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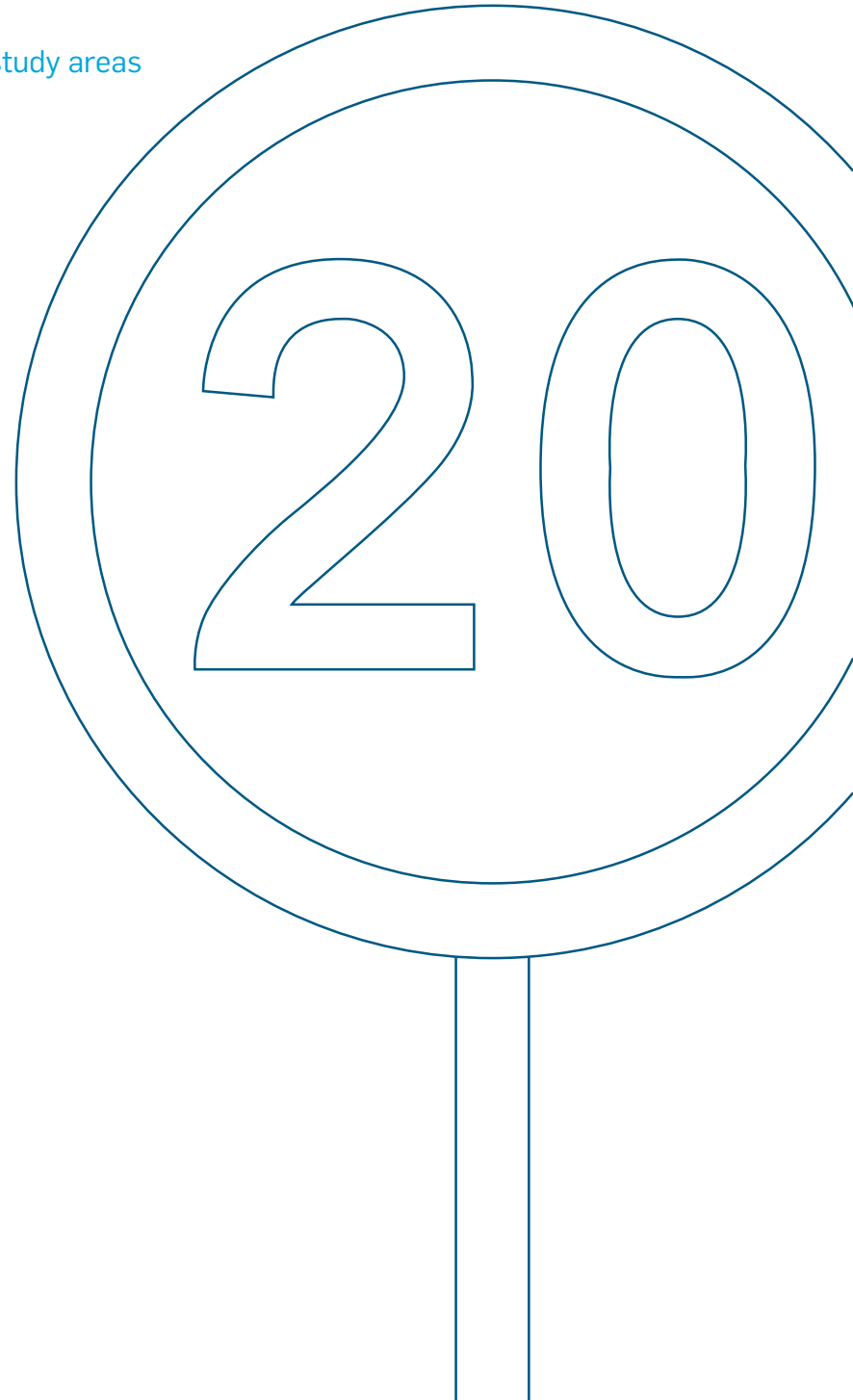
20mph Research Study

Supporting Technical Appendix
Analysis of GPS journey speeds in case study areas

November 2018

Report by Atkins, AECOM, and Professor Mike Maher (UCL)



Notice

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Document history

Job number: 5133131			**Document ref:**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 0.4	Draft report template	RF	JR	JR	JR	01/12/16
V1	Initial draft for DfT review	SC	-	-	-	-
V2	Draft for DfT review	SC	RF	RF	JR	16/01/17
V3	Response to DfT comments	SC	NN	RF	JR	03/03/17
V3.4	Road lengths updated	JR	-	-	-	26/05/17
V3.5	Minor updates, to ensure consistency with Spot Speed Report	JR	-	-	-	19/06/17
V3.6	S1.6 updated with 2016 freeflow speed data	JR	-	-	-	29/06/17
V3.7	Reference to Bristol Evaluation Study included	JR	-	-	-	15/02/18
V4.0	Updated data for Liverpool and Nottingham	SC	RF	JR	JR	25/04/18
V5.0	With comparator analysis	RF, SC	RF, JR	JR, MM	JR	04/05/18
V7.0	Final	-	-	-	JR	28/08/18

Analysis spreadsheet for each of the residential, city centre areas are here (see sub folders):
P:\GBBMA\HandT\CS\Projects\5133131- Provision of 20mph Research\40 Technical\Task 3.6 Speed Data\3. Tomtom\7. Area Outputs and Analysis

Graphs for reporting are found here:
P:\GBBMA\HandT\CS\Projects\5133131- Provision of 20mph Research\40 Technical\Task 3.6 Speed Data\3. Tomtom\9. Report\REPORT GRAPHS.xls

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1. Introduction

1.1. Background

Atkins, Aecom and Professor Mike Maher were commissioned by the Department for Transport (DfT) in 2014, to address a gap in the evidence available on the effectiveness of 20mph speed limit (signed only) schemes. Whilst there is evidence suggesting that 20mph zones are effective in reducing collisions and speeds (as well as leading to other benefits), there is an evidence gap on the effectiveness of 20mph speed limits (i.e. 20mph limits with no physical traffic calming measures). The research is intended to inform future DfT policy development on 20mph speed limits, and influence scheme development and delivery.

A key element of the study involves examining the impact of 20mph limits on speeds in the 12 case study areas which form the basis for the research, using a variety of data sources:

- area-wide speed data from in-car GPS devices in each of the case study areas;
- spot speed data collected by local authorities representing the 12 case study areas, using inductive loops, radar devices or similar technology;
- questionnaire responses from residents and drivers in each of the case study areas; and
- focus group responses.

This document reports on the analysis of speed outcomes in 20mph limit areas using GPS vehicle data for the 12 case study areas selected for this research. The results from other areas of analysis are reported separately, and will be brought together in the Final Report for the study.

20mph limits and 20mph zones

There are two distinct types of 20mph schemes:

- 20mph limits - indicated by speed limit (and repeater) signs only; and
- 20mph zones - designed to be 'self-enforcing' through the introduction of traffic calming measures (e.g. speed humps, chicanes).

The study is primarily interested in looking at speed outcomes (e.g. % compliance, median speed, speed profile) of **new 20mph limits (signed only)**. However, in some cases, the limits were introduced in areas with existing traffic calming, enabling a comparison of the outcomes associated with the two approaches to be undertaken.

In addition, most case studies had some existing 20mph limits or zones in place. These areas provide contextual evidence of the broader decline/increase in speeds that may be happening in the area, in the absence of any speed limit change; and enable levels of compliance to be compared.

None of the case studies contain new 20mph zones (involving the introduction of a lower limit at the same time as new physical traffic calming measures). This was not the purpose of the research, and the outcomes of 20mph zones have been covered in other research studies.

Case study scheme typologies

The twelve case studies have been categorised into the following scheme typologies:

- Predominantly residential and schools – small scale standalone: Walsall (Rushall) and Winchester (Stanmore).
- Predominantly residential and schools – area-wide: Liverpool (Area 7), Liverpool (Area 2), Middlesbrough, Calderdale (Phase 1), Nottingham (Area 3), Brighton (Phase 2), Portsmouth, Chichester.
- City or town centre and adjacent residential areas: Brighton (Phase 1), Winchester (City Centre).

1.2. Summary of existing evidence on speeds in 20mph zones and limits

1.2.1. Evidence on 20mph zone

Since the publication Circular Roads 4/90 by the Department for Transport in December 1990, local traffic authorities have been able to implement 20mph speed limit zones – comprising a 20mph limit and physical traffic calming measures such as speed humps, chicanes, and raised junctions.

Two extensive studies undertaken by the Transport Research Laboratory (Webster & Mackie, 1996[1]; and Webster and Layfield, 2003[2]) suggest that 20mph zones can result in substantial reductions in average speed of around 9mph. In both studies, the average before speeds for these schemes were around 25mph, dropping to well below 20mph post implementation.

- Webster & Mackie (1996) researched the before and after speeds of 20mph zones across England, implemented in the early 1990s.

  At the time, Circular 4/90 stated that 20mph zones could only be implemented if traffic calming was installed as part of the scheme or if a short stretch of road had a significant reason for speed reduction (for example high incident rate). Schemes were initially implemented for a temporary period of up to 18 months. Authorities were not required to undertake speed measurements prior to scheme implementation, but in order for a scheme to be granted permanent status by the then Department of Transport, it had to be demonstrated that the average speed in the area had dropped to 20mph or below at two or more representative locations within the zone area.

  At the time of the study, 200 schemes had been installed in the UK, and 82 had been granted permanent status. The most quoted reason for applying for authorisation was accident reduction. The average length of road included within zone areas was 2.5km. About 80% were in residential areas, with the remainder in shopping and commercial areas.

  Of the 200 zones considered within the study, before and after speed data had been collected for 32 schemes. This showed an average reduction in speed of 9.3mph, from 25.2mph to 15.9mph (see Figure 1-1). The report also found that traffic flow reduced by 27% within zones and increased by 12% outside the zones, although data was only available for 19 schemes, and not necessarily the same schemes as those included in the speed data analysis.

- A similar study of 20mph zones in London was undertaken by Webster and Layfield in 2003.

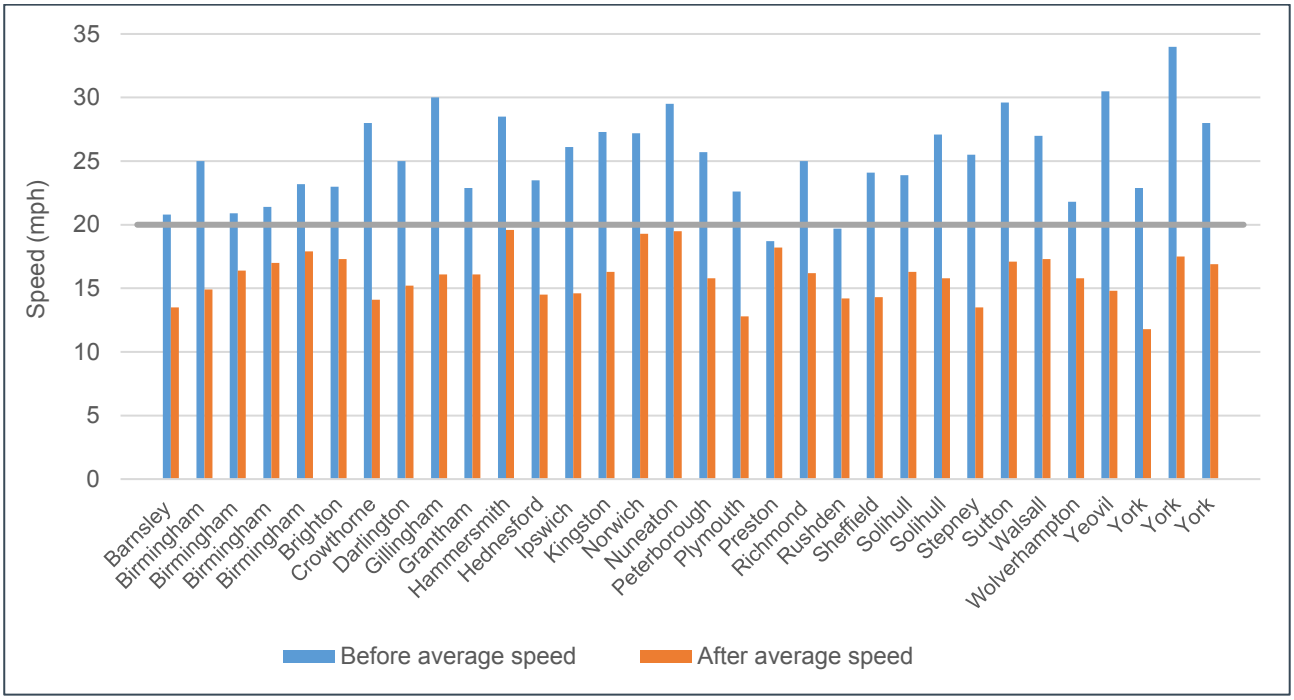
  In 1999, the Road Traffic Regulation Act was amended to allow local authorities to designate 20mph speed limits without prior approval of the Secretary of State. Two distinct types of 20mph speed limits were made possible: 20mph limits indicated by speed limit and repeater signs only, and 20mph zones designed to be self-enforcing through the introduction of physical traffic calming measures.

  Initial contact with the London Boroughs indicated that the number of 20mph zones being installed in London had increased from 5 per year (up to 1999) to over 30 per year by 2002, with 137 zones in place at the time of the study. Most of the zones were in residential areas, with over half containing schools and colleges. The average length of road in each zone was 3.4km.

  Before and after speed data was only available for 14 of the schemes. The data showed average traffic speed reductions of 9.1mph following implementation. The report does not provide the before and after speeds for these schemes, but does report an average after speed of 16.6mph across 22 schemes, suggesting average speeds before implementation were around 25mph. Traffic flow reduced by an average of 15% in the 11 schemes for which flow data was available.

[1] Webster, D.C and Mackie, A. M (1996*); Review of Traffic Calming Schemes in 20mph Zones*. Road Safety Division. Transport Research Laboratory.
[2] Webster, D.C and Layfield, R.E (2003); Review of 20mph Zones In London Boroughs. Transport Research Laboratory.

Figure 1-1 Before and after average speeds for thirty-two 20mph zones implemented across England in the early 1990s (Webster and Mackie, 1996)



Furthermore, Allot & Lomax in a report for DETR (2001)[3] investigated speed impacts in six 20mph zones in the north west of England. They found mean speeds fell by 8.7mph in traffic calmed locations, and by 5.5mph at locations in between.

The above UK findings are supported by similar findings from Northern Europe. For example, research by Engel & Thomsen (1992)[4] in Denmark reported mean speed reductions of 11km/h as a result of the traffic calmed 30km/h streets. In addition, Janssen (1991) (cited in Toy et al. 2012[5]) reported that average speeds fell by 22% in two large demonstration projects (Eindhoven and Rijswijk) implemented in the Netherlands in the 1970s.

Other research has been undertaken, but there seems to be a lack of clarity about whether the evidence relates to pure zones, pure speed limits or hybrid schemes (see Rapid Evidence Review for further information).

1.2.2. Evidence on 20mph limits (signed only)

Evidence available on UK signed only schemes, at the time this study was commissioned, was more limited.

- Between 1998 and 2000, a national trial programme of *advisory 20mph speed limits* was undertaken, involving 75 residential areas across Scotland. Burns et al. (2001)[6] analysed the impact of the *advisory limits* over 18-24 months after they were implemented. The overall average speed reduction was 1.2mph (from 23.4mph before the scheme was introduced to 22.2mph after). The closer the average speed of the road was to 20mph, the smaller the reduction in the average speed. The 85th percentile speed dropped by an average of 1.1mph (from 29.4mph to 28.3mph), with smaller reductions where the before 85th percentile was closer to 20mph.

[3] Department of the Environment, Transport and the Regions (DETR) (2001) Urban Street Activity in 20mph zones – Final Report (Allott & Lomax – Babtie Group)
[4] Engel U. & Thomsen L.K. (1992) Safety effects of speed reducing measures in Danish residential areas in Accident Analysis & Prevention, 24(1)
5 Toy et al. (2012) Delivering soft measures to support signs-only 20mph limits, UWE Bristol
6 Burns, A et al (2001) 20mph Speed Reduction Initiative. Scottish Executive Central Research Unit and Society of Chief Officers of Transportation in Scotland (SCOTS)

- An early evaluation of the city-wide scheme implemented in Portsmouth in 2008-09 (Atkins, 2010)[7] reported an average speed reduction of 1.3mph (from 19.8mph to 18.5mph). The biggest reductions speed occurred at sites with higher before speeds: less than 20mph = -0.7mph, 20-24mph = -2.3mph, more than 24mph = -7.4mph.

- In 2010, Bristol City Council implemented 20mph pilots in Inner South and Inner East Bristol, covering some 500 roads and 30,000 households. The monitoring and evaluation report (BCC, 2012)8 reported slight reductions in mean average speeds of between 0.9mph (23.6mph to 22.7mph) in Inner South Bristol and 0.5mph (23.4mph to 22.9mph) in Inner East Bristol.

  A further evaluation study was published in early 2018[9], following the roll out of 20mph limits across the remainder of the city. Analysis of area-wide Trafficmaster GPS data for six months before and six months after the introduction of 20mph limits showed a 0.8mph reduction in average speed, but was not supported by statistical analysis or comparison against background trends. Spot speed data from automatic traffic counts showed a statistically significant 2.7mph decrease in vehicle speeds on roads where the 20mph speed limit was introduced, when controlling for other factors that might affect speed (areas, calendar year, time of day, season, type of road, and day of week). The largest reduction in speed was on 20mph A and B roads.

- In 2012, Edinburgh City Council implemented a pilot 20mph Limit (signed only) in South Edinburgh. Forty-eight 'before' speed surveys were undertaken across a sample of street locations in the pilot area, including streets on the external boundary. Surveys were undertaken at the same locations after implementation. Of these, 20 locations remained with a 30mph limit, while 28 locations changed to the new 20mph limit. The evaluation report (ECC, 2013)[10] shows a reduction in average speeds of 1.9mph (from 22.8 to 20.9mph) at the sites where the speed limit reduced to 20mph. After speeds also reduced at the 20 locations that retained a 30mph limit, the reduction was only 0.8mph (to 25.4mph) - less than the fall witnessed across 20mph limit streets.

In continental Europe, 30kph (~20mph) speed limits, with and without physical traffic calming measures, have been more common place in recent decades, and this provides some further evidence on the effectiveness of signed only limits.

- Mackie (1998)[11] reviewed research undertaken by Pfundt et al (1989) into the effects/outcomes of twenty-four 30kph schemes with traffic calming measures against thirty-six 30kph schemes without any physical measures (signs only). The analysis showed reductions in the 85th percentile vehicle speeds in signed only schemes averaged just 1kph, compared to 4kph for schemes with traffic calming measures. The average before speed for both sets of schemes was 48kph.

- In Europe, the city of Graz in Austria introduced a city-wide 30kph trial between 1992 and 1994 which covered approximately 75% of the total road network. The trial was part of a city wide traffic plan which included a strategy to promote walking, cycling and public transport through improving infrastructure and an education/awareness campaign to limit the volume and speed of traffic in the city. Research by Wernsperger and Sammer (1995)[12] showed that the average and 85th percentile speeds dropped immediately at the commencement of the trial (from 46.9kmph to 42.7kmph). There was a sharp reduction in the higher speeds, with the proportion travelling at more than 50kph in the 30kph limits falling from 7.3% to 3%. However by 2002, the mean and 85th percentile speeds had increased and the speed reduction was only 0.4kph for mean speeds and 1.9kph for 85th percentile speeds (Fischer, 2010)[13].

[7] Atkins and Portsmouth City Council (2010); Interim Evaluation of the Implementation of 20 mph Speed Limits in Portsmouth, Department for Transport.
[8] Bristol City Council, (2012), *20mph speed limit pilot areas: Monitoring Report*.
[9] Pilkington P et al. (2018), Bristol Twenty Miles Per Hour Limit Evaluation (BRITE) Study: Analysis of the 20mph Rollout Project, University of the West of England.
[10] Edinburgh City Council (2013); South Central Edinburgh 20mph Limit Pilot Evaluation, Transport and Environment Committee, 27th August 2013.
[11] Mackie A M (1998); Urban speed Management Methods, TRL Report 363, Transport Research Laboratory, Crowthorne.
[12] Wernsperger, F and Sammer, G (1995); Results of the scientific investigation accompanying the pilot trial of 30 kph limit in side streets and 50 kph limit in priority streets. Transport Research Laboratory.
[13] Fischer, T (2010); Traffic Safety in Graz, Reggio Emilia.

Summary of findings

Existing research suggests 20mph zones can achieve substantial reductions in average speed, of around 9-10mph. This evidence is largely based on schemes which are small scale (typically covering a few kms of road length), have a before speed well above 20mph (typically around 25mph), and were implemented in the 1990s and early 2000s primarily to address location-specific safety issues.

Evidence for 20mph limits, although more limited, suggests that signed only schemes deliver much smaller reductions in average speed (typically around 1-2mph). The schemes involved tend to be large area-wide initiatives, with lower before speeds (closer to 20mph), and have been introduced to deliver an area-wide change rather than address location-specific issues.

This evidence provides a benchmark against which the results from this study can be compared.

1.3. Structure of report

The remainder of this report has been structured as follows.

Chapter 2 sets out the research themes and hypotheses to be examined.

Chapter 3 provides a description of the GPS data used for the analysis, and sets out the overall methodology. Further information is presented in Appendix A, and details of the quality assurance process are set out in Appendix C.

Chapters 4-6 set out the key findings from the analysis, by theme:

- Chapter 4 looks at the impact of **new 20mph limits (signed only**) on speed compliance and profile. These roads represent the core focus for this research study. The results are presented separately for predominantly residential and city centre case studies; reflecting the different road environments (e.g. function, geometry, volume of traffic), journey characteristics, and potentially different driving behaviours in the two types of areas. A statistical comparison with the change in speed a set of comparator areas is also presented, to estimate whether the change in speed in the 20mph limit case study areas is likely to be due to the introduction of the 20mph limit, or part of a wider trend in speeds affecting both 20mph and 30mph roads.

- Chapter 5 examines how the effectiveness of **20mph limits (signed only)** varies over time, based on the Portsmouth case study. This scheme was implemented substantially earlier than other case study schemes, enabling long term analysis to be undertaken (comparing outcomes one year and seven years' post implementation).

- Chapter 6 compares outcomes in the **new 20mph limits (signed only)** with those on:
  - other 20mph roads - new 20mph limits (existing calming), old 20mph limits (signed only), old 20mph limits (with calming); and
  - 30mph and 40mph roads within the study areas.

  Contextual evidence of the broader decline/increase in speeds that may be happening in the area and in the absence of any speed limit change will help interpret the observed change on new 20mph limits (signed only). For example, it may identify whether drivers are generally becoming speed conditioned and driving more slowly on all roads, or whether they are they driving faster on 30mph and 40mph roads to catch-up time lost on the now slower 20mph roads.

  This evidence also enables levels of compliance on different types of 20mph roads to be compared, for example, to understand if signed only limits are as effective as those with traffic calming in place to encourage speed compliance.

Finally, Chapter 7 sets out the conclusions, structured around the research hypotheses.

Area specific results are presented in Appendix B.

2. Research themes and hypotheses

2.1. Introduction

A number of research themes have been identified from the logic maps developed as part of the wider study methodology, in order to provide focus to the analysis. These are summarised in **Error! Reference source not found.**, along with the relevant data sources.

The key research themes to be addressed using the GPS vehicle data are:

- % compliance
- Median speed
- Speed profile (i.e. the distribution of speeds)
- Relationship between after speeds and characteristics of area
- Effectiveness of 20mph limits over time
- Speed displacement impacts
- Effectiveness of 20mph limits versus 20mph zones

The detailed hypotheses to be tested are shown in Table 2-1, and are addressed in the relevant chapters later in this report.

Where possible, outcomes in the new 20mph limits (signed only) will be compared with those on:

- other 20mph roads - new 20mph limits (existing calming), old 20mph limits (signed only), old 20mph limits (with calming); and
- 30 and 40mph roads within the study areas.

Contextual evidence of the broader decline / increase in speeds that may be happening in the area, in the absence of any speed limit change, will help interpret the observed change on new 20mph limits (signed only). For example, it may identify whether drivers are generally becoming speed conditioned and driving more slowly on all roads, or whether they are they driving faster on 30 and 40mph roads to catch-up time.

It will also enable levels of compliance on different types of 20mph roads to be compared.

Table 2-1 Research themes to be examined

Theme	Description	GPS vehicle data	Local authority spot speed data	Residents' and drivers' questionnaires
1. % compliance	- Before vs. after compliance - Level of compliance - Relationship between compliance and before speed - Relationship between compliance and time of day (as proxy measure for volume of traffic)	✓ *(Based on before and after comparison of area-wide data)*	✓ *(Where speeds are reported using appropriate speed bands, e.g. Portsmouth, Winchester Stanmore, Winchester City Centre)*	✓ *(Based on reported driver behaviour responses)*
2. Average speed	- Change in average speed - Relationship between before speed and change in average speed	✓ *(Based on before and after comparison of area-wide data)*	✓	✓ *(Based on perceived changes in driver behaviour)*
3. Speed profile	- Overall profile - Top and bottom percentile speeds - Proportion driving at 20mph, 24mph, 30mph (or similar) [14]	✓ *(Based on before and after comparison of area-wide data, interpolated from data regarding each 5th percentile speed)*	✓ *(Where speeds are reported using appropriate speed bands, e.g. Portsmouth, Winchester Stanmore, Winchester City Centre)*	✓ *(Based on perceived changes in driver behaviour)*
4. Relationship between after speeds and characteristics of area	- Change in % compliance, average speed and 85th percentile speeds by (i) Functional Road Class, (ii) land use type, and (iii) street environment (based on road width, distance from road to houses, age of housing, amount of greenspace, etc.).	✓ *(Based on before and after comparison of area-wide data, by Functional Road Class)*	✓ *(By analysing images of the road environment for locations demonstrating good or poor compliance)*	✓ *(Based on use of regression analysis to determine association between street environment and perceived changes in driver behaviour)*

[14] Threshold values of less than or equal to 20mph, over 24mph and over 30mph have been selected for the following reasons:

- less than or equal to 20mph – to test compliance with the new limit;
- over 24mph – to examine to what extent self-enforcement is it effective over 24mph and below 24mph (Research Question 3a), and to test existing guidance (DfT Circular 2013/01) regarding the likelihood of 20mph limits being self-enforcing; and
- over 30mph – to reflect the previous speed limit and test what impact the new limit has had on the proportion driving at speeds which are no longer considered appropriate for the environment (also the fastest drivers).

Note - Circular (01/2013, DfT), Setting Local Speed Limits states that if the mean speed is already at or below 24mph on a road, introducing a 20mph speed limit through signage alone is likely to lead to general compliance with the new speed limit.

Theme	Description	GPS vehicle data	Local authority spot speed data	Residents' and drivers' questionnaires
5. Effectiveness of 20mph limits over time	- Change in % compliance, median speed, speed profile and 85th percentile speeds over time	✓ *(Based on 1 year and 7 year post implementation data for Portsmouth only)*	×	×
6. Relationship between after speeds and socio-demographic factors or driver behaviour	- Change in % compliance, average speed and 85th percentile speeds by (i) gender-age-affluence (ii) typical compliance behaviour, and (iii) local/regular drivers.	×	×	✓ *(Based on use of regression analysis to determine association between street environment and perceived changes in driver behaviour)*
7. Relationship between after speeds and levels of support/awareness	- Change in % compliance, average speed and 85th percentile speeds by (i) levels of support (ii) awareness of 20mph limits.	×	×	✓ *(Based on use of regression analysis to determine association between street environment and perceived changes in driver behaviour)*
8. Accuracy of perceptions about speed	- On problem streets with on-going speeding issues	×	✓ *(Based on analysis of speed data collected for roads identified as having on-going speeding problems - e.g. Portsmouth, Middlesbrough)*	×
9. Speed displacement impacts	- Change in speed compliance on surrounding roads: (i) other residential streets with 30mph limits (ii) strategic routes.	✓ *(Based on before and after comparison of area-wide data)*	× *(No case study authority has collected data for parallel 20mph roads)*	✓ *(Based on perceived changes in driver behaviour)*
10. Effectiveness of 20mph limits versus 20mph zones	- How do outcomes (e.g. % compliance) of 20mph speed limits compare with those in similar 20mph zones?	✓ *(Based on before and after comparison of area-wide data, by type of 20mph limit)*	✓ *(Where appropriate monitoring data is available)*	✓ *(Indirectly, based on perceived need for traffic calming)*

Table 2-2 Detailed hypotheses to be addressed using the GPS vehicle data

Theme	Description	Hypothesis to be tested
1. % compliance	Before vs. after compliance	H_0: There is no noticeable change in the % compliance with the speed limit following 20mph implementation (i.e. % complying with 30mph before vs. % complying with 20mph limit after). H_1: There is a noticeable change in the % compliance e.g. higher or lower compliance compared to 20mph limit.
	Level of compliance	H_0: The majority of drivers comply with the 20mph limit. H_1: The majority of drivers' travel (i) more than 20mph; (ii) between 20 and 24mph; (iii) more than 24mph.
	Relationship between compliance and before speed	H_0: There is no relationship between levels of compliance and before speeds. H_1: Levels of compliance vary according to before speeds (e.g. compliance is highest where before speeds are lowest or less than 24mph).
	Relationship between compliance and time of day	H_0: There is no variation in compliance by time of day. H_1: Levels of compliance vary by time of day (e.g. due to the impact of traffic volume, and different behaviours at different times of the day).
2. Median speed	Change in average speed	H_0: There is no noticeable change in average speed following 20mph implementation. H_1: There is a noticeable reduction in average speed following 20mph implementation.
	Relationship between before speed and change in average speed	H_0: There is no noticeable relationship between before speed and change in average speed – i.e. the mph or % reduction is similar across the range of before speeds. H_1: The biggest/smallest change in average speed occurs on roads with highest/lowest before speeds.
3. Speed profile	Overall profile	H_0: There is no noticeable change in the profile of speeds following 20mph implementation. H_1: There is a noticeable change following 20mph implementation towards a flatter profile (i.e. smaller standard deviation/smaller inter-quartile range/more people driving closer to the average).
	Top and bottom percentile speeds	H_0: There is no noticeable change in the 85th percentile speeds. H_1: There is a noticeable reduction in the 85th percentile speeds.
	Proportion driving at 20mph, 24mph, 30mph (or similar)	H_0: There has been no change in the proportion of drivers travelling (i) less than 20mph; (ii) less than 24mph; (iii) less than 30mph. H_1: There has been a noticeable reduction in the proportion of drivers travelling at these speeds.
4. Relationship between after speeds and characteristics of area	Change in % compliance, median speed and 85th percentile speeds by (i) Functional Road Class, (ii) land use type, (iii) street environment.	H_0: There is no relationship between % compliance, median speed and 85th percentile speeds and (i) Functional Road Class, H_1: Levels of compliance, etc. vary by Functional Road Class.
5. Effectiveness of 20mph limits over time (in Portsmouth)	Change in % compliance, median speed and 85th percentile speeds over time	H_0: There is no variation in % compliance, median speed and 85th percentile speeds over time. H_1: % compliance, median speed and 85th percentile speeds increase/reduce over time.

Theme	Description	Hypothesis to be tested
6. Relationship between after speeds and socio-demographic factors or driver behaviour	Change in % compliance, median speed and 85th percentile speeds by (i) gender-age-affluence (ii) typical compliance behaviour, and (iii) local/regular drivers.	-
7. Relationship between after speeds and levels of support/awareness	Change in % compliance, median speed and 85th percentile speeds by (i) levels of support (ii) awareness of 20mph limits.	-
8. Accuracy of perceptions about speed	On problem streets with on-going speeding issues	-
9. Speed displacement impacts	Change in speed compliance on surrounding roads: i) other residential streets with 30mph limits (ii) strategic routes.	H_0: There is no change in speed compliance on surrounding roads: (i) other residential streets with 30mph limits (ii) strategic routes. H_1: Speeds increase/decrease on surrounding residential streets with 30mph limits. H_2: Speeds increase/decrease on nearby strategic routes.
10. Effectiveness of 20mph limits versus 20mph zones	How do outcomes (e.g. % compliance) of 20mph speed limits compare with those in similar 20mph zones?	H_0: There is no variation in % compliance, median speed and 85th percentile speeds by type of 20mph limit. H_1: % compliance, median speed and 85th percentile speeds are more/less effective in 20mph signed only limits.

3. Methodology approach

3.1. Introduction

This analysis has been undertaken using GPS data from TomTom's Traffic Stats database. In general, data has been purchased for one year before and one year after the introduction of 20mph limits, with the after data starting at least 6 months after implementation to allow time for the scheme outcomes to settle.

TomTom stores second-by-second probe data from all TomTom GPS devices where users voluntarily and explicitly agree to share the journey time statistics anonymously. All TomTom navigation systems record their location each second, and this data can be uploaded to TomTom either automatically (in the case of connected devices) or during the installation of periodic software updates when connected to a personal computer. The TomTom database includes data from personal navigation devices (PNDs), embedded in-car devices, fleet management systems and navigation apps on smartphone handsets.

A growing proportion of the data comes from in-car fitted connected devices which are recording all of the time, even when not actively being used for navigation. The rest of the data comes from stand-alone devices, which only record data when actively being used for navigation.

All data received is processed to protect privacy and filter out potentially anomalous results before storing it within a geographic database (known as the Traffic Stats Database) which can be queried online. The database attaches individual GPS probes to road 'segments'. Segments are short sections of the road network (typically less than 100m long in urban areas), which represent the lowest level of granularity that data can be spatially disaggregated to.

For the purpose of this analysis, TomTom's **Custom Area Analysis (CAA) tool** has been used to obtain area-wide data for each of the case study areas. The Custom Area Analysis tool returns the following statistics for each road segment in each traversable direction within the area selected:

- Average travel time
- Average speed
- Median speed
- Standard deviation speed
- Sample size
- 5th – 95th percentile speed
- Functional Road Class

Segments are typically 5m to 200m in length, and are typically shorter for smaller roads with frequent intersections. Each segment is categorised based on TomTom's international Functional Road Classification (FRC), as shown below.

Table 3-1 Functional Road Classification (FRC) definitions

FRC	Limitations
0	Motorway, freeway or other major arterial road
1	Major road less important than a motorway/freeway or major arterial road
2	Any other major road not included within categories 0 or 1
3	Secondary roads - *Roads used to travel between different parts of the region.*
4	Local connecting roads - *Roads making all settlements accessible or making parts of a settlement accessible.*
5	Local roads of high importance - *Local roads that are the main connections within a settlement, where important through traffic is possible e.g. arterial roads within suburban areas, industrial areas or residential areas.*
6	Local roads - *Roads of minor connecting importance within a settlement.*

FRC	Limitations
7	Local roads of minor importance - *Roads that only have a destination function, e.g. dead-end roads, roads inside living area, alleys: narrow roads between buildings, in a park or garden.*
8	All other roads contained within the TomTom Traffic Stats Database

Given the nature of 20mph limit schemes, the majority of segments in the case study areas fall into FRC 4-7.

3.2. Strengths and limitations of TomTom data

TomTom's key strength is its ability to provide a very large sample of retrospective data (an ability to 'go back in time' to prior the 20mph limit implementation), on an area-wide basis, which allows detailed analysis of speed compliance, median speed and speed profiles.

Table 3-2 TomTom Data Strengths and Limitations

Strengths	Limitations
• Data is available since 2008, so can be used retrospectively. • Data is available for a whole area, rather than spot locations. • Potential for high sample of GPS data over an area, given the number of roads and timespan. • Data is based primarily on GPS devices in private vehicles (rather than delivery vans or HGVs, for example). • Data can be disaggregated into time periods (up to seven). • Data can be disaggregated into small road 'segments'. • Possible to integrate with other GIS data sources for further analysis.	• Some residential roads may have low sample rates due to the low volumes of traffic on these links, or low use of personal navigational devices and applications for local trips (although connected devices transmit at all times). • Potential for low sample on individual segments on some roads. • In less affluent areas there may be fewer vehicles with access to satellite navigational devices. • TomTom does not record vehicle class or accurate traffic counts. • Data is only available where a vehicle traverses a whole segment. Part segment traversals (where the driver's destination is part way along the segment, including cul-de-sacs) are not recorded in the database. • The sample may not be representative of all drivers. Drivers with GPS devices may have different characteristics (they may be more affluent or drive longer distances), or may drive differently to those without. However, many of the units are running in a 'passive' mode and should not affect driving behaviour.

The following paragraphs expand further on the limitations, and demonstrate how our methodology will overcome them.

Sample sizes on individual road segments in residential area may be low, due to lower volumes of traffic and use of navigational devices. Indeed, on particular segments, low sample sizes may relate to a small number of drivers making the same trip on a frequent basis, which could bias results to their particular behaviour characteristics. However, it is considered that the aggregation of multiple segments over large areas will mean that these biases on individual segments will be smoothed out (i.e. while one segment might be biased towards a very conservative driver another might be biased towards a more aggressive driver and the combining of segments over an area is likely to therefore provide a balanced view for all drivers). Overall it is considered a high sample area-wide analysis will provide robust conclusions. Analysis is therefore likely to be more accurate the larger the area considered, and therefore the main focus of analysis will be at the case study or pan-case study level, with limited disaggregation by smaller geographical sub-areas. The sample sizes of each study area are discussed further in Section 3.4.

There will also be examples of the same drivers being represented several times in the dataset, on different road segments, with no means of determining how many discrete drivers are represented in the data. The recurrence of the same drivers at different points in the network is not considered an issue though, as it is desirable to monitor their behaviour on different segments of roads as they may respond to each differently

depending on the conditions. Across the whole sample of area-wide data, the number of discrete drivers represented will be high.

While it is not possible to determine what proportion of all vehicle trips are captured by TomTom for the specific case studies, TomTom consider that their users represent between 3% and 7% of all vehicles depending on the location and road classification considered.

3.3. Data specification for case study areas

3.3.1. Geographical areas analysed

Customer Area Analysis data has been obtained for all roads within each of the case study areas. Maps of the case study areas, along with details of each of the 20mph limit schemes, are provided in the **Case Study Description Report**.

3.3.2. Before and after timespans

For each case study area, data has been purchased for one year before and one year after:

- One year 'before' data covers the period **12-24 months before** implementation (i.e. leaving a gap of one year), to avoid any changes in behaviour in the run up to implementation, as a result of consultation and education activities, disruption due to works, or phased implementation in the immediate area. However, it is noted that some case study schemes are part of a wider city-based initiative, and implementation activities focused on other parts of the city may have had some influence on behaviour in the case study area during this period (e.g. Liverpool, Nottingham).

- One year 'after' data starts at least **6 months after** implementation, to allow time for the scheme outcomes to settle.

There is one exception, Portsmouth, where two 'after' years have been analysed (instead of one year before and one year after), to examine how effectiveness varies over time. This scheme was implemented substantially earlier than other case study schemes, enabling long term analysis of outcomes to be undertaken.

The specific analysis timescales for each case study scheme are set out in Table 3-3 below:

Table 3-3 Before and after timespans

	Scheme Implementation Date	**Time Span 1** ***(12-24 months before, except Portsmouth)***	**Time Span 2** ***(6-18 months after, except Portsmouth)***
Walsall (Rushall) **(R-SM1)**	**Mar 2014**	1st Mar 2012 – 28th Feb 2013	1st Oct 2014 – 30th Sep 2015
Winchester (Stanmore) **(R-SM2)**	**Jul 2014**	1st Jul 2012 – 30th Jun 2013[15]	1st Apr 2015 – 31st Mar 2016[16]
Winchester (City Centre) **(TC-AW2)**	**Sep 2014**		
Liverpool (Area 7) (Adj. to City Centre) **(R-AW1a)**	**Apr 2014**	1st Apr 2012 – 31st Mar 2013	1st Nov 2014 – 31st Oct 2015
Liverpool (Area 2) (NE of City Centre) **(R-AW1b)**	**Jan 2015**	1st Jan 2013 – 31st Dec 2013	1st Aug 2015 – 31st Jul 2016
Middlesbrough (Phase 1 and 2) **(R-AW2)**	Mar 2012 – **Jun 2012**; Mar 2013 – **Jun 2013**	1st Jun 2010 – 31st May 2011	1st Jan 2014 – 31st Dec 2014
Calderdale **(R-AW3)** (Phase 1 – Siddal, Southowram, Skircoat Green, Saville Park, Manor Heath, Coronation, Extended Town Centre)	**Jun – Jul 2015** *(Siddal and Southowram in June 2015, rest in July 2015)*	1st Jul 2013 – 30th Jun 2014	1st Dec 2015 – 30st Nov 2016

[15] Two nearby areas in Winchester combined for analysis. Time Span 1 chosen as the earlier of the two area before periods.

[16] Two nearby areas in Winchester combined for analysis. Time Span 2 chosen as the later of the two area after periods.

	Scheme Implementation Date	Time Span 1 *(12-24 months before, except Portsmouth)*	Time Span 2 *(6-18 months after, except Portsmouth)*
Nottingham - Bestwood **(R-AW4)**	**26th Apr 2014**	1st Apr 2012 – 31st Mar 2013	1st Nov 2014 – 31st Oct 2015
Brighton Phase 2 (N of City Centre) **(R-AW5)**	**16 Jun 2014**	1st Jun 2012 – 31st May 2013	1st Jan 2015 – 31st Dec 2015
Portsmouth **(R-AW6)**	Jun 2007 – **Mar 2008**	1st Oct 2008 – 30th Sep 2009 (1 year after)	1st Oct 2014 – 30th Sep 2015 (7 years after)
Chichester **(R-AW7)**	**Jul 2013**	1st Jul 2011 – 30th Jun 2012	1st Feb 2014 – 31st Jan 2015
Brighton Phase 1 **(TC-AW1)** (City Centre and Adjacent Residential Area)	**Apr 2013**	1st Apr 2011 – 31st Mar 2012	1st Nov 2013 – 31st Oct 2014

3.3.3. Time periods

The TomTom data has been analysed for two time periods:

- Peak Periods, defined as Monday-Friday 0700-1000 & 1600-1900 combined; and
- Non-peak Periods, defined as all other hours, including weekends.

Two time periods only have been selected, in an effort to keep sample sizes as high as possible to overcome any potential for issues with biases or results being skewed by segments with low samples.

The reasons for splitting out the peak period from the rest of the data are as follows:

- Use of the network is highest in the peaks. This is when the largest number of people are travelling, and when conflicts between vehicles and with non-motorised modes are most likely to occur.
- To see if driver response differs to other times of the day, due to different driver behaviour characteristics (more aggressive, more focused on time of trip due to value of time).
- Roads tend to be most congested during the peaks and the effects of 20mph limits may be diluted during these periods.

The data has also been aggregated to form a 24-hour view of network performance.

3.4. CAA sample sizes for case study areas

The table below shows the pre and post implementation sample sizes (as vehicle kilometres) within the TomTom journey time data in each of the case study areas.

Table 3-4 Sample of TomTom vehicle kilometres by case study area

Study Area	Dist-ance (KM)	Before			After		
		New 20mph (signed only)	Other 20mph roads[1]	30mph and 40mph roads	New 20mph (signed only)	Other 20mph roads[1]	30mph and 40mph roads
Walsall	-	6,267	569	19,503	6,755	572	24,766
Winchester (Stanmore)	-	5,807	2,400	43,555	7,271	3,167	59,528
Liverpool (Area 7)	-	20,761	79,012	1,144,092	18,076	67,593	1,275,596
Liverpool (Area 2)	-	23,565	45,073	656,869	42,056	66,104	1,140,156
Middlesbrough	-	27,572	7,917	708,755	41,225	12,599	972,435
Calderdale	-	28,029	2,281	128,390	79,674	6,632	307,687
Nottingham, Bestwood	-	9,218	7,966	552,418	11,076	7,355	576,701
Brighton Phase 2	-	278,035	56,763	1,258,047	332,180	68,645	1,477,147
Portsmouth	-	197,838	11,988	1,088,712	265,136	16,588	1,685,760
Chichester	-	77,509	36,627	561,341	82,615	37,416	569,998
Brighton Phase 1 (Residential)		475,787	28,837	299,870	515,442	30,918	318,834
Brighton Phase 1 (City Centre)	-	210,397	14,450	46,047	216,726	18,847	46,429
Winchester (City Centre)	-	63,944	3,146	13,912	79,548	3,787	18,322
TOTAL	**1,187**	**1,424,730**	**297,029**	**6,521,510**	**1,697,779**	**340,223**	**8,473,359**

1. Combines New 20 (existing calming), Old 20 (with calming), and Old 20 (signed only).

Residential case studies (new 20mph signed only), including Portsmouth = 1,150,388 veh-kms
Residential case studies (new 20mph signed only), excluding Portsmouth = 952,551 veh-kms
City Centre case studies (new 20mph signed only) = 274,342 veh-kms

Table 3-4 shows that across the study areas 1,187km of roads are being analysed, with over 8 million vehicles kilometres (VKMs)[17] of TomTom data in the before period, and over 10 million vehicle kilometres (VKM) of TomTom data in the after period. These are substantial quantities of observed data, which gives confidence that the outcomes are representative across the areas analysed.

The after sample sizes are higher than the before sample sizes, due to the increased number of TomTom users over time.

[17] Vehicle kilometres (VKMs) are a measure of traffic volume that considers the total distance travelled by users rather than just the number of users. This is determined by multiplying the number of vehicles on a set of road segments by the corresponding length of the segments.

3.5. Categorisation of speed limits and presence of pre-existing traffic calming interventions in case study areas

Information on the location of 20mph speed limits in each of the case study areas has been taken from TomTom's UK Map Product (Shape File). An additional patch was provided by TomTom (2016.09) comprising updated data on the location of 20mph limits in each of the case study areas. This was based on information provided by the relevant local authorities and TomTom's Mobile Mapping imagery. The 2016 patch provides comprehensive data on the location of current 20mph limits (as of September 2016), but does not identify roads which already had a 20mph limit in place prior to the role out of the area-wide scheme, nor does it distinguish between signed only limits and zones (with physical traffic calming measures in place).

As a result, the study team also used street view image websites to view every road within the case study areas, and:

- confirm the existence of the 20mph limit;
- identify what speed limit was in place prior to the role out of the area-wide scheme (using old street-level imagery from Google StreetView archive); and
- record any physical traffic calming measures (e.g. road humps, chicanes) which were in place prior to the role out of the area-wide scheme or have been introduced since.

Each road was then classified as follows:

Table 3-5 Categorisation of Roads for Analysis

Name	Traffic Calming	Before Speed	After Speed
New 20mph limit (signed only)	No/minimal physical traffic calming	30mph	20mph
New 20mph limit (existing calming)	Substantial pre-existing traffic calming	30mph	20mph
Old 20mph limit (signed only)	No/minimal physical traffic calming	20mph	20mph
Old 20mph limit (with calming)	Substantial pre-existing traffic calming, often combined with 20mph zone sign	20mph	20mph
30mph (no change)	No/minimal physical traffic calming	30mph	30mph
40mph (no change)	No/minimal physical traffic calming	40mph	40mph

The above exercise was a substantial task and relied on comprehensive historical imagery to allow before and after comparisons to be made. In general, there was sufficient imagery available for the case studies to allow this task to be completed. The exception was Calderdale, where at the time of writing, the images available for most of the case study area pre-dated the implementation of the 20mph scheme. Nevertheless, detailed maps were provided by the Council, and it was still possible to use Google StreetView to check for pre-existing traffic calming and old 20mph limits.

3.6. Data analysis approach for case study areas

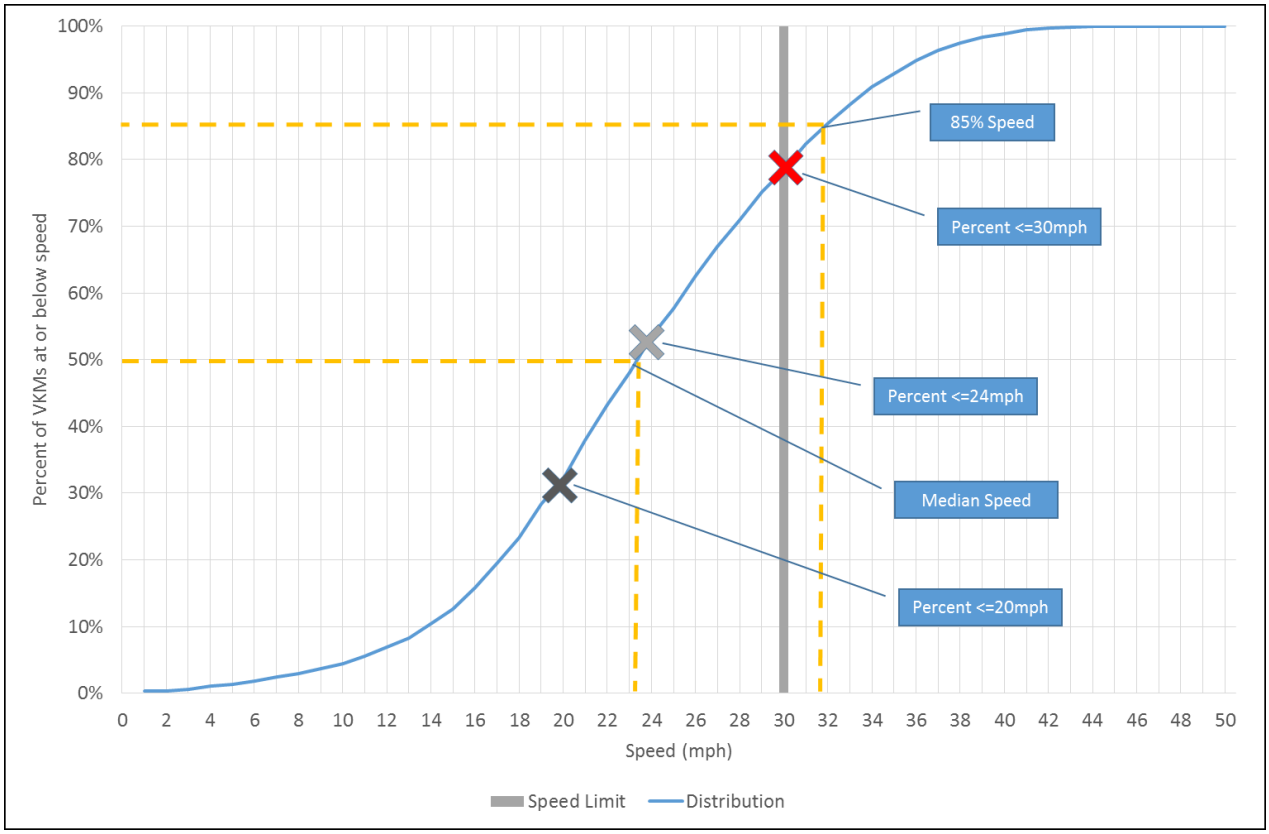
3.6.1. Key profile metrics

The analysis presented in the subsequent chapters is based on the following key metrics:

- % veh-kms driven compliantly (i.e. at or under the speed limit);
- Median speed;
- Percentage driving below 24mph and 30mph;
- 85% percentile speed;
- Profile of speeds (veh-kms driven at each speed in the network).

All of these metrics can be ascertained from a distribution profile of speeds given a specific subset of the road network. Figure 3-1 demonstrates how, given a speed profile, it is possible to understand the key research metrics by analysing the profile.

Figure 3-1 Example speed profile curve



TomTom data used for this analysis is provided at a granular level with the road network divided into 'segments'. Each of these segments has data relating to the speeds of those who traversed the segment assigned to it. A detailed description outlining the methodology for creating a distribution curve for each of these segments, and the approach for combining segments to create an area wide, high sample distribution curve is provided in Appendix A.

3.6.2. Distinguishing between 'policy' and other factors affecting speed

The purpose of this research is to identify the policy impact of 20mph limits on speeds. As illustrated above, speeds on a particular segment can be influenced by a range of factors other than the speed limit:

- unusual or random behaviour, e.g. looking for a parking space, stopping to talk to a neighbour, or similar;
- environmental constraints, e.g. slowing to allow another car to pass, due to parked cars reducing the width of the carriageway;
- congestion, which may constrain speeds due to the volume of traffic on the network; and
- behavioural characteristics, e.g. differences in the preferred driving speeds of individual drivers.

In order to focus on the policy impacts, the following approaches have been used:

- Use of the median to measure average speeds, to dampen the impact of very slow vehicles (see Box A).
- Presentation of speed change data separately for (i) all segments, and (ii) those with a 'before' median speed greater than 20mph. 20mph schemes are expected to have the most impact on segments where vehicles were previously travelling at a higher speed. On segments where the 'before' median speed is less than 20mph, it is likely that the speeds are already constrained by various factors highlighted above (unusual or random behaviour, environmental constraints, congestion, or behavioural characteristics) and the 20mph limit may simply formalise what is already the practical speed limit.
- Separate reporting of results by time of day – Higher levels of congestion are likely in the peak periods.
- Separate analysis of residential and city centre areas – Higher levels of congestion are likely in city centre areas.

- Comparison of outcomes in new 20mph limits (signed only) with those in other 20mph roads, and on 30 and 40mph roads - to give an indication of any potential wider increases or decreases in speed.

The proportion of vehicles travelling very slowly and their impact on the median can be interpreted from the speed profile curves produced for each area.

Box A. Use of median, rather than the harmonic mean, to measure average speed

A key analysis statistic is average speed. Prior to undertaking this analysis, consideration was given to the relative merits of using the median, harmonic or arithmetic mean, to represent average speed. Each of these is calculated differently, and gives a very different average.

- The **harmonic mean -** sum of distance divided by a sum of time **-** is generally used for rate-based data. However, this gives extra importance to those journeys that spend more time traversing the segment (perhaps due to unusual or random events). This dampens the calculated average, and is likely to produce a figure which is much lower than the speed which most users would intuitively assume to be the average.
- The **arithmetic mean** - sum(sample*average speed)/sum(sample) - is more informative about driver response to speed limits and non-driver perception of the road's attractiveness as a route, as it gives equal importance to each observation irrespective of the fact that those travelling slower were on the link for longer. Nevertheless, it is still somewhat dampened by the slower moving vehicles, due to factors other than the speed limit.
- Finally, the **median** denotes the value lying at the midpoint of a frequency distribution of observed values – half of the data is above this value and half is below. This has been identified as the preferred metric for this analysis, for the following reasons:
  - It is least affected by the slow-moving vehicles, and therefore most closely represents typical policy-driven speed behaviour.
  - It also has an advantage from a policy perspective, in that it provides a meaningful statistic. We know 50% of drivers go above this speed and 50% below, so it perhaps gives a better understanding of how non-drivers will feel about the speeds on the road, particularly if interpreted alongside 85th percentile speeds.

    In contrast, both the harmonic and arithmetic mean are difficult to interpret from a policy perspective. They don't tell us how many people are driving above or below the average point, or anything about the profile either side of the average – just that the profile of speeds above the average is balanced by the profile below the average (in terms of the sum of speeds/sample).

See Appendix A.2 for further explanation.

3.6.3. Loss of some segments during data matching process

Customer Area Analysis data is provided on a different background map to the Map Product containing the speed limit data. Segments do not always match between the two datasets if there have been changes to the road layout, and all segment IDs are different. A matching process has been developed by the study team to combine the two datasets, but approximately 15% of segments from the CAA dataset have been lost due to this issue. Despite this, it is considered that as there will be tens of millions of vehicles kilometres of data included in the analysis, the conclusions drawn will still be meaningful despite the loss of some road segments.

3.7. Comparator area analysis

3.7.1. Purpose

A key element of the approach involves undertaking similar analysis in a set of 30mph limit comparator areas, to estimate whether the change in speed in the 20mph limit case study areas is likely to be due to the introduction of the 20mph limit, or part of a wider trend in speeds affecting both 20mph and 30mph roads.

Following discussion with the DfT, it was agreed that the approach would focus on selecting three comparator areas matching the average characteristics of three groupings of case studies, and undertaking statistical analysis to compare the change in median speed observed on 20mph roads for each of the case

studies with the change on 30mph roads in the matched comparator areas. While a separate comparator area could be identified for each case study area, this does not represent a cost-effective approach.

3.7.2. Selecting and defining the comparator areas

The comparator areas need to be as similar as possible to the case study areas to provide a robust comparison.

The size of each comparator area is approx. 20km^2 to broadly reflect the size of the largest case study areas.

The comparator areas for each case study group have been selected on the basis of the following criteria:

- **Implementation date** – For each case study area, TomTom data was purchased for one year before and one year after. Due to budget considerations, it was not possible to purchase separate timespans for each case study. Instead, data was purchased for up to two sets of timespans for each case study area. It is therefore important that the case studies within each group were implemented at similar times.

- **Region** – Comparator area to be located in the same region(s) as the case studies in each group.

- **Rural Urban Classification (RUC)**[18] – Comparator area to be located in the same Rural Urban Classification as the case studies in each group, to ensure case study and comparator areas have broadly similar geographical characteristics (e.g. population density, land-use, road types, traffic volumes, etc.).

- **Index of Multiple Deprivation (IMD) Income Quintile** – Comparator area to have a similar IMD score as the average IMD score across the case studies included in each group, to ensure case study and comparator areas have similar urban density, road environment and socio-economic characteristics.

  The Index of Multiple Deprivation (IMD) is the overall measure of multiple deprivation experienced by people living in an area. It is calculated for all LSOAs in England. LSOAs are then ranked according to their deprivation relative to other areas. The 2015 indices are based on 37 separate indicators, organised across 7 domains of deprivation, when are then combined using weighting to calculate an overall IMD score. The 7 domains of deprivation are: Income Deprivation; Employment Deprivation; Education, Skills and Training Deprivation; Health Deprivation and Disability; Crime; Barriers to Housing and Services; and Living Environment Deprivation.

  The income element of the IMD data is considered to provide a good proxy for urban density, road environment and socio-economic characteristics.

- **Absence of 20mph area-wide limit** in the vicinity of the area.

- **Size and shape of urban area** – Can a 20km2 rectangle area of built up development be identified? TomTom data is purchased on a rectangular area basis.

[18] The Rural Urban Classification (RUC) system is an Official Statistic, used to distinguish rural and urban areas.

Box B. Evidence regarding the potential influence of deprivation on speeds

- Regression analysis based on the residents' questionnaire data shows higher self-reported compliance amongst residents in deprived areas. It is suggested that the level of deprivation is an indicator of road environment and other factors. Areas with high deprivation may contain higher density development, and are unlikely to include houses with large front gardens, grass verges, or areas of open space. Resident drivers in these areas may be driving on a less frequent basis.
- Analysis of spot speed data shows that the poorest compliance is associated with road environments which create a perception of space and openness, and provide the driver with good visibility, e.g. wide roads, large front gardens, with low levels of on-street parking (generally more affluent areas).
- Drivers participating in in-depth interviews stated that they are more likely to slow down on roads which are narrow, twisty, or have a high volume of parked cars (making it physically difficult or less safe to travel faster); or are congested or have higher traffic flows (requiring or encouraging slower driving).
- Regression analysis based on the questionnaire data shows higher support for 20mph limits amongst non-car owning households.

Road type (in terms of coverage of important strategic roads, important local roads, and minor local roads) has been considered in the analysis stage. Selecting areas on the basis of Rural-Urban Classification ensures similar types of areas are selected with broadly similar road characteristics and volumes of traffic.

Level of congestion is another potential selection criteria. However, 20mph limits are generally implemented on minor local roads where congestion is unlikely to be a key determinant of speed, and analysing trends by road type will capture any congestion impacts.

Relative priority given to selection criteria

In general:

- Implementation date, Rural-Urban Classification, and Region has been used to collate case studies into three groups.
- Rural-Urban Classification and Region has then been used to select potential comparator areas with similar geographical characteristics.
- Finally, absence of an 20mph area-wide limit and Income Index of Multiple Deprivation data has been used to narrow down to a shortlist of potential comparator areas; with a more qualitative approach used to make the final selection.

3.7.3. Grouping of case studies

In the first instance, the case studies have been grouped into three broad comparator groups based on Rural Urban Classification (RUC) types and regions (Table 3-6):

- Comparator A (Urban City and Town classification – South);
- Comparator B (Urban Major and Minor Conurbation classification – Midlands and North); and
- Comparator C (Urban City and Town classification – North).

In general, Rural-Urban Classification has been given more importance than region, as this is more likely to identify factors relevant to vehicle speeds (in terms of geographical characteristics).

The approach ensures that the three biggest case study areas (Brighton, Liverpool, and Middlesbrough) are all covered by separate comparator areas.

Table 3-6 Case study areas and comparator descriptions

Case Study	Rural Urban Classification	Region	Size (km2)	Comparator Area	Comparator Description
Brighton (Phase 2)	Urban City or Town	SE	24.9	Comparator A	30mph roads in 'Urban City and Town' area in the South (SE), in areas with similar affluence / deprivation characteristics
Chichester	Urban City or Town	SE	7.6		
Brighton (Phase 1)	Urban City or Town	SE	7.0		
Winchester (City Centre)	Urban City or Town	SE	1.0		
Winchester (Stanmore)	Urban City and Town	SE	3.6		
Walsall	Urban Major Conurbation	WM	0.5	Comparator B	30mph roads in 'Urban Major or Minor Conurbation' area in the Midlands and North (WM, NW, YH, EM), in areas with similar affluence / deprivation characteristics
Liverpool (Area 7)	Urban Major Conurbation	NW	15.8		
Liverpool (Area 2)	Urban Major Conurbation	NW	19.3		
Calderdale (Phase 1)	Urban Major Conurbation	Y&H	4.2		
Nottingham (Bestwood)	Urban Minor Conurbation	EM	7.9		
Middlesbrough	Urban City and Town	NE	18.6	Comparator C	30mph roads in 'Urban City and Town' area in the North (NE), in areas with similar affluence / deprivation characteristics

The before and after timespans for each comparator area are shown in Table 3-7.

Table 3-7 Case study areas and comparator descriptions

Case Study	Rural Urban Classification	Implementation Date	Case Study Time Span 1	Case Study Time Span 2	Region	Comparator Area	Comparator Time Span 1	Comparator Time Span 2
Walsall (Rushall) (R-SM1)	Urban Conurbation – Midlands and North	**Mar 2014**	1st Mar 2012 – 28th Feb 2013	1st Oct 2014 – 30th Sep 2015	West Midlands	B1	Apr 2012 – Mar 2013 (B1)	Nov 2014 – Oct 2015 (B1)
Winchester (Stanmore) (R-SM2)	Urban City and Town – South	**Jul 2014**	1st Jul 2012 – 30th Jun 2013	1st Apr 2015 – 31st Mar 2016	South East	A2	Jul 2012 – Jun 2013 (A2)	Apr 2015 – Mar 2016 (A2)
Liverpool (Area 7) (R-AW1a)	Urban Conurbation – Midlands and North	**Apr 2014**	1st Apr 2012 – 31st Mar 2013	1st Nov 2014 – 31st Oct 2015	North West	B1	Apr 2012 – Mar 2013 (B1)	Nov 2014 – Oct 2015 (B1)
Liverpool (Area 2) (R-AW1b)	Urban Conurbation – Midlands and North	**Jan 2015**	1st Jan 2013 – 31st Dec 2013	1st Aug 2015 – 31st Jul 2016	North West	B2	Apr 2013 –Mar 2014 (B2)	Nov 2015 – Oct 2016 (B2)
Middlesbrough (R-AW2)	Urban City and Town – North	**Jun 2012**; **Jun 2013**	1st Jun 2010 – 31st May 2011	1st Jan 2014 – 31st Dec 2014	North East	C	June 2010 – May 2011 (C)	Jan 2014 – Dec 2014 (C)
Calderdale (Phase 1) (R-AW3)	Urban Conurbation – Midlands and North	**Jun 2015**	1st Jul 2013 – 30th Jun 2014	1st Dec 2015 – 30st Nov 2016	Yorkshire and the Humber	B2	Apr 2013 –Mar 2014 (B2)	Nov 2015 – Oct 2016 (B2)
Nottingham (Bestwood) (R-AW4)	Urban Conurbation – Midlands and North	**26th Apr 2014**	1st Apr 2012 – 31st Mar 2013	1st Nov 2014 – 31st Oct 2015	East Midlands	B1	Apr 2012 – Mar 2013 (B1)	Nov 2014 – Oct 2015 (B1)
Brighton (Phase 2) (R-AW5)	Urban City and Town – South	**16 Jun 2014**	1st Jun 2012 – 31st May 2013	1st Jan 2015 – 31st Dec 2015	South East	A2	Jun 2012 – May 2013 (A2)	Feb 2015 – Jan 2016 (A2)
Chichester (R-AW6)	Urban City and Town – South	**Jul 2013**	1st Jul 2011 – 30th Jun 2012	1st Feb 2014 – 31st Jan 2015	South East	A1	May 2011 – Apr 2012 (A1)	Dec 2013 – Nov 2014 (A1)
Brighton (Phase 1) (TC-AW1)	Urban City and Town – South	**Apr 2013**	1st Apr 2011 – 31st Mar 2012	1st Nov 2013 – 31st Oct 2014	South East	A1	May 2011 – Apr 2012 (A1)	Dec 2013 – Nov 2014 (A1)
Winchester (City Centre) (TC-AW2)	Urban City and Town – South	**Sep 2014**	1st Jul 2012 – 30th Jun 2013	1st Apr 2015 – 31st Mar 2016	South East	A2	Jun 2012 – May 2013 (A2)	Feb 2015 – Jan 2016 (A2)

3.7.4. Identification of comparator areas for each case study grouping

The relevant Rural Urban Classifications (RUC) were mapped for each of the Comparator Area regions, to identify lower tier local authorities with the same RUC as the case studies (e.g. Figure 3-2 and 3-3). This enabled local authority comparator areas to be identified. The process resulted in:

- 65 potential comparator authorities for Group A (Urban City and Town classification – South);
- 35 potential comparator authorities for Group B (Urban Major and Minor Conurbation classification – Midlands and North); and
- 65 potential comparator authorities for Group C (Urban City and Town classification – North).

Figure 3-2 Urban City and Town areas in the South East (Comparator A)

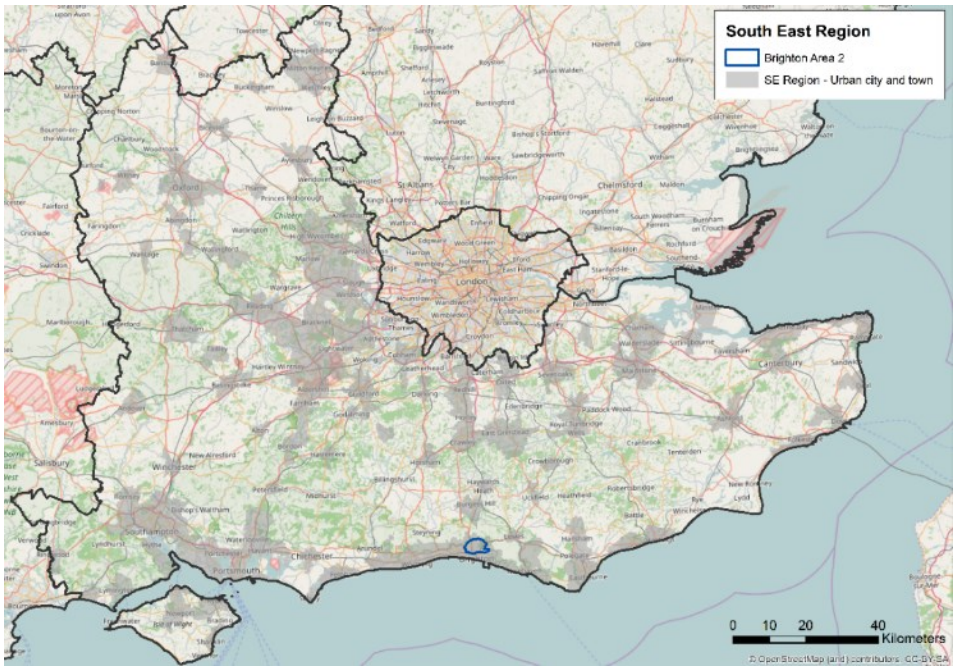
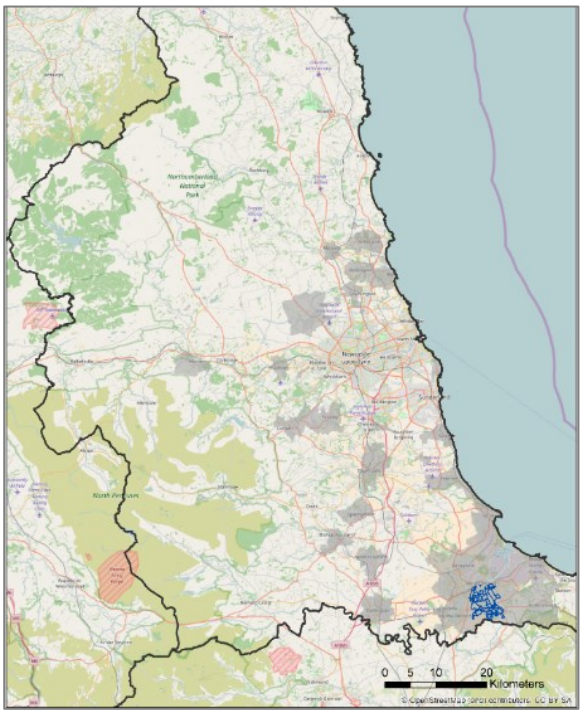


Figure 3-3 Urban City and Town areas in the North East (Comparator C)



Identifying a short-list

In order to narrow down the list of potential comparator areas, the following approach was then used.

The Index of Multiple Deprivation Income Quintile was identified at LSOA[19] level and averaged to give:

- the average Income Quintile across the case study areas within each group; and
- the average Income Quintile for each local authority area within the relevant region.

For each case study group (A, B, and C), the average Income Quintile was used to select potential comparator locations with similar average Income Quintiles at a local authority level.

The potential comparator locations were then examined to confirm whether they contained any area-wide 20mph limits. As there is no definitive national map of speed limits, the following evidence was used:

- The 20s Plenty website includes a list of all local authorities known to be implementing a community-wide 20mph limit (http://www.20splenty.org/20mph_places).
- Contacting local authorities to ask about the presence of area-wide 20mph limits.
- Information from Speedmap (www.speedmap.co.uk)[21].
- Web-based research, including using Google StreetView to check the current speed limit on a random selection of roads.

3.7.5. Short-listed and selected comparator areas

Comparator A (Urban City and Town classification - South)

Table 3-8 shows the short-listed comparator areas for Group A. The biggest case study area in Group A is Brighton (population 155,000); so the selection criteria is skewed towards matching the characteristics of the Brighton area.

The selected comparator area is **Worthing**. This has a large population (100,000), lends itself well to the selection of a 20km^2 rectangle (capturing ~500km of road length), and is known to have rejected proposals for an area-wide 20mph limit following a very high profile and confrontational campaign in 2014.

It is also a seaside location, with some similarities with Brighton in terms of housing type, and attracting visitors (although to a less extent than Brighton).

The centre of Worthing is used as a comparator to Brighton City Centre and Winchester City Centre schemes.

The selected area includes a broad range of residential areas *.

Consideration was given to selecting Reading. However, this is a much bigger town than Brighton, and especially the Chichester and Winchester case studies. Crawley was rejected because it is too small to allow a 20km^2 of data to be selected. It is also a new town, so therefore very different in character to Brighton, Chichester and Winchester.

Comparator B (Urban Major / Minor Conurbation classification – North and Midlands)

Group B includes the two Liverpool case studies, Nottingham (Bestwood) and a small case study area in Rushall (all relatively deprived areas); and Calderdale (a more affluent area).

Table 3-9 shows the short-listed comparator areas for Group B. The recommended comparator areas were Sandwell or Wolverhampton, both located next to each other in the West Midlands, and next to Walsall (with a number of 20mph pilots, including Rushall case study).

The selected comparator area is **Wolverhampton**, as the area has a clearer distinction between city centre and residential areas, then other options. This enables the city centre area to be discarded to focus on the comparison of residential areas.

[19] Local Super Output Areas (LSOA) are geographical areas used by government for the reporting of small area statistics in England and Wales.

[21] Speedmap is a project five years in the making with the aim of producing a network-independent national speed limit map for the UK.

Comparator C (Urban City and Town classification - North)

Group C includes Middlesbrough (Urban City and Town). Table 3-10 shows the short-listed comparator areas for Group C, with both Hartlepool and Sunderland as the main contenders.

Both comprise a simple geographical area, with a clear city centre area which would be removed from the TomTom datasets to ensure focus on residential areas. Both have a small number of 20mph zones in place, but accounting for less than 2% of roads. Both have plans for area-wide 20mph limits, but beyond the timescales of our analysis.

On balance, **Sunderland** was selected, as this is a larger city with a population closer to that of Middlesbrough.

Table 3-8 Shortlisted Comparator Areas for Group A (Urban City and Town classification – South)

Case Study LAs – Average Income Quintile	Potential Comparator Authorities	Comparator Authorities Avrg Income Quintile	Popul-ation	Estimated extent of 20mph in residential areas	Available rectangle (min 20km^2)	Comments
Case Study average = 3.09 **Chichester = 3.25** **Brighton = 2.95** **Winchester = 4.00** **Mix of residential and city centre schemes.** ***Brighton population = 155,000***	Ashford	2.91	Too small (58,000)	4%	23 km^2	-
	Reading	2.97	162,000 (LA) 318,000 (Built-up Area)	2%	26 km^2	**Reserve** - Large area, but area-wide limit introduced in May 2016. Our analysis would finish in Jan 2016, and could avoid area covered by limit, so driving behaviour should not be affected by pre-implementation publicity. Large town with scope to include a variety of residential environments. Much bigger town than Brighton, and especially Chichester and Winchester.
	Crawley	2.98	106,000	2%	17 km^2	**Reserve** - No evidence of area-wide 20mph limit, but rectangle area available is less than 20km2, and less road length than Worthing or Reading.
	Adur	3.02	Too small	-	-	-
	Arun	3.05	Too small	-	-	-
	Lewes	3.06	Too small (16,000)	-	-	-
	Gosport	3.15	82,000	1%	33 km^2	HCC confirmed that most roads in Gosport are 30mph. But, population lower than other candidate areas, and town centre area is relatively small.
	Canterbury	3.16	Too small (43,000)	3%	13 km^2	-
	Worthing	3.25	100,000	1%	24 km^2	**Selected** - 20mph area-wide limit rejected in 2014.

Table 3-9 Shortlisted Comparator Areas for Group B (Urban Major / Minor Conurbation classification – North and Midlands)

Case Study LAs – Average Income Quintile	Potential Comparator Authorities	Comparator Authorities Avrg Income Quintile	Popul-ation	Estimated extent of 20mph in residential areas	Available rectangle (min 20km^2)	Comments
Case Study average = 1.69 **Liverpool = 1.50** **Walsall = 1.80** **Nottingham = 1.83** **Calderdale = 2.93** **All residential schemes.**	Sandwell	1.69	-	2%	50km^2	**Reserve** - The 20mph zones were originally put in around schools. A 20mph limit has been introduced in West Bromwich town centre (~2015, TBC). This would need to be removed from the dataset anyway, as the schemes all focus on residential areas. Other (smaller) town centre areas would also need to be removed - Oldbury, Rowley Regis, Smethwick, Tipton, Wednesbury. In Dec 2017 the Council announced plans for a borough-wide 20mph limit, following the death of a child in 2016.
	Knowsley	1.79	-	6%	-	Higher presence of 20mph limits than other options. Hard to define rectangle, given shape of area.
	Wolverhampton	1.89	-	1%	35km^2	**Preferred** - Blanket 20mph limit (without calming) implemented in Wolverhampton City Centre in 2002. Traffic calming measures subsequently added. This area would need to be removed. 20mph zones also introduced in more than 20 places (in ~2014) to lower vehicle speeds and reduce road casualties. No other evidence of an area-wide scheme.
	Birmingham	1.95	-	?	-	Currently rolling out an area-wide 20mph limit. First area implemented in Oct 2014. Pre-implementation period would impact on the time periods selected for our analysis.
	W. Lancashire (Ormskirk and Skelmersdale)	1.95	-	?	-	Area-wide 20mph limit introduced in South Ormskirk in 2014.

Table 3-10 Shortlisted Comparator Areas for Group C (Urban City and Town classification – North)

Case Study LAs – Average Income Quintile	Potential Comparator Authorities	Comparator Authorities Avrg Income Quintile	Popul-ation	Estimated extent of 20mph in residential areas	Available rectangle (min 20km^2)	Comments
Case Study average = 2.20 **Middlesbrough = 2.20** **Residential scheme.** ***Middlesbrough population = 138,000 (local authority), 275,000 (city).***	South Tyneside	1.97	150,000 (LA) Part of Tyneside	3%	51km^2	More complex geographical area. Would need to remove town centres of South Shields, Jarrow and Hebburn – leading to loss of data.
	Hartlepool	2.14	92,000	1%	31km^2	Limits introduced in some villages, but these would be outside area of analysis. Plans announced in 2016 for an area-wide limit in part of the city, but implementation period is beyond period of our analysis (finishes Oct 2015). Simple geographical area, with clear city centre area, which would be removed to ensure focus on residential areas.
	Sunderland	2.17	174,286 (LA) 275,300 (City)	2%	47km^2	**Preferred** - A pilot programme of 20mph zones in 6 areas within the city has been implemented in recent years. In Dec 2017, Council announced plans for an area-wide limit in the north of the city, but implementation period is substantially beyond period of our analysis (finishes Oct 2015). Simple geographical area, with clear city centre area, which would be removed to ensure focus on residential areas.
	Gateshead	2.41	120,000 (LA) Part of Tyneside	4%	-	20mph limits at 80 locations in town centres, outside schools, and in residential areas with existing traffic calming, since 2010. In 2015, the Council announced plans to introduce a 20mph blanket speed limit across the whole of Whickham (a town in Gateshead).

3.7.6. Processing of TomTom data

The comparator data for the selected areas was processed in the same way as the case study data. The following metrics were generated for each comparator area, disaggregated by road type (e.g. important local roads, minor local roads):

- distance of 30mph roads (kms);
- sample VKMs observed (kms);
- median speed, change in median speed;
- 85th percentile speed, change in 85th speed.

3.7.7. Statistical analysis

A weighted least squares analysis (to take account of the different sample sizes) was then undertaken to examine the change in speeds for case study areas against the comparator areas (representing a difference in difference approach[22]).

The model was specified as follows:

$$E(xB_i) = \mu_i^{(x)}$$
$$E(xA_i) = \mu_i^{(x)} + d_i + \beta$$
$$E(yB_i) = \mu_i^{(y)}$$
$$E(yA_i) = \mu_i^{(y)} + d_i$$

with weights mxB_i, mxA_i, myB_i and myA_i respectively (based on sample vehicle kilometres). Where, x refers to the case study area and y to the comparator area; B refers to the before period and A to the after period, and i refers to the individual case study areas and corresponding comparator areas.

So:

$E(xB_i)$ = Expected speed* in case study area i in the before period B

$E(xA_i)$ = Expected speed* in case study area i in the after period A

$E(yB_i)$ = Expected speed* in comparator area i in the before period B

$E(yA_i)$ = Expected speed* in comparator area i in the after period A

$\mu_i^{(x)}$ = Sample speed* for case study area i

$\mu_i^{(y)}$ = Sample speed* for comparator area i

d_i = Background change in speed in the comparator area relevant to case study i (which is assumed to apply equally to both the case study and comparator area)

β = Treatment effect (the change in speed as a result of the change in speed limit).

** Refers to median speed, 85th percentile speed, or 15-85th percentile range, depending on the model in question.*

The crucial parameter is β which is the difference between the change in speed in the case study areas and the change in speed in the corresponding comparator areas, as a result of the change in speed limit.

The statistical analysis was undertaken for all roads (based on an aggregation of the datasets for all three road types), just major strategic roads, just important local roads and just minor local road respectively. Separate tests were undertaken to test the relative change in median speed, 85th percentile speed, and 15-

[22] Comparing the change over time in the case study areas to the change over time for the comparator areas (control areas)

85th percentile range. 95th percent confidence intervals have been calculated to determine the statistical significance of changes observed.

Table 3-11 Statistical analysis undertaken

Area Type	Road Types	Metric
Residential	All road types (Major strategic roads + Important local roads + Minor local roads)	Median speed
City Centre	Important local roads	85th percentile speed
	Minor local roads	15-85th percentile range

Although the statistical approach uses data for each individual case study area, the result (in terms of a statistically significant change or not) applies to the set of case studies as a whole, and does not identify whether the change in any one particular case study area is significant. This is consistent with the approach adopted in the rest of the report which presents the results at an aggregate level (and only includes disaggregated case study results in Appendix B).

The case study and comparator data was weighted using sample vehicle kilometres to give more emphasis to the larger case study areas. A version of the statistical model was also tested without weights. This treats all of the case studies equally, and is more of a measure of scheme performance rather than driver behaviour.

See Appendix A.4 for further detail on the statistical analysis undertaken.

4. Impact of new 20mph limits (signed only) on speeds

4.1. Introduction

This chapter looks at the impact of new 20mph limits (signed only) on speed compliance and profile. These roads represent the core focus for this research study.

The results are presented separately for **predominantly residential** and **city centre** case studies; reflecting the different road environments (function, geometry, volume of traffic), journey characteristics, and potentially different driving behaviours in the two types of areas. The results are aggregated across the relevant case study areas for each category, with case study specific data presented in Appendix A.

4.1.1. Predominantly residential areas

Section 4.2 presents aggregated results for the following **predominantly residential** case study areas:

- Walsall (Rushall)
- Winchester (Stanmore)
- Liverpool (Area 7) (Adj. to City Centre)
- Liverpool (Area 2) (NE of City Centre)
- Middlesbrough (Phase 1 and 2)
- Calderdale (Phase 1)[23]
- Nottingham (Bestwood)
- Brighton Phase 2 (N of City Centre)
- Chichester
- Brighton Phase 1 (predominantly residential areas only, City Centre area excluded)

Small-scale and area-wide residential schemes are grouped together, due to the smaller sample sizes associated with the small-scale residential schemes - Walsall (Rushall) and Winchester (Stanmore).

Portsmouth has not been included in the above aggregation as this case study specifically examines long terms changes in post scheme outcomes.

Results are presented:

- **At an aggregate level** – Across all roads and time periods.
- **By time period (peak and non-peak)** – Focusing specifically on roads with a median 'before' speed of >20mph (where driver speed is not constrained by congestion or the nature of the road environment) - to see if driver response differs to other times of the day, due to journey purpose related driver behaviour characteristics.
- **By median 'before' speed (<20mph, 20-24mph, 24mph+)** – A new 20mph limit has more scope to affect driver behaviour where 'before' speeds were typically greater than 20mph; and where driver speed is not constrained by congestion or the nature of the road environment.
- **By Functional Road Class** –To see if driver response differs depending on the function/classification of the road and the level of traffic.

4.1.2. City centre areas

Section 4.3 presents aggregated results for the following **city centre** case study areas:

- Brighton Phase 1 (City Centre area only; adjacent residential areas excluded)
- Winchester (City Centre).

Analysis on city centres is restricted to just the aggregate level due to there being insufficient data for city centres to allow disaggregating into sub-analyses.

[23] Area described as 'Extended Town Centre' is predominantly residential.

4.2. Impact of new 20mph (signed only) limits on residential roads

4.2.1. What is the impact of 20mph limits on residential areas?

Context

This section examines how speeds have changed on roads in predominantly residential areas, previously under a 30mph speed limit that are now reduced to 20mph, indicated by signs only. The analysis is based on a total road length of 451km, with almost one million vehicle kilometres of data informing the before analysis and just over one million informing the after analysis. We can therefore be confident that our findings are based on a substantial set of roads and trips.

Table 4-1 shows the high level results relating to these roads, while Figure 4-1 shows the before and after speed distribution curve. Both outputs are based on 24-hour data, combining peak and non-peak periods.

The graph shows the percentage of driver vehicle kilometres (vkms) traveling at or below a specific speed; with 20mph and 30mph speeds highlighted by vertical lines to show the before and after speed limits. It seems reasonable to expect that when the speed limit was 30mph a high percentage of cars would travel at/close to this speed, resulting in the curve of the graph being skewed to the right hand side. Upon implementation of the 20mph limit, a higher percentage of drivers are expected to be travelling at lower speeds, moving the distribution curve to the left.

Results

Before implementation - A high proportion of drivers were already travelling at speeds close to 20mph, prior to the introduction of the new limits. The median speed was just 21.1mph, 44% were already driving less than 20mph, and 65% were driving less than 24mph - perhaps due to road conditions (e.g. congestion), layout (e.g. curvature or width of road, or presence of signals/crossings, etc.) or driver behaviour (i.e. each person's driving characteristics).

Change in median speed - Table 4-1 shows a slight reduction in median speed post implementation, from 21.1mph to 20.5mph, a 0.7mph reduction. This is also visible in Figure 4-1, with the distribution curve shifting marginally to the left. The change is small because a high proportion of drivers were already travelling below the new speed limit.

Change in speed profile – Vehicles travelling at higher speeds in the before period have reduced their speed more (by about 1mph), than those already travelling at lower speeds. This can be seen by the size of the gap between the before and after lines in Figure 4-1, they are further apart for speeds above 24mph. Furthermore, the proportion of drivers travelling over 24mph has reduced by 5%; compared with a 2% increase in the proportion travelling at 20-24mph, and a 3% increase in drivers travelling less than 20mph. As a result, the 85th percentile speed has reduced by 1.1mph (substantially more than the median).

The spread of speeds, indicated by the 15^{th}-85^{th} percentile range, has declined by 1.3mph.

There are now slightly more drivers travelling at speeds close to 20mph, which may be encouraging other faster drivers to slow down.

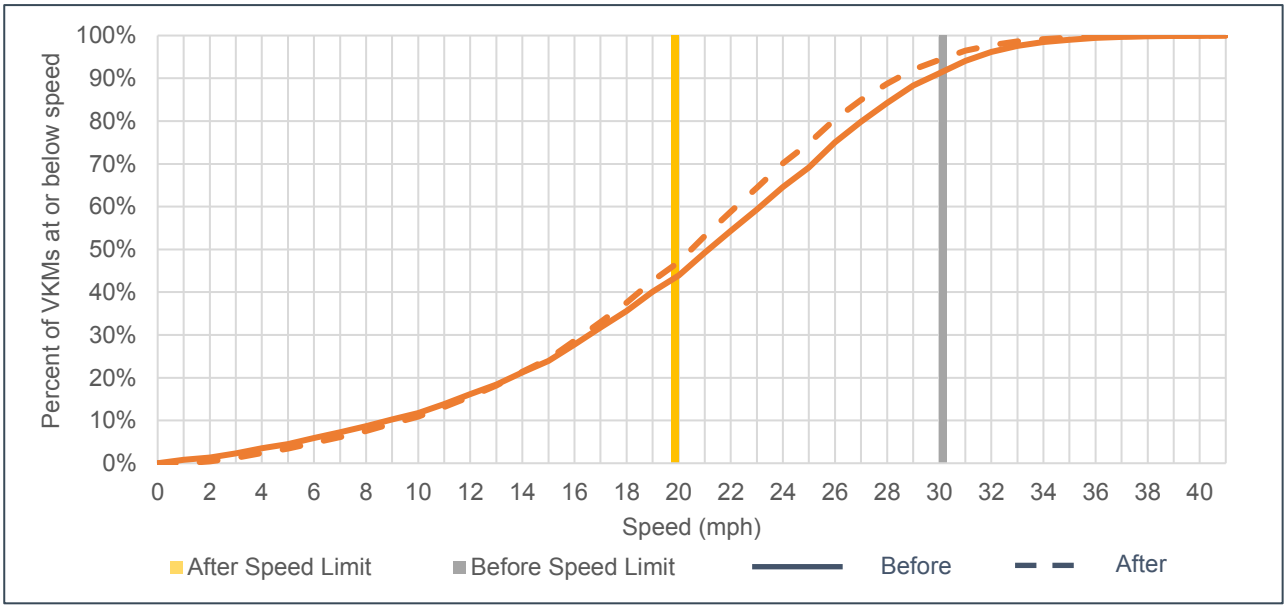
Post implementation compliance – Due to the small reduction in speeds, compliance with the new 20mph speed limit is still around half. Some 47% of drivers are complying with the new limit, compared with 91% compliance when the speed limit was 30mph. This represents a small increase in those travelling below 20mph.

Table 4-1 New 20mph limits (signed only) - Key outputs, residential areas

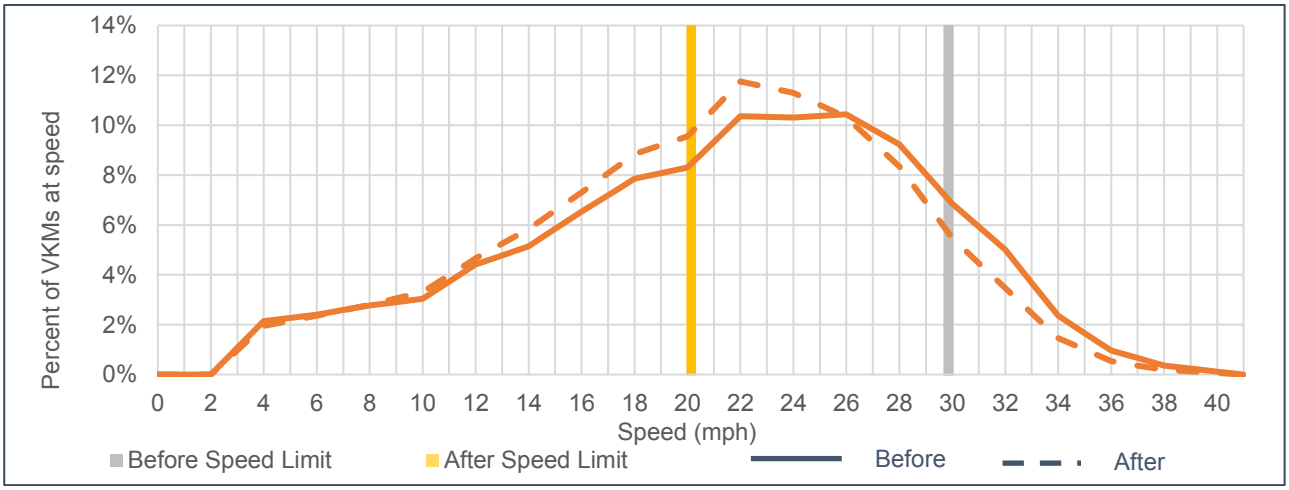
New 20mph limits (signed only)		Before	After	Diff
Speed limit		30mph	20mph	-
Road length		450.5km	450.5km	-
Sample VKMs observed		952,551km	1,136,370km	-
Compliance		91%	47%	-
Median speed		21.1mph	20.5mph	-0.7mph
85th percentile speed		28.1mph	27.0mph	-1.1mph
15th - 85th percentile		16.6mph	15.2mph	-1.3mph
% driving	**<20mph**	44%	47%	+3%
	20-24mph	21%	23%	+2%
	24-30mph	26%	24%	-2%
	>24mph, >30mph	35%, 9%	30%, 6%	-5%, -3%

Figure 4-1 New 20mph limits (signed only) - Residential areas

Cumulative speed distribution



Actual speed distribution



Case study differences – Similar analysis for each case study area is provided in Appendix B. In general, all areas show similar trends, with a few exceptions:

- Post-implementation compliance across all residential-based case studies varies from 32% to 55%, with the exception of Walsall where compliance is 16%. Before speeds were much higher in Walsall than elsewhere, and despite reporting the largest reduction in median speed (-1.5mph), the majority of drivers still seem to be travelling well in excess of 20mph.
- The post implementation speed profile curve is generally to the left of the before curve (as in Figure 4-1 above), at least for speeds above 20mph, indicating a general reduction in speeds and a reduction in the proportion travelling below 20mph. The only exception is Middlesbrough, where speeds have increased slightly (the median has increased from 19.6mph to 20.2mph), suggesting that something else may be happening in the area to affect speeds other than the introduction of 20mph speed limits. The median speed was already below 20mph, and it is possible that the introduction of the 20mph limit may have encouraged some drivers to increase their speeds, now seeing 20mph as a target.

Summary of findings

A high proportion of drivers were already travelling at speeds close to 20mph, prior to the introduction of the new limits. The median speed was just 21.1mph, and 44% were already driving less than 20mph.

While speeds have reduced since the introduction of the 20mph speed limit, they have not reduced substantially – averaging around a 1mph reduction for drivers previously travelling more than 24mph, and less for other drivers. The median speed has reduced by -0.7mph, the 85th percentile speed by 1.1mph, and the spread of speeds (indicated by the 15th-85th percentile range) has declined by 1.3mph.

Overall compliance with the new limits is 47%, with an extra three percentage points of additional drivers travelling at or below 20mph. These results show that the new limits do not encourage compliance to the same extent as the pre-scheme speed limit.

4.2.2. How does this impact differ, depending on the before speed?

Context

It is reasonable to expect that the change in speed could differ depending on the speed vehicles drove on each road prior to the introduction of the new limit. For example, some roads may be narrow, winding or have on street parking, all of which could result in a lower pre-scheme median speed, because of the characteristic of the road rather than the speed limit. In contrast a wider, straight road in an open location may naturally encourage drivers to drive faster. It could be that these two types of roads evoke a different response to the introduction of the new 20mph speed limit.

This section therefore examines how speed impacts vary across roads with a before median speed of A) <20mph, B) 20-24mph, and C) >24mph - in an attempt to split out the natural characteristics of different roads.

Table 4-2 shows the high-level results for the different categories of road, and Figure 4-2 shows the before and after speed distribution curves. Both outputs are based on 24-hour data, combining peak and non-peak periods.

Results

Before implementation - The majority of road length in the sample falls into the lowest speed category and already had a median speed of <20mph (315km, 70%) prior to the introduction of the 20mph limit. It could be argued that in these cases the new speed limit is formalising a lot of the previous behaviour. Only 56.4km (13%) of the road length in the sample falls into the top speed category, with a before median speed of >24mph and the most potential for speeds to reduce.

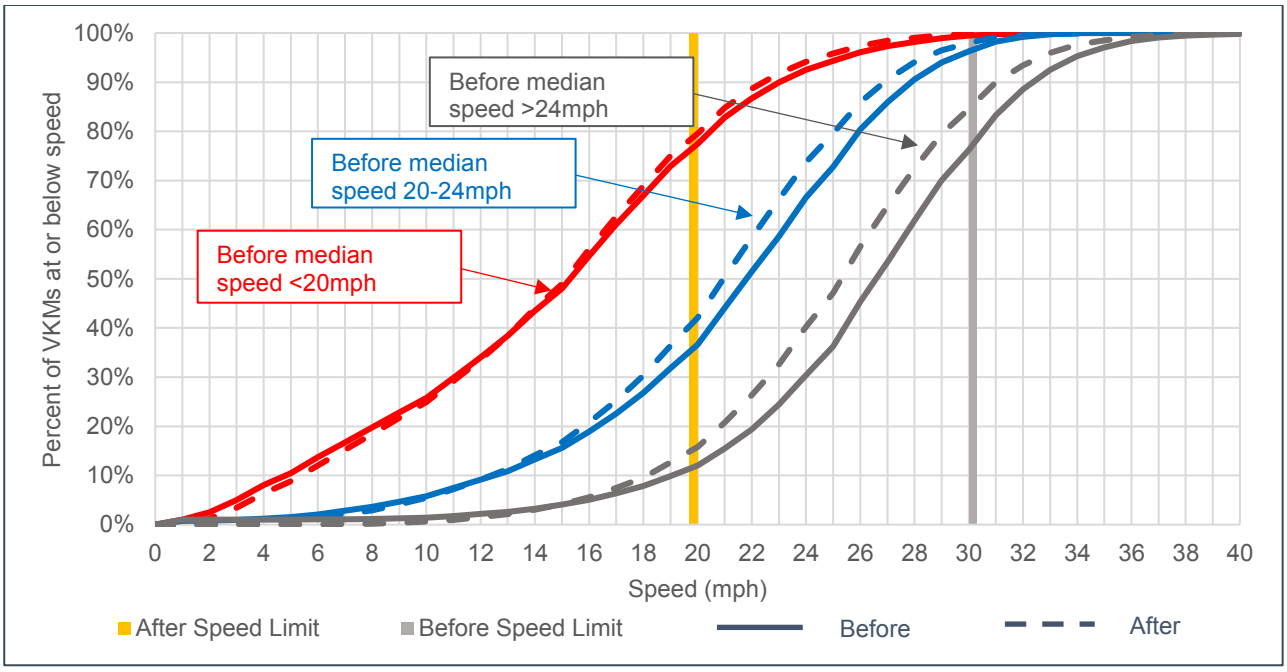
However, the total vehicle kilometres in each category is similar (although there are fewer faster roads they have more traffic on them) suggesting that the impact of each category on the results in Section 4.2.1 is broadly equal.

Table 4-2 New 20mph limits (signed only) - Key outputs, by pre-scheme speed

New 20mph limits (signed only)	A - Before Median <20mph			B - Before Median 20-24mph			C - Before Median >24mph		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	20mph		30mph	20mph	
Approx road length[a]	315.4km (70%)			78.6km (17%)			56.4km (13%)		
Sample VKMs Observed	356,252 kms	416,511 kms		285,998 kms	330,117 kms		310,301 kms	389,742 kms	
Compliance	100%	80%	-20%	96%	42%	-54%	77%	16%	-61%
Median Speed (mph)	15.3	15.1	-0.2	21.8	21.0	-0.9	26.5	25.2	-1.3
85th Percentile (mph)	21.5	20.9	-0.6	26.8	25.9	-1.0	31.1	30.0	-1.2
15th - 85th percentile	14.8	13.9	-0.9	12.1	11.5	-0.6	10.3	10.3	0.0
% Driving <20mph	78%	80%	+2%	37%	42%	+5%	12%	16%	+4%

a. The results are based on an aggregation of peak and non-peak outputs. Segments may fall into different categories depending on the time of day.

Figure 4-2 New 20mph limits (signed only) – Cumulative speed distribution, by pre-scheme speed



Speed changes across the three categories – Figure 4-2 shows speed reductions across all three speed categories, i.e. the after curve is to the left hand side of the before curve. However the scale of the reduction, demonstrated by the gap between the lines, is greater on roads with a higher pre-scheme median speed. This is also evident in Figure 4-2 which shows that the reduction in the median and 85th percentile speed is greatest on roads with the highest before speeds (-1.3mph and -1.2mph respectively), and lowest on the roads with the slowest before speeds (-0.2mph and -0.6mph respectively). This is likely to be because fewer drivers are required to adjust their behaviour on slower roads, with the opposite being true on higher speed roads.

However, the speed reductions are small, particularly when compared with the overall differences between the three categories. For example, the post-scheme speed profile for category C roads (>24mph) is still above the pre-scheme profile for category B roads (20-24mph) and the same is observed between categories B and A (<20mph). This tells us that road characteristics are a larger determinant of the speed drivers will adopt, than whether the road has a 20mph or 30mph limit. Put another way, drivers are generally

basing the speed they are willing to drive on a road based on some other factor than whether the speed limit is 20mph or 30mph, which only has a small dampening effect on speeds.

Focusing on the highest speed roads (shown in grey) it is interesting to note that the reduction in speed achieved is similar from around 24mph onwards, with all vehicles at these speeds reducing speeds by around 1mph. It might have been expected that the fastest vehicles (say those at 30mph) would reduce their speed more than slower vehicles (say those at 24mph) because they need to adjust more to be compliant. However, the graph suggests an almost uniform reduction, regardless of speed. This perhaps hints that the 20mph signs do have a dampening effect on speeds but this is still subject to individual user characteristics in terms of driving style and choices.

Post implementation compliance – Not surprisingly, speed limit compliance is much higher on roads which previously had the slowest speeds (with 80% driving <20mph), and much poorer on roads which previously had faster speeds (42% for Category B and 16% for Category C).

On the slowest roads (before median speed <20mph) compliance is high at 80%. However, 78% of drivers were already travelling below 20mph before the limit was introduced – possibly due to the features of the road such as street furniture, narrow streets or high pedestrian levels which naturally limit the speeds drivers can travel at – and following the change to the limit, this proportion only increased by 2 percentage points.

On the fastest roads (before median speed >24mph), compliance is low with only 16% of drivers travelling at or below the speed limit. This could be because the nature of the roads (e.g. minimal road furniture, low traffic flow or low local pedestrian levels), combined with the introduction of a new limit (primarily enforced by signs only), is insufficient to change drivers' behaviour.

Summary of findings

Two main conclusions can be drawn from this analysis.

Firstly, the introduction of a 20mph limit (signed only) has a bigger impact on roads with higher pre-scheme speeds, although even on the fastest roads the median speed reduction is still small (1.3mph).

Secondly, road characteristics (as approximated by pre-scheme speed) have a much larger impact on the speeds that drivers choose to adopt than whether the road has a 30mph or 20mph limit. This is evidenced by the fact that there are examples of roads where most drivers were already driving <20mph, even when the limit was 30mph (in these instances, the change of speed limit mainly formalised what was already occurring). In addition the speed distribution profiles for the three categories show a clear distinction from each other, both before and after the introduction of the new limit.

It appears that some roads lend themselves to good 20mph compliance more than others, probably due to the characteristics of the roads themselves.

It is worth noting that the majority of road length in the sample falls into the lowest speed category and already had a median speed of <20mph (315km, 70%) prior to the introduction of the 20mph limits. The change in speeds on these roads is very small (-0.2mph for the median, and -0.6mph for the 85th percentile).

4.2.3. How does this impact differ by time of day (for links with a median before speed of >20mph)?

Context

This section aims to examine the effect of journey purpose (represented by time of day) on speeds in new 20mph limits (signed only). It is expected that during peak periods, the majority of drivers will be commuters and business travellers; and during off-peak periods most drivers will be making social and leisure trips. Economic theory tells us that the value of time during peak periods is greater than that during non-peak periods. This may result in a difference in how commuters and business travellers (in the peaks) and social and leisure travellers (at other times of the day) respond to the introduction of 20mph speeds.

In order to accurately observe drivers' behaviour, only roads with a before median speed above 20mph are considered. This is because we want to remove roads that are showing slower speeds due to congestion (something that is likely to occur more often in the peak periods), so that the analysis can instead isolate the

driver behaviour relating to commuting and business trips, rather than artificially picking up differences of congestion. By looking at only roads with a before median of over 20mph it is possible to consider these roads as a free-flowing network, meaning that speed of travel is predominantly chosen by the driver, rather than forced on them by the conditions.

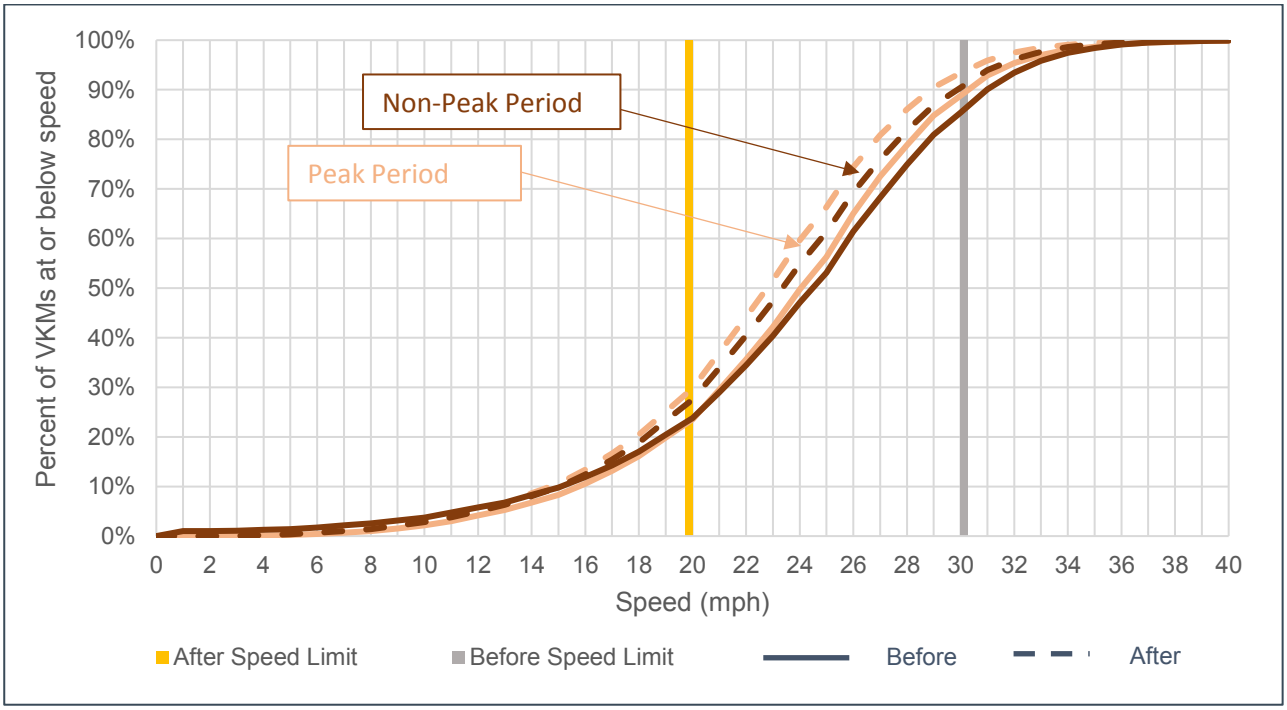
Table 4-3 shows the high-level results for each period, and Figure 4-3 shows the before and after speed distribution curves.

Table 4-3 New 20mph limit (signed only) - Key outputs, by time period (for links with a median before speed of >20mph)

New 20mph limit (signed only)	Peak Periods			Off-peak Periods		
	Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	20mph	
Road length[a]	130.4km			138.7km		
Sample VKMs Observed	127,617km	162,521km		468,681km	557,338km	
Compliance	89%	30%	-59%	86%	27%	-58%
Median Speed (mph)	24.0	22.8	-1.2	24.5	23.4	-1.1
85th Percentile (mph)	29.0	27.8	-1.2	29.9	28.6	-1.2
% Driving <20mph	24%	30%	+6%	24%	27%	+4%

a. The 'distance of road' differs between the peak and off-peak period because a higher proportion of segments had zero sample in the peak period and were therefore excluded from the analysis. In Tables 4-1 and 4-2, the results are based on an aggregation of peak and non-peak outputs. The road length for the peak plus off-peak samples has been divided by two to avoid double counting segments, and to just report the total for unique segments. In the above table, the road length for the combined peak and non-peak sample is 269km, which is double the 135km road length reported in Table 4-2 for segments with a median before speed of >20mph.

Figure 4-3 New 20mph limits (signed only) – Cumulative speed distribution, by time period



Results

Peak vs. non-peak differences - There is very little difference between the peak and off-peak findings:

- Prior to the new limit, both peak and off-peak periods had 24% of vehicle kilometres at or below 20mph.

- Following the introduction of the new limit, both periods saw similar increases in the percentage of speeds at or below 20mph, to 30% and 27% respectively. Driver compliance may be slightly exaggerated during peak periods due to any residual congestion during peak times.
- Both periods saw similar drops in median (-1.2mph and -1.1mph respectively) and 85th percentile speeds (-1.2mph and -1.2mph respectively).
- The speed distribution curves for the two periods (as shown in Figure 4-3) are also very similar. The peak period curves are both slightly to the left of their off-peak counterparts. This may be explained by residual congestion not filtered out by limiting the analysis to roads where the pre-scheme median speed is above 20mph.

Summary of findings

The profile of speeds for the two time periods (for links with a median before speed of >20mph) are so similar that there is little reason to believe that there is a difference in how peak and off-peak drivers respond to the introduction of the 20mph speed limits.

With no difference found between these time periods, the remainder of analysis in this report considers just the 24-hour period data for all analyses.

4.2.4. How does this impact differ by road class?

Context

Section 4.2.2 shows that the pre-scheme median speed of a road has a large impact on how the road responds to the lowering of the speed limit. It was suggested that slower roads may be more likely to be minor, narrower roads, while faster roads are likely to be more strategic, wider roads. This section uses TomTom's functional road class definition to further examine whether this is the case.

Functional road classes (FRCs) are defined in detail in Table 3-1, earlier in this report. In brief, they define the road classification from Motorways (0) through to local roads of minor importance (7). This is a good proxy for the size and strategic nature of each road. For the purpose of this analysis, 20mph roads have been grouped into three categories:

- Major strategic roads (FRC 1-3);
- Important local roads (FRC 4-5);
- Minor local roads (FRC 6-7).

Table 4-4 shows the high level results for the different categories of road, and Figure 4-4 shows the before and after speed distribution curves. Both outputs are based on 24-hour data, combining peak and non-peak periods. Note that Major Strategic Road data is greyed out due to the limited length of road represented in the sample, and not included in the graph.

Results

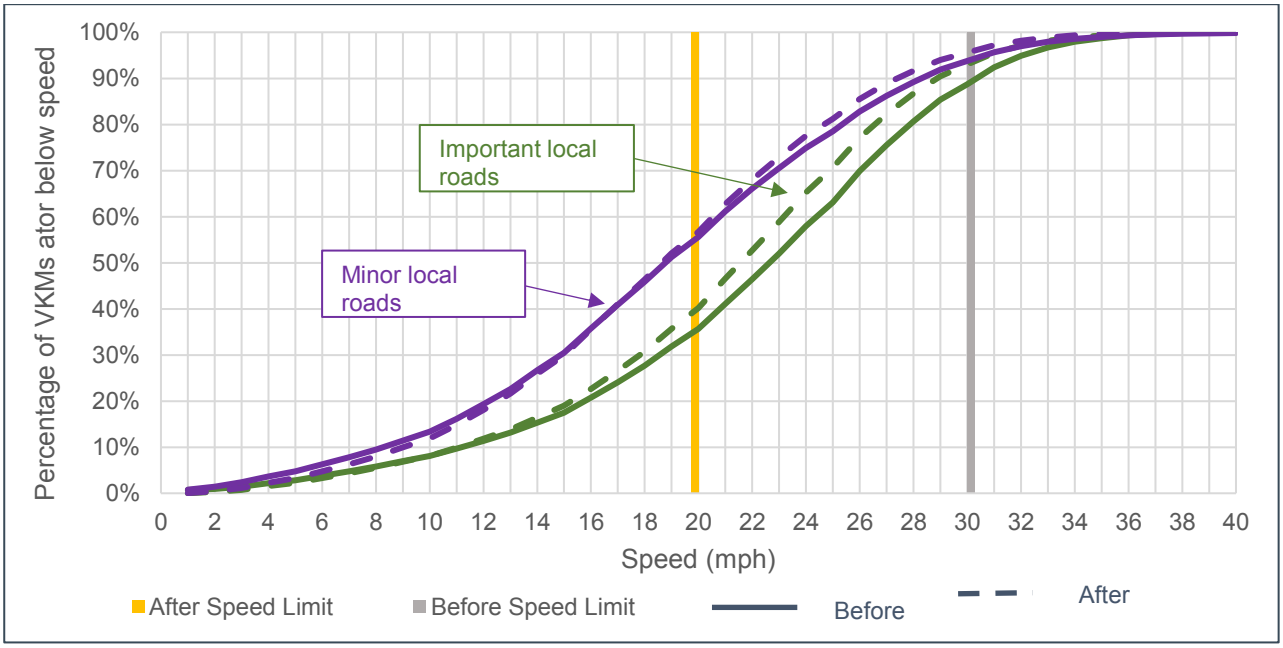
Function and before speed of roads within 20mph limit areas –Table 4-5 shows that the vast majority of new 20mph roads are 'minor local roads' (393kms, 87%), followed by 'important local roads' (52.4kms, 12%). There are very few 'major strategic roads' included in the scheme areas (5.3kms, 1%[24]). As reported elsewhere, many schemes specifically excluded strategically important roads due to their important function.

[24] Mainly located in Brighton Phase 2.

Table 4-4 New 20mph limit (signed only) - Key outputs, by functional road classification

New 20mph limit (signed only)	Major strategic roads			Important local roads			Minor local roads		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	20mph		30mph	20mph	
Road length	5.3km (1%)			52.4km (12%)			392.8km (87%)		
Sample VKMs Observed	237,113 km	247,200 km		405,779 km	496,901 km		309,658 km	392,268 km	
Compliance	92%	46%	-46%	89%	40%	-49%	94%	57%	-37%
Median Speed (mph)	21.5	20.8	-0.8	22.6	21.6	-1.1	18.7	18.6	-0.1
85th Percentile (mph)	28.3	27.2	-1.1	28.9	27.6	-1.3	26.5	25.9	-0.6
15th - 85th percentile	18.7	17.1	-1.6	15.1	14.2	-0.9	15.7	14.8	-0.9
% Driving <20mph	43%	46%	+3%	36%	40%	+5%	56%	57%	+1%

Figure 4-4 New 20mph limit (signed only) – Cumulative speed distribution, by road type



A cross-tabulation of road classification with median before speed (see Table 4-5) shows that segments with a pre-scheme median speed below 20mph were almost exclusively minor local roads (comprising 95% of road length within the sample), while segments with a pre-scheme median speed above 24mph comprise a much higher proportion of important local roads.

Table 4-5 Relationship between pre-scheme speed and functional road classification

New 20mph limit (signed only)	Approx. road length with a before median speed <20mph		Approx. road length with a before median speed 20-24mph		Approx. road length with a before median speed >24mph	
Major strategic roads	0.6%	2.0km	1.9%	1.5km	3.2%	1.8km
Important local roads	4.2%	13.1km	18.0%	14.2km	44.3%	25.0km
Minor local roads	95.2%	300.3km	80.1%	63.0km	52.5%	29.6km

a. The results are based on an aggregation of peak and non-peak outputs. Segments may fall into different categories depending on the time of day.

It is suspected that 'important local roads' are generally wider roads which provide access to key local destinations or connect important routes; and 'minor local roads' are likely to be narrower roads, primarily

within residential areas or estates, where drivers may struggle to reach higher speeds due to parked cars, cul-de-sacs, or high volume of pedestrians in the area (e.g. outside a school). It appears that 'minor local roads' tend to naturally have lower speeds.

Before implementation – The before data shows that speeds on 'important local roads' were notably higher than on 'minor local roads', as expected. 'Important local roads' had both a higher median (22.6mph vs 18.7mph) and 85th percentile speeds (28.9mph vs 26.5mph). In addition, a lower proportion of speeds were below 20mph (36% vs 56%), and compliance with the previous 30mph limit was also lower (89% vs. 94%), implying the need for some vehicles to reduce their speed by more than 10mph to comply with the new limit.

This supports the conclusion that there are intrinsic differences in how motorists feel they can drive on these different classes of roads.

Post implementation – Following implementation of the new limit, speeds reduced on both types of roads, but only by a small amount: of around 1mph on 'important local roads' (where speeds were higher in the before period), and less than 1mph on 'minor local roads', with corresponding reductions in the median and 85th percentile speeds.

Figure 4-4 shows that the reduction in speed is small, when compared with the difference between the two types of road categories. The before and after speed curves for 'important local roads' (the green lines) are both located to the right of the before and after curves for 'minor local roads' (the purple lines). This again tells us that road characteristics are a larger determinant of driver speed than whether the road has a 20mph or 30mph speed limit in place.

Summary of findings

In summary, it appears that while the introduction of the 20mph speed limits has reduced speeds slightly, the major factor relating to how drivers will respond to speed limits of 30mph or 20mph is the character of the road itself. The changes in speed due to different characters and classifications of roads are far larger than the changes brought about by lowering the speed limit.

The median and 85th percentile speeds have reduced more on major strategic roads (-0.8mph and -1.1mph) and important local roads (-1.1mph and -1.3mph); than on minor local roads (-0.1mph, -0.6mph).

Overall, 'minor local road' segments with a before median speed of <20mph account for over half (67%) of road length within the case study sample. As shown in Section 4.2.2, the introduction of 20mph limits has had only a very small impact on roads with a before median speed of <20mph, reducing the median speed by just 0.2mph. It is therefore not surprising that the reduction in median speed across the whole sample is only -0.7mph (see Section 4.2.1).

4.2.5. Results of comparator analysis

As outlined in Section 3.7, each case study area has been associated with a comparator area, used as a control for what would have been likely to occur over time had the 20mph signed only limits not been introduced. This provides context against which to measure the observed speed changes in the case study areas.

Speed trend in comparator areas

The comparator areas have been analysed using the same methodology as applied to the case study areas, to identify before and after median, 85th percentile and 15th-85th percentile range speeds for analysis and comparison with the case study area results.

A summary of the high level metrics for the residential comparator areas is provided in Table 4-6 and Table 4-7. The tables demonstrate that in all instances median speed and 85th percentile speed has reduced in the comparator areas. This provides some context in which to view the case study area results. The comparator areas are designed to control for background factors and attempt to isolate the impact of the 20mph speed limit change as the main differentiator between a case study area and its comparator area. The reduction in speeds observed in the comparator areas are of similar magnitudes as the reductions seen in case study areas. This casts some doubt on whether the introduction of 20mph has been the cause of the reduction in

speeds observed in case study areas. Statistical tests on the data will be used to provide an understanding of whether the case study area speed reductions are significant.

Table 4-7 also provides insight into how the 15-85th percentile range of speeds has changed in the comparator areas. This seems to be a mixed response with some ranges increasing and some decreasing but all within the scale of +/-1mph. Where the range has increased, this can be interpreted as the 15th percentile speed reducing by ***more than*** the reduction in the 85th percentile.

Table 4-6 Sample size and median speeds for residential comparator areas

		Sample VKMs observed		Median speed		
	Comparator Area	**Before**	**After**	**Before**	**After**	**Diff**
Residential	A1: Worthing	979,473	1,026,961	25.0	24.0	-1.0
	A2: Worthing	1,069,224	1,449,319	24.4	23.9	-0.5
	B1: Wolverhampton	1,759,714	2,239,861	25.5	24.8	-0.7
	B2: Wolverhampton	1,563,626	4,494,554	25.3	24.5	-0.8
	C: Sunderland	430,125	434,504	25.7	25.6	-0.1

Table 4-7 85th percentile and speed range for residential comparator areas

		85th Percentile speed			15-85th Percentile range		
	Comparator Area	**Before**	**After**	**Diff**	**Before**	**After**	**Diff**
Residential	A1: Worthing	30.6	30.0	-0.6	13.8	13.9	+0.1
	A2: Worthing	30.3	29.9	-0.4	14.2	14.0	-0.1
	B1: Wolverhampton	31.1	30.6	-0.5	15.2	15.4	+0.2
	B2: Wolverhampton	30.9	30.6	-0.3	15.3	16.2	+0.9
	C: Sunderland	32.1	31.4	-0.6	15.4	14.4	-1.0

Statistical analysis to compare case study and comparator trends

Table 4-8 to Table 4-12 show the residential statistical analysis outputs for all roads (based on an aggregation of the datasets for all three road types), just major roads, just important local roads and just minor local road respectively. Note that not all case study areas have new 20mph signed only roads in all three road categories and so the number of case study area observations differs in each test (e.g. major strategic roads with 20mph limits are only present in the two Brighton case study areas).

The results show that the reduction in speeds in the case study areas is found to be statistically significant relative to the comparator areas, when all road types are considered in aggregate. The relative change, as a result of the 20mph limit policy is estimated at -0.38mph for the median speed, -0.72mph for the 85th percentile speed, and -1.06mph for the 15th-85th percentile range.

More detailed analysis by road type shows that the relative reduction in the median and 85th percentile speeds is significant for important local roads (-0.81mph and -1.11mph respectively) but not for major or minor local roads. It therefore appears that the important local roads are driving the overall results, and are where there is the most confidence that a small decrease in speed has occurred due to the introduction of 20mph (signed only) limits.

Table 4-8 Statistical outcomes – All roads (predominantly residential areas only)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.38mph	-0.72mph	-1.06mph
Lower 95% CI	-0.63mph	-1.01mph	-1.46mph
Upper 95% CI	-0.12mph	-0.43mph	-0.67mph
Statistically Significant?	Yes	Yes	Yes
Number of matched pairs in sample[a]	21	21	21

a. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 2 for major strategic roads, 9 for important local roads, and 10 for minor local roads.

Table 4-9 Statistical outcomes – Major strategic roads (predominantly residential areas only)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.06mph	-0.65mph	-2.00mph
Lower 95% CI	-0.29mph	-3.65mph	-13.98mph
Upper 95% CI	0.17mph	2.36mph	9.98mph
Statistically Significant?	No	No	No
Number of matched pairs in sample[b]	2	2	2

b. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 2, reflecting the number of residential case studies with major strategic roads.

Table 4-10 Statistical outcomes – Important local roads (predominantly residential areas only)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.81mph	-1.11mph	-1.00mph
Lower 95% CI	-1.23mph	-1.64mph	-1.45mph
Upper 95% CI	-0.39mph	-0.58mph	-0.56mph
Statistically Significant?	Yes	Yes	Yes
Number of matched pairs in sample[c]	9	9	9

c. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 9, reflecting the number of residential case studies with important local roads.

Table 4-11 Statistical outcomes – Minor local roads (predominantly residential areas only)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.02mph	-0.25mph	-0.49mph
Lower 95% CI	-0.23mph	-0.54mph	-0.83mph
Upper 95% CI	0.19mph	0.03mph	-0.16mph
Statistically Significant?	No	No	Yes
Number of matched pairs in sample[d]	10	10	10

d. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 10, reflecting the number of residential case studies with minor local roads.

The results are consistent with the earlier findings which shows that, in absolute terms, median and 85th percentile speeds have reduced most on important local roads (-1.1mph and -1.3mph); and less on major strategic roads (-0.8mph and -1.1mph) and particularly minor local roads (-0.1mph, -0.6mph).

The data tested in each of the models is provided in Appendix A.5.

Unweighted test – The above models were also run in an unweighted format, so as to treat all case study areas equally. Without weighting, none of the key metrics were found to be statistically significant. The only outcome that was significant was a small reduction in the 15-85th percentile range for the aggregated speeds for all roads.

Wider evidence on trends in speed in urban areas

The above results suggest that the absolute changes in speed observed in the case study areas are partly due to the implementation of 20mph limits (specifically on important local roads), but also reflect background trends in speed on urban roads.

Wider evidence suggests that there has indeed been a small downward trend in speeds in recent years, across a range of road types, based on data collected by the DfT on locally managed A roads and free-flowing 30mph roads.

Between December 2011 and December 2015, average vehicle speeds on locally managed A roads during the weekday morning peak dropped at a fairly consistent rate by 1.9mph, from 25.4mph to 23.5mph. This trend may have extended to the 20mph limit roads in the case study areas, but potentially to a lesser extent as levels of enforcement are typically lower on 20mph roads.

In addition, between 2011 and 2016, there was a slight reduction in average free flow speeds for cars – of less than 1mph on 30mph roads (31mph in 2011, 31mph in 2016).

Summary of findings

Statistical analysis shows a significant reduction in speeds, relative to similar 30mph comparator areas, for 'important local roads' in residential areas.

The relative change on important local roads in residential areas is estimated at -0.8mph for the median speed and -1.1mph for the 85th percentile speed.

The findings suggest that the absolute changes in speed observed in the case study areas are partly due to the implementation of 20mph limits, but also reflect background trends in speed on urban roads.

Wider evidence on trends in speed in urban areas

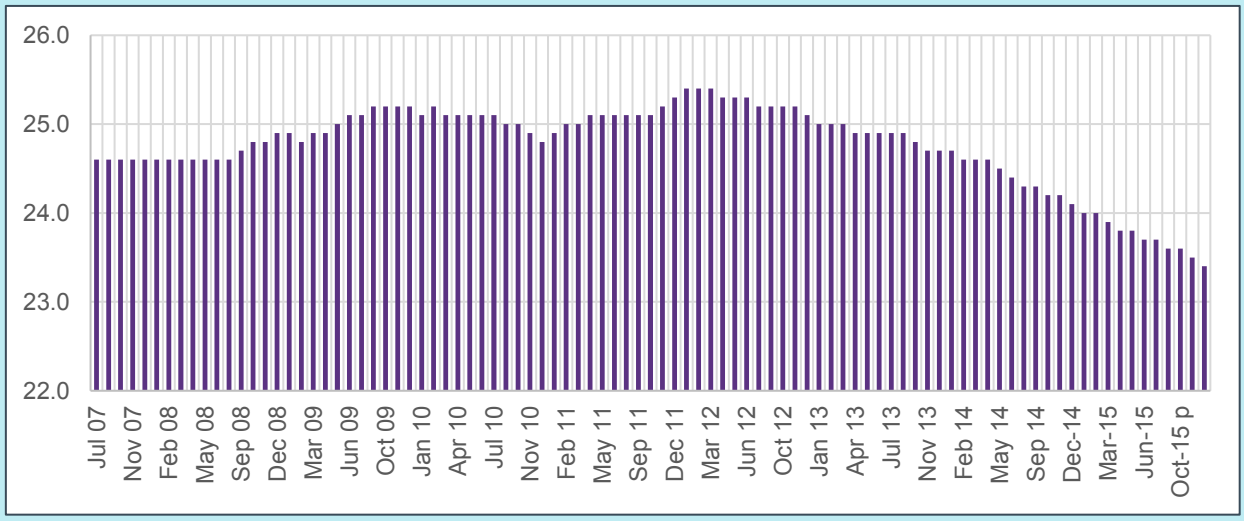
Average vehicle speeds on local authority A roads (Department for Transport, 2017a[25])

DfT published statistics on average speeds on local authority A roads suggest that average speeds fell between 2014 and 2016: by 1.0mph across all A roads (all day), by 0.8mph in urban areas (all day), and by 0.7mph in rural areas; and by 0.9mph in the weekday morning peak, and by -1.1mph in the weekday evening peak. This broadly corresponds to the 'before' and 'after' period for many of the case study schemes.

The dataset weights speed observations from a sample of vehicles by associated traffic flows so that it is representative of traffic volumes on the roads in different locations and at different times of day. The statistics are compiled of journey time data from in-vehicle global positioning systems (GPS) and flows estimated using automatic traffic counters and the Department's manual traffic count data.

Previous statistics suggest that speeds had been dropping steadily on these roads since 2011. Between December 2011 and December 2015, average vehicle speeds during the weekday morning peak dropped at a fairly consistent rate by 1.9mph, from 25.4mph to 23.5mph (Figure A) (Department for Transport, 2016[26]). The methodology used for calculating the average weekday morning peak statistics changed in 2016 so more recent statistics are not directly comparable.

Figure A: Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads (mph) – to Dec 2015



Free flow speeds on 30mph roads in Great Britain (Department for Transport, 2017b[27])

Since 2011, the Department for Transport has published average speeds in free flowing conditions on roads in Great Britain. These are based on speed data collected from a sample of DfT's Automatic Traffc Counters (ATCs), chosen to exclude locations where external factors might restrict driver behaviour (e.g. junctions, hills, sharp bends and speed enforcement cameras). A total of 29 sites are on 30mph roads. The statistics provide insights into speeds at which drivers choose to travel when free to do so, but are not estimates of average speeds across the whole network.

Between 2011 and 2016, there was a slight reduction in average free flow speeds for cars – of less than 1% on 30mph roads (31mph in 2011, 31mph in 2016).

[25] Department for Transport (2017a) Average speed on local 'A' roads: monthly and annual averages (Table CGN0501) – updated May 2017. https://www.gov.uk/government/statistical-data-sets/average-speed-and-delay-on-local-a-roads-cgn05

[26] Department for Transport (2016) Average vehicle speeds (flow-weighted) during the weekday morning peak on locally managed 'A' roads, by local authority in England: annual average from year ending July 2007 (Table CGN0206) – last update in February 2016. https://www.gov.uk/government/statistical-data-sets/cgn02-flow-weighted-vehicle-speeds

[27] Department for Transport (2017) Free flow vehicle speeds in Great Britain: 2016 tables https://www.gov.uk/government/statistics/free-flow-vehicle-speeds-in-great-britain-2015

4.3. Impact of new 20mph (signed only) limits on city centre roads

4.3.1. What is the impact of 20mph limits on city centre areas?

Context

While the previous section focused on new 20mph roads in predominantly residential areas, this section examines how speeds have changed in city centre areas, and draws comparisons with the residential findings. The areas included in the analysis are:

- Winchester City Centre (core city centre area, and residential streets within historic centre); and
- Brighton Phase 1 (city centre area only; adjacent predominantly residential areas excluded).

Both areas contain narrow roads, and a number of roads are lined with retail units. Much of Winchester City Centre is a historical conservation area, with very narrow and constrained streets.

The analysis is based on 20.6km of road length (compared with 443.4km of residential areas), and almost 300,000 vehicle kilometres of speed data in each period (compared with about one million for residential areas). The sample sizes are much smaller than for the residential analysis, but still considered substantial enough to give some indication of driver behaviour in city centre areas.

Table 4-12 shows the high-level results relating to these roads, and Figure 4-5 shows the before and after speed distribution curves. Both outputs are based on 24-hour data, combining peak and non-peak periods.

Results

Before implementation - The majority of city centre road length within the sample already had a median speed of <20mph (16.9km, 82%) prior to the introduction of the 20mph limits; a further 3.2km (16%) had a median speed of 20-24mph, and just 0.5km (2%) had a median speed of >24mph.

Most drivers were therefore already travelling at speeds of less than 20mph; more so than in the residential areas. The median speed was just 18.0mph, 59% were already travelling below 20mph, and 79% were driving less than 24mph.

This is likely due to the nature of the city centres areas, and the large number of factors potentially obstructing vehicle flow - narrow streets, roadside loading and unloading activity, buses stopping to pick-up/drop-off passengers, on-street parking, and large numbers of pedestrians on the footpaths and crossing roads.

Analysis by functional road classification shows that over half (55%) of new 20mph limits were ‘minor local roads’, 27% were ‘important local roads’, and 19% were ‘major strategic roads’. Overall, 53% of road length in the city centre sample comprises ‘minor local roads’ with a before median speed of <20mph.

Change in median speed - Table 4-12 shows a slight reduction in median speed post implementation, from 18.0mph to 17.1mph, a 0.9mph reduction (slightly higher than the 0.7mph reduction observed in residential areas). As in residential areas, but more so here, the change is small because a high proportion of drivers were already travelling slowly.

Change in speed profile - Figure 4-5 shows that the reduction in speed comes from the higher speed section of the curve. This is shown by the size of the gap between the before and after lines, which, increases for higher speeds, reaching a maximum reduction of 1.5-2mph. In addition, the proportion of drivers travelling over 24mph has reduced by a sizeable 7%; compared with a 1% increase in the proportion travelling at 20-24mph, and a 6% increase in drivers travelling less than 20mph. As a result, the 85th percentile speed has reduced by 1.6mph (almost double the reduction in the median). The spread of speeds, indicated by the 15^{th}-85^{th} percentile range, has declined by 2.0mph.

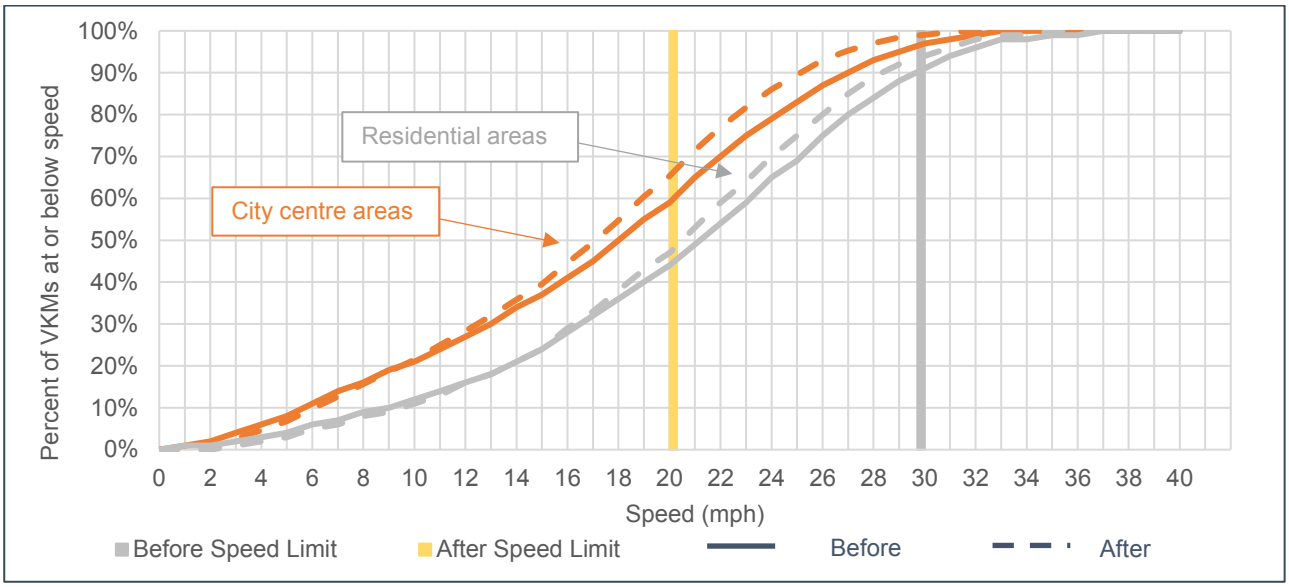
Post implementation compliance – Due to the higher number of vehicles already travelling below 20mph, there is a moderate level of compliance with the new 20mph limit, 65% (compared with 47% in residential areas). However, this still represents only a 6% increase in vehicles travelling at 20mph or less.

Table 4-12 New 20mph limit (signed only) – Key outputs, city centre areas

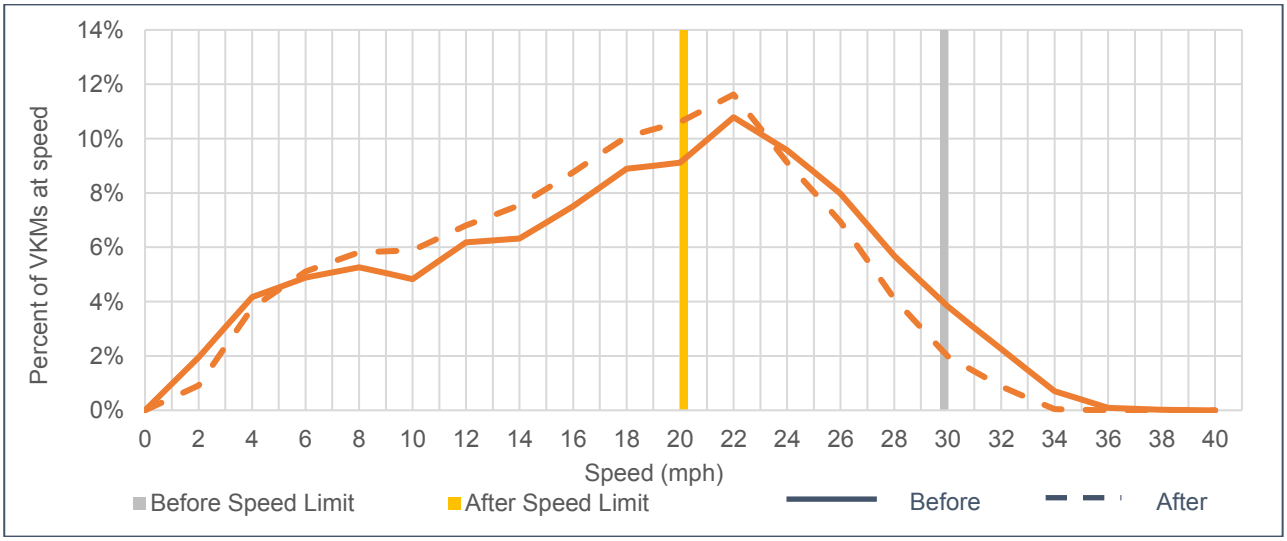
New 20mph limit (signed only)		Before	After	Diff
Speed limit		30mph	20mph	-
Road length		20.6km		-
Sample VKMs observed		274,342km	296,273km	-
Compliance		97%	65%	-
Median Speed		18.0mph	17.1mph	-0.9mph
85th Percentile Speed		25.4mph	23.8mph	-1.6mph
15th - 85th percentile		17.9mph	16.0mph	-2.0mph
% driving	**<20mph**	59%	65%	+6%
	20-24mph	20%	21%	+1%
	>24mph, >30mph	21%, 3%	14%, 1%	-7%, -2%

Figure 4-5 New 20mph limits (signed only) – City centre vs. residential areas

Cumulative speed distribution



Actual speed distribution (city centre areas)



Comparison to residential speed distribution - Figure 4-5 also has the residential distribution shown for comparison. Firstly, it is evident that speeds are generally slower in city centres, likely due to the amount of interaction with pedestrians and cyclists, crossing points, and high density of buses and parking traffic. In terms of the change in curve due to the implementation of 20mph, it appears the city centre has had a larger reduction, especially at higher speeds.

Summary of findings

The impact of new 20mph limits (signed only) has been small in both residential and city centre areas. However, these results suggest that there has been a slightly bigger change in city centre areas; with a higher reduction in median speed (-0.9mph vs -0.7mph), a bigger reduction in the 85th percentile speed (-1.6mph vs. 1.1mph), and a larger increase in the proportion travelling < 20mph (+6% vs. +3%).

4.3.2. Results of comparator analysis

As outlined in Section 3.7, each case study area has been associated with a comparator area, used as a control for what would have been likely to occur over time had the 20mph signed only limits not been introduced. This provides context against which to measure the observed speed changes in the case study areas.

Speed trend in comparator areas

The city centre comparator areas have been analysed using the same methodology as applied to the case study areas. This analysis provides before and after median, 85th percentile and 15th-85th percentile range speeds for analysis and comparison with the case study area results.

A summary of the city centre comparator area high level figures is provided in Table 4-13 and Table 4-14. Both use the Worthing comparator area but with different date ranges to closely match the date ranges used in the city centre case study areas.

Table 4-13 Sample size and median speeds for city centre comparator areas

		Sample VKMs observed		Median		
	Comparator Area	Before	After	Before	After	Diff
City	A1: Worthing	52,900	57,325	19.8	19.2	-0.6
	A2: Worthing	60,868	82,402	19.6	19.3	-0.3

Table 4-14 85th percentile and speed range for city centre comparator areas

		85th Percentile			15-85th Percentile Range		
	Comparator Area	Before	After	Diff	Before	After	Diff
City	A1: Worthing	26.3	25.7	-0.6	13.6	13.8	+0.2
	A2: Worthing	26.0	25.7	-0.3	13.9	13.8	-0.1

Speed trend in comparator areas

The tables demonstrate that in both instances median speed and 85th percentile speed has reduced in comparator areas. This provides some context in which to view the case study area results. The comparator areas are designed to control for background factors and attempt to isolate the impact of the 20mph speed limit change as the main differentiator between a case study area and its comparator area.

As with the residential analysis, the reduction in speeds observed in the comparator areas are of similar magnitudes as the reductions seen in case study areas. This casts some doubt on whether the introduction of 20mph has been the cause of the reduction in speeds observed in case study areas. Once more, statistical tests have been conducted to provide further clarity.

Table 4-14 also provides insight into how the 15-85th percentile range of speeds has changed in the comparator areas. This seems to be a mixed response with some ranges increasing and some decreasing but all within the scale of +/-0.2mph. where the range has increased, this can be interpreted as the 15th percentile speed reducing by ***more than*** the reduction in the 85th percentile.

Statistical analysis to compare case study and comparator trends

Table 4-15 to Table 4-17 show the city centre statistical analysis outputs for all roads, important local roads and minor local road analyses respectively. This includes just the Brighton Phase 1 Core City Centre and Winchester City Centre areas being compared to the Worthing City Centre comparator area, and thus has substantially less data and observations than the residential analysis above. Note that it is not possible to conduct separate analyses on major roads as there is only one instance of city centre major roads (in Brighton Phase 1 City Centre), however this data is included in the all roads output.

The results for the aggregation of all road types are all significant. The relative change across all roads, as a result of the 20mph limit policy, is estimated at -0.57mph for the median speed, -0.99mph for the 85th percentile speed, and -1.27mph for the 15th-85th percentile range.

However, further investigation shows that on important local roads and minor local roads none of the changes observed in the case study areas are statistically significant. This could be a reflection of the greater number of observations in the aggregated dataset, which gives greater confidence that small changes are significant. It is also possible that the change observed in the aggregated dataset is driven by the relative change in speeds on major strategic roads in Brighton Phase 1. The actual change in median, 85th percentile, and 15th-85th percentile speeds on these roads is -0.73mph, -1.33mph, and -1.93mph, compared with -0.33mph, -0.19mph, and +0.80mph in the comparator areas; supporting this hypothesis. This observation also has the highest weighting in the aggregated statistical model.

Table 4-15 Statistical outcomes – All roads (city centres)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.57mph	-0.99mph	-1.27mph
Lower 95% CI	-0.97mph	-1.67mph	-2.35mph
Upper 95% CI	-0.16mph	-0.31mph	-0.19mph
Statistically Significant?	Yes	Yes	Yes
Number of matched pairs in sample[a]	5	5	5

a. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 5 reflecting all road type and case study areas in City Centres.

Table 4-16 Statistical outcomes – Important local roads (city centres)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.72mph	-1.20mph	-1.14mph
Lower 95% CI	-3.72mph	-5.07mph	-5.85mph
Upper 95% CI	2.27mph	2.66mph	3.57mph
Statistically Significant?	No	No	No
Number of matched pairs in sample[b]	2	2	2

b. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 2, reflecting the number of city centre case study areas to include important local roads.

Table 4-17 Statistical outcomes – Minor local roads (city centres)

	Relative change in median speed	Relative change in 85th percentile speed	Relative change in 15-85th percentile range
Estimated change in case study areas, relative to comparator areas	-0.26mph	-0.29mph	-0.48mph
Lower 95% CI	-2.94mph	-5.98mph	-1.03mph
Upper 95% CI	2.42mph	5.40mph	0.07mph
Statistically Significant?	No	No	No
Number of matched pairs in sample[c]	2	2	2

c. Refers to the number of case study vs. comparator area comparisons included in the statistical model. In this case, 2, reflecting the number of city centre case study areas to include minor local roads

Unweighted test – The above models were also run in an unweighted format, so as to treat all case study areas equally. As with the weighted analysis, only the changes for all roads are found to be statistically significant, with all three metrics (median, 85th percentile and range of speeds) found to be significant.

Summary of findings

Statistical analysis shows a significant reduction in speeds, relative to similar 30mph comparator areas, for an aggregation of all road types in city centre areas.

The relative change across all roads in city centre areas, is estimated at -0.6mph for the median speed, and -1.0mph for the 85th percentile speed.

The findings suggest that the absolute changes in speed observed in the case study areas are partly due to the implementation of 20mph limits, but also reflect background trends in speed on urban roads.

5. Effectiveness of new 20mph limits (signed only) over time (Portsmouth)

5.1. Introduction

This chapter examines how the effectiveness of **20mph limits (signed only)** varies over time, based on the Portsmouth case study. This scheme was implemented substantially earlier than other case study schemes, enabling long term analysis to be undertaken (comparing outcomes one year and seven years post implementation). Note there will be no pre-scheme data used in this analysis, so the only comparison is between one year after and seven years after to understand the long-term impact of these interventions.

5.2. What is the long-term impact of 20mph limits in Portsmouth?

Context

The effect of the introduction of new 20mph roads could change over time. The initial results could be indicative of long term results, or things could change. For example, it is possible that there is an initial rejection of the change, believing the pre-scheme speed to have been adequate, before compliance improves over time as the new speed limits become 'normal'. Alternatively, the initial compliance could be the peak, and apathy could grow over time leading to increased levels of speeding over time. The purpose of this section is therefore to use the Portsmouth case study area, which has been in place for over seven years now, to understand how the one year after and seven year after outputs compare.

The comparison of one year after and seven years after 20mph signed only speed outputs is provided in Table 5-1. There are 212.4km of 20mph signed only roads in the TomTom data for analysis, and so there is good coverage on which to base the analysis. The speed profile analysis is also provided for these roads in Figure 5-1.

Table 5-1 Portsmouth one year and seven year after key speed outputs

		1 Year After	7 Years After	Diff
Speed limit		20mph	20mph	-
Road length		212.4km	212.4km	-
Sample VKMs observed		197,838km	265,136km	-
Compliance		58%	62%	+4%
Median speed		18.4mph	17.9mph	-0.5mph
85th percentile speed		25.8mph	24.8mph	-1.0mph
15th-85th percentile		15.2mph	14.1mph	-1.0mph
% driving	**<20mph**	58%	62%	+4%
	20-24mph	20%	21%	+1%
	>24mph	22%	18%	-4%

Results

One year after implementation – In Portsmouth, one year after the implementation of 20mph signed only areas, the percentage of drivers traveling at or below 20mph was 58% (high, when compared with the other case studies). Many roads inside these areas are narrow with parked cars on each side further narrowing the road.

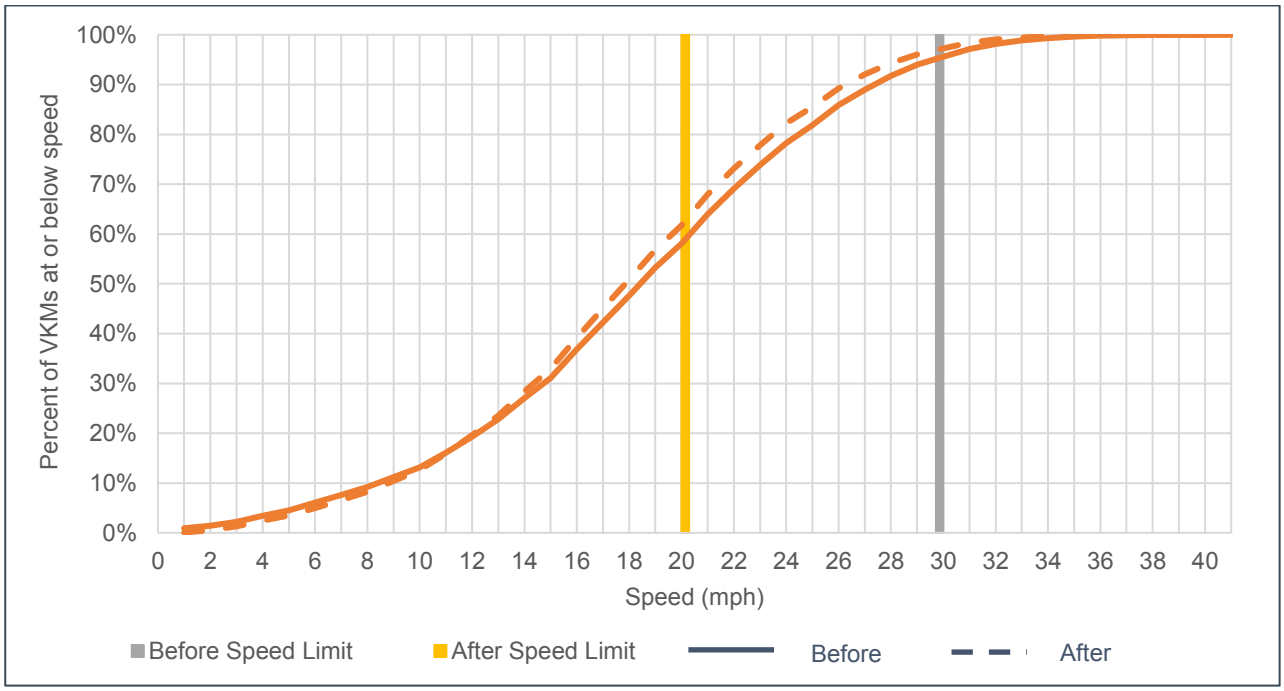
Post implementation compliance and speed changes - The table shows that compliance has increased over time, from 58% compliance in year one to 62% compliance in year seven. All the metrics tell the same narrative, with median speed reducing from 18.4mph to 17.9mph over time and 85th percentile speeds

following the same trend. While there may be an external influence causing this change (such as increased congestion), the results may indicate that 20mph signed only roads 'bed in' over time with increased levels of compliance. This could be due to motorists becoming more receptive to the change in speed limit over time. For example, in year one most will remember having previously driven on the road with a 30mph speed limit and may believe that the change was unnecessary. By year seven the change in speed limit will perhaps no longer be recalled and motorists will simply be responding to the signage at face value. Further evidence on why this effect may be occurring may emerge from other research strands (e.g. the local stakeholder interviews).

Care must be taken in taking the Portsmouth finding and extrapolating wider. Within Portsmouth, 20mph limits cover an extensive area, comprising a high proportion of all roads in the City. Peer pressure may be a factor. Furthermore, drivers may be forced into adopting compliant behaviour if other motorists are complying, due to not being able to overtake them.

Figure 5-1 shows the speed distribution profiles for Portsmouth 20mph signed only roads at one year and seven years after introduction. It supports the findings of the tabular results in that speeds have reduced over time. This reduction comes from the higher speed section of the curve, suggesting it is those who didn't comply at first who are starting to change their behaviour as time elapses.

Figure 5-1 Speed Profile for Portsmouth 20mph signed only



Summary of findings

In summary, while it is not wise to over generalise based on one case study area, the evidence from Portsmouth is that there has been an increase in 20mph compliance over time. The changes could be unique to Portsmouth, or influenced by a wider national downward trend in speeds on local roads. However, the wider conclusion is that there is no evidence to support a view that compliance will worsen over time.

6. How do outcomes compare with other speed limit areas?

6.1. Introduction

The previous chapter considered how new 20mph (signed only) roads are performing following their introduction. This chapter provides some context by comparing the outcomes for the **new 20mph limits (signed only)** roads with the outcomes for:

- other 20mph roads - new 20mph limits (existing calming), old 20mph limits (signed only), old 20mph limits (with calming); and
- 30mph and 40mph roads within the study areas.

Contextual evidence of the broader decline/increase in speeds that may be happening in the area, in the absence of any speed limit change, will help interpret the observed change on new 20mph limits (signed only). For example, it may identify whether drivers are generally becoming speed conditioned and driving more slowly on all roads, or whether they are they driving faster on 30mph and 40mph roads to catch-up time lost on the now slower 20mph roads.

This evidence also enables levels of compliance on different types of 20mph roads to be compared, for example, to understand if signed only limits are as effective as those with traffic calming in place to encourage speed compliance.

This chapter only presents results for **predominantly residential schemes**, where sample sizes are higher. For city centre areas, the sample sizes are small and may not provide robust results. Across the two case study areas which have been categorised as city centre areas, there are no new 20mph limits (with existing calming), 0.6km of old limits (with calming), 5.7km of old limits (signed only), and only 9.2km of 30mph and no 40mph limits.

6.2. How do outcomes compare with new 20mph limits (with existing calming)?

Context

This section compares outcomes for:

- New 20mph limits (signed only) - which are the main focus for this research; and
- New 20 limits (existing calming) - where new 20mph limits have been introduced on roads with existing traffic calming.

This enables us to examine whether the presence of existing physical measures such as road humps and chicanes encourages a higher level of compliance and delivers bigger reductions in speed.

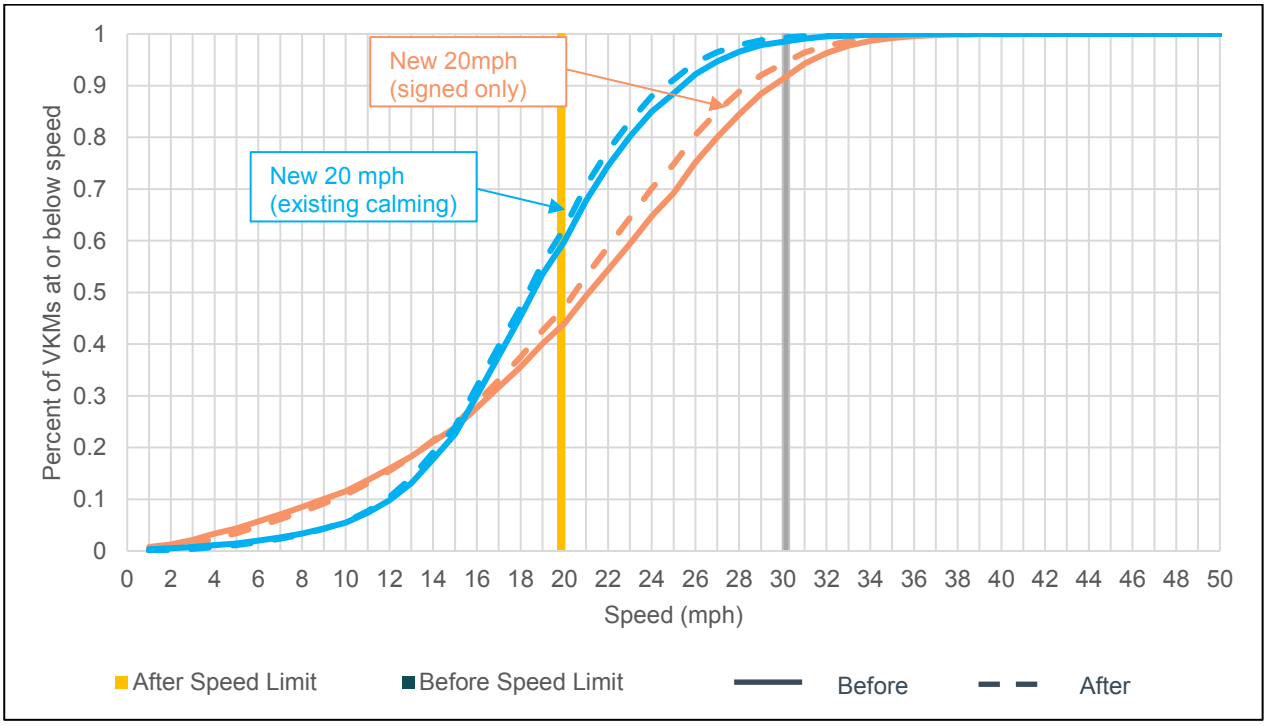
It should be noted that none of the case studies contain new 20mph zones (involving the introduction of a lower limit at the same time as new physical traffic calming measures). This was not the purpose of the research, and the outcomes of 20mph zones have been covered in other research studies. Table 6-1 shows the high-level results for the two types of schemes, and Figure 6-1 shows the before and after speed distributions. Both outputs are based on 24-hour data, combining peak and non-peak periods. Only results for predominantly residential roads are presented here.

The road length and sample size for new 20mph limits (existing calming) is much less than for new 20mph limits (signed only), but still provides a substantial amount of data for comparison (28km of road length, and around 55,000 vehicle kilometres of trips).

Table 6-1 New 20mph limit roads (signed only vs. existing calming) – Key outputs

Pre-dominantly residential areas only	New 20mph limit (signed only)			New 20mph limit (existing calming)		
	Before, After, Diff			Before, After, Diff		
Speed limit	30mph	20mph		30mph	20mph	
Road length	450.5km	450.5km		28.8km	28.8km	
Sample VKMs Observed	952,551km	1,136,370km		47,559km	56,661km	
Compliance	91%	47%	-44%	98%	62%	-36%
Median Speed (mph)	21.1	20.5	-0.7	18.6	18.3	-0.2
85th Percentile (mph)	28.1	27.0	-1.1	24.0	23.5	-0.6
15th-85th percentile	16.6	15.2	-1.3	10.6	10.2	-0.4
%<20mph	44%	47%	+3%	60%	62%	+3%
Major strategic roads	5.3km (1%)			0.0km (0%)		
Important local roads	52.4km (12%			7.4km (26%)		
Minor local roads	392.8km (87%)			21.4km (74%)		

Figure 6-1 New 20mph limit roads (signed vs calmed) – Cumulative speed distribution



Results

Comparison of results for the two categories of road suggests that speeds have reduced less on roads where physical traffic calming is already in place. The results for new 20mph limits (with existing calming) show a smaller reduction in median speed (-0.2 vs -0.7mph), 85th percentile speed (-0.6 vs -1.1mph) and the 15th-18th percentile range (-0.4mph vs -1.3mph).

Speeds were already lower on roads with existing calming, prior to the change in limit, e.g. 18.6mph vs. 21.1mph for the median speed. This is despite calmed roads comprising a higher proportion of important local roads, which typically have higher flows, and higher speeds.

It appears that the presence of physical measures (road humps, chicanes) has already encouraged drivers to change their behaviour and to adopt slower speeds, leaving little scope for a further reduction in response to the lowering of the speed limit.

Summary of findings

In summary, the introduction of 20mph limits on already traffic calmed roads has reduced speeds less than on new (signed only) limits. Speeds were already lower on roads with existing calming, prior to the change in limit. It appears that the presence of physical measures (road humps, chicanes) has already encouraged drivers to change their behaviour and to adopt slower speeds, leaving little scope for a further reduction in response to the lowering of the speed limit.

6.3. How do outcomes compare with old 20mph limits?

Context

This section compares outcomes for new 20mph limits (signed only) with those for old 20mph limits (signed only and with existing calming). This will allow us to see if the new limits are operating as well as old limits, and if not, explore some of the reasons why this may be (e.g. set on different road types). It will also allow us to see if having more 20mph roads in an area has changed behaviour on pre-existing 20mph roads.

Table 6-2 shows the high-level results for the different 20mph road section, and Figure 6-2 shows the before and after speed distributions. Both outputs are based on 24-hour data, combining peak and non-peak periods. Only results for predominantly residential roads are presented here.

The road lengths and sample sizes for the two old 20mph limit categories are much less than for new 20mph limits (signed only), but still provides a substantial amount of data for comparison. The results for old 20mph limits (signed only) is based on 15.7km of road length, and around 56,000 vehicle kilometres of trips; while the results for old 20mph limit (with calming) is based on 171.7km of road length, and around 175,000 vehicle kilometres of trips.

Table 6-2 Comparison of new and old 20mph limits – Key outputs

Pre-dominantly residential areas only	New 20mph limit (signed only)			Old 20mph limit (signed only)[1]			Old 20mph limit (with calming)		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed limit	30mph	20mph		20mph	20mph		20mph	20mph	
Road length	450.5km	450.5km		15.7km[(2)]	15.7km[(2)]		171.7km[(3)]	171.7km[(3)]	
Sample VKMs observed	952,551	1,136,370		53,292	59,291		166,594	185,047	
Compliance	91%	47%	-44%	65%	68%	+3%	67%	66%	-1%
Median Speed (mph)	21.1	20.5	-0.7	16.5	16.1	-0.4	17.0	17.2	+0.2
85th Percentile (mph)	28.1	27.0	-1.1	25.1	23.8	-1.3	23.6	23.9	+0.3
15th-85th percentile	16.6	15.2	-1.3	16.8	15.4	-1.5	12.8	12.7	-0.1
%<20mph	44%	47%	+3%	65%	68%	+3%	67%	66%	-1%
Major strategic roads	5.3km (1%)			0.9km (6%)			1.2km (1%)		
Important local roads	52.4km (12%)			2.2km (14%)			7.1km (4%)		
Minor local roads	392.8km (87%)			12.6km (80%)			163.4km (95%)		

1. *Excludes old 20mph limit (signed only) in Chichester, as this covers the City Centre area, and is predominantly non-residential.*
2. *Predominantly located in Chichester (42%) and Brighton Phases 1 and 2 (56%).*
3. *78% of old 20mph limits (with calming) are in Liverpool Area 2, with most of the remaining roads located in Liverpool Area 7, Middlesbrough and Brighton City Centre.*

Results

Old 20mph limit (with calming) - There has been little change in speeds on old 20mph limits (with calming), with the median changing by just -0.2mph between the before and after periods.

Speeds were already low on these roads, when compared with the before speeds on new 20mph (signed only) limits (e.g. 17.0mph vs 21.1mph based on the median speed), and a higher proportion were already travelling less than 20mph (67% vs. 44%).

It appears that extending the area covered by 20mph limits has not changed driver behaviour on the existing 20mph roads (with calming).

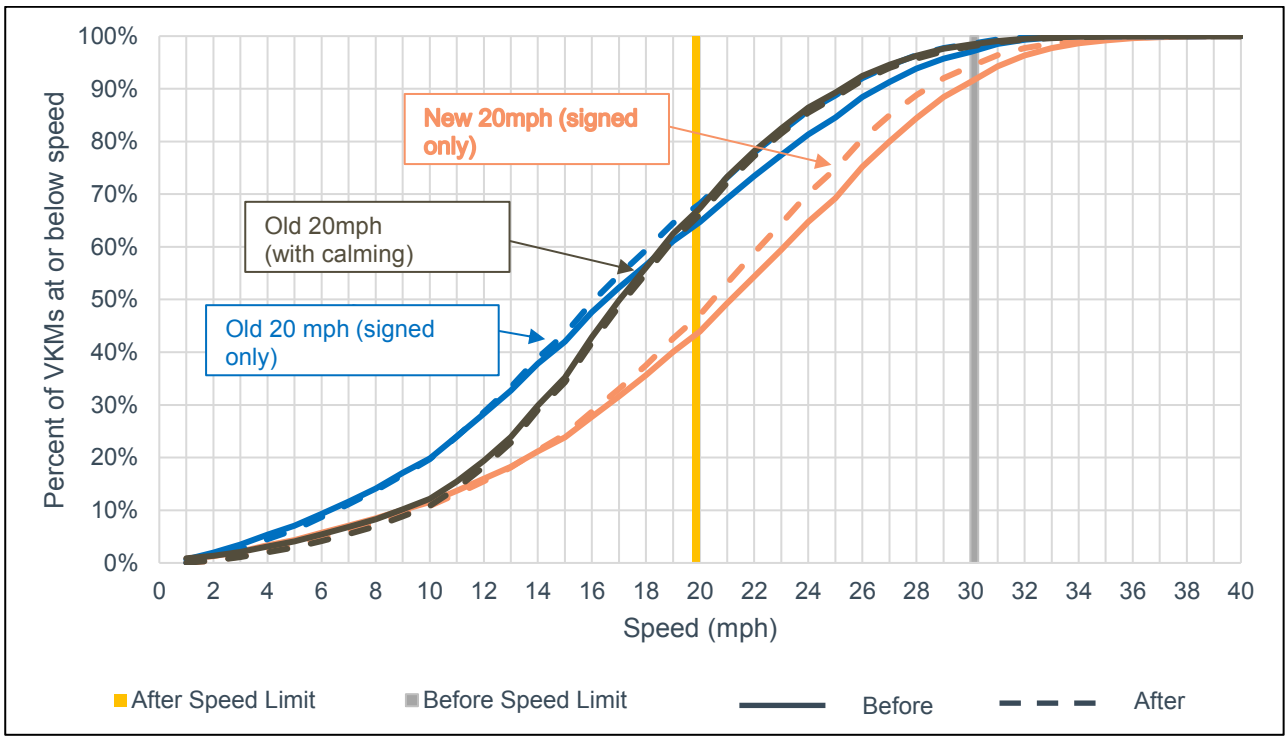
Old 20mph limit (signed only) – The sample of speeds for this category of road is relatively small, but shows a similar reduction in speed to that observed on new 20mph limits (signed only), at least in terms of the higher end speeds (e.g. -1.3mph vs -1.1mph based on the 85th percentile speed).

Speeds were already low on these roads, when compared with the before speeds on new 20mph (signed only) limits (e.g. 16.5mph vs 21.1mph based on the median speed), and a higher proportion were already travelling less than 20mph (65% vs. 44%).

While extending the area covered by 20mph limits has not changed driver behaviour on the existing 20mph roads (with calming), it appears that there has been some reduction on existing 20mph roads (with signs only). It is possible that the presence of calming (road humps, chicanes) and the nature of existing 20mph calmed roads (which are nearly all minor local roads) has already encouraged drivers to reduce their speed as much as they are willing to do so, in the absence of more proactive enforcement. However, on existing 20mph limits (signed only) drivers may have been encouraged to reduce their speeds further, in line with their behaviour on new (signed only) limits.

Compliance – Both categories of older 20mph road demonstrate a higher level of compliance than the new 20mph (signed only) limits. This could be because compliance improves over time, and the previous roads have had their speed limit in place for a longer time. Alternatively, it could be that the new 20mph roads have characteristics which make them less desirable to comply with a lower speed limit (e.g. wider, straighter, busier roads, etc.).

Figure 6-2 Comparison of new and old 20mph limits – Cumulative speed distribution



Summary of findings

In summary, this section has considered how the new 20mph limits have performed against older 20mph limits (signed only or with traffic calming).

The key finding is that the new 20mph signed only roads are not as effective as older 20mph roads at encouraging slower speeds. The percentage compliance on older roads is 68% for signed only limits and 66% on calmed roads, compared with 47% on new 20mph limits (signed only). This may be because the compliance improves over time and the new limits have not had time to become fully effective, or because the nature of the roads they have been introduced on (i.e. perhaps the previous 20mph limits were on roads which for physical / geometric reasons meant speeds would naturally be lower).

The analysis shows that extending the area covered by 20mph limits has not changed driver behaviour on the existing 20mph roads (with calming). However, there has been a reduction on existing 20mph roads (with signs only), with higher end speeds reducing by a similar amount to those on new 20mph limits (signed only). It is possible that the presence of calming (road humps, chicanes) and the nature of existing 20mph calmed roads (which are nearly all minor local roads) has already encouraged drivers to reduce their speed as much as they are willing to do so, in the absence of more proactive enforcement. However,

on existing 20mph limits (signed only) drivers may have been encouraged to reduce their speeds further, in line with their behaviour on new (signed only) limits. Further evidence however, is needed to support this conclusion.

6.4. Has there been an impact on 30mph or 40mph roads since the introduction of new 20mph limits?

Context

So far, the analysis in this report has only considered the impact on 20mph roads. However, it is possible that the introduction of 20mph roads in the case study areas could have an impact on other surrounding 30mph and 40mph roads. For example, if drivers have reduced speeds in 20mph roads, then they may want to driver faster on surrounding roads to counteract any lost time on 20mph roads. In contrast, perhaps vehicles will become conditioned to driving at slower speeds and thus continue to drive slower on surrounding roads too. This section looks at the effect (if any) the new 20mph limits have had on 30mph and 40mph roads nearby.

Table 6-3 shows the key statistics relating to 30mph and 40mph roads alongside the previously shown results for new 20mph signed only roads. There are very large samples of vkms for each of these groups of roads (~one million plus) and therefore there is confidence that the outputs are robust.
Figure 6-3 shows the speed distribution profile for each of these groups also, to allow analysis of changes in the profile.

Results

Change in median speed – Both 30mph and 40mph roads see a decrease of -0.5mph in the median speed. While the difference between the before and after figures is small, it could suggest that drivers are getting used to travelling at slower speeds (becoming speed conditioned) and are carrying this behaviour from the 20mph roads onto surrounding roads. The data shows no evidence to suggest that drivers are trying to compensate for any time lost traveling at 20mph on faster roads.

Change in speed profile – Figure 6-3 shows the speed distribution profiles for these three speed classifications. It shows that the overall shape of the distribution of 30mph and 40mph roads have remained consistent. The before and after lines are almost identical, with the only difference a minor shift to the left (slower) following the introduction of 20mph limits in the study areas. This further endorses that there has been no “making up for lost time” behaviour in response to the 20mph limits, and potentially a small reduction in speed due to speed conditioning.

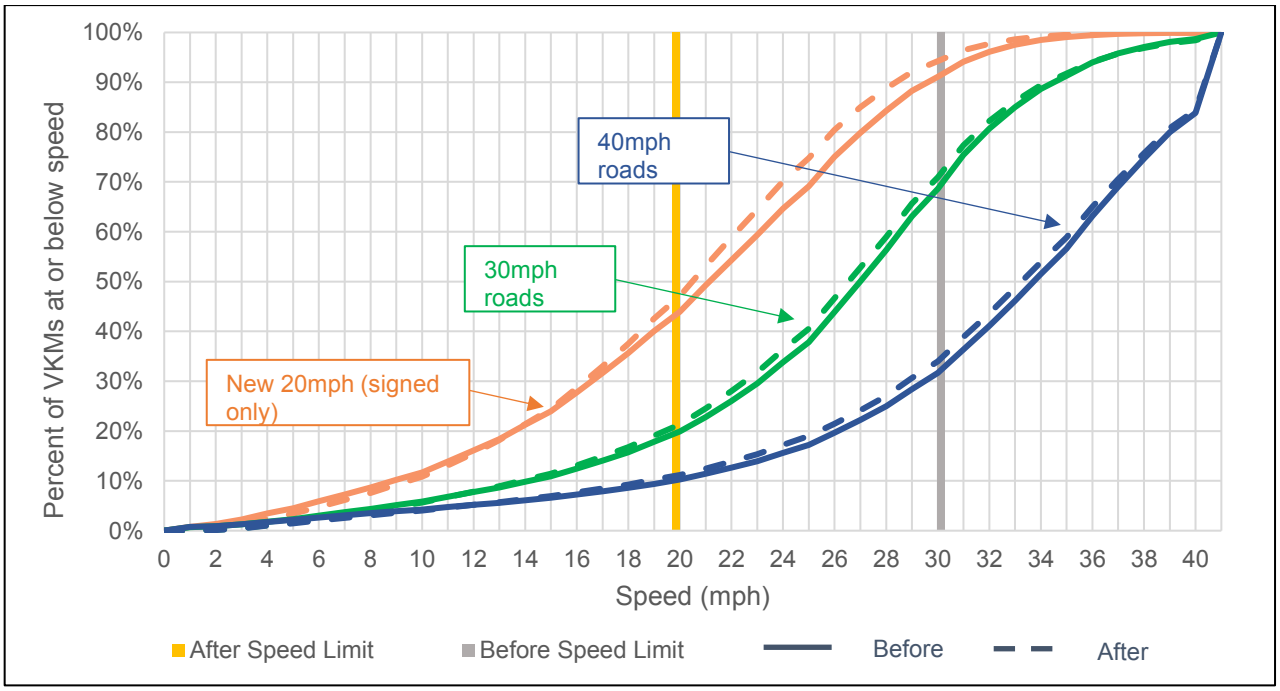
Post implementation compliance - The table shows that 40mph compliance is good (84%) but that compliance worsens as the speed limit lowers, dropping to 71% on 30mph roads and 47% on new (signed only) 20mph roads.

Since the implementation of the new 20mph roads there has been a 3% increase in speed limit compliance on 30mph roads, and no change (0%) on 40mph roads. It can also be seen that on both 30mph roads and 40mph roads there is a decrease in median speed since the introduction of 20mph limits.

Table 6-3 Comparison of 20/30/40mph road key outputs

Residential areas only	New 20mph limit (signed only)			30mph Roads			40mph Roads		
	Before, After, Diff			Before, After, Diff			Before, After, Diff		
Speed Limit	30mph	20mph		30mph	30mph		40mph	40mph	
Distance of Roads	450.5km	450.5km		456.6km	456.6km		46.0km	46.0km	
Sample VKMs Observed	952,551	1,136,370		4,305,056	5,321,683		1,067,782	1,401,167	
Compliance	91%	47%	-44%	68%	71%	+3%	84%	84%	0%
Median Speed	21.1	20.5	-0.7	27.0	26.6	-0.5	34.1	33.6	-0.5
85th Percentile Speed	28.1	27.0	-1.1	33.0	32.7	-0.3	40.3	40.2	-0.1
15th-85th percentile	16.6	15.2	-1.3	15.4	15.6	+0.2	15.8	17.0	+1.2
%<20mph	44%	47%	+3%	20%	21%	+1%	10%	11%	+1%

Figure 6-3 Speed profile for new 20mph roads, 30mph and 40mph roads



Summary of findings

In summary, there appears to have been a reduction in speed on 30mph and 40mph roads since the introduction of new 20mph limits in the case study areas, with both categories experiencing a reduction of 0.5mph in median speed. This reduction occurs across the whole speed profile, suggesting that we can reject the hypothesis that drivers may try to make up for lost time on 20mph roads by compensating on 30mph and 40mph roads.

The reduction in speeds on these roads suggests that drivers are becoming more speed conditioned, and driving at slower speeds. This may be a result of the 20mph limits encouraging lower speeds on other roads in the area.

Note: levels of compliance are substantially higher on 40mph roads (84%) and 30mph roads (71%), than they are on new 20mph (signed only) roads (47%).

7. Summary and conclusions

7.1. Introduction

A summary of the findings is presented below.

7.2. To what extent do drivers comply with the limit?

Evidence from the journey speed analysis shows that following implementation, 47% of drivers in residential areas and 65% of drivers in city centre areas (equating to 51% across both categories) complied with the new 20mph limit, travelling at speeds of less than 20mph. Whilst a substantial proportion are exceeding the limit, the majority are travelling less than 24mph (i.e. at speeds close to 20mph): 70% in residential areas and 85% in city centre areas.

The nature of the roads where the limits have been introduced means that lower speeds were already 'self-enforced'. Reducing the speed limit to 20mph has helped reinforce this process. There are now slightly more drivers travelling at speeds of less than 24mph (+5 percentage points in residential areas, and +7 percentage points in city centre areas), suggesting faster drivers have slowed down.

7.3. How has the profile of speeds changed?

The journey speed analysis shows that the median speed has fallen by 0.7mph in residential areas and 0.9mph in city centre areas. Faster drivers have reduced their speed more, with the 85th percentile speed[28] falling by -1.1mph in residential areas and by -1.6mph in city centre areas, based on journey speed data. This is a key finding, as other research shows that higher speeds are associated with increased safety risk (more collisions, increased severity, perceptions that the environment is not safe for vulnerable users).

The overall change in speeds is greater where speeds were faster before. The median speed fell by -1.3mph on residential roads with a before speed of more than 24mph; and by -1.1mph on 'important local roads'[29] which typically had higher before speeds.

The results suggest that road characteristics have a much larger impact on the speeds that drivers choose to adopt than whether the road has a 30mph or 20mph limit. The differences in speed between the different road categories are far larger than the changes brought about by lowering the speed limit.

Bigger changes were recorded at individual spot speed sites, with the change in mean speed varying from -7.2mph (reduction) to +4.3mph (increase); and the change in 85th percentile speeds varying from -9.0mph (decrease) to +7.6mph (increase).

The reductions in average speed in the case study areas are similar to those observed in other research studies, which have reported reductions in average speed of 0.5-2mph (with varying accountability for background trends).

7.4. What evidence is there of a 20mph limit impact?

Statistical analysis shows a significant reduction in speeds, relative to similar 30mph comparator areas, for 'important local roads' in residential areas and for an aggregation of all road types in city centre areas:

- The relative change on important local roads in residential areas is estimated at -0.8mph for the median speed and -1.1mph for the 85th percentile speed.
- The relative change across all roads in city centre area, is estimated at -0.6mph for the median speed, and -1.0mph for the 85th percentile speed.

[28] This is the speed that 85 percent of vehicles do not exceed.

[29] Case study roads have been classified as 'minor local roads', 'important local roads', and 'major strategic roads' using TomTom's Functional Road Classes, which provides a proxy for the size, nature and purpose of each road.

The findings suggest that the absolute changes in speed observed in the case study areas are partly due to the implementation of 20mph limits, but also reflect background trends in speed on urban roads.

7.5. How have speeds on neighbouring roads changed?

Journey speed analysis shows a small decline in speeds on surrounding 30mph and 40mph roads across the case study areas; suggesting that in general, drivers are not trying to make up for lost time when leaving a 20mph limit area.

7.6. How do speeds compare in 20mph limits and zones?

Some case study roads where the speed limit changed from 30mph to 20mph already had traffic calming in place, in the form of speed humps / tables or chicanes. These have essentially become new 20mph zones. In addition, almost all of case studies had the some pre-existing 20mph limits (signed only and with calming) in place prior to the implementation of the main area-wide scheme; often located outside schools. These roads did not experience a change in limit over the course of the research, but driver behaviour may have been influenced by the introduction of a new 20mph limit over the wider area.

Post implementation of 20mph limits, there is a higher level of compliance on already traffic calmed roads (62%), older 20mph limits (with calming) (66%), older 20mph limits (signed only) (68%); than on new 20mph (signed only) roads (47%).

Extending the area covered by 20mph limits has not changed driver behaviour on adjacent older 20mph limits (with traffic calming), but it appears that there has been some reduction on adjacent older 20mph limits (signed only). It is possible that the presence of calming (road humps, chicanes) and the nature of the associated roads (which are nearly all minor local roads) has already encouraged drivers to reduce their speed as much as they are willing to do so, in the absence of more proactive enforcement.

However, on older 20mph limits (signed only) drivers may have been encouraged to reduce their speeds further, in line with their behaviour on new 20mph limits. The sample size for older 20mph limits is smaller than for the other categories of road, and further evidence is needed to support this conclusion.

Appendices

Appendix A. Methodology details

A.1. Methodology for calculating speed distribution profile

A.1.1. Introduction

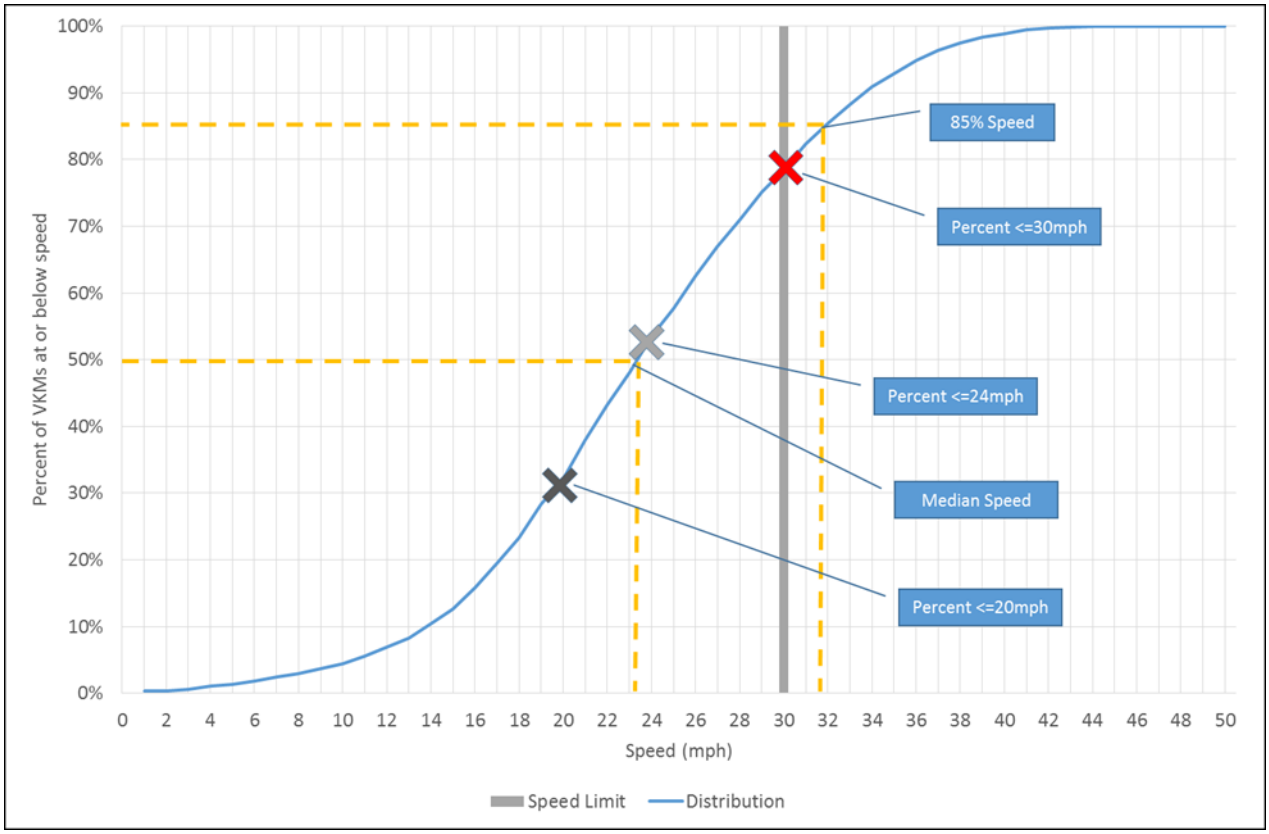
This appendix outlines in detail the methodology for converting TomTom CAA data into a speed distribution profile that can be used to address the research questions relating to the 20mph speed limit evaluation. CAA data provides information for every road segment within an area, in a set time period and date range. Data included on each segment in CAA output includes:

- Distance
- Average Travel Time
- Median Travel Time
- Average Speed
- Median Speed
- Sample
- Every 5th percentile speed from 5% to 95% (i.e. 19 values)

It is this data, along with contextual data about the segments in the network (i.e. pre-scheme speed limit, post-scheme speed limit, FRC, etc.), that has been used to provide answers to the DfT's research questions.

The distribution curve comprises speed on the x-axis and vehicle distance on the y-axis (with vehicle distance converted to a percentage of all vehicle distance). Each data point on the curve has then been used to inform the number of vehicle kilometers driven on the network at the given speed.

Figure A1. Example speed profile curve



A.1.2. Speed profile on a single segment

TomTom CAA data provides every 5th percentile speed on each segment. To smooth the distribution profile, the individual percentile speeds have been estimated by interpolating between the 5th percentiles provided, to provide every percentile speed from the 5th to 95th percentile. This estimation is achieved through geometric interpolation, see the example below. This provides a profile for each segment.

Table 7-1 Example of geometric interpolation between 5th percentiles

Percentile	**10th**	**11th**	**12th**	**13th**	**14th**	**15th**
Speed	**43.0**	42.6	42.2	41.8	41.4	**41.0**

Example geometric calculation to estimate the 12th percentile from the 10th and 15th percentiles:

$$P_{12} = P_{10} \times \left(\frac{P_{15}}{P_{10}}\right)^{\frac{(12-10)}{5}}$$

A.1.3. Speed profile across multiple segments

The value in the TomTom data relates to the high samples provided across thousands of segments, and robust conclusions can only be drawn across multiple segments. The methodology for combining the thousands of segments in each area into a single profile is presented below. ***Note - the example is based on every 5th percentile data (in order to fit on a single page) but the same approach has been applied to individual percentile speeds, estimated using interpolation as discussed above.***

Estimating the speed profile across multiple segments (Worked Example)

This example demonstrates how a distribution curve has been estimated from 5th percentile speed data (same approach can be applied to individual percentile data), aggregated across multiple segments of different lengths. The approach requires the segments to be weighted by vehicle kilometres (instead of just using the sample) so that segments of different lengths and samples are treated proportionally in the output. ***The resultant profile graph therefore represents the vehicle kilometres observed at each speed in the area***.

Step 1 - The first step is to identify how many vehicles are represented by each 5th percentile of speed data, and the total distance driven by these vehicles. *For example, Segment 1 has a sample of 200 vehicles. Its length is 0.45km and so there is a total of 90 vehicle kilometres observed on this segment. As such, each 5th percentile speed can be thought to represents 4.5km of observations (5% of the total 90km observed).*

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
						5th Percentile Speeds (e.g. 85th percentile speed is the speed 85% of vehicle are observed going faster than)																		
Segment ID	**Speed Limit**	**Segment Length**	**Sample**	**Total VKM Driven on Segment (C*D)**	**5% of total VKM (5%*E)**	P5	P10	P15	P20	P25	P30	P35	P40	P45	P50	P55	P60	P65	P70	P75	P80	P85	P90	P95
1	32kph (20mph)	0.45km	200	90km	4.5km	32	30	28	24	22	21	20	20	19	16	16	14	10	9	8	6	5	4	3
2	32kph (20mph)	0.23km	100	23km	1.15km	50	46	44	42	39	35	33	31	30	30	30	29	29	27	24	20	18	16	12
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
X	32kph (20mph)	0.34km	120	40.8km	2.04km	46	44	42	39	35	33	31	30	30	30	29	29	27	24	20	18	16	16	12

Step 2 - For each segment, we are then able to estimate the total distance being driven at different speeds. *For example, on Segment 1, 4.5km are being driven at about 32kph, another 4.5km at 30kph, another 4.5km at 28km/hr and so on until the final 4.5km at 3kph.* A rough speed distribution (or profile) can be created for each individual segment by attributing 5% of the total VKMs on the segment to each 5th percentile speed. The resulting distributions for Segments 1, 2 … X are shown below.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
						5th Percentile Speeds (e.g. 85th percentile speed is the speed 85% of vehicle are observed going faster than)																		
Segment ID	**Speed Limit**	**Segment Length**	**Sample**	**Total VKM Driven on Segment (C*D)**	**5% of total VKM (5%*E)**	P5	P10	P15	P20	P25	P30	P35	P40	P45	P50	P55	P60	P65	P70	P75	P80	P85	P90	P95
1	32kph (20mph)	0.45km	200	90km	4.5km	32	30	28	24	22	21	20	20	19	16	16	14	10	9	8	6	5	4	3
2	32kph (20mph)	0.23km	100	23km	1.15km	50	46	44	42	39	35	33	31	30	30	30	29	29	27	24	20	18	16	12
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
X	32kph (20mph)	0.34km	120	40.8km	2.04km	46	44	42	39	35	33	31	30	30	30	29	29	27	24	20	18	16	16	12

Segment 1 gives distribution		**Segment 2 gives distribution**		…	**Segment X gives distribution**		**All Segment Distribution of Speeds**	
Speed (kph)	**VKM**	**Speed (kph)**	**VKM**		**Speed (kph)**	**VKM**	**Speed (kph)**	**VKM**
1	0.00	1	0.00	…	1	0.00	1	Sum of Segment 1, 2 … X 1kph VKMs
2	0.00	2	0.00	…	2	0.00	2	Sum of Segment 1, 2 … X 2kph VKMs
3	4.50	3	0.00	…	3	0.00	3	…
4	4.50	4	0.00	…	4	0.00	4	…
5	4.50	5	0.00	…	5	0.00	5	…
6	4.50	6	0.00	…	6	0.00	6	…
7	0.00	7	0.00	…	7	0.00	7	…
8	4.50	8	0.00	…	8	0.00	8	…
9	4.50	9	0.00	…	9	0.00	9	…
10	4.50	10	0.00	…	10	0.00	10	…
40	0.00	40	0.00	…	40	0.00	40	…
41	0.00	41	0.00	…	41	0.00	41	…
42	0.00	42	1.15	…	42	2.04	42	…
43	0.00	43	0.00	…	43	0.00	43	…
44	0.00	44	1.15	…	44	2.04	44	…
45	0.00	45	0.00	…	45	0.00	45	…
46	0.00	46	1.15	…	46	2.04	46	…
47	0.00	47	0.00	…	47	0.00	47	…
48	0.00	48	0.00	…	48	0.00	48	…
49	0.00	49	0.00	…	49	0.00	49	…
50	0.00	50	1.15	…	50	0.00	50	Sum of Segment 1, 2 … X 50kph VKMs

Step 3 - The final step (also shown above) is to aggregate all the individual segment distributions to create an area wide distribution of VKMs observed at each speed.

It is accepted that the above approach does not provide a perfect representation of the profile of speeds in the area, but instead provides an approximation based on the limitations of the percentile data provided by TomTom. Each individual segment profile has the potential to be very lumpy due to some segments having low samples. However once these individual distributions are aggregated to an area wide distribution, the imperfect nature of each individual segment profile is averaged out to create a smooth distribution for the area, that meets expectations of typical traffic behaviour.

A.2. Use of the median, rather than the harmonic or arithmetic mean, to measure average speed

A key statistic, often quoted in literature regarding 20mph limits, is the change in average speed, and the absolute before and after average speeds. Prior to undertaking this analysis, consideration was given to the relative merits of using the median, harmonic or arithmetic mean, to represent average speed. Each of these is calculated differently, and gives a very different average, as shown in the example below:

Example calculation of median, harmonic mean, and arithmetic mean

Probe	Length (m)	Speed (mph)	1/speed	Time (sec)
1	66	25.0	0.040	5.9
2	66	5.0	0.200	29.7
3	66	30.5	0.033	4.9
4	66	23.0	0.043	6.5
5	66	27.3	0.037	5.4
6	66	4.8	0.208	30.9
7	66	19.9	0.050	7.5

Harmonic Average Speed = 12.18mph
Arithmetic Average Speed = 19.68mph
Median Speed = 22.5mph

In this example, most vehicles are traversing the segment at 'typical' speeds of 20-30mph. However, two vehicles traverse the segment much slower - near 5mph - perhaps looking for a parking space, stuck behind a bus, allowing another car to pass (due to parked cars reducing the width of the carriageway), stopping to talk to a neighbour, or similar.

The **harmonic mean** is generally used for rate-based data (such as speed) and is calculated as the sum of distance divided by a sum of time (or as number of observations divided by the sum of the inverse speeds). However, this gives extra importance (extra weighting essentially) to those journeys that spend more time traversing the segment and less weight to those who spend less time on the segment. Therefore the harmonic average speed of these observations is just 12.2mph. While this is appropriate when examining network performance, it is considered to be less meaningful from a 20mph policy context as the speed of users is more important than the network performance. Six of the eight vehicles were travelling over 20mph, and it is anticipated that intuitively most drivers, pedestrians and cyclists, would estimate that average speed as being above 20mph; mentally discounting the two travelling very slowly as unusual behaviour. It is hard to argue to a cyclist traversing the above segment that (s)he should feel safer because the average speed is just 12mph. In reality, the cyclist will be affected by the 6 vehicles travelling 20mph or higher and less affected by the 2 vehicles travelling around 5mph.

The **arithmetic mean** - sum(sample*average speed)/sum(sample) - is perhaps slightly more informative about driver response to speed limits and cyclist's perception of the road's attractiveness as a route, as it gives equal importance to each observation irrespective of the fact that those travelling slower were on the link for longer. In the above example, the arithmetic mean is calculated as 19.68mph – closer to the typical performance of the six vehicles travelling at typical speed. Nevertheless, it is still somewhat dampened by the slower moving vehicles.

Finally, the **median** denotes the value lying at the midpoint of a frequency distribution of observed values – half of the data is above this value and half is below. This has been identified as the preferred metric for this analysis, for the following reasons:

- It is least affected by the slow-moving vehicles, and therefore most closely represents typical performance. In the above example, the median has been calculated as 22.5mph; the closest of the three metrics to the typical performance of the six vehicles travelling at 'normal' speeds.

- It also has an advantage from a policy perspective, in that it provides a meaningful statistic. In terms of the effect on cyclists, for example, we know 50% of drivers go above this speed and 50% below, so it maybe gives a better understanding of how a cyclist will feel about the speeds on the road, particularly if interpreted alongside 85th percentile speeds.
  In contrast, both the harmonic and arithmetic mean are difficult to interpret from a policy perspective. They don't tell us how many people are driving above or below the average point, or anything about the profile either side of the average – just that the profile of speeds above the average is balanced by the profile below the average (in terms of the sum of speeds/sample).

Consideration was given to removing very slow vehicles from the dataset. In most cases, the speed at which these vehicles are travelling is driven by factors other than the 20mph policy. However, this would require use of an arbitrary cut-off speed, and may exclude some slow speeds which are of relevance to the policy, e.g. vehicles slowing to allow another car to pass (due to parked cars reducing the width of the carriageway).

The proportion of vehicles travelling very slowly and their impact on the median can be interpreted from the speed profile curves produced for each area.

A.3. Concentration of slow moving links in sample

To understand the likely impact that very slow moving segments may have on the analysis presented in this report, analysis has been conducted on slow segments, to see what proportion of the sample these represent. Slow segments have been defined as segments where the 85th percentile speed is less than or equal to 5mph.

When we consider this definition of a slow segment, the data shows that 3.8% and 4.2% of the pre-scheme and post-scheme vehicle kilometres driven respectively are on segments defined as slow. This tells us that only a small fraction of all vehicle kilometres in our analysis sample are on 'slow segments' and so the results reported should not be strongly affected by such segments. Further, the fact the percentage of slow segment vehicle kilometres remains reasonably consistent between before and after data means the comparisons made in this report should be fair.

A.4. Statistical analysis for comparator analysis

A weighted least squares analysis (to take account of the different sample sizes) has been undertaken to examine the average change in median, 85th percentile, and 15th-85th percentile speeds for case study areas, against the comparator areas (representing a difference in difference approach[30]).

The speeds are sampled and the precision of the average speeds in a study area or its comparator area will depend on the size of the area, the length of roads within the area and the number of vehicles tracked by TomTom during the period. Ideally this variation in precision should be taken account of in the analysis or modelling.

Some typical data is presented below.

Median speeds in study and comparator areas – example data (artificially generated)

Area	xB	xA	yB	yA	mxB	mxA	myB	myA
1	26.12	25.37	32.06	30.21	14.06	14.41	18.38	21.92
2	30.14	30.99	28.02	31.42	11.78	11.57	24.35	29.50
3	28.91	30.05	29.15	29.82	7.84	8.17	21.58	26.07
4	25.35	27.13	28.49	32.04	10.93	13.08	21.84	21.59
5	26.83	19.23	30.47	28.91	5.58	5.43	17.28	21.85
6	27.15	22.44	31.00	35.67	6.38	7.22	17.66	20.83
7	25.29	27.80	30.78	34.74	16.07	14.51	22.05	20.21
8	22.55	22.17	31.76	31.90	5.30	6.02	17.42	21.39

[30] Comparing the change over time in the case study areas to the change over time for the comparator areas (control areas)

9	23.80	25.53	30.14	30.50	7.57	8.71	16.59	15.83
10	31.00	23.39	29.57	28.88	15.62	18.80	22.41	25.25
11	30.01	29.00	30.72	29.97	13.73	13.26	19.31	20.88

The data has been artificially generated. The "x" refers to the case study area and the "y" to the comparator area; and the "B" refers to the before period and the "A" to the after period. We could imagine that the data in columns 2 to 5 are the recorded median speeds in the areas in these periods. The values in columns 6 to 9 are some indicator of the sample size from which the corresponding median speeds have been obtained. The precise values here do not matter; it is simply that some median speeds are based on appreciably larger sample sizes than others. The comparator area values are generally larger and more uniform; whereas the case study area values are more varied.

Differences diffx = xA-xB and diffy = yA-yB can then be calculated and used in a paired sample t-test

Carrying out this test in R, using the command `t.test(diffx, diffy, paired=T, alternative = "two.sided")`, we get as output:

```
      Paired t-test

data:  diffx and diffy

t = -2.1997, df = 10, p-value = 0.05247

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

 -4.74867070  0.03048889

sample estimates:

mean of the differences

              -2.359091
```

So the best estimate of the adjusted change in speeds from before to after is a drop of 2.36 mph, but with a 95% confidence interval of (-4.75, 0.03).

It is possible to fit a model that *does* take account of the different sample sizes and hence different levels of precision in the speeds in the eleven case study areas, eleven comparator areas and two periods. It assumes that the variance of the speed estimate is inversely proportional to the sample size for that area/period.

We use a weighted least squares model, specified as follows:

$$E(xB_i) = \mu_i^{(x)}$$
$$E(xA_i) = \mu_i^{(x)} + d_i + \beta$$
$$E(yB_i) = \mu_i^{(y)}$$
$$E(yA_i) = \mu_i^{(y)} + d_i$$

with weights mxB_i, mxA_i, myB_i and myA_i respectively. The μ's are the mean speeds for the case study areas and comparator areas in the before periods; d_i is the background (trend) changes in mean speeds in the area relevant to site i (which is assumed to apply equally to both the case study area and the comparator), and β is the treatment effect (the change in mean speed as a result of the implementation of the 20 mph limit).

R code for fitting this is:

```
xall <- c(xB,xA,yB,yA)
wt <- c(mxB,mxA,myB,myA)
N <- 11
t.test(diff,mu=0,alternative="two.sided")
mu <- c(1:N,1:N,(N+1):(2*N),(N+1):(2*N))
fmu <- factor(mu)
d <- c(rep(1,N),2:(N+1),rep(1,N),2:(N+1))
fd <- factor(d)
beta <- c(rep(0,N),rep(1,N),rep(0,2*N))

##########################
# now fit WLS linear model
##########################

fit <- lm(xall ~ fmu+fd+beta-(1),weights=wt)
summary(fit)
Nparams <- 3*N+1; ndf <- 4*N-Nparams  # residual degrees of freedom
est <- as.numeric(coef(fit)[Nparams])
se <- sqrt(vcov(fit)[Nparams,Nparams])
tcrit <- qt(0.975,ndf); est-tcrit*se; est+tcrit*se  # 95% CI
```

and the parameter estimate is found to be -2.29 with a 9% confidence interval of (-4.56, -0.01). This gives a slightly narrower confidence interval than the paired sample t test.

If we use the code above *but with no weights*, then we get *exactly* the same results as from the paired sample t test (an estimate of -2.36 and a 95% confidence interval of (-4.75, 0.03)).

A.5. Data for statistical analysis

As described above, aggregated data for each case study area and comparator area is required to feed into the Weighted Least Squares (WLS) model to test the significant of speed changes observed in the case study areas. The data fed in to the model is provided in the following six tables:

- Residential median data
- Residential 85th percentile data
- Residential 15-85th percentile range data
- City Centre median data
- City Centre 85th percentile data
- City Centre 15-85th percentile range data

Residential median inputs to WLS Model

		Median		VKM			Median		VKM	
Type	**Case Study**	**Before**	**After**	**Before**	**After**	**Comparator**	**Before**	**After**	**Before**	**After**
Major Roads	Brighton (Phase 2)	25.799	25.280	31,524	37,219	Worthing A2	25.453	24.958	455,246	592,403
Major Roads	Brighton (Phase 1, Res)	20.640	19.835	205,589	209,982	Worthing A1	25.898	25.164	428,126	430,152
Important Local Roads	Walsall (Rushall)	28.666	27.115	5,757	6,295	Wolverhampton B1	25.013	24.496	543,335	738,443
Important Local Roads	Liverpool (Area 7)	25.442	25.029	4,988	4,298	Wolverhampton B1	25.013	24.496	543,335	738,443
Important Local Roads	Liverpool (Area 2)	28.323	23.233	3,523	7,292	Wolverhampton B2	24.816	24.164	493,650	1,485,288
Important Local Roads	Middlesbrough	22.787	23.715	3,677	6,045	Sunderland C	26.386	26.164	229,938	234,502
Important Local Roads	Calderdale (Phase 1)	25.072	23.953	20,864	62,405	Wolverhampton B2	24.816	24.164	493,650	1,485,288
Important Local Roads	Nottingham (Bestwood)	23.498	22.408	923	1,113	Wolverhampton B1	25.013	24.496	543,335	738,443
Important Local Roads	Brighton (Phase 2)	21.742	20.683	126,315	146,958	Worthing A2	25.268	24.950	415,747	580,297
Important Local Roads	Chichester	22.905	21.425	50,849	54,082	Worthing A1	25.617	25.055	372,597	401,347
Important Local Roads	Brighton (Phase 1, Res)	22.524	21.099	188,883	208,414	Worthing A1	25.617	25.055	372,597	401,347
Minor Local Roads	Walsall (Rushall)	18.095	17.363	510	460	Wolverhampton B1	17.194	17.151	141,496	195,174
Minor Local Roads	Winchester (Stanmore)	19.835	19.233	5,807	7,271	Worthing A2	19.997	19.815	198,231	276,619
Minor Local Roads	Liverpool (Area 7)	19.698	19.459	15,773	13,778	Wolverhampton B1	17.194	17.151	141,496	195,174
Minor Local Roads	Liverpool (Area 2)	19.914	20.549	20,041	34,764	Wolverhampton B2	17.097	17.513	127,519	320,919
Minor Local Roads	Middlesbrough	18.932	19.463	23,895	35,180	Sunderland C	18.709	18.910	84,429	83,162
Minor Local Roads	Calderdale (Phase 1)	18.063	18.551	7,165	17,269	Wolverhampton B2	17.097	17.513	127,519	320,919
Minor Local Roads	Nottingham (Bestwood)	21.046	21.277	8,295	9,963	Wolverhampton B1	17.194	17.151	141,496	195,174
Minor Local Roads	Brighton (Phase 2)	20.008	19.481	120,195	148,004	Worthing A2	19.997	19.815	198,231	276,619
Minor Local Roads	Chichester	17.980	17.919	26,661	28,534	Worthing A1	20.272	19.901	178,751	195,462
Minor Local Roads	Brighton (Phase 1, Res)	16.657	16.426	81,316	97,046	Worthing A1	20.272	19.901	178,751	195,462

Residential 85th percentile inputs to WLS Model

		85th Percentile		VKM			Median		VKM	
Type	**Case Study**	**Before**	**After**	**Before**	**After**	**Comparator**	**Before**	**After**	**Before**	**After**
Major Roads	Brighton (Phase 2)	29.938	29.377	31,524	37,219	Worthing A2	30.732	30.323	455,246	592,403
Major Roads	Brighton (Phase 1, Res)	27.794	26.454	205,589	209,982	Worthing A1	31.066	30.486	428,126	430,152
Important Local Roads	Walsall (Rushall)	33.705	32.334	5,757	6,295	Wolverhampton B1	30.654	30.395	543,335	738,443
Important Local Roads	Liverpool (Area 7)	30.937	30.646	4,988	4,298	Wolverhampton B1	30.654	30.395	543,335	738,443
Important Local Roads	Liverpool (Area 2)	33.626	28.182	3,523	7,292	Wolverhampton B2	30.503	30.359	493,650	1,485,288
Important Local Roads	Middlesbrough	28.761	29.531	3,677	6,045	Sunderland C	32.376	31.510	229,938	234,502
Important Local Roads	Calderdale (Phase 1)	30.434	29.608	20,864	62,405	Wolverhampton B2	30.503	30.359	493,650	1,485,288
Important Local Roads	Nottingham (Bestwood)	27.303	26.120	923	1,113	Wolverhampton B1	30.654	30.395	543,335	738,443
Important Local Roads	Brighton (Phase 2)	27.973	26.808	126,315	146,958	Worthing A2	30.560	30.269	415,747	580,297
Important Local Roads	Chichester	30.506	28.588	50,849	54,082	Worthing A1	30.803	30.332	372,597	401,347
Important Local Roads	Brighton (Phase 1, Res)	28.591	26.866	188,883	208,414	Worthing A1	30.803	30.332	372,597	401,347
Minor Local Roads	Walsall (Rushall)	23.841	23.221	510	460	Wolverhampton B1	24.636	24.237	141,496	195,174
Minor Local Roads	Winchester (Stanmore)	26.189	25.457	5,807	7,271	Worthing A2	26.536	26.175	198,231	276,619
Minor Local Roads	Liverpool (Area 7)	26.724	26.269	15,773	13,778	Wolverhampton B1	24.636	24.237	141,496	195,174
Minor Local Roads	Liverpool (Area 2)	27.655	27.604	20,041	34,764	Wolverhampton B2	24.383	24.598	127,519	320,919
Minor Local Roads	Middlesbrough	26.853	26.931	23,895	35,180	Sunderland C	27.925	27.773	84,429	83,162
Minor Local Roads	Calderdale (Phase 1)	25.608	25.882	7,165	17,269	Wolverhampton B2	24.383	24.598	127,519	320,919
Minor Local Roads	Nottingham (Bestwood)	28.410	28.153	8,295	9,963	Wolverhampton B1	24.636	24.237	141,496	195,174
Minor Local Roads	Brighton (Phase 2)	27.208	26.268	120,195	148,004	Worthing A2	26.536	26.175	198,231	276,619
Minor Local Roads	Chichester	24.476	24.313	26,661	28,534	Worthing A1	26.990	26.241	178,751	195,462
Minor Local Roads	Brighton (Phase 1, Res)	24.997	23.815	81,316	97,046	Worthing A1	26.990	26.241	178,751	195,462

Residential 15-85th percentile range inputs to WLS Model

		15-85th Range		VKM			Median		VKM	
Type	**Case Study**	**Before**	**After**	**Before**	**After**	**Comparator**	**Before**	**After**	**Before**	**After**
Major Roads	Brighton (Phase 2)	10.077	10.352	31,524	37,219	Worthing A2	13.713	14.018	455,246	592,403
Major Roads	Brighton (Phase 1, Res)	19.239	17.38	205,589	209,982	Worthing A1	13.167	13.761	428,126	430,152
Important Local Roads	Walsall (Rushall)	11.304	11.454	5,757	6,295	Wolverhampton B1	14.140	14.306	543,335	738,443
Important Local Roads	Liverpool (Area 7)	12.665	12.568	4,988	4,298	Wolverhampton B1	14.140	14.306	543,335	738,443
Important Local Roads	Liverpool (Area 2)	12.608	9.947	3,523	7,292	Wolverhampton B2	14.193	15.201	493,650	1,485,288
Important Local Roads	Middlesbrough	12.031	11.499	3,677	6,045	Sunderland C	13.272	12.192	229,938	234,502
Important Local Roads	Calderdale (Phase 1)	13.163	12.704	20,864	62,405	Wolverhampton B2	14.193	15.201	493,650	1,485,288
Important Local Roads	Nottingham (Bestwood)	8.872	8.708	923	1,113	Wolverhampton B1	14.140	14.306	543,335	738,443
Important Local Roads	Brighton (Phase 2)	14.473	14.003	126,315	146,958	Worthing A2	12.571	12.584	415,747	580,297
Important Local Roads	Chichester	15.391	14.478	50,849	54,082	Worthing A1	12.215	12.465	372,597	401,347
Important Local Roads	Brighton (Phase 1, Res)	15.704	14.657	188,883	208,414	Worthing A1	12.215	12.465	372,597	401,347
Minor Local Roads	Walsall (Rushall)	12.497	12.691	510	460	Wolverhampton B1	14.608	13.969	141,496	195,174
Minor Local Roads	Winchester (Stanmore)	12.529	11.903	5,807	7,271	Worthing A2	13.840	13.377	198,231	276,619
Minor Local Roads	Liverpool (Area 7)	14.903	14.343	15,773	13,778	Wolverhampton B1	14.608	13.969	141,496	195,174
Minor Local Roads	Liverpool (Area 2)	15.434	14.362	20,041	34,764	Wolverhampton B2	14.371	13.935	127,519	320,919
Minor Local Roads	Middlesbrough	15.390	14.767	23,895	35,180	Sunderland C	16.390	15.707	84,429	83,162
Minor Local Roads	Calderdale (Phase 1)	14.916	14.63	7,165	17,269	Wolverhampton B2	14.371	13.935	127,519	320,919
Minor Local Roads	Nottingham (Bestwood)	14.299	13.617	8,295	9,963	Wolverhampton B1	14.608	13.969	141,496	195,174
Minor Local Roads	Brighton (Phase 2)	15.800	14.68	120,195	148,004	Worthing A2	13.840	13.377	198,231	276,619
Minor Local Roads	Chichester	12.881	12.734	26,661	28,534	Worthing A1	13.750	13.395	178,751	195,462
Minor Local Roads	Brighton (Phase 1, Res)	16.472	15.084	81,316	97,046	Worthing A1	13.750	13.395	178,751	195,462

City Centre median inputs to WLS Model

		Median		VKM			Median		VKM	
Type	Case Study	Before	After	Before	After	Comparator	Before	After	Before	After
Major Roads	Brighton (Phase 1, CC)	18.323	17.593	160,187	161,290	Worthing A1	19.424	19.090	11,082	11,955
Important Local Roads	Brighton (Phase 1, CC)	21.701	19.943	21,812	22,452	Worthing A1	21.654	20.947	29,397	32,138
Important Local Roads	Winchester (Core CC)	18.267	17.231	58,202	72,711	Worthing A2	21.354	20.872	34,159	48,028
Minor Local Roads	Brighton (Phase 1, CC)	14.321	13.864	28,399	32,983	Worthing A1	15.751	15.407	12,420	13,232
Minor Local Roads	Winchester (Core CC)	12.708	12.212	5,742	6,837	Worthing A2	15.577	15.642	14,256	17,684

City Centre 85th percentile inputs to WLS Model

		85th Percentile		VKM			Median		VKM	
Type	Case Study	Before	After	Before	After	Comparator	Before	After	Before	After
Major Roads	Brighton (Phase 1, CC)	26.010	24.678	160,187	161,290	Worthing A1	24.899	24.708	11,082	11,955
Important Local Roads	Brighton (Phase 1, CC)	27.912	25.539	21,812	22,452	Worthing A1	27.556	26.805	29,397	32,138
Important Local Roads	Winchester (Core CC)	23.839	22.415	58,202	72,711	Worthing A2	27.167	26.724	34,159	48,028
Minor Local Roads	Brighton (Phase 1, CC)	21.443	20.932	28,399	32,983	Worthing A1	21.855	21.318	12,420	13,232
Minor Local Roads	Winchester (Core CC)	18.164	17.276	5,742	6,837	Worthing A2	21.787	21.825	14,256	17,684

City Centre 15-85th percentile range inputs to WLS Model

		15-85th Range		VKM			Median		VKM	
Type	Case Study	Before	After	Before	After	Comparator	Before	After	Before	After
Major Roads	Brighton (Phase 1, CC)	19.480	17.554	160,187	161,290	Worthing A1	11.919	12.722	11,082	11,955
Important Local Roads	Brighton (Phase 1, CC)	13.873	12.644	21,812	22,452	Worthing A1	12.485	12.910	29,397	32,138
Important Local Roads	Winchester (Core CC)	13.720	13.076	58,202	72,711	Worthing A2	12.805	13.034	34,159	48,028
Minor Local Roads	Brighton (Phase 1, CC)	15.151	14.708	28,399	32,983	Worthing A1	12.212	12.276	12,420	13,232
Minor Local Roads	Winchester (Core CC)	10.930	10.405	5,742	6,837	Worthing A2	12.880	12.770	14,256	17,684

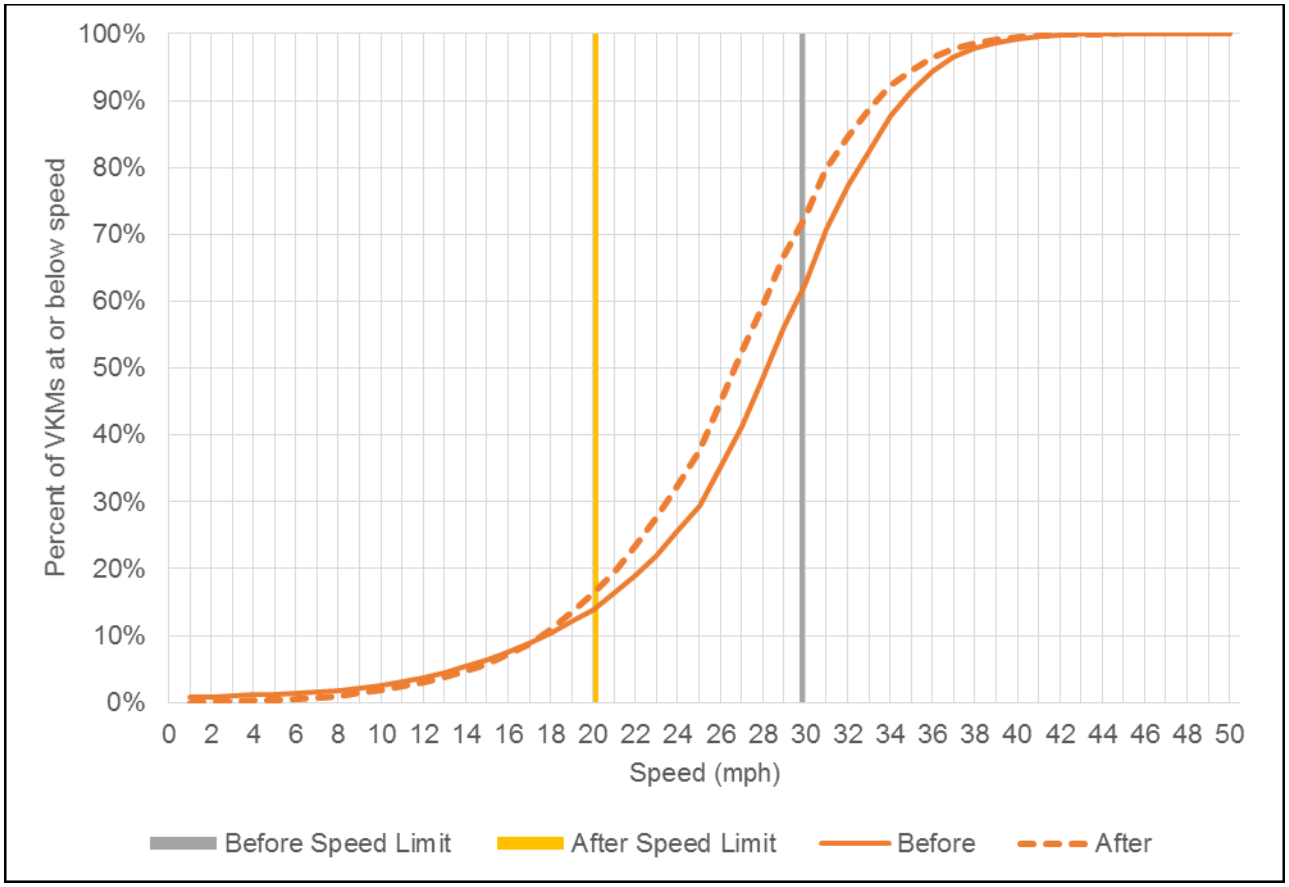
Appendix B. Area specific results

B.1. Walsall - Rushall (R-SM1)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	4.4km	4.4km	-
Sample VKMs Observed	6267km	6755km	-
Compliance	62%	16%	-
Where before <20mph	*100%*	*82%*	-
Where before >24mph	*56%*	*8%*	-
Median Speed	28.2mph	26.7mph	-1.5mph
Where before <20mph	*16.4mph*	*16.0mph*	*-0.4mph*
Where before >24mph	*29.2mph*	*27.8mph*	*-1.4mph*
15th Percentile Speed	20.5mph	19.5mph	0.9mph
85th Percentile Speed	33.5mph	32.0mph	-1.5mph
15th-85th percentile	13.0mph	12.6mph	-0.5mph

New 20mph limits (signed only) – Cumulative speed distribution

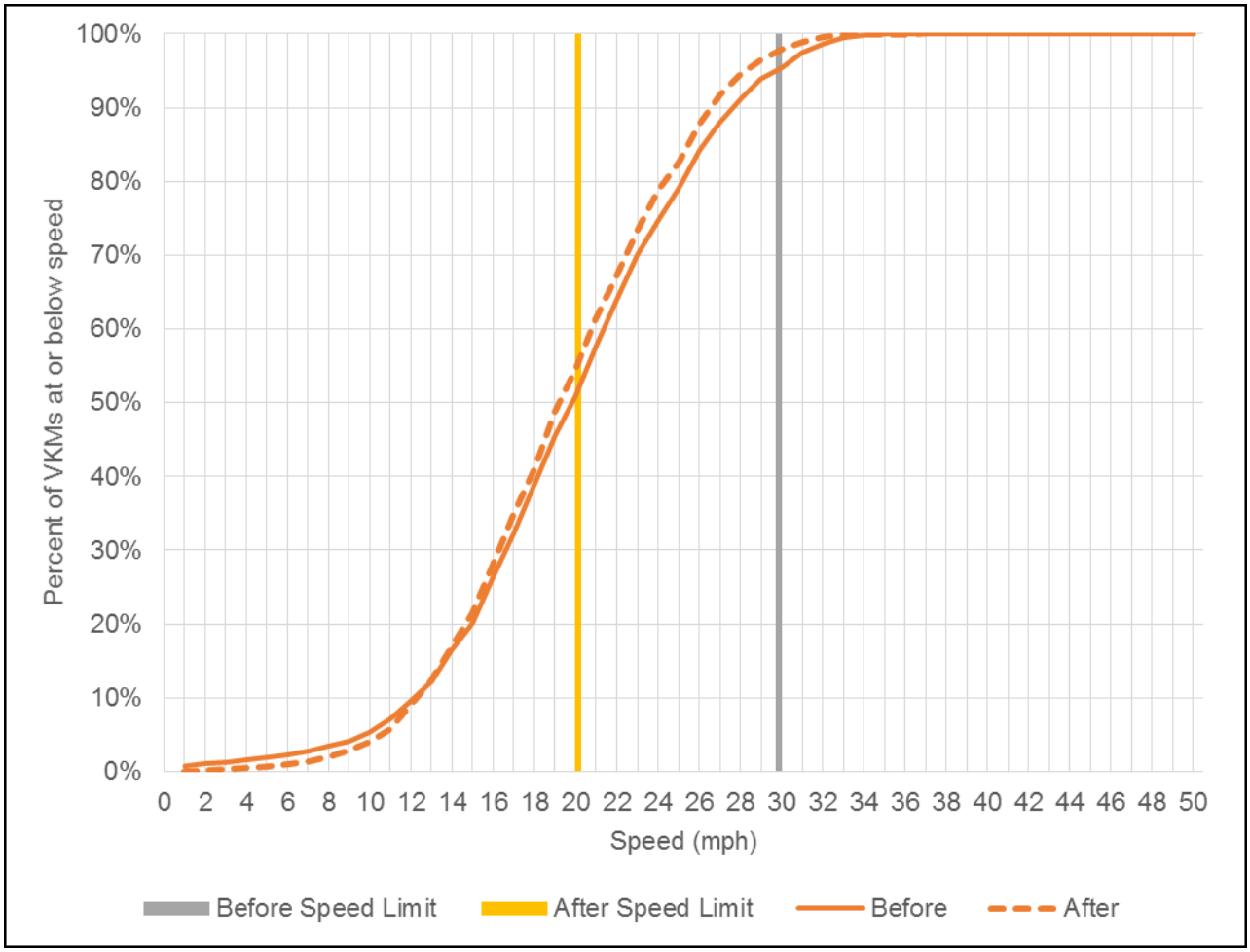


B.2. Winchester - Stanmore (R-SM2)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	5.7km	5.7km	-
Sample VKMs Observed	5807km	7271km	-
Compliance	95%	55%	-
Where before <20mph	*100%*	*81%*	-
Where before >24mph	*87%*	*32%*	-
Median Speed	19.8mph	19.2mph	-0.6mph
Where before <20mph	*16.6mph*	*16.4mph*	*-0.2mph*
Where before >24mph	*24.4mph*	*24.8mph*	*+0.4mph*
15th Percentile Speed	13.7mph	13.6mph	0.1mph
85th Percentile Speed	26.2mph	25.5mph	-0.7mph
15th-85th percentile	12.5mph	11.9mph	-0.6mph

New 20mph limits (signed only) – Cumulative speed distribution

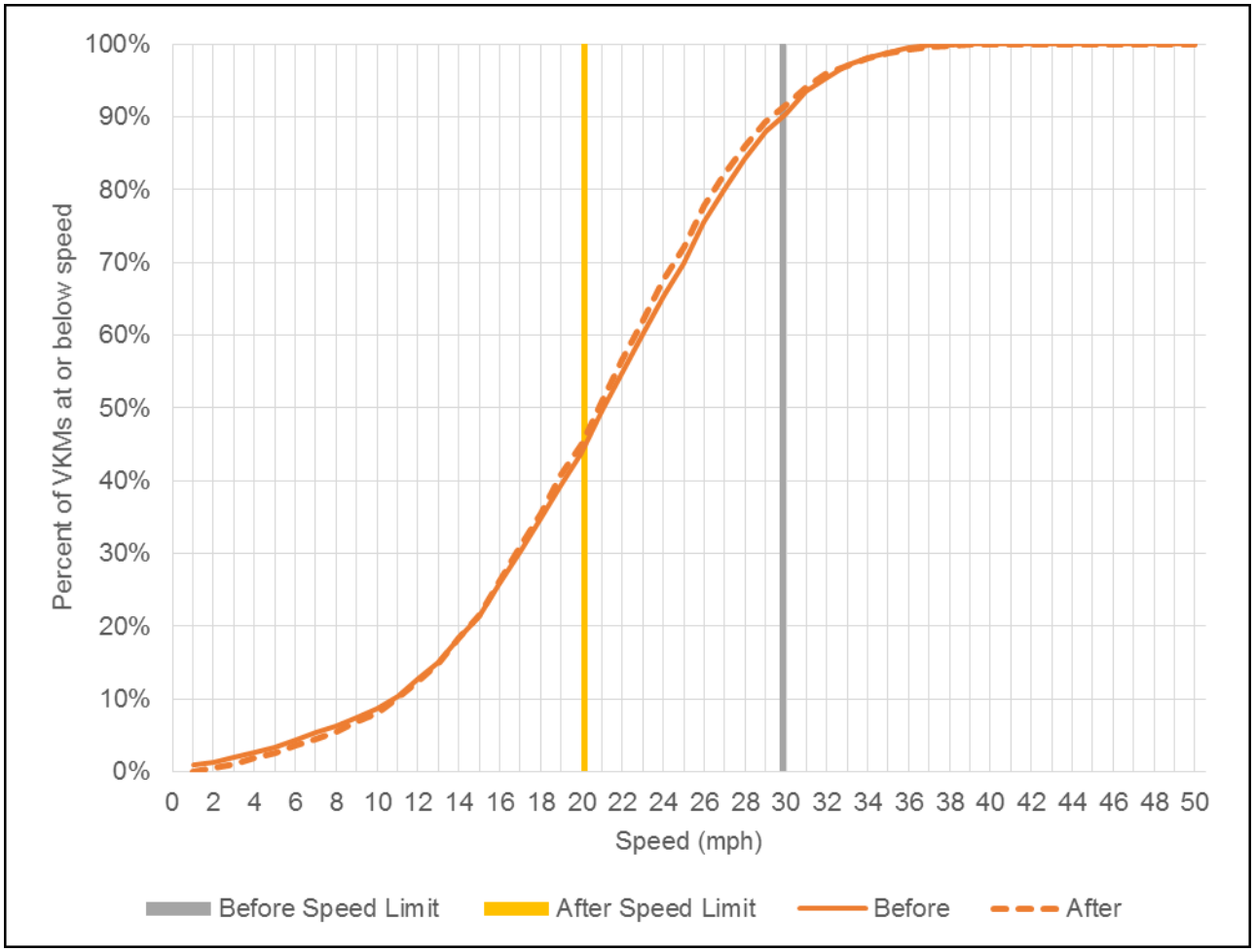


B.3. Liverpool (Area 7) - Adj. to City Centre (R-AW1a)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	27.4km	27.4km	-
Sample VKMs Observed	20761km	18076km	-
Compliance	91%	45%	-
Where before <20mph	*100%*	*82%*	-
Where before >24mph	*78%*	*16%*	-
Median Speed	21.1mph	20.8mph	-0.3mph
Where before <20mph	*15.5mph*	*15.5mph*	*No change*
Where before >24mph	*26.1mph*	*25.5mph*	*-0.6mph*
15th Percentile Speed	13.0mph	13.0mph	-0.1mph
85th Percentile Speed	28.2mph	27.7mph	-0.4mph
15th-85th percentile	15.2mph	14.7mph	-0.5mph

New 20mph limits (signed only) – Cumulative speed distribution

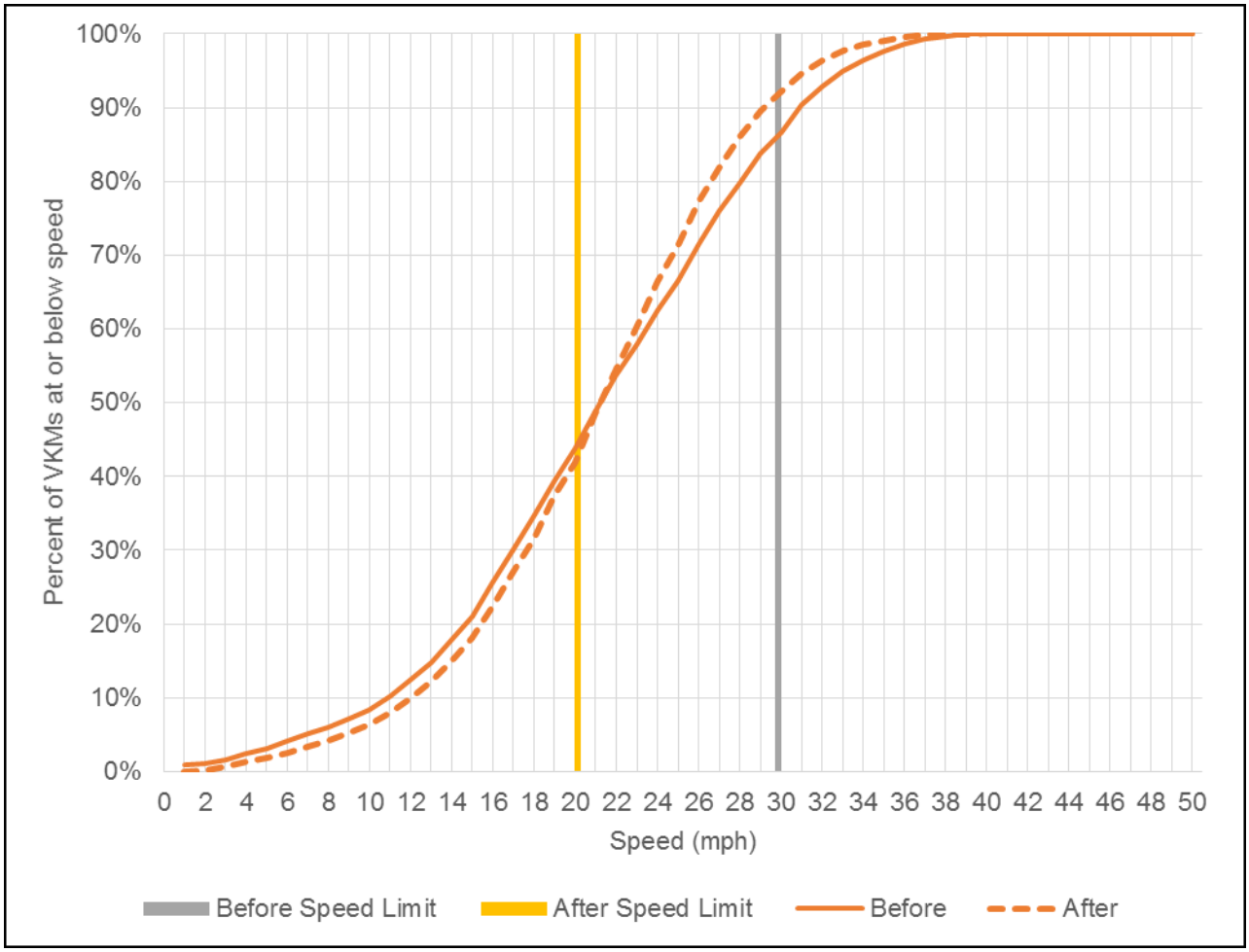


B.4. Liverpool (Area 2) - NE of City Centre (R-AW1b)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	44.4km	44.4km	-
Sample VKMs Observed	23,565km	42,056km	-
Compliance	87%	43%	-
Where before <20mph	*100%*	*77%*	-
Where before >24mph	*66%*	*15%*	-
Median Speed	21.0mph	21.1mph	+0.1mph
Where before <20mph	*15.9mph*	*16.4mph*	*+0.5mph*
Where before >24mph	*27.8mph*	*25.4mph*	*-2.4mph*
15th Percentile Speed	13.0 mph	13.9 mph	+0.9 mph
85th Percentile Speed	29.3mph	27.7mph	-1.5mph
15th-85th percentile	16.3mph	13.8mph	-2.4mph

New 20mph limits (signed only) – Cumulative speed distribution

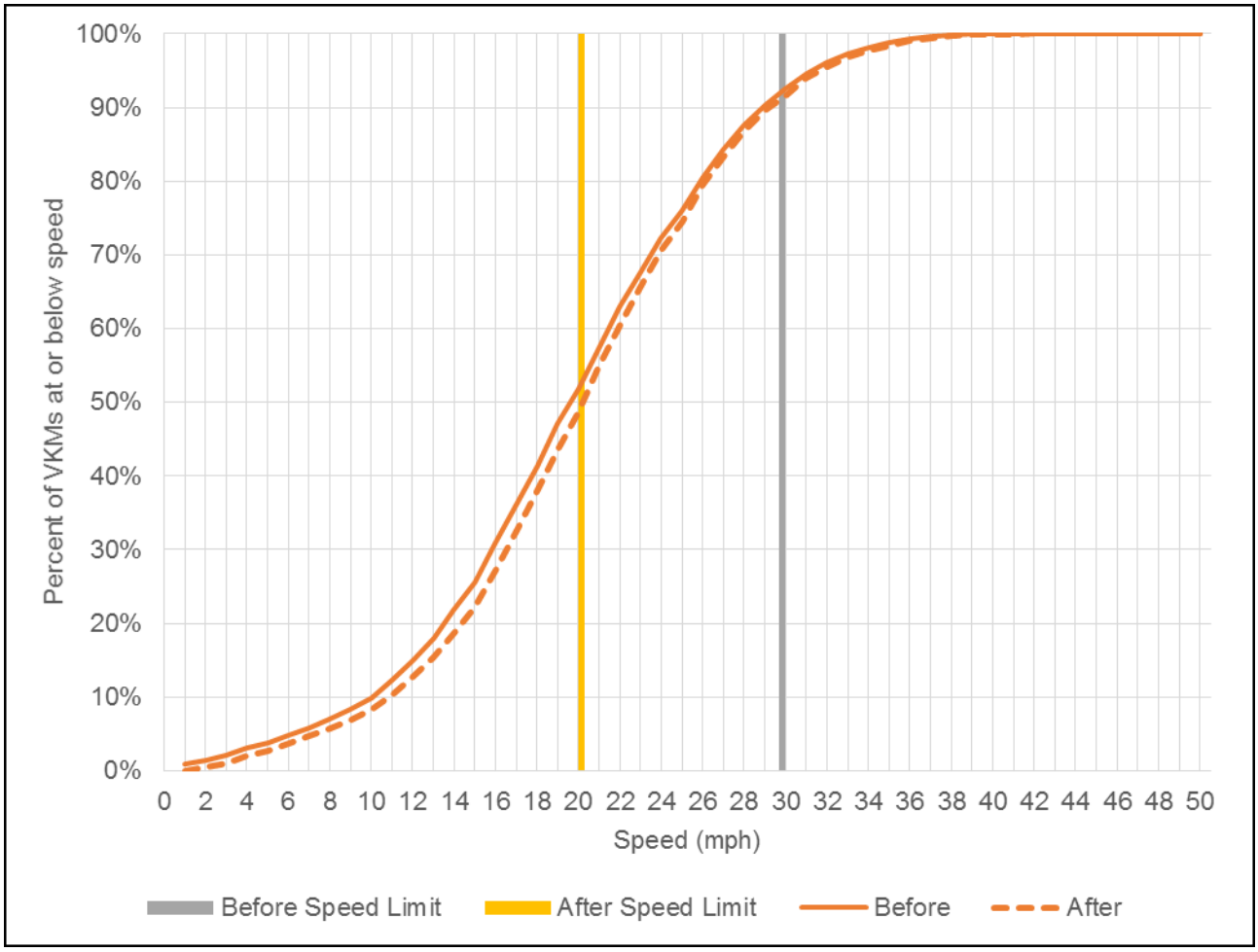


B.5. Middlesbrough - Phase 1 and 2 (R-AW2)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	58.1km	58.1km	-
Sample VKMs Observed	27572km	41225km	-
Compliance	92%	49%	-
Where before <20mph	*100%*	*78%*	-
Where before >24mph	*73%*	*10%*	-
Median Speed	19.6mph	20.2mph	+0.6mph
Where before <20mph	*15.6mph*	*16.2mph*	*+0.6mph*
Where before >24mph	*26.8mph*	*26.9mph*	*+0.1mph*
15th Percentile Speed	12.0mph	12.9mph	+0.8mph
85th Percentile Speed	27.2mph	27.5mph	+0.3mph
15th-85th percentile	15.2mph	14.6mph	-0.5mph

New 20mph limits (signed only) – Cumulative speed distribution

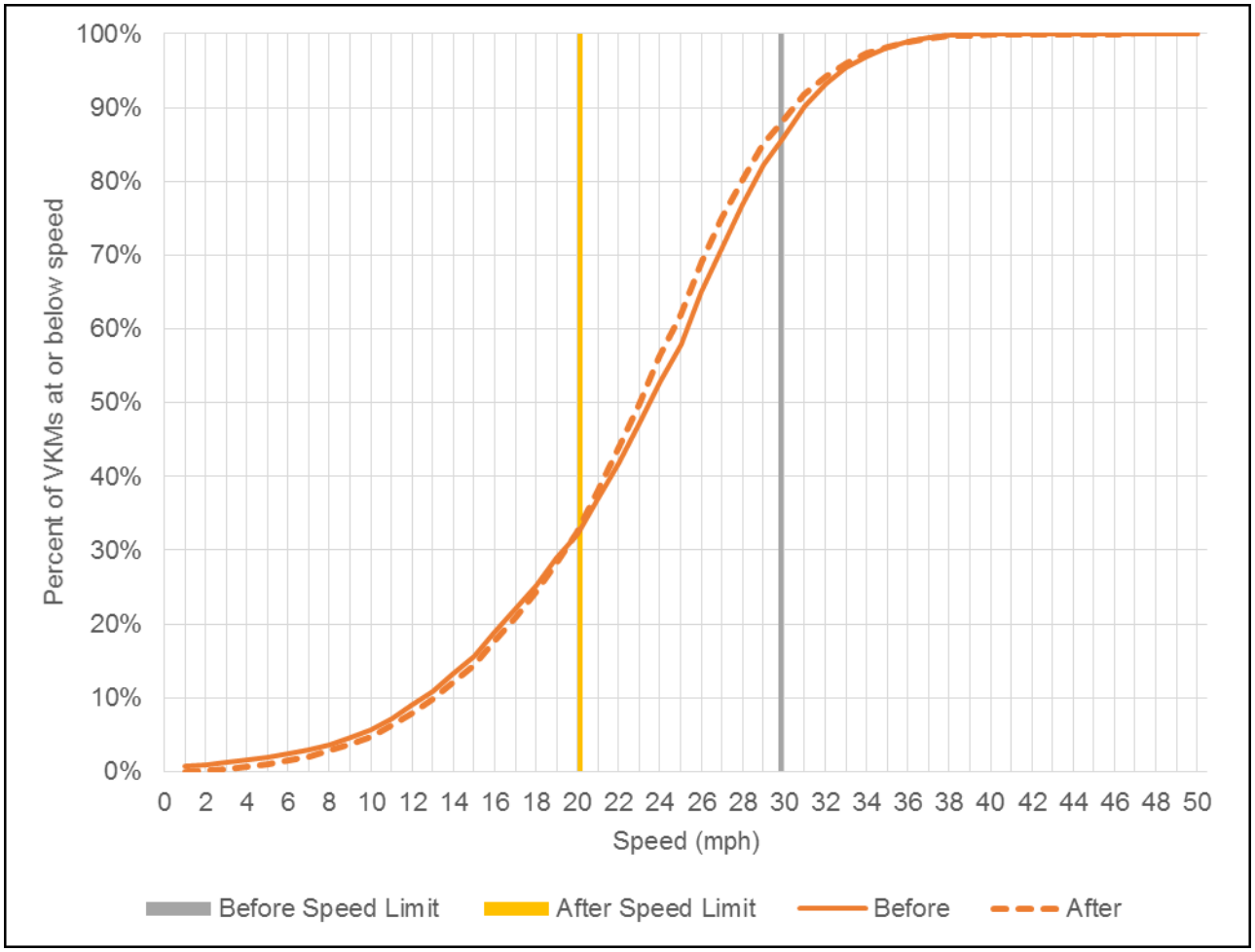


B.6. Calderdale - Phase 1 (R-AW3)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	41.6km	41.6km	-
Sample VKMs Observed	28029km	79674km	-
Compliance	86%	32%	-
Where before <20mph	*100%*	*76%*	-
Where before >24mph	*76%*	*14%*	-
Median Speed	23.5mph	23.0mph	-0.5mph
Where before <20mph	*15.4mph*	*15.9mph*	*+0.5mph*
Where before >24mph	*26.6mph*	*25.7mph*	*-0.9mph*
15th Percentile Speed	14.8mph	15.2mph	+0.4mph
85th Percentile Speed	29.7mph	29.0mph	-0.7mph
15th-85th percentile	15.0mph	13.8mph	-1.2mph

New 20mph limits (signed only) – Cumulative speed distribution

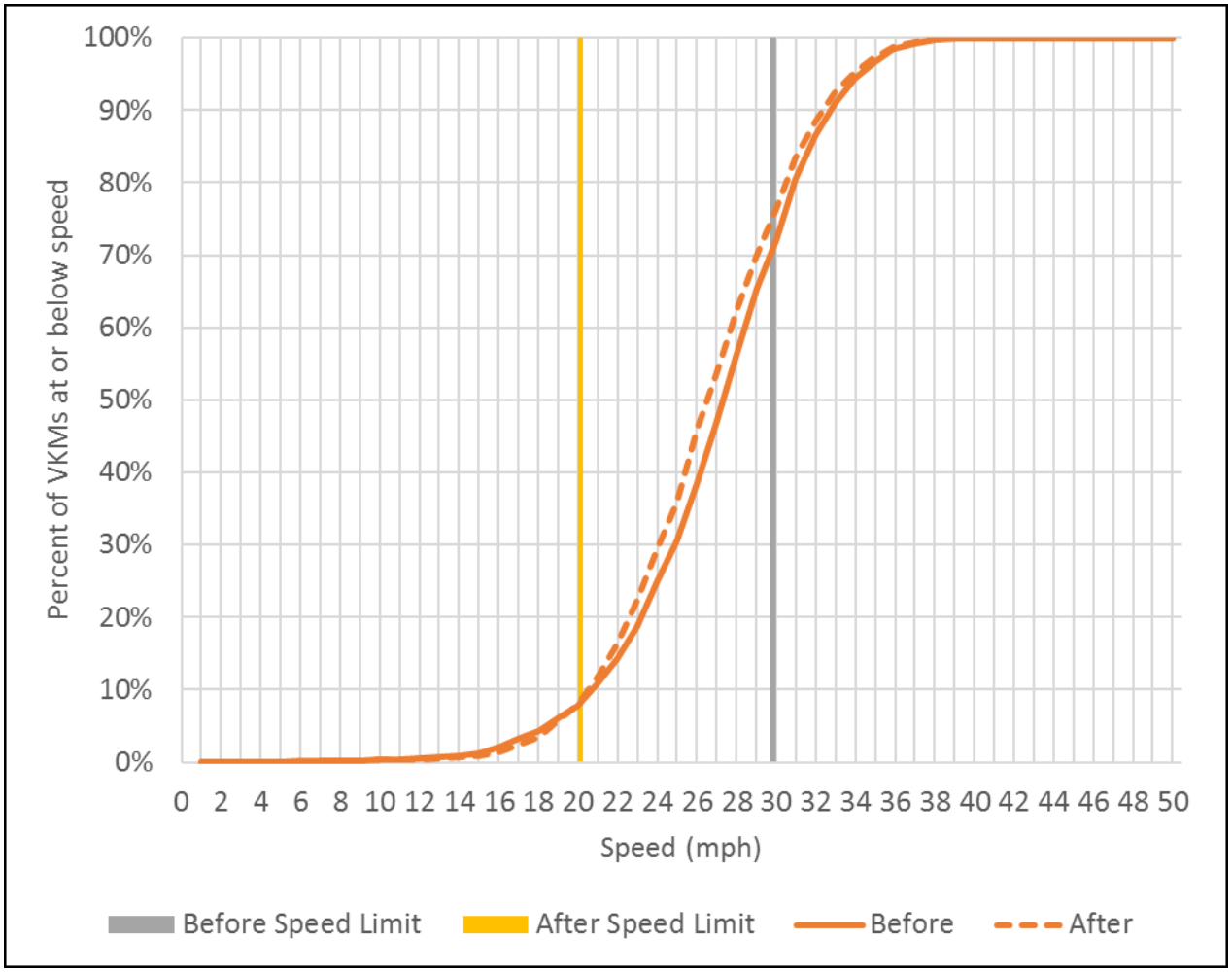


B.7. Nottingham - Bestwood (R-AW4)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	17.9km	17.9km	-
Sample VKMs Observed	9,218km	11,076km	-
Compliance	91%	40%	-
Where before <20mph	*100%*	*75%*	-
Where before >24mph	*72%*	*8%*	-
Median Speed	21.4mph	21.4mph	No Change
Where before <20mph	*16.7mph*	*16.8mph*	*+0.1mph*
Where before >24mph	*27.3mph*	*26.5mph*	*-0.8mph*
15th Percentile Speed	14.4mph	14.8mph	+0.3mph
85th Percentile Speed	28.2mph	27.9mph	-0.4mph
15th-85th percentile	13.8mph	13.1mph	-0.7mph

New 20mph limits (signed only) – Cumulative speed distribution

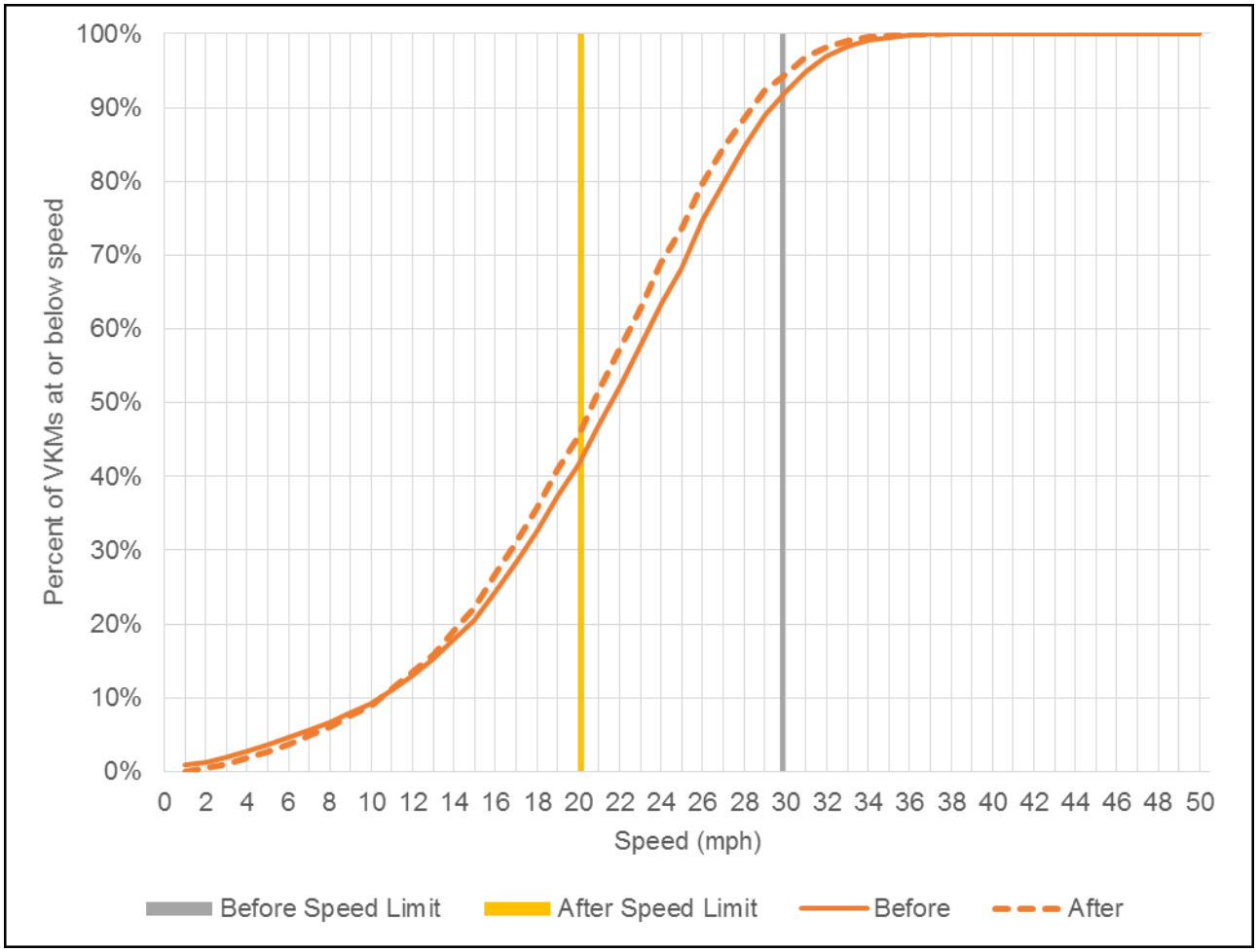


B.8. Brighton Phase 2 - N of City Centre (R-AW5)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	117.6km	117.6km	-
Sample VKMs Observed	278035km	332180km	-
Compliance	92%	45%	-
Where before <20mph	*100%*	*81%*	-
Where before >24mph	*79%*	*14%*	-
Median Speed	21.6mph	20.7mph	-0.9mph
Where before <20mph	*15.8mph*	*15.4mph*	*-0.4mph*
Where before >24mph	*26.4mph*	*25.5mph*	*-0.9mph*
15th Percentile Speed	12.9mph	12.6mph	-0.3mph
85th Percentile Speed	28.0mph	27.0mph	-1.0mph
15th-85th Percentile	15.2mph	14.5mph	-0.7mph

New 20mph limits (signed only) – Cumulative speed distribution

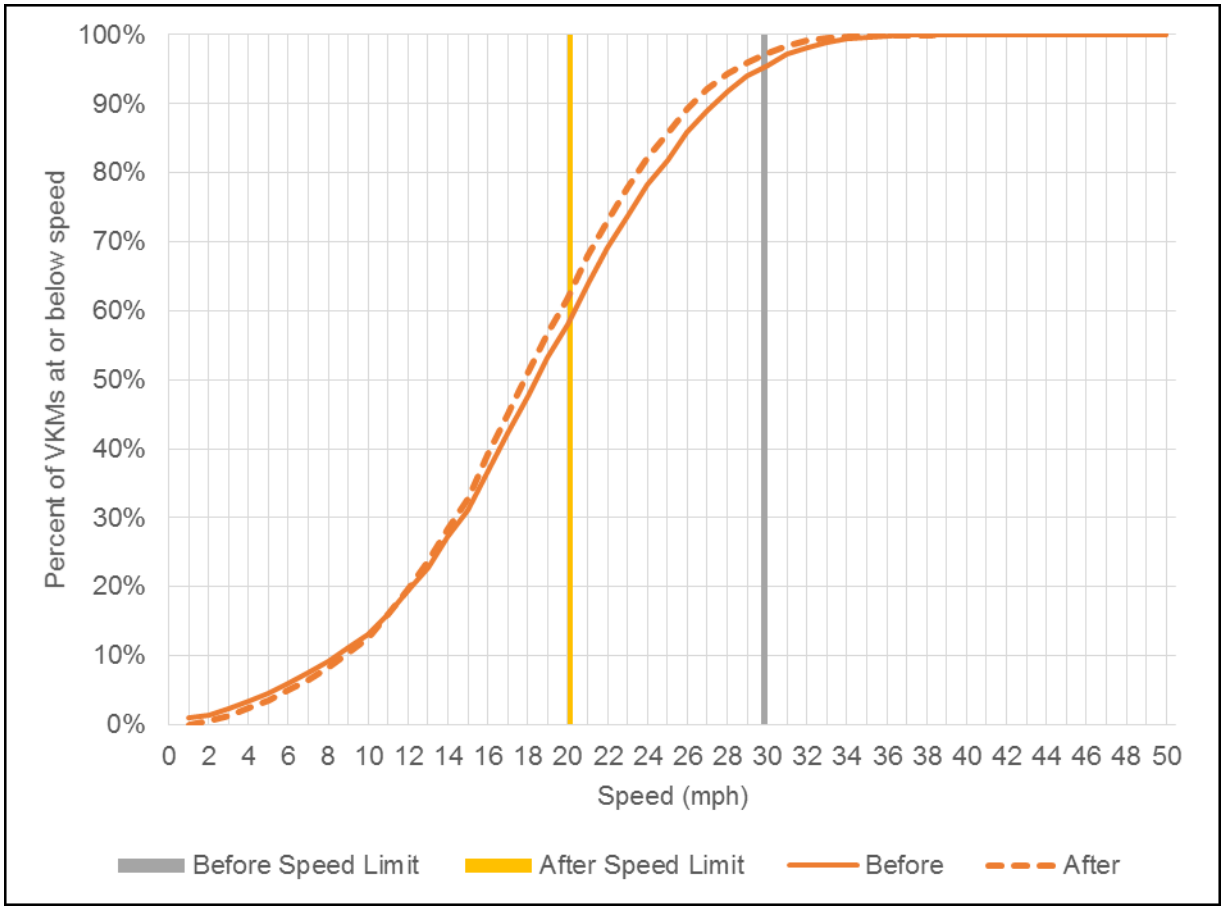


B.9. Portsmouth (R-AW6)

New 20mph limits (signed only) – Key outputs

		1 Year After	7 Years After	Diff
Speed limit		20mph	20mph	-
Road length		212.4km	212.4km	-
Sample VKMs observed		197,838km	265,136km	-
Compliance		58%	62%	+4%
Median speed		18.4mph	17.9mph	-0.6mph
15th percentile speed		10.6mph	10.7mph	-0.1mph
85th percentile speed		25.8mph	24.8mph	-0.9mph
15th-85th percentile		15.2mph	14.1mph	1.0mph
% driving	**<20mph**	58%	62%	+4%
	20-24mph	20%	21%	+1%
	>24mph	22%	18%	-4%

New 20mph limits (signed only) – Cumulative speed distribution

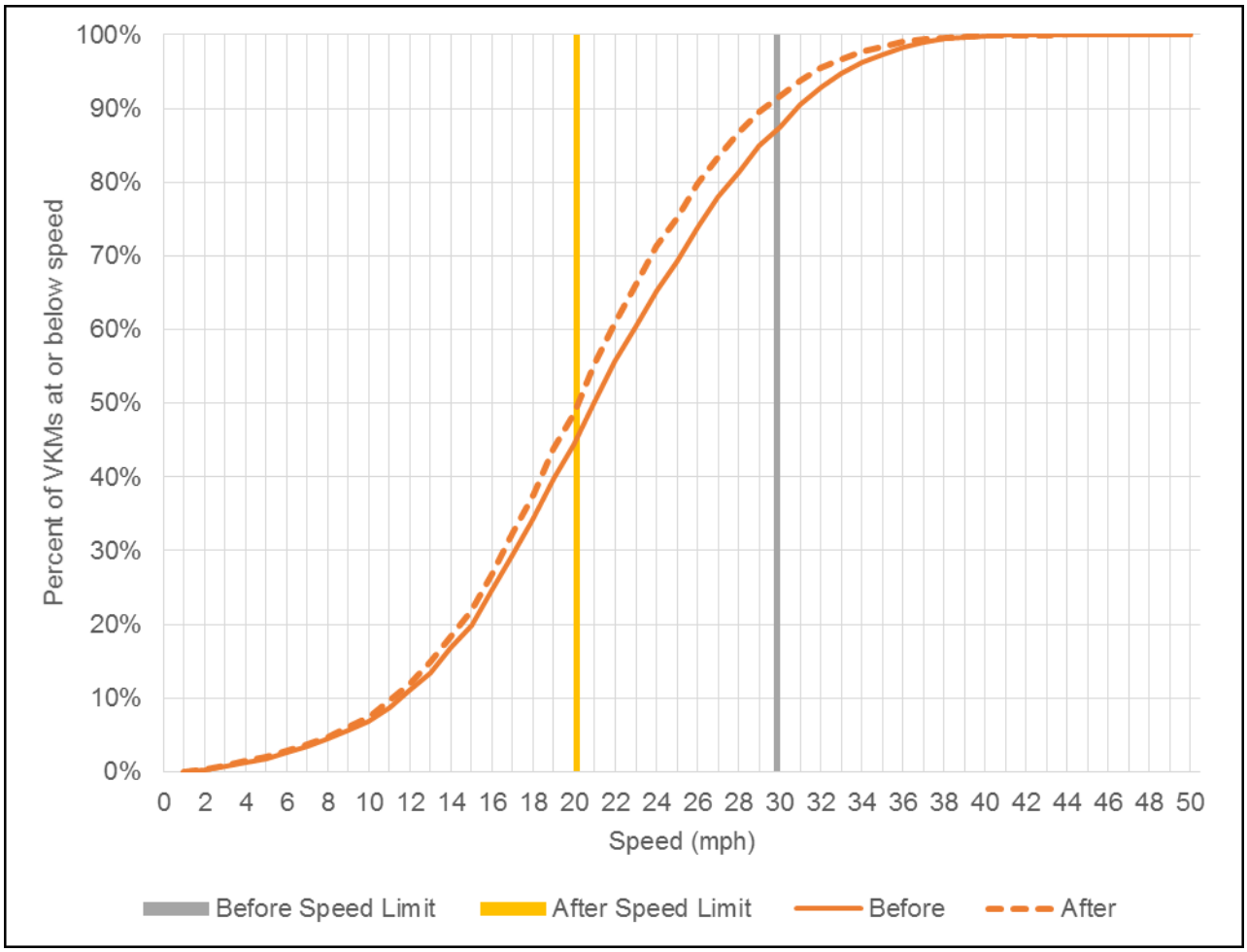


B.10. Chichester (R-AW7)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	66.4km	66.4km	-
Sample VKMs Observed	77509km	82615km	-
Compliance	87%	49%	-
Where before <20mph	*100%*	*81%*	-
Where before >24mph	*64%*	*13%*	-
Median Speed	21.0mph	20.2mph	-0.8mph
Where before <20mph	*16.1mph*	*15.9mph*	*-0.2mph*
Where before >24mph	*28.0mph*	*26.1mph*	*-1.9mph*
15th Percentile Speed	13.5mph	13.1mph	0.4mph
85th Percentile Speed	29.1mph	27.5mph	-1.6mph
15th-85th percentile	15.6mph	14.4mph	1.2mph

New 20mph limits (signed only) – Cumulative speed distribution

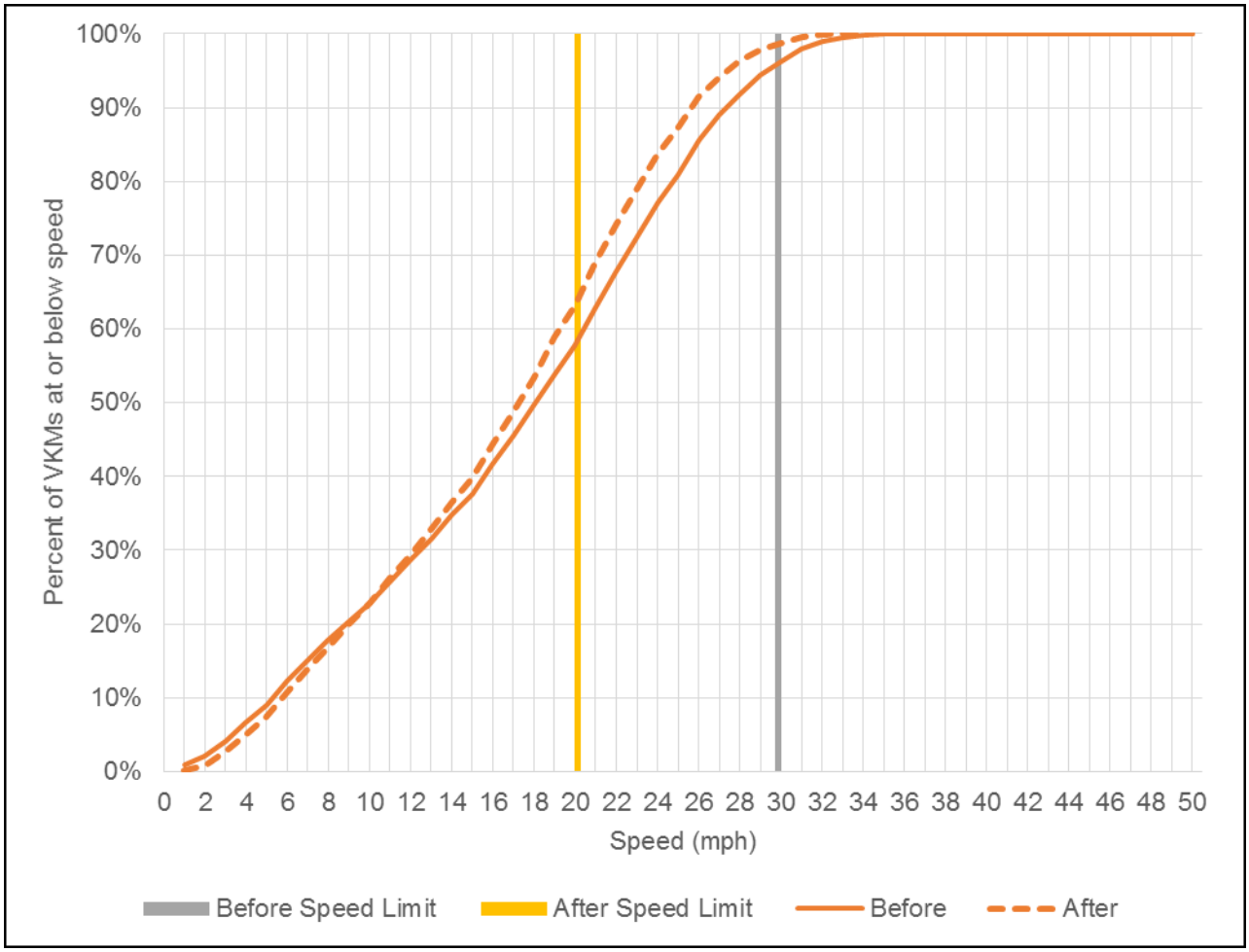


B.11. Brighton Phase 1 a) City Centre area only (TC-AW1)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	7.2km	7.2km	-
Sample VKMs Observed	210,397km	216,726km	-
Compliance	96%	63%	-
Where before <20mph	*99%*	*75%*	-
Where before >24mph	*85%*	*25%*	-
Median Speed	18.1mph	17.3mph	-0.8mph
Where before <20mph	*15.1mph*	*14.8mph*	*-0.3mph*
Where before >24mph	*25.3mph*	*23.6mph*	*-1.7mph*
15th Percentile Speed	6.9mph	7.4mph	-0.4mph
85th Percentile Speed	25.8mph	24.3mph	-1.5mph
15th-85th percentile	18.9mph	17.0mph	-1.9mph

New 20mph limits (signed only) – Cumulative speed distribution

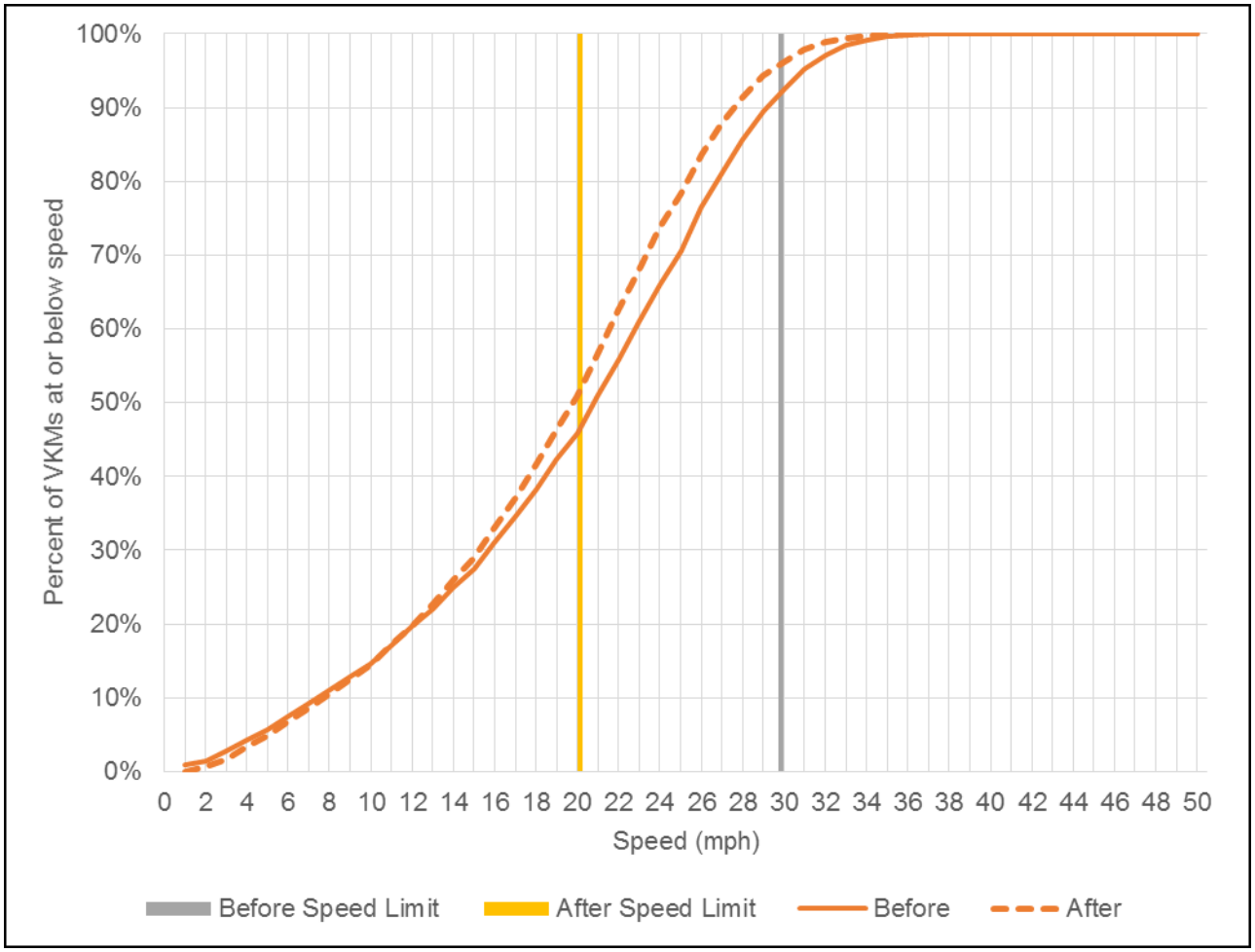


Brighton Phase 1 b) Adjacent Residential Area (TC-AW1)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	67.1km	67.1km	-
Sample VKMs Observed	475,787km	515,442km	-
Compliance	92%	51%	-
Where before <20mph	*99%*	*79%*	-
Where before >24mph	*78%*	*18%*	-
Median Speed	20.8mph	19.8mph	-1mph
Where before <20mph	*14.5mph*	*14.1mph*	*-0.4mph*
Where before >24mph	*26.2mph*	*24.8mph*	*-1.4mph*
15th Percentile Speed	10.1mph	10.2mph	+0.1mph
85th Percentile Speed	27.8mph	26.3mph	-1.5mph
15th-85th percentile	17.7mph	16.2mph	-1.6mph

New 20mph limits (signed only) – Cumulative speed distribution

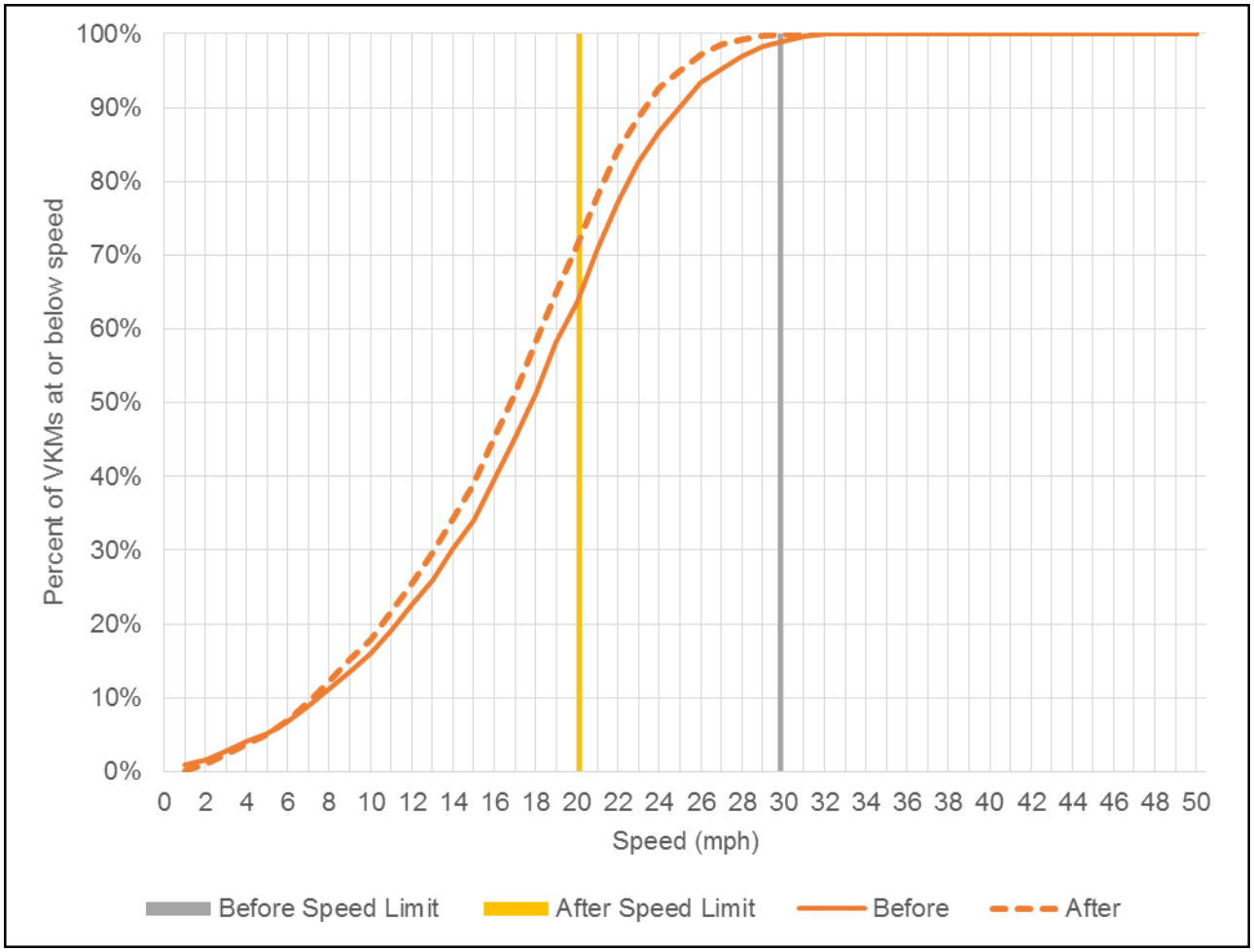


B.12. Winchester - City Centre (TC-AW2)

New 20mph limits (signed only) – Key outputs

	Before	After	Difference
Speed Limit	30mph	20mph	-
Distance of Roads	13.4km	13.4km	-
Sample VKMs Observed	63944km	79548km	-
Compliance	99%	71%	-
Where before <20mph	*100%*	*86%*	-
Where before >24mph	*85%*	*28%*	-
Median Speed	17.8mph	16.8mph	-1mph
Where before <20mph	*15.2mph*	*14.6mph*	*-0.6mph*
Where before >24mph	*25.4mph*	*22.8mph*	*-2.6mph*
15th Percentile Speed	9.6mph	9.0mph	-0.6mph
85th Percentile Speed	23.6mph	22.2mph	-1.4mph
15th-85th percentile	14.0mph	13.2mph	-0.7mph

New 20mph limits (signed only) – Cumulative speed distribution



B.13. Case study areas road lengths

The following tables contain details of the total road length analysed in this report, split by case study area and road type.

The analysis is based on only those segments where:

- a TomTom device has been detected in both the before and after period, and
- where it has been possible to match the TomTom record to a segment on our base map.

This means that the total road length in the TomTom sample may be less than the total road length for the study area. The percentage of the total road length in the case study area covered in the TomTom sample used for the analysis presented in this report is summarised in the end column of the tables.

a) New 20mph limits (signed only) – road length (kms)

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)	Total road length in study area (km)	Percentage of roads covered by TomTom data
				<20mph	20-24mph	>24mph					
R-SM1	Walsall (Rushall)	Residential	**4.4**	2.3	0.7	1.4	0.0	1.4	3.0	5.8	75.9
R-SM2	Winchester (Stanmore)	Residential	**5.7**	3.7	1.2	0.8	0.0	0.0	5.7	13.5	42.2
R-AW1a	Liverpool (Area 7)	Residential	**27.4**	21.3	2.9	3.2	0.0	1.1	26.2	52.0	52.7
R-AW1b	Liverpool (Area 2)	Residential	**44.4**	34.3	7.0	3.1	0.0	0.5	43.9	84.0	52.9
R - AW2	Middlesbrough	Residential	**58.1**	46.2	8.3	3.7	0.0	2.8	55.3	97.0	59.9
R-AW3	Calderdale	Residential	**41.6**	29.4	5.2	7.0	0.0	8.2	33.4	76.0	54.7
R-AW4	Nottingham	Residential	**17.9**	12.4	3.3	2.1	0.0	0.1	17.8	60.0	29.8
R-AW5	Brighton (Phase 2)	Residential	**117.6**	78.6	24.2	14.8	1.0	12.2	104.0	160.0	73.5
R-AW7	Chichester	Residential	**66.4**	41.3	14.2	10.8	0.0	12.1	54.3	67.0	99.1
TC-AW1	Brighton (Phase 1)	Residential	**67.1**	45.9	11.7	9.6	4.3	14.1	48.7	108	68.8
TC-AW1	Brighton (Phase 1)	City Centre	**7.2**	5.8	1.0	0.3	2.5	0.7	3.8		
TC-AW2	Winchester	City Centre	**13.4**	11.1	2.2	0.2	0.0	5.4	8.0	14.0	95.7
All residential areas			**450.5**	315.4	78.6	56.4	5.3	52.4	392.8		
All city centre areas			**20.6**	16.9	3.2	0.5	2.5	6.1	11.8	-	--
All scheme areas			**464.0**	325.6	81.4	56.9	7.8	58.6	397.0	737.3	62.9

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b) New 20mph limits (existing calming)

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)	Total road length in study area (km)	Percentage of roads covered by TomTom data
				<20mph	20-24mph	>24mph					
R-SM1	Walsall (Rushall)	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-SM2	Winchester (Stanmore)	Residential	**1.2**	0.5	0.7	0.0	0.0	0.0	1.2	1.2	100
R-AW1a	Liverpool (Area 7)	Residential	**0.7**	0.6	0.1	0	0.0	0.0	0.7	0.7	100
R-AW1b	Liverpool (Area 2)	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R - AW2	Middlesbrough	Residential	**9.1**	8.9	0.2	0.0	0.0	0.1	9.0	12.0	75.8
R-AW3	Calderdale	Residential	**1.0**	0.5	0.5	0.0	0.0	1.0	0.0	1.0	100.0
R-AW4	Nottingham	Residential	**8.6**	8.0	0.6	0.0	0.0	0.0	8.6	12.0	71.7
R-AW5	Brighton (Phase 2)	Residential	**3.0**	2.0	0.5	0.4	0.0	1.1	1.9	5.0	60.0
R-AW7	Chichester	Residential	**5.1**	1.6	3.4	0.1	0.0	5.1	0.0	3.0	170
TC-AW1	Brighton (Phase 1)	Residential	**0.1**	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
TC-AW1	Brighton (Phase 1)	City Centre	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
TC-AW2	Winchester	City Centre	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All residential areas			**28.8**	22.2	5.9	0.7	0.0	7.4	21.4	-	-
All city centre areas			**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	-	-
All scheme areas			**28.8**	22.2	5.9	0.7	0.0	7.4	21.4	-	-

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c) Old 20mph limits (signed only)

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)	Total road length in study area (km)	Percentage of roads covered by TomTom data
				<20mph	20-24mph	>24mph					
R-SM1	Walsall (Rushall)	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-SM2	Winchester (Stanmore)	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-AW1a	Liverpool (Area 7)	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-AW1b	Liverpool (Area 2)	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R - AW2	Middlesbrough	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
R-AW3	Calderdale	Residential	**0.4**	0.4	0.0	0.0	0.0	0.4	0.0	0.4	100
R-AW4	Nottingham	Residential	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-AW5	Brighton (Phase 2)	Residential	**2.5**	1.2	0.9	0.5	0.7	1.1	0.7	5.0	50.0
R-AW7	Chichester	Residential	**6.5**	6.0	0.4	0.1	0.0	0.0	6.5	7.0	92.9
TC-AW1	Brighton (Phase 1)	Residential	**6.2**	6.0	0.0	0.3	0.2	0.7	5.4	15.0	61.3
TC-AW1	Brighton (Phase 1)	City Centre	**3.0**	2.9	0.0	0.1	0.2	0.2	2.6		
TC-AW2	Winchester	City Centre	**2.7**	2.7	0.0	0.0	0.0	0.0	2.7	0.0	0.0
All residential areas			**15.7**	13.6	1.3	0.9	0.9	2.2	12.6	-	-
All city centre areas			**5.7**	5.6	0.0	0.1	0.2	0.2	5.3	-	-
All scheme areas			**21.3**	19.2	1.3	1.0	1.1	2.4	17.9	30.4	70.1

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d) Old 20mph limits (existing calming)

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)	Total road length in study area (km)	Percentage of roads covered by TomTom data
				<20mph	20-24mph	>24mph					
R-SM1	Walsall (Rushall)	Residential	**1.0**	0.1	0.8	0.1	0.0	0.0	1.0	1.1	90.9
R-SM2	Winchester (Stanmore)	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-AW1a	Liverpool (Area 7)	Residential	**72.2**	63.6	7.9	0.7	1.1	4.4	66.6	122.0	59.2
R-AW1b	Liverpool (Area 2)	Residential	**66.6**	56.7	7.2	22.7	0.0	2.5	64.0	88.0	75.7
R - AW2	Middlesbrough	Residential	**4.7**	4.7	0.0	0.0	0.0	0.0	4.7	7.0	67.1
R-AW3	Calderdale	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
R-AW4	Nottingham	Residential	**2.5**	2.4	0.1	0.0	0.0	0.0	2.5	5.0	50.0
R-AW5	Brighton (Phase 2)	Residential	**15.6**	14.0	1.0	0.5	0.0	0.0	15.5	18.0	86.7
R-AW7	Chichester	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TC-AW1	Brighton (Phase 1)	Residential	**9.2**	8.8	0.3	0.1	0.0	0.1	9.2	10.0	92
TC-AW1	Brighton (Phase 1)	City Centre	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
TC-AW2	Winchester	City Centre	**0.6**	0.6	0.0	0.0	0.0	0.0	0.6	0.7	85.7
All residential areas			**171.7**	150.3	17.2	4.1	1.2	7.1	163.4	-	-
All city centre areas			**0.6**	0.6	0.0	0.0	0.0	0.0	0.6	-	-
All scheme areas			**172.3**	150.9	17.2	4.1	1.2	7.1	164.0	-	-

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e) 30mph road

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)
				<20mph	20-24mph	>24mph			
R-SM1	Walsall (Rushall)	Residential	**5.0**	1.7	0.7	2.6	0.0	2.5	2.4
R-SM2	Winchester (Stanmore)	Residential	**8.6**	4.3	1.4	2.9	0.0	3.7	4.9
R-AW1a	Liverpool (Area 7)	Residential	**68.0**	25.7	7.2	35.1	27.9	16.5	23.7
R-AW1b	Liverpool (Area 2)	Residential	**45.6**	14.6	4.6	26.3	2.4	29.1	14.1
R - AW2	Middlesbrough	Residential	**136.5**	55.0	23.9	57.6	19.5	49.8	67.1
R-AW3	Calderdale	Residential	**24.4**	13.4	3.5	7.5	3.7	7.5	13.2
R-AW4	Nottingham	Residential	**33.6**	13.6	5.7	14.3	5.1	12.0	16.5
R-AW5	Brighton (Phase 2)	Residential	**87.8**	35.0	19.7	33.1	16.7	19.2	52
R-AW7	Chichester	Residential	**35.1**	7.7	6.4	21	16.9	13.5	4.8
TC-AW1	Brighton (Phase 1)	Residential	**12.1**	3.2	1.8	7.1	8.4	2.5	1.2
TC-AW1	Brighton (Phase 1)	City Centre	**1.3**	1.0	0.3	0.0	1.1	0.0	0.2
TC-AW2	Winchester	City Centre	**7.9**	5.4	0.5	2	0	2.1	5.8
All residential areas			**456.6**	174.2	74.9	207.5	100.6	156.3	199.7
All city centre areas			**9.2**	6.4	0.8	2.0	1.1	2.1	6.0
All scheme areas			**453.2**	176.3	74.2	202.7	98.2	155	200

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f) 40mph roads

ID	Case Study area	Category	Total road length in TomTom sample	By before mean speed			Major strategic roads (FRC1-3)	Important local roads (FRC4-5)	Minor local roads (FRC6-7)
				<20mph	20-24mph	>24mph			
R-SM1	Walsall (Rushall)	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-SM2	Winchester (Stanmore)	Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R-AW1a	Liverpool (Area 7)	Residential	**1.2**	0.0	0.0	1.2	1.2	0.0	0.0
R-AW1b	Liverpool (Area 2)	Residential	**9.1**	1.2	0.6	7.4	8.3	0.7	0.1
R - AW2	Middlesbrough	Residential	**19.8**	1.4	1.1	17.3	10.7	9.1	0.0
R-AW3	Calderdale	Residential	**0.1**	0.0	0.0	0.1	0.1	0.0	0.0
R-AW4	Nottingham	Residential	**4.7**	0.1	0.2	4.4	3.9	0.8	0.0
R-AW5	Brighton (Phase 2)	Residential	**5.6**	0.3	0.3	5.0	1.8	3.8	0.0
R-AW7	Chichester	Residential	**4.5**	0.0	0.1	4.4	0.7	3.8	0.0
TC-AW1	Brighton (Phase 1)	Residential	**1.0**	0.0	0.0	1.0	0.0	1.0	0.0
TC-AW1	Brighton (Phase 1)	City Centre	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TC-AW2	Winchester	City Centre	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All residential areas			**46.0**	3.0	2.3	40.7	26.8	19.1	0.1
All city centre areas			0.0	0.0	0.0	0.0	0.0	0.0	0.0
All scheme areas			**46.0**	3.0	2.3	40.7	26.8	19.1	0.1

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Appendix C. Quality assurance

C.1. Introduction

The findings presented in this report are based on a number of data sources and calculations and manipulations involving databases, GIS and spreadsheets. To ensure the data is manipulated correctly and consistently, checking procedures were adopted throughout the process to provide quality assurance.

C.2. Checks on TomTom data specifications

While we cannot check the processing of data on TomTom's servers or how they process their data, checks were conducted to ensure that the data requests were correct. TomTom Custom Area Analysis data is requested from a web portal in which a geographic area, time periods and date ranges are used to select data for each of the case study areas.

Once these queries of the TomTom database had been set up, an independent check of the data requests was undertaken to ensure that the date ranges and areas matched up with the specifications provided in Section 3 of this report, and that the time periods were as agreed for the analysis.

C.3. Agreement of methodology

The methodology used to analyse speeds in this report is unique, as it is not known that this approach has been adopted before. As such, a technical note was written by Atkins outlining the proposed methodology and shared with the DfT and Mike Maher for review, before adoption. Once agreement was reached, the study continued with the approach outlined.

C.4. Checks on speed limits

Upon downloading the TomTom speed data and road mapping, basic sense checks were completed by displaying the data in GIS:

- ***Check on speed limit locations*** – Speed limits were thematically mapped, then checked against local authority 20mph limit mapping and spot checked against Google Streetview imagery (see Figure C1 overleaf).
- ***Check on average speeds*** – Average speed outputs were thematically mapped, to ensure these adhered to common sense checks against the speed limit maps (e.g. if average speed was far above the speed limit then this would trigger a consistency issue).

C.5. Consistency of processing

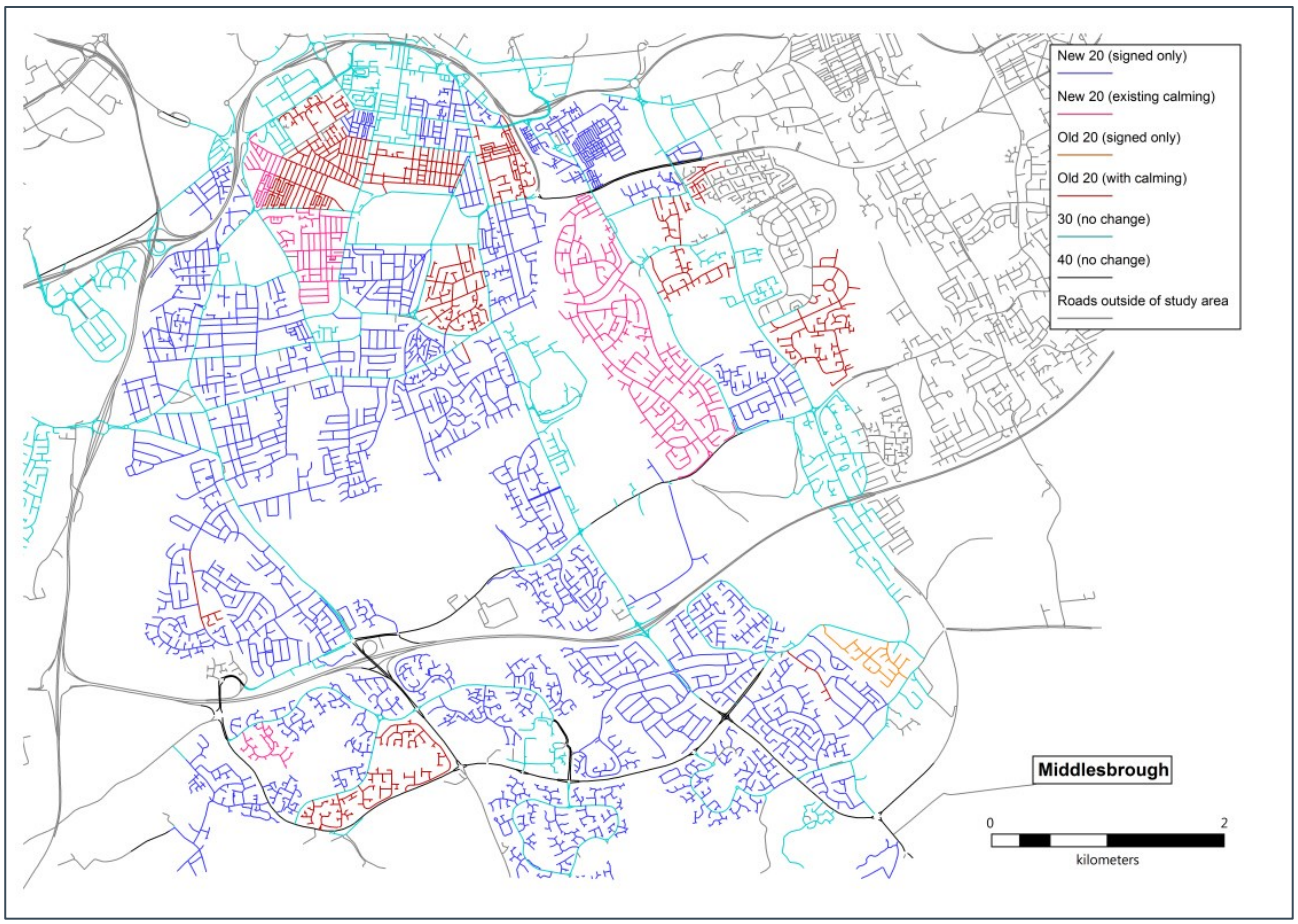
In order to ensure all case study area's data was processed consistently, a spreadsheet template for manipulating any case study area was developed along with processing instructions. This template was independently reviewed and checked for accuracy and performance by someone not directly involved in the core project. Spreadsheet best practice (version history, checks, colour coded cells) were adopted to ensure effective use of spreadsheets.

C.6. Checks on distance

The processing spreadsheet splits analysis into vehicle kilometres driven on different speed limit and traffic calming road combinations referred to as "road types". One check on each case study area undertaken is that the total vehicle kilometres driven at each speed limit/traffic calming combination does not sum to more than the case study wide vehicle kilometres observed in the whole case study area (i.e. each speed limit's VKM is less than or equal to all VKM).

Finally, for the core analysis in the main part of this report, all case study outputs were aggregated into one analysis to give study wide results. Once again, it was checked that the distance of each road type had followed through from the individual case study analysis through to the study wide analysis.

Figure C1. Check on speed limit locations (example)



C.7. Checks on response to change

The analysis spreadsheet was set up to allow filtering to different road types. This allowed a basic 'common sense' check that the speed profile changed logically with each change in road type. For example, does the speed flow curve move to the left when a lower speed is chosen, etc.

Similarly, the fact that the 30mph and 40mph speed flow curves show little change between the pre and post scheme distribution is further evidence of consistency. Given that the scheme involved no changes to 40mph roads, it is a reassuring test to check the total distance of 40km roads does not change between before and after the scheme, and that the profile of speeds on these roads remains reasonably consistent.

C.8. Checks against area maps

For each case study area, a physical paper map was marked up with speed limit information and traffic calming information taken from Google Streetview. These were then coded into GIS software, before being cross-referenced into the TomTom data to allow analysis of each road type. These case study maps were referred to during the speed analysis for basic checks of whether each road type is present within each case study area (e.g. some areas have no 20mph zones and hence should not give speed data outputs for 20mph roads with calming). The GIS maps also provided a secondary check that the relative distance of roads of each type in each case study analysis is correct.

C.9. Spot checks on outcomes

The core outcomes reported in this report were spot checked. For some figures, we traced the calculations through from the raw TomTom outputs and maps to confirm that the number was correct. This was a test that the formulas and logic in the spreadsheet was giving the result we were expecting.

C.10. Checks on reporting

Finally, the spreadsheets were independently checked, to ensure that the results have been correctly transcribed to this report.

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