Expansion factors are used to convert 12 hour manual counts into flows for an average 24 hour period in the given year. On minor roads there are three expansion factor categories, allocated by location.

Expansion factors are calculated from Automatic Traffic Counter data. To produce an expansion factor, the count at each ATC for every day of the year are split into day-time and night-time. The total count for the year is divided by the given day-time count and the number of days in the year, giving an expansion factor for that day. The median expansion factor for all ATCs within each expansion factor category is then calculated for each day.

Expansion factor calculation

$e_{xd} = median_x (f_{at} / (f_{ad} \times n))$

Where:

e_{sd} = Expansion factor for category *x* on day *d*
f_{at} = Total (*t*) daily flows for site *a* in the given year
f_{ad} = Day-time (7am-7pm) daily flows for site *a* on day *d*
n = Number of days in the given year

Appendix B: Growth Factors

Growth factors are normally applied when sites cannot be counted in the current year. For the benchmark, the traffic counts were carried out over 2 years, 2018 and 2019. To calculate a 2019 benchmark traffic estimate, 2018 AADFs had growth factors applied to them.

Growth factors are produced from Automatic Traffic Counter data, by comparing the reference year and the previous year's level of traffic within each growth factor category. This produces a rate of change which is applied as a growth factor. There are four growth factor categories for minor roads which are based on the road category and location.

Growth factor calculation

$g_x = t_{xp} / t_{xc}$

Where:

g_x = Growth factor in category *x*
t_{xp} = Traffic in category *x* for the previous year *p*
t_{xc} = Traffic in category *x* for the current year *c*

DfT is grateful to Charles Lound from the Office for National Statistics (ONS) Methodology Advisory Service (MAS) for his input, advice and peer-review

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