COMISIWNTRAFNIDIAETH
TRANSPORTCOMMISSION
DE-DDWYRAIN CYMRU / SOUTH EAST WALES

Summary Background

JULY 2020

Mae'r ddogfen yma hefyd ar gael yn Gymraeg.
This document is also available in Welsh.

WG40870 Digital ISBN 978-1-80038-723-2

SUMMARY BACKGROUND

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1. THE M4 IN SOUTH EAST WALES

Context

1.1. This part of our report explains the nature of congestion on the M4 in South East Wales. The road is a complex system, used for many different purposes at different times. There are a number of different traffic patterns that have been looked at, each of which offers a different perspective on congestion. The analysis concludes with an examination of the causes of congestion.

1.2. The analysis in this section focuses on Junctions 23 (Rogiet) to 29 (Castleton) in both directions. This is because this section of the motorway experiences the worst congestion in the South East Wales area.

1.3. The M4 around Newport, part of the Trans-European Road Network, is the most heavily used road in Wales and is vital to vehicle movements within and into South Wales.

1.4. The stretch of motorway between Junctions 25 and 26 (incorporating the Brynglas tunnels) is the fourth most congested stretch of urban motorway in the UK and is ranked within the top 50 traffic hotspots in Europe.[1] Over a 12-month period, observed data shows a total of 1,477 registered incidences of congestion (around four per day).

1.5. Part of the motorway was originally conceived as a northern bypass around Newport. This accounts for many of the now-problematic design features of the road, in particular frequent Junctions, high gradients and poor alignment with the surrounding road network.

1.6. The combination of this history and development within the area means the M4 is now, by some margin, the primary east-west road corridor for regional travel within South East Wales and into England. It carries a far higher volume of traffic than it was originally designed for.

1.7. This traffic travels close to a large number of urban areas, and exceptionally close to a number of residential areas in Newport. This is unusual for a UK motorway. Figure 1.1 shows the location of the M4 in the region along with trunk roads, railway lines and built up areas.

[1] Source: Inrix

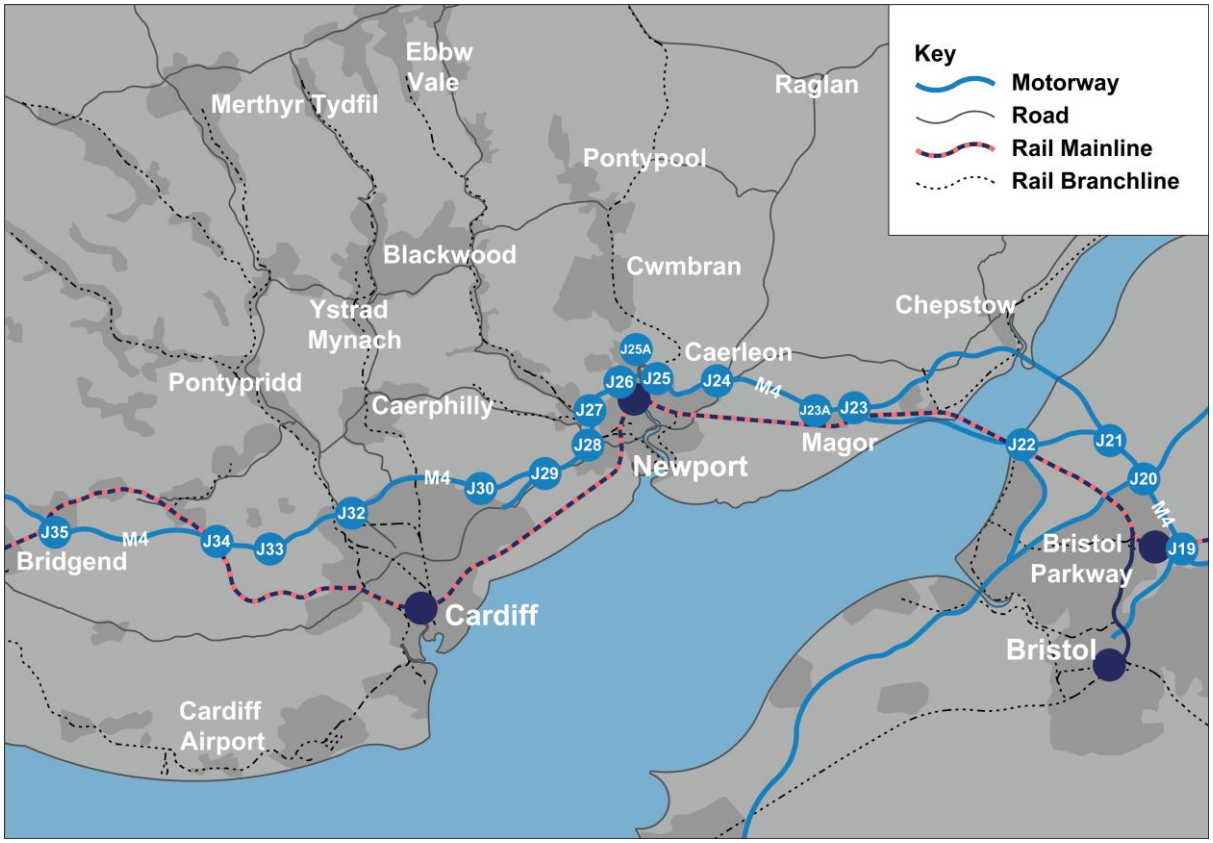


Figure 1.1: The M4 in the region

Traffic patterns on the M4

1.8. We have considered the main patterns of traffic on the M4 in South East Wales between Junctions 23 to 29:

- eastbound and westbound
- hourly patterns over the day
- daily patterns over the week
- seasonal patterns over the year

1.9. Annex A tells the story of the typical peak hour going in each direction in the morning and the evening.

Eastbound and westbound

1.10. Over the course of a typical day, 112,000 vehicles travel eastbound and 114,000 travel westbound on at least part of this length of the M4. The road is therefore broadly balanced. This scale of flow is far higher than the original design specification of the road.

1.11. Figure 1.2 demonstrates the Annual Average Daily Traffic (AADT) for each Junction and link in both directions. The AADT is calculated by dividing the annual volume of traffic by 365. In broad terms, over the course of a typical day:

- the motorway is busiest between Junctions 29 (Castleton) and 28 (Tredegar) in both directions, with nearly 60,000 vehicles in either direction
- flows reduce to under 40,000 vehicles between Junctions 26 and 25A. This reflects a significant outflow in both directions immediately before the Brynglas tunnels, where the motorway reduces down to two lanes in either direction
- traffic volumes are around 50,000 to the east of the tunnels, reducing to around 40,000 over the Prince of Wales Bridge

1.12. However, there are east-west asymmetries during different times of the day. In particular:

- in the mornings, more vehicles travel eastbound than westbound
- in the afternoon and evenings, more vehicles travel westbound than eastbound

1.13. These asymmetries suggest there are more people living in Wales and working in England than living in England and working in Wales. When combined with the constraint of the Brynglas tunnels, the impact is particularly poor journey time reliability on the eastbound approach to the tunnels in the morning and the westbound approach in the evening.

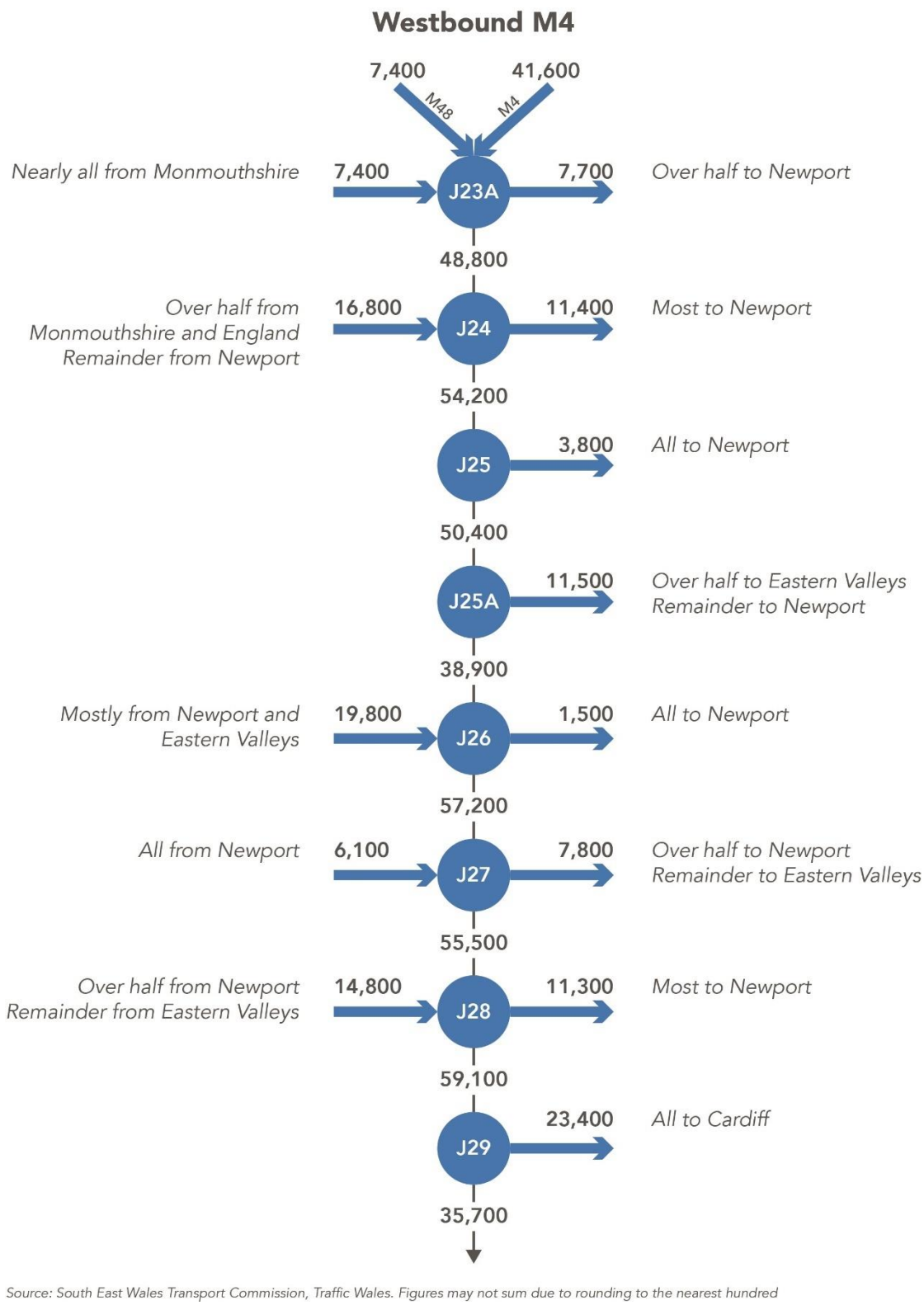
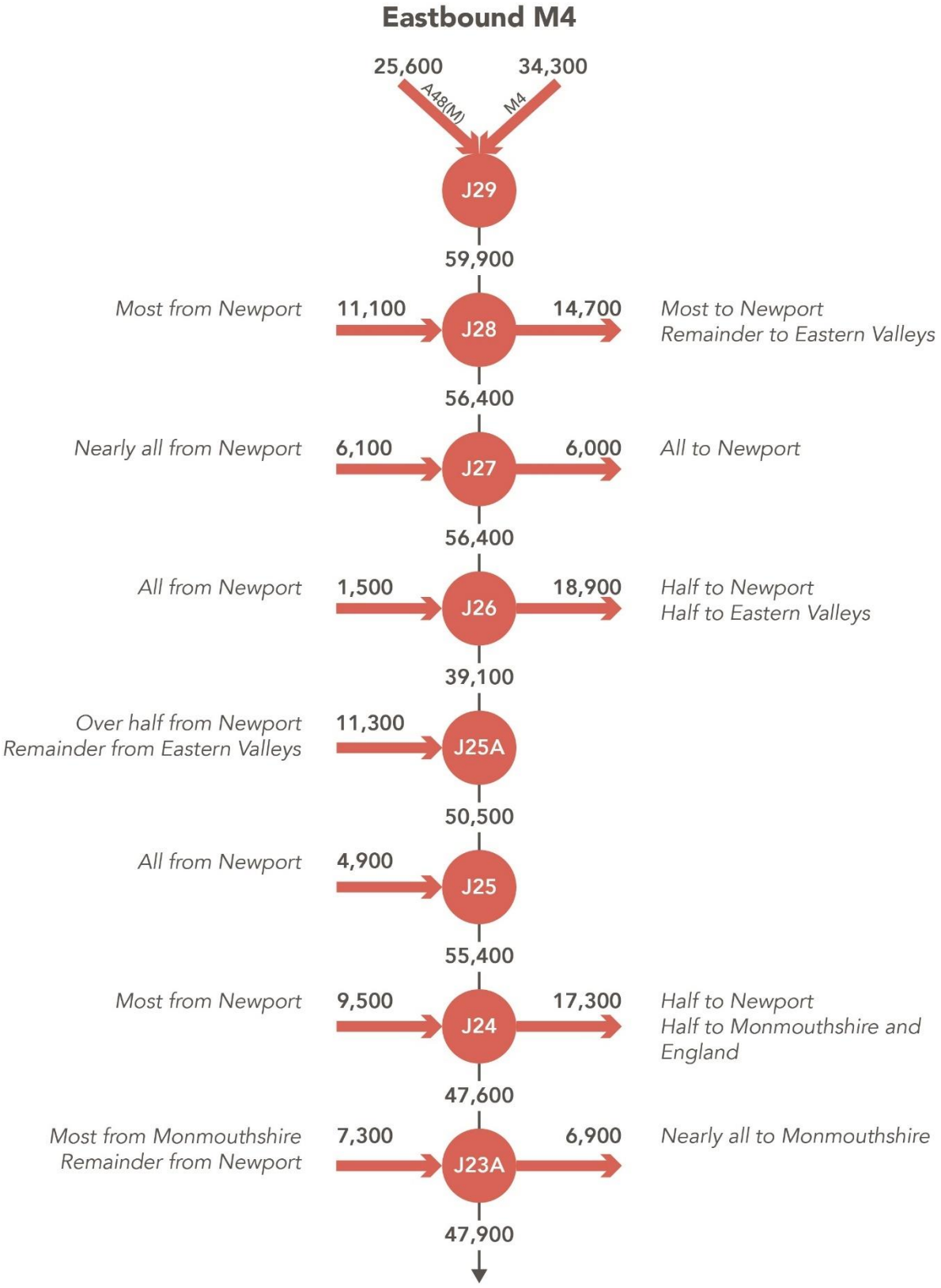


Figure 1.2A: Volume of flow on a typical weekday for each Junction link in each direction (westbound)



Source: South East Wales Transport Commission, Traffic Wales. Figures may not sum due to rounding to the nearest hundred

Figure 1.2B: Volume of flow on a typical weekday for each Junction link in each direction (eastbound)

Daily patterns

1.14. For a typical weekday, there are two strong peaks - in the morning, and across the afternoon and early evening.

1.15. Figure 1.3 depicts the hourly traffic flow profile and the hourly traffic speed profile at two important Junction links (Junctions 28 to 29 eastbound and 24 to 25 westbound). In the morning, the peak period generally runs from 6am to 9am, with the highest flows around 6.30am. In the afternoon, it is generally 3pm to 7pm. The hourly traffic speed profile demonstrates the 'trough' in speeds broadly correlates with the 'peak' in flow. The median speed is depicted as a solid blue line.

1.16. Figure 1.4 summarises the trough speeds experienced by traffic during the peak times at each Junction link. The speed profiles vary significantly across different links at different times of day. Median speeds and journey time reliability are generally worse approaching the Brynglas tunnels in either direction.

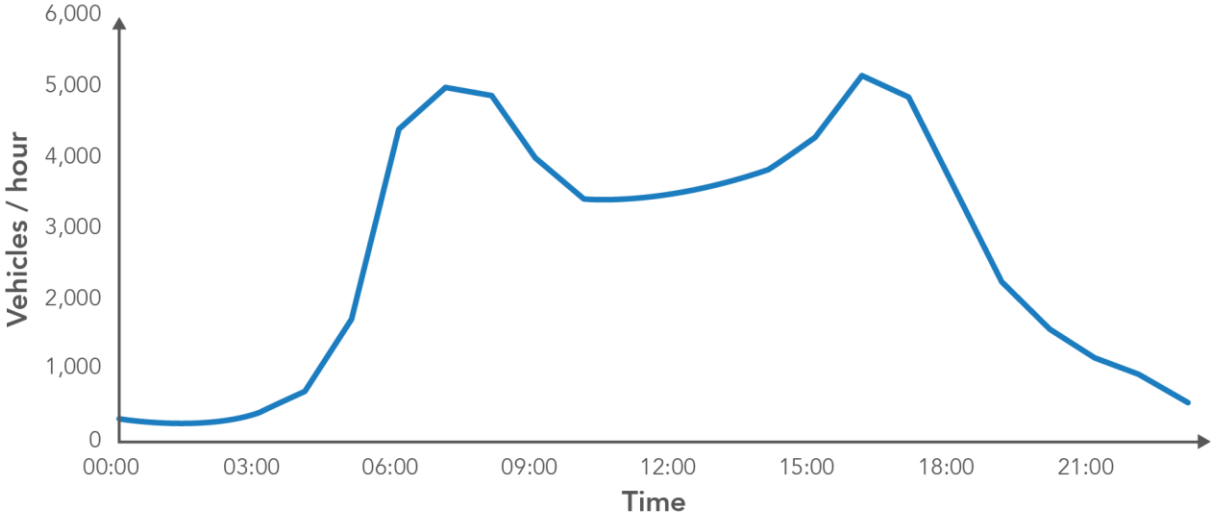
1.17. We have also investigated the journey time reliability across different stretches of the motorway. From our engagement, it is clear that individuals and businesses place significant weight on knowing approximately how long their journeys will take.

1.18. A wide variance of speeds demonstrates poor journey time reliability. We have observed this for many stretches of the motorway, especially going eastbound in the mornings and westbound in the evenings. This is also depicted in figure 1.4.

1.19. It is important to note that, outside these peak times, both journey time reliability and average speeds are often reasonable.

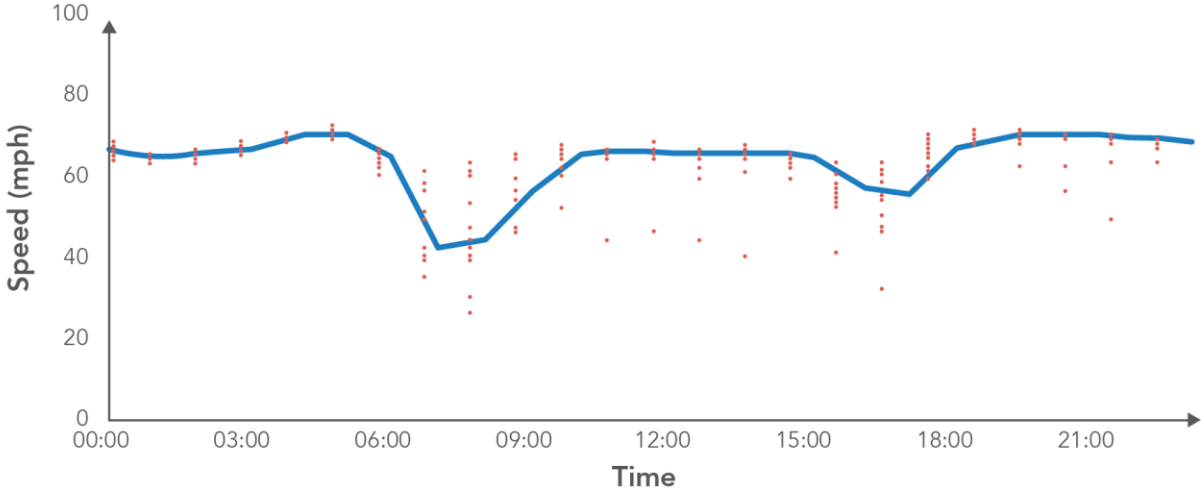
M4 J28 to 29 *typical weekday*

Hourly traffic flow profile: eastbound



Hourly traffic flow profile variation in average weekday (Monday to Thursday. Hourly traffic flows average across the whole of 2019. Mondays to Thursdays have been averaged on the basis that hourly traffic flow profiles on these days are very similar.

Hourly traffic speed profile: eastbound



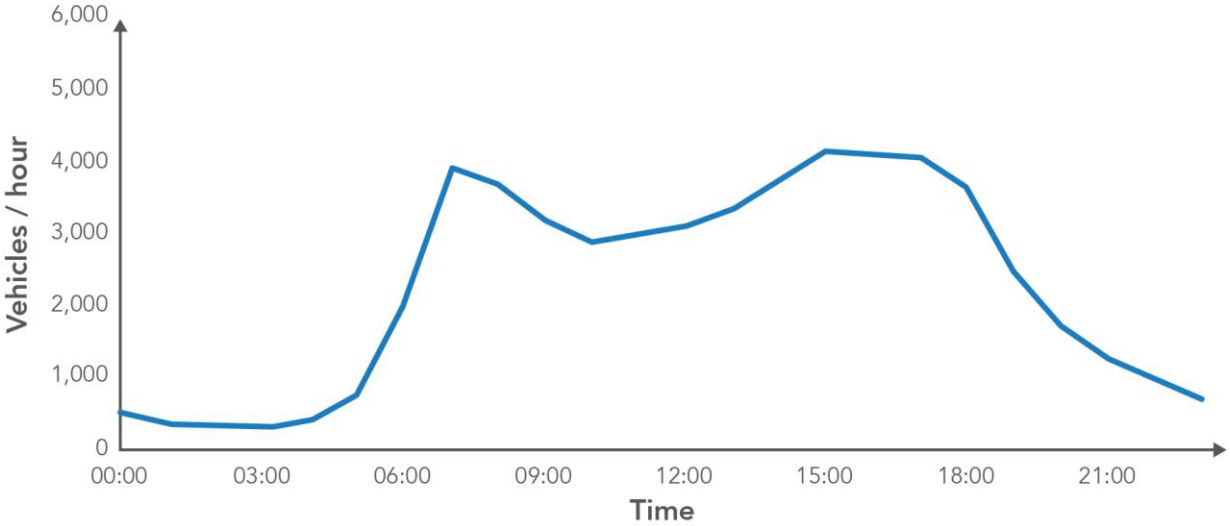
Hourly traffic flow profile variation in average median hourly speed across an average weekday (Monday to Thursday). Based on one week of data from each month in 2018. Scattered dots give an indication of speed variability on a typical weekday as a measure of journey time reliability.

Source: Traffic Wales

Figure 1.3A: Typical hourly flow and distribution of median speeds at key Junction links (eastbound)

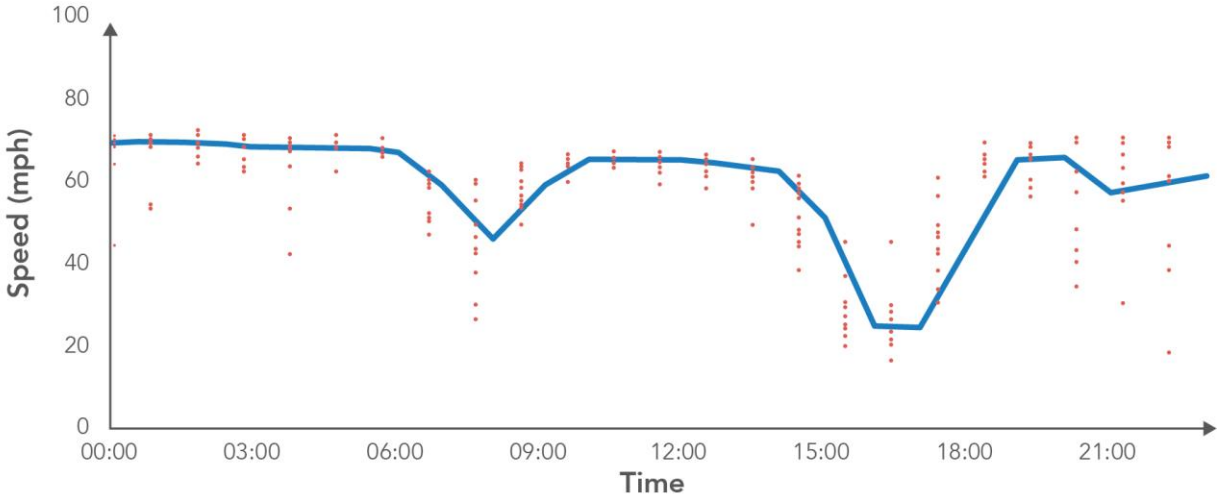
M4 J24 to 25 *typical weekday*

Hourly traffic flow profile: westbound



Hourly traffic flow profile variation in average weekday (Monday to Thursday). Hourly traffic flows average across the whole of 2019. Mondays to Thursdays have been averaged on the basis that hourly traffic flow profiles on these days are very similar.

Hourly traffic speed profile: westbound



Hourly traffic flow profile variation in average median hourly speed across an average weekday (Monday to Thursday). Based on one week of data from each month in 2018. Scattered dots give an indication of speed variability on a typical weekday as a measure of journey time reliability.

Source: Traffic Wales

Figure 1.3B: Typical hourly flow and distribution of median speeds at key Junction links (westbound)

Eastbound - morning peak		
Junction link	Lowest median speed	Journey time reliability
Junction 29 - 28	55 mph	Poor
Junction 28 - 27	40 mph	Poor
Junction 27 - 26	40 mph	Very Poor
Junction 26 - Brynglas Tunnels - 25A	45 mph	Good
Junction 25 - 24	55 mph	Good
Junction 24 - 23A	65 mph	Good

Westbound - evening peak		
Junction link	Lowest median speed	Journey time reliability
Junction 23A - 24	45 mph	Very Poor
Junction 24 - 25	25 mph	Very Poor
Junction 25A - Brynglas Tunnels - 26	40 mph	Poor
Junction 26 - 27	50 mph	Poor
Junction 27 - 28	60 mph	Moderate
Junction 28 - 29	65 mph	Moderate

Source: Traffic Wales. For lowest median speed we have taken the slowest median speed during the peak period. Speeds have been rounded to the nearest 5mph

Figure 1.4: Lowest median speed and journey time reliability at Junction links

Daily inflows and outflows

1.20. It is helpful to relate the performance of different parts of the road at peak times with the degree of traffic entering and exiting the motorway. These traffic movements tell us about the types of journeys people are using the motorway for and show the particular concentrations of vehicles which contribute to congestion. Figure 1.5 summarises weekday vehicle movements for a typical peak hour in the morning and evening.

1.21. This demonstrates how westbound evenings mirror eastbound mornings and similarly how westbound mornings mirror eastbound evenings, reflecting the commuting tides on the road. It also shows how movements joining and leaving the road are not evenly distributed across Junctions. In particular, some Junctions are especially tidal, by which we mean that much more traffic flows in one direction compared to the other at a particular time of the day. Junction 26 is an example. It also shows how the large number of Junctions and degree of inflow and outflow means that the volume of traffic rises and falls by significant proportions across a relatively short distance.

1.22. Going eastbound from Cardiff on a typical morning, a very high volume of traffic joins the motorway at Junction 29. There is moderate inflow and outflow at Junctions 27 and 28, before a very significant net outflow at Junction 26, just before the tunnels. Immediately after the tunnels, a similar number of vehicles join the motorway and there is moderate inflow and outflow at East Newport. The Junctions approaching the Prince of Wales Bridge are relatively quiet. These patterns are broadly mirrored going westbound in the evenings.

1.23. Going westbound from the Prince of Wales Bridge on a typical morning, there is relatively little inflow and outflow until East Newport (Junction 24) when a large number of vehicles join and leave the road. A moderate amount of vehicles leave before the tunnels and then a very large number join immediately after. There is significant net outflow at Junctions 28 and 29. These patterns are broadly mirrored going eastbound in the evenings.

	Eastbound Morning		Westbound Evening		Westbound Morning		Eastbound Evening	
	Joiners	Leavers	Joiners	Leavers	Joiners	Leavers	Joiners	Leavers
J23	not included	750	750	not included	750	not included	not included	750
J23A	750	500	500	750	750	500	500	500
J24	1,000	1,500	1,500	1,250	1,500	1,000	750	1,500
J25	500	no exit	no entry	500	no entry	250	500	no exit
J25A	1,000	no exit	no entry	1,000	no entry	1,000	1,000	no exit
Brynglas Tunnels								
J26	250	1,750	1,750	250	2,000	0	0	1,750
J27	750	750	500	1,000	750	500	500	500
J28	750	1,250	1,500	1,000	1,250	1,500	1,250	1,750
J29	2,500	not included	not included	2,250	not included	1,750	2,250	not included

Source: Welsh Government, figures are rounded to the nearest 250

Figure 1.5: Scale of Junction joiners and leavers in each direction in a typical weekday morning and evening peak hour

Weekly patterns

1.24. The daily pattern described above relates to a typical weekday, defined as Monday to Thursday. However, there are different patterns on Fridays, Saturdays and Sundays.

1.25. Friday has a less pronounced morning peak than a typical weekday morning, with higher median speeds and better journey time reliability. However, the afternoon and evening are usually much worse (in part due to weekly commuters). The lowest median speed is similar to a typical weekday, but the length of the trough is significantly longer (approximately three hours rather than one hour).

1.26. Saturday and Sunday are both generally better than weekdays and Fridays. The flow profile is very different; there is only one peak, not two. Flows peak around lunchtime and dissipate slowly over the early afternoon.

1.27. In summary, for a typical weekend, going westbound:

- on Fridays, significant congestion problems exist from Junction 23 until Junction 26; the situation dramatically improves once the tunnels are cleared

- on Saturdays, there is a particular issue between Junctions 24 and 25 at lunchtime but conditions improve by the time the tunnels are reached

- on Sundays, there is no significant deterioration in median speeds or journey time reliability

1.28. For a typical weekend, going eastbound:

- on Fridays, there is a notable absence of a morning peak drop in performance. From the afternoon, traffic is marginally worse than the average weekday when approaching the tunnels. Once traffic has travelled through the tunnels, there are no material issues

- on Saturdays, the road performs better than a typical weekday and there are no substantive issues

- on Sundays, there are some problems approaching the tunnels in the afternoon but none after the tunnels

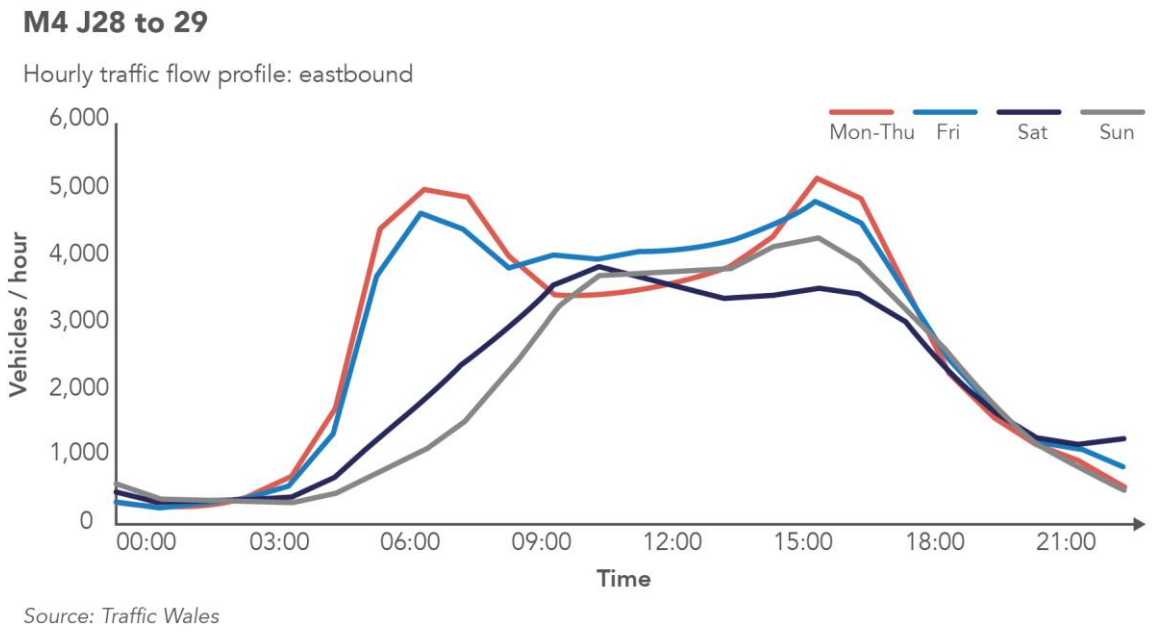


Figure 1.6A: Speed profile between Junctions 28 to 29 (eastbound)

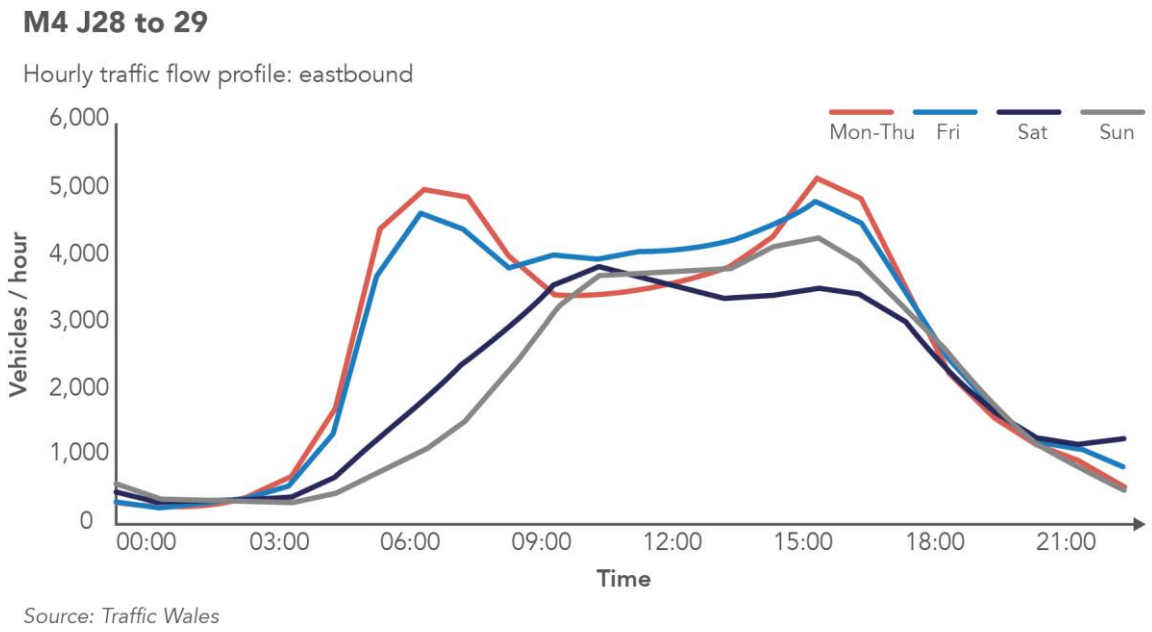


Figure 1.6B: Speed profile between Junctions 24 to 25 (westbound)

Other patterns

1.29. The M4 experiences high traffic flows throughout the year. However, there is a pattern of seasonality: December, January and February exhibit relatively lower flows, which rise gradually to the summer and persist until October.

1.30. This seasonality is influenced by the school calendar, although it is difficult to disaggregate the impacts from other travel purposes, especially tourism and leisure. Analysis from two recent half-terms suggests traffic volumes are slightly lower in the morning, eliminating the normal morning peak-time trough in average speed. This shows that even a modest reduction in traffic can have a dramatic impact on average speed. However, differences in traffic volumes during the afternoon and early evening are not significant enough to cause much difference to the afternoon peak-time trough. Figure 1.7 demonstrates this effect.[2]

[2] Half-terms were selected to isolate the impact of school traffic from holiday traffic, which would be associated with Christmas, Easter and summer periods

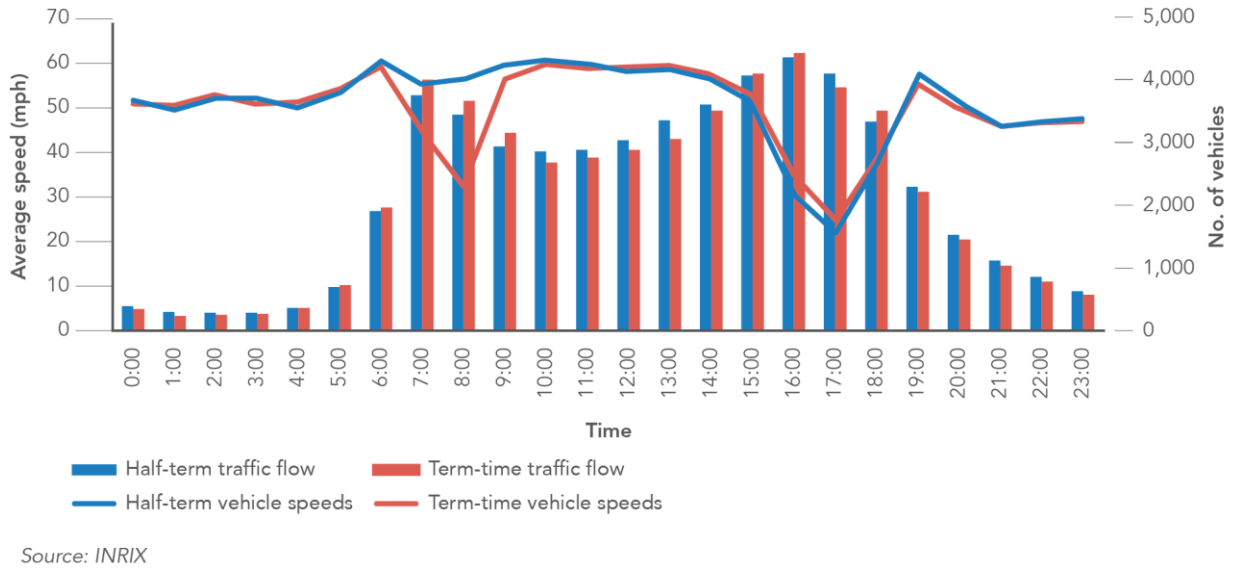


Figure 1.7: Speed profiles and traffic flows for autumn half term and term time westbound between Junctions 24 and 25

Composition of M4 traffic

1.31. There are two important ways to distinguish between types of traffic flow on the motorway: vehicle type and journey length. The composition remains largely similar along this length of the M4.

1.32. By number, the composition of vehicles is largely cars. The percentage of cars is highest in the evening peak, comprising generally more than 80% of vehicles. Heavy and light goods vehicles comprises around 20% of traffic during peak times and approximately 30% in the inter-peak period, although this is mostly because the number of cars is lower, rather than because freight vehicles is higher in absolute terms. The M4 carries considerably more light and heavy goods vehicles than any other part of the road network in Wales.[3] The composition remains largely similar along the M4.

1.33. Occupancy rate varies depending on if the journey is a work commute or for other purposes. For most commutes, the average occupancy is 1.4. This is similar to the UK average for motorway use, which is around 1.5.[4]

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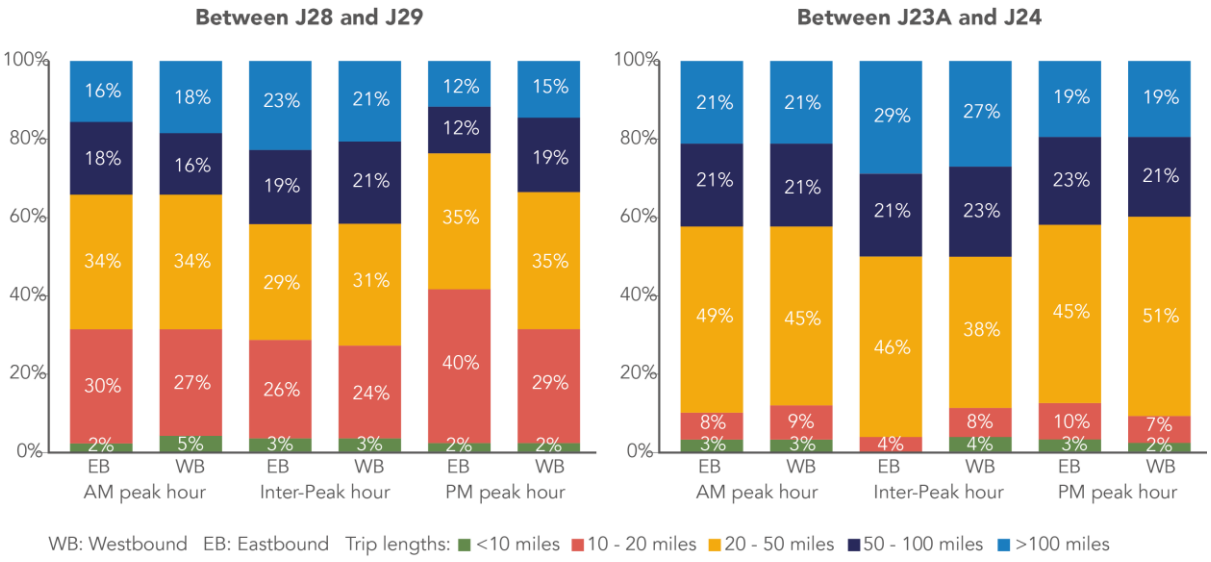
[3] 3 Source: Welsh Government, M4 Corridor Around Newport Project Public Inquiry Proof of Evidence – Traffic, January 2017, collaborated with DfT traffic counts

[4] Source: DfT Data Book 2019

1.34. In terms of journey length, there is a material difference between the eastern end (Junction 23A) and western end (Junction 29) of the motorway (see figure 1.8):

- **Around Junctions 23A and 24**, approximately 90% of trips are over 20 miles, with around 40% of journeys over 50 miles, at peak times. There are very few journeys under 20 miles

- **Around Junctions 28 and 29**, approximately 65% of journeys are over 20 miles, with around 30% of journeys over 50 miles, at peak times. There is a far higher proportion of journeys under 20 miles



Source: Welsh Government. Total trips shown on this section are by distance band by time period of a typical weekday.

Figure 1.8: Distribution of journey lengths at J23A to J24 and J28 to J29

1.35. This demonstrates that longer journeys on the road are more prevalent at the eastern end. In both cases, there are more long journeys between the peaks than during peak periods and the eastbound and westbound directions are broadly balanced.

Origins and destinations

1.36. We have sought to understand the nature of the major origin and destination patterns on the road. These will change over time but provide a good picture of how people are currently using the M4 and how goods are being moved across the region.

1.37. The origin and destination patterns have been obtained from detailed transport models which make use of anonymised mobile phone information to provide a high-quality dataset. Further details on the models used is set out in Annex B.

1.38. Figure 1.9 shows the origin and destination of traffic which passes each motorway Junction and figure 1.10 sets out the top ten origin and destination pairs. In figure 1.9 the 'Central Valleys' consist of Merthyr Tydfil and Rhondda Cynon Taff local authorities, and the 'Eastern Valleys' consist of Blaenau Gwent, Torfaen and Caerphilly local authorities.

1.39. The analysis demonstrates the cities of Cardiff, Newport and Bristol feature prominently as origins and destinations, as opposed to the counties sited to the north of the motorway. Combined, the three cities account for more than half of all traffic on the motorway in South East Wales. The scale of Newport as an origin and destination is particularly notable, given it is around a half the size of Cardiff and a third the size of Bristol. It is interesting to note that the top four pairs do not involve travelling through the Brynglas tunnels.

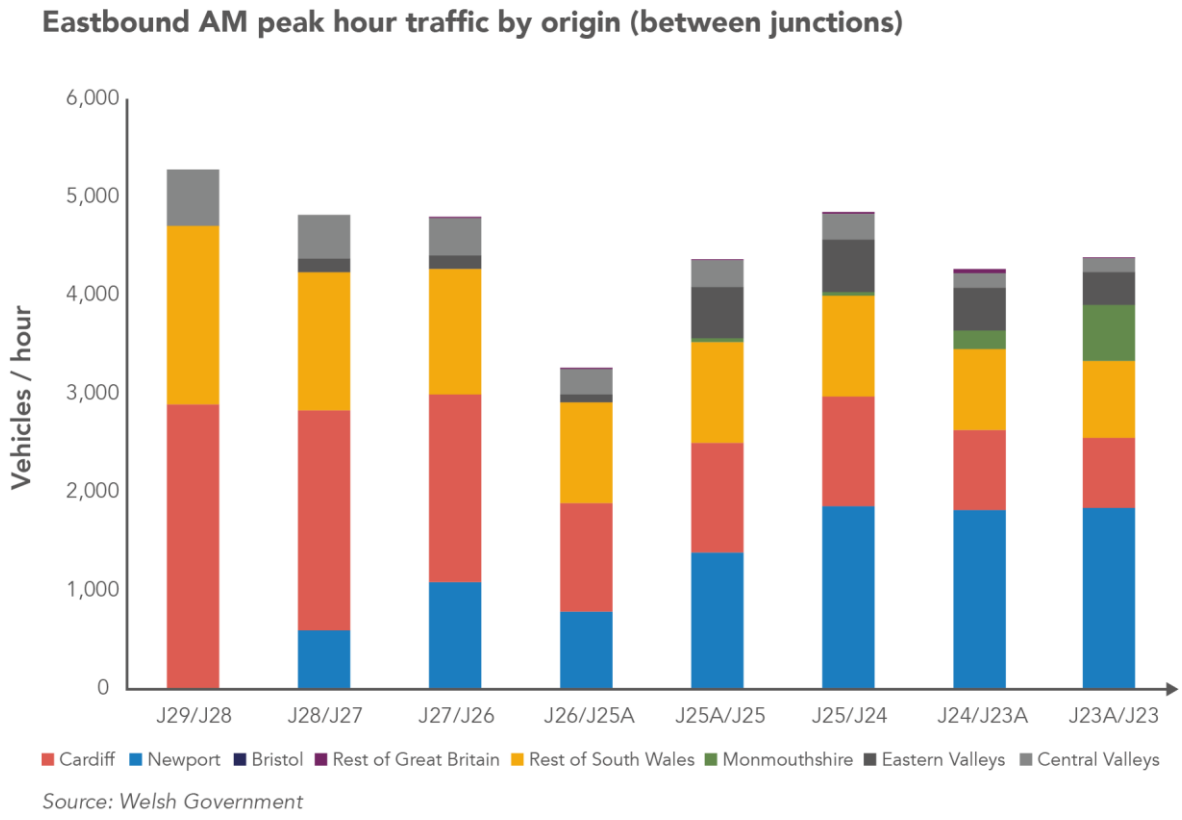


Figure 1.9A: Typical morning summary origin and destinations (eastbound origin)

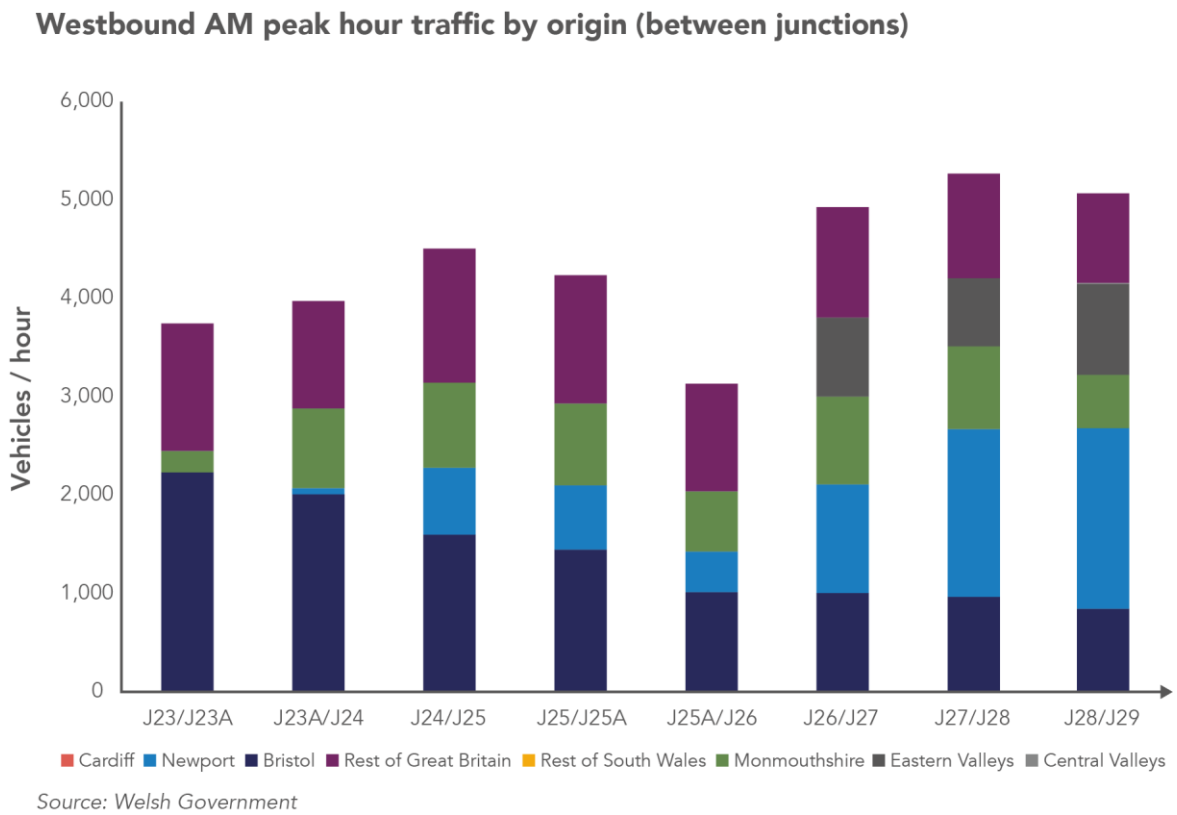


Figure 1.9B: Typical morning summary origin and destinations (westbound origin)

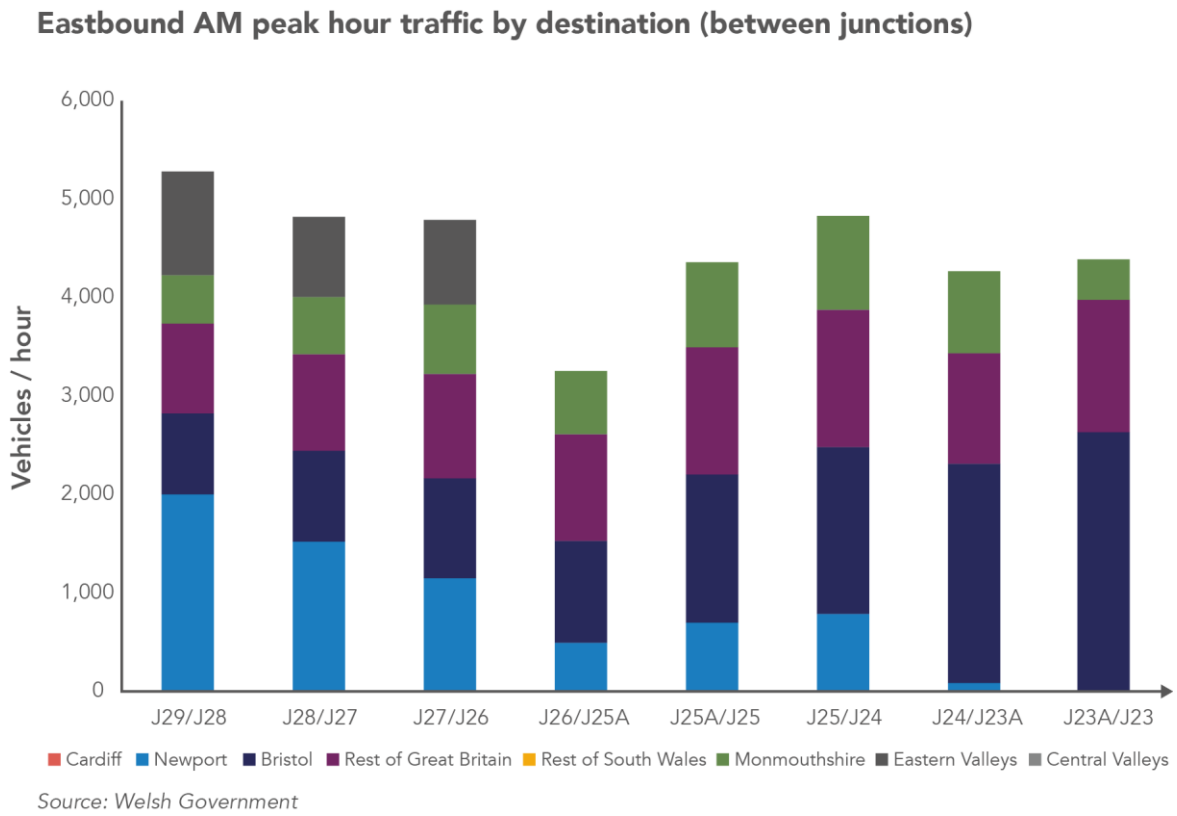


Figure 1.9C: Typical morning summary origin and destinations (eastbound destination)

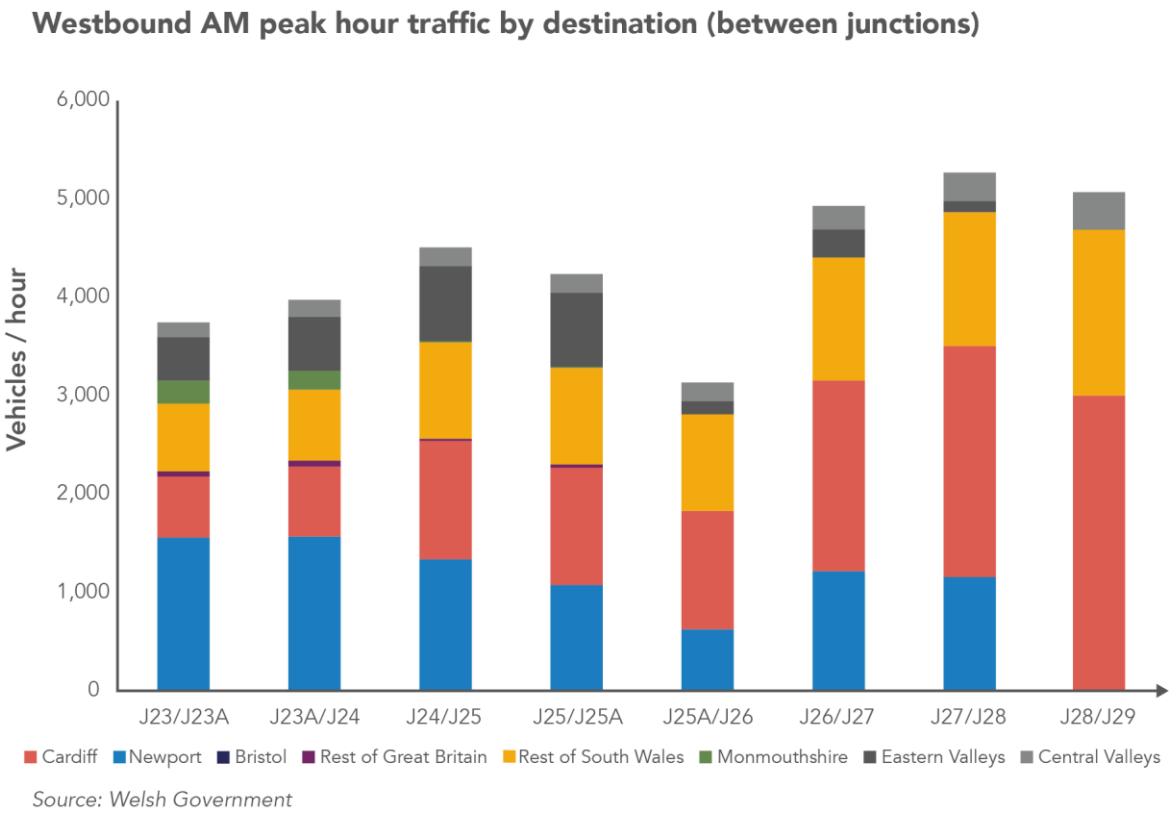


Figure 1.9D: Typical morning summary origin and destinations (westbound destination)

Ranking	AADT	From	To
1	9,400	Cardiff	West Newport
2	8,800	West Newport	Cardiff
3	6,300	Greater Bristol	East Newport
4	6,100	East Newport	Greater Bristol
5	5,500	West Newport	West Newport
6	5,500	West Newport	Greater Bristol
7	5,400	Greater Bristol	West Newport
8	5,000	Cardiff	East Newport
9	4,600	Monmouthshire	Cardiff
10	4,400	East Newport	Cardiff

Source: Welsh Government. AADT (Annual Average Daily Traffic)

Figure 1.10: Table of top 10 origin-destination pairs with the Annual Average Daily Traffic flow

Causes of congestion on the M4

1.40. In Our Approach (October 2019), we said we intended to consider the root causes of congestion on the M4 in South East Wales. In broad terms, there are three causes: the nature of the road, incidents and the sheer volume of traffic. Each is discussed in turn below.

Nature of the road

1.41. The nature of the physical infrastructure is key to the speed at which different levels of traffic can flow. Infrastructure contributes especially to congestion in the case of the M4 in South East Wales as the evidence suggests we are close to the practical operating capacity of the motorway. In an effort to provide regular, high volume, fast-moving traffic, most motorways have at least three lanes, a hard shoulder and limited curvature and elevation. While the M4 in South East Wales exhibits some of these features some of the time, there are notable departures, in particular:

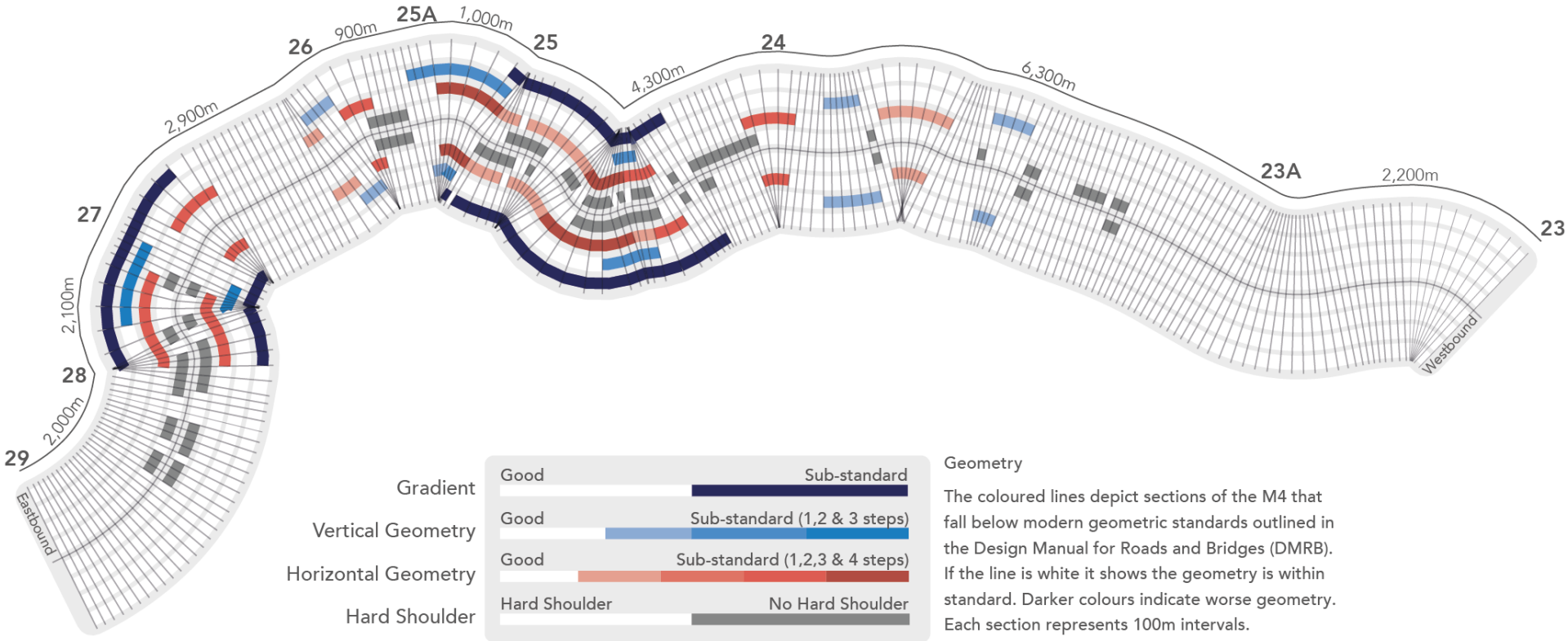
- **Lane reduction**. On many occasions, one of the three lanes is a dedicated off-slip in advance of a Junction. This in effect reduces the motorway to a dual carriageway for through traffic. This can cause bottlenecks similar to the Brynglas tunnels and contribute to poor lane discipline

- **Bends and slopes**. Between Junctions 24 and 27 especially, the curvature and gradient of the road are significantly greater than the standards set for a national speed limit motorway. For many sections, the standards suggest the speed limit should be 50mph or lower

- **Hard shoulders** are intermittent. The worst affected area is between Junction 23A and Junction 28 (in both directions), due to the number of structures which constrain the highway corridor. This has significant implications for the impact of incidents

- **Frequent Junctions,** resulting in many weaving movements with vehicles accelerating, decelerating and changing lanes over relatively short distances

1.42. Figure 1.11 shows that taken together, these elements are particularly evident either side of the Brynglas tunnels between Junctions 28 and 26, and Junctions 24 and 25. In comparison, there is relatively good motorway either side of our main area of focus - west of Junction 29 and east of Junction 23.



Source: Topographical Survey (Arup) and DMRB (Design Manual for Roads and Bridges contains information about current standards related to the design, assessment and operation of motorway and all-purpose trunk roads in the United Kingdom).

Figure 1.11: Summary of departures from standards along the M4 in South East Wales

Incidents

1.43. Research has shown that a significant amount of congestion on the UK motorway network is associated with causes other than traffic volume; incidents and roadworks in particular.[5] Across the UK, around 25% of congestion involves an incident and 10% involves roadworks. An incident is defined as any unplanned event, including but not limited to accidents. Figure 1.12 categorises incident types and disruption periods for the stretch of the M4 we are focussed on for 2019. Roadworks and breakdowns account for the majority of incidents

		Disruption Duration				
Incident Type	Number of Incidents	No disruption	Less than 15 mins	Up to 1 hour	Up to 2 hours	More than 3 hours
Roadworks/Repairs	407	30%	22%	7%	6%	36%
Breakdown	363	56%	25%	15%	4%	0%
Collision	172	24%	30%	31%	10%	5%
Debris/Obstruction	100	31%	58%	9%	1%	1%
Stationary Vehicle	38	47%	34%	16%	0%	3%
Other*	25	48%	28%	12%	4%	8%
Weather	18	28%	33%	17%	11%	12%
Total	1,123	39%	28%	14%	5%	15%

Source: Incidents recorded by the Welsh Government Traffic Officers (WGTO) during the period 1st Jan 2019 - 31st Dec 2019. Other This category includes animals, pedestrians, police instruction, spillages and fire incidents.*

Figure 1.12: Incidents and disruption time in 2019 between J23 to J29

1.44. Welsh Government Traffic Officers respond to an average of over 250 incidents per week in South Wales, many of which are on the M4 between Junctions 23 and 29. Vehicle breakdowns are the single most common type of unplanned incidents and these have a particular knock-on effect where there is no hard shoulder.

1.45. In general, roadworks for planned maintenance are limited to off-peak periods, avoiding a significant impact on congestion. However, a significant amount of repair and maintenance of major M4 infrastructure is needed in the coming

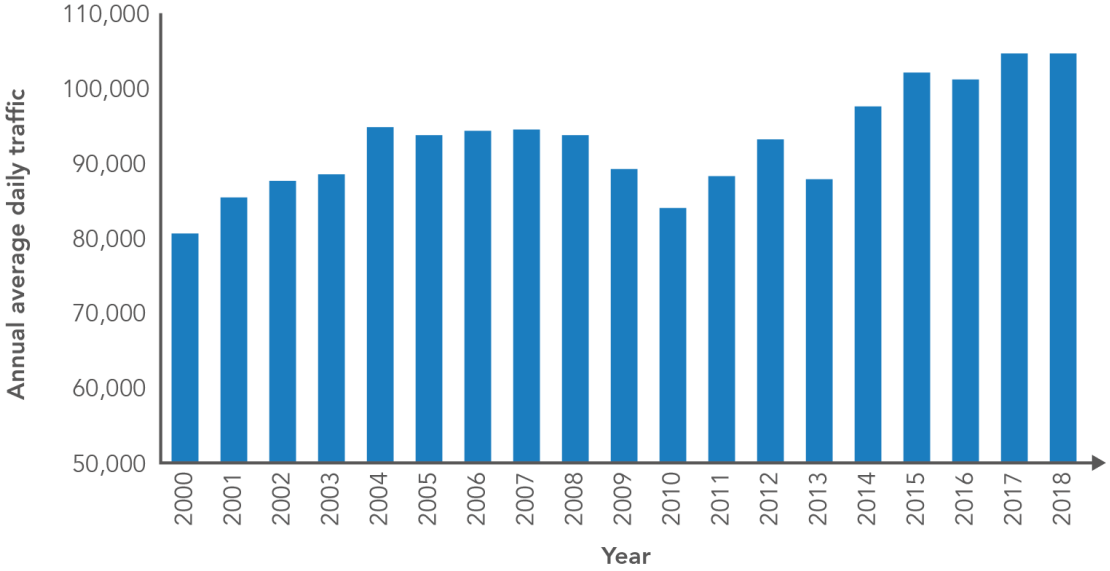
[5] Source: Transport Research Laboratory and Highways England, TRL News, 2005

years. This is likely to require significant traffic management and potential lane closures.

Traffic volume

1.46. The single biggest cause of congestion on the M4, by some margin, is the sheer traffic volume at particular times of day. This, in and of itself, has further underlying causes. Some of these causes are described in this report in Part 4: Transport Movements in South East Wales, which seeks to understand the types of journeys made on the M4.

1.47. Traffic data shows that the level of traffic on the M4 has increased significantly over time. Figure 1.13 shows how traffic has increased since 2000. This is consistent with the general UK growth in motorway travel. On the M4 specifically, the removal of the tolls at the Prince of Wales Bridge in December 2018 has also contributed to higher traffic volumes, especially on the far eastern stretch of M4 in Wales – there was an increase in traffic of 11% in 2019.[6]

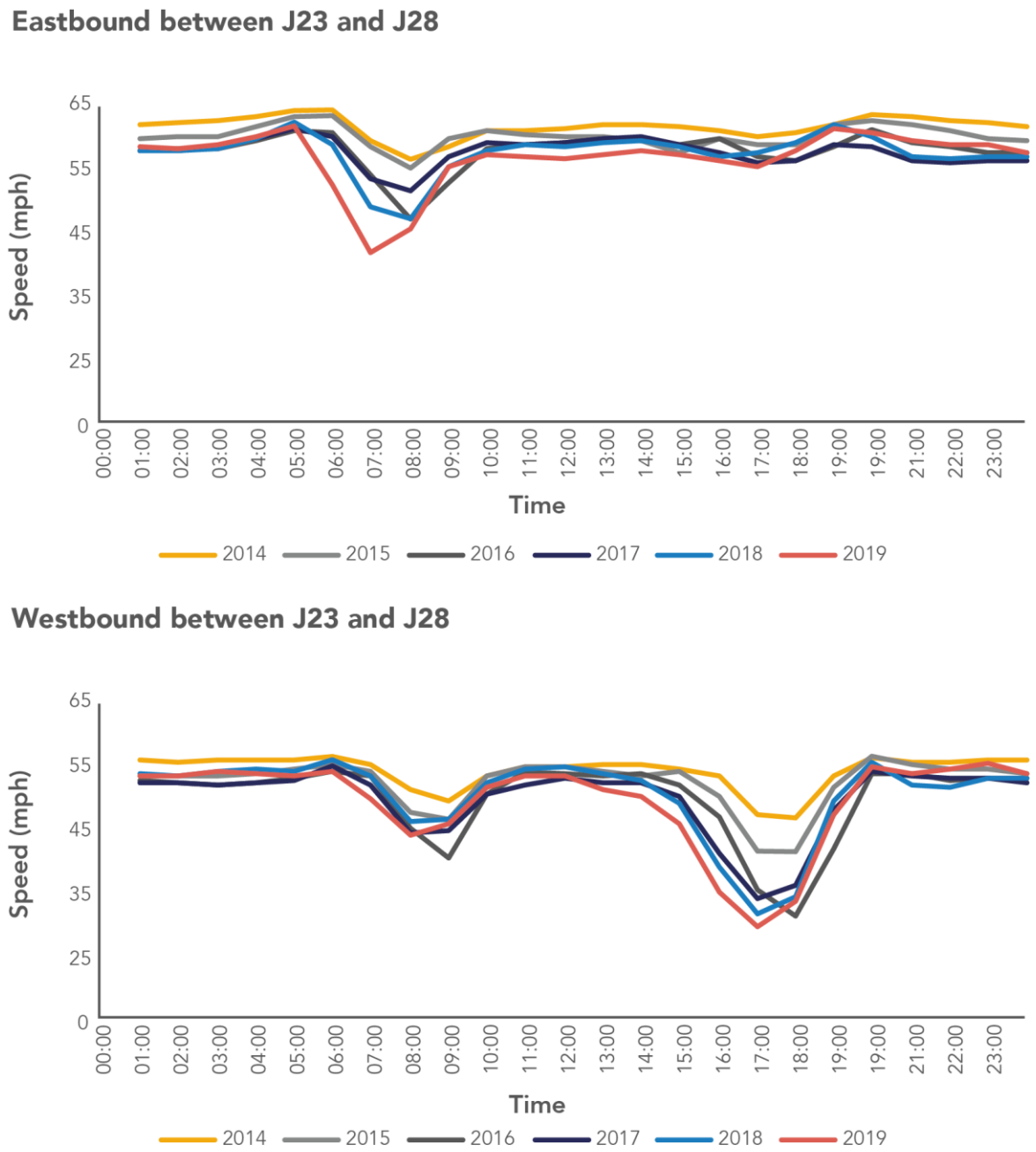


Source: Department for Transport

Figure 1.13: Traffic volumes (Annual Average Daily Traffic Flow) on the M4 over time since 2000

[6] Source: Traffic Wales

1.48. Figure 1.14 shows how average speeds have decreased over the last six years. We can see that the morning and afternoon troughs have increased in duration, starting earlier in the day. The effect of increased traffic in 2019 is clearly seen on the eastbound morning and westbound evening speeds. In addition, westbound speeds have decreased more than eastbound speeds over time. This deterioration is most pronounced in the eastern parts of the road, reflecting greater travel between Wales and England, especially between Newport and Bristol.



Source: INRIX, Welsh Government

Figure 1.14: Average speeds going eastbound and westbound over the last six years (2014-2019)

Road resilience

1.49. These causes of congestion contribute to and demonstrate the lack of resilience on the road. In other words, when one thing happens, there are a series of disproportionate knock-on impacts. This gives a sense of future problems should the volume of traffic attempting to use the road increase, something which many forecasts predict.

1.50. There are many different ways to measure the operating capacity of roads (the number of vehicles which can pass along a stretch in a given period of time). However, many of these are not appropriate for the M4 in South East Wales as there are so many deviations from standard motorway design. As such, the question of capacity is best explored by the relationship between the speed of traffic and the level of flow.

1.51. 'Speed flow' curves provide a relationship between traffic flow and vehicle speeds. Figure 1.15 below shows a generalised speed flow curve. The curve is split into two distinct parts: the free flow section and the congested section. The free flow section is a horizontal line, which shows that the vehicles travel at an average free flow speed up to an optimum flow. With flows beyond this value, the curve switches to a parabolic curve. In this part, as the flow increases, the speed decreases up to a maximum flow. At this turning point, as more vehicles are added to the network they are forced to queue, meaning that flow actually decreases due to the fall in speeds.

1.52. There is clear evidence of persistent 'flow breakdown' at some of the more problematic M4 Junction links; in particular, on the westbound approach to the Brynglas tunnels. Figure 1.16 demonstrates that in conditions where flows are less than 3,500 vph (vehicles per hour), a consistent speed of around 60 mph is normally maintained. As flow passes 3,500 vph, the average speed begins to drop significantly. Flows over 4,000 vph generate flow breakdowns which significantly impact both speed and flow. Speeds drop to around 20 mph and flow drops to around 3,500 vph as the congestion cannot process traffic at the 'normal' rate, compounding the impact on average speed.

1.53. This suggests that, based on the current infrastructure, there is a maximum number of vehicles which can travel along the stretch of motorway in an hour, regardless of the speed at which they travel. This means it is unlikely to be possible for a significantly greater number of vehicles per hour to travel on those stretches of road. Indeed, further loading is likely to disproportionately increase congestion, as even a small amount of additional traffic volume can lead to a disproportionate decrease in average speed and journey time reliability.

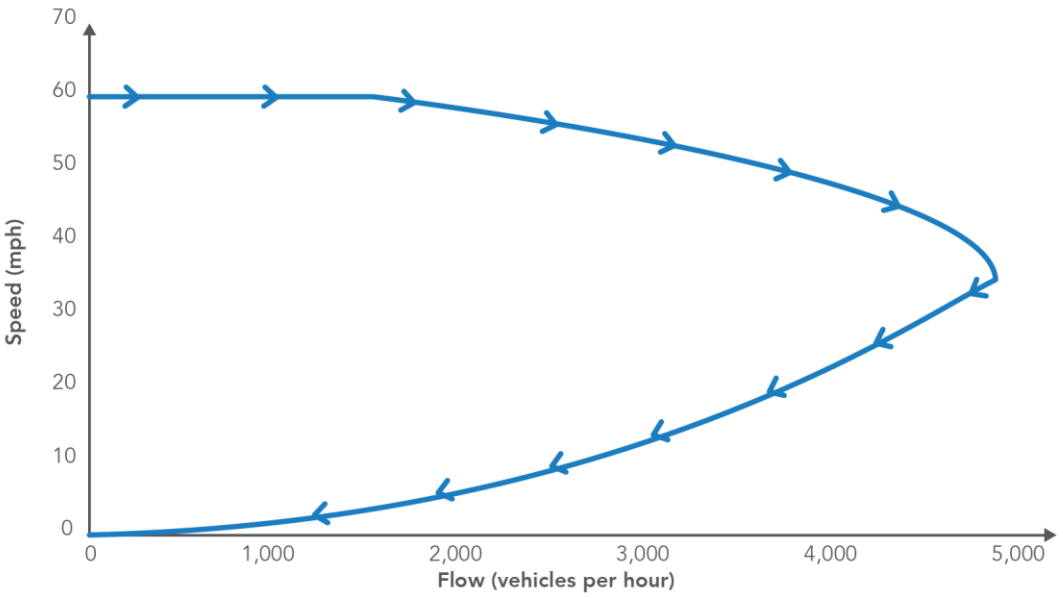
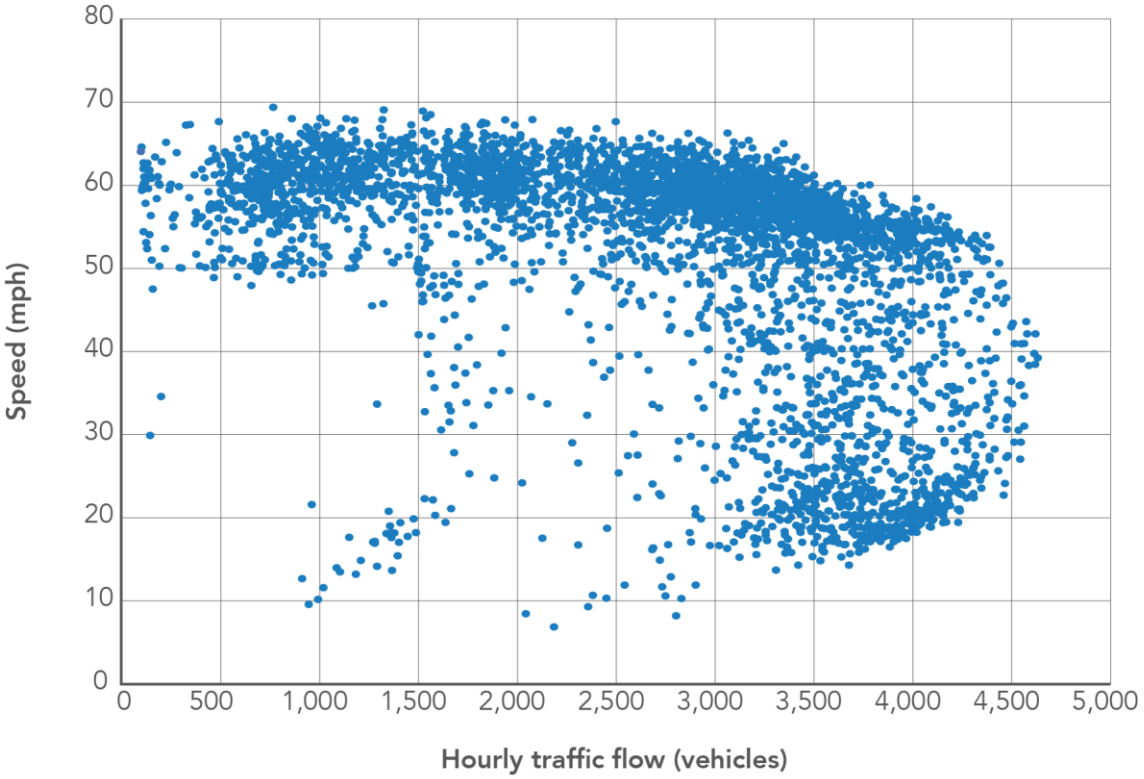


Figure 1.15: Illustrative speed flow curve showing the relationship between speed and traffic flow



Source: Traffic Wales

Figure 1.16: Relationship between speed and flow for the Brynglas tunnels westbound approach (Junctions 24 to 25)

Fast-track recommendations

1.54. The analysis presented in this part is highly pertinent to the three 'fast-track' recommendations presented In *Progress Update (December 2019):*

- **Introduce an average speed control of 50mph** in place of the current variable speed limit from around Junction 24 (Coldra) and up to Junction 28 (Tredegar Park)
- **Provide additional lane guidance** on the westbound approach to the Brynglas tunnels and use physical interventions to prevent late lane changes
- **Enhance traffic officer support** by formalising response time targets and extending the range of patrolling to also cover the A48 and A4810 in Newport

1.55. The purpose of the recommendations was to partially mitigate the effects of a large number of joiners and leavers at closely-sited Junctions, the nature of the M4 infrastructure, and the motorway's susceptibility to incidents. All of these contribute to the conclusion that the motorway is operating close to its practical capacity. The recommendations are consistent with the analysis presented in this document.

Wider road network

1.56. The M4 in South East Wales is highly connected to the wider road network via the large number of Junctions. Given the volume of regional commuter traffic on the motorway, these roads are the key entry and exit points for most users of the motorway. In general, these roads are not alternatives to the motorway because they are mostly not orientated in an east-west trajectory, reflecting the topography of the region.

1.57. The wider network also suffers from significant traffic volumes and congestion. Many of these roads have direct access to the motorway. In particular:

- A470 at Junction 32
- A4051 at Junction 26
- A4042 at Junction 25A
- A449 at Junction 24
- M48 at Junction 23

1.58. There has been an increase in congestion along many of these roads over the past five years. For example, the annual average daily traffic on the A4042 near

Newport (in both directions) increased from 22,000 in 2014 to 26,000 in 2019; an 18% increase over five years. While the M4 carries more traffic than these roads, the rate of growth on the wider network has generally been higher than that of the M4.

1.59. There are significant congestion hotspots. These tend to focus on the roads going into the cities of Cardiff and Newport and the major roads within those cities.

1.60. This analysis demonstrates the potential problems which would be caused by shifting traffic off the M4 and onto the wider road network. It cannot be considered a sustainable alternative given the degree of congestion on these roads. This is particularly relevant for the A48 and A4810 which run to the south of Newport.[7]

1.61. Local traffic generally uses local roads, and traffic completing medium and long distance journeys generally uses the M4. However, as use of the road network grows, we expect there to be greater interaction between the two types of road as drivers search for the most optimal route. This demonstrates a broader lack of resilience in the wider road network. These movements are further explained within Part 4: Transport Movements in South East Wales.

[7] Source: INRIX, Welsh Government

2. STUDY AREA CONTEXT

Trends in South East Wales

Population

2.1 The population of South East Wales (Cardiff, Newport, Monmouthshire, Blaenau Gwent, Torfaen, Caerphilly, Merthyr Tydfil, Rhondda Cynon Taf and the Vale of Glamorgan) is just over 1.5 million,[8] with Cardiff and Newport local authorities comprising a third of this total.

2.2 The population of South East Wales is projected to grow over the next two decades, especially in Cardiff and Newport. Bristol is also set to grow in population. Since the early 2000s, Bristol and Cardiff have experienced steady growth rates of between 5% and 6% for each five-year period. Newport's growth rate has been slower – just over 1% in the early 2000s but has accelerated in the last five-year period with 4.5% growth.[9] In contrast, population growth has been lower in the surrounding counties of Rhondda Cynon Taff, Merthyr Tydfil, Blaenau Gwent, Vale of Glamorgan, Torfaen, Caerphilly, Bridgend and Monmouthshire.

2.3 Figures 2.1 and 2.2 demonstrate the degree of projected population growth and its focus on cities. Bristol, Cardiff and Newport will all get much larger over the next 16 years. Cardiff will see the largest growth of the three cities and is projected to grow by 25% between 2015 and 2036. Newport is projected to show the lowest growth rate of the three cities. However, it should be noted that previous population projection figures have underestimated growth in Newport.

2.4 Outside of Cardiff and Newport, it is projected that the rest of South East Wales will see a slight drop in population, meaning that a greater proportion of the total of South East Wales' population will be located within these two cities by 2036. Between 2026 and 2036, it is projected that the cities of Cardiff and Newport will comprise 38% of South East Wales' population, an increase of 4% from 2015. Figure 2.3 shows the proximity of areas of higher density populations to the M4.

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[8] Source: Experian 2016

[9] Source: ONS mid-year estimates

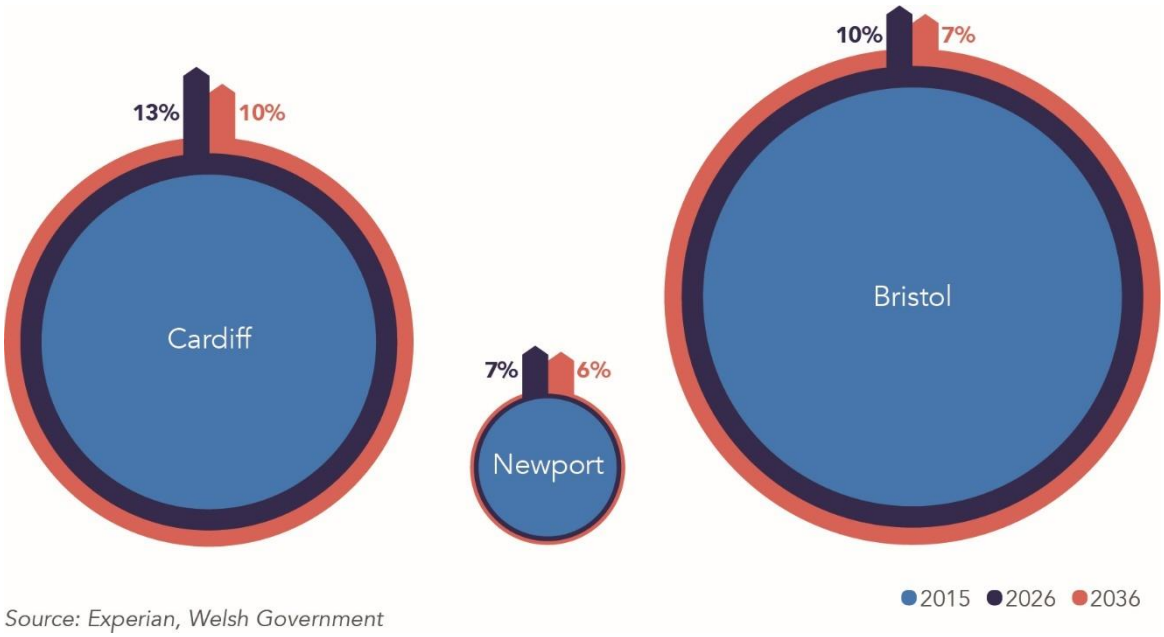

Figure 2.1: Population growth in the three cities

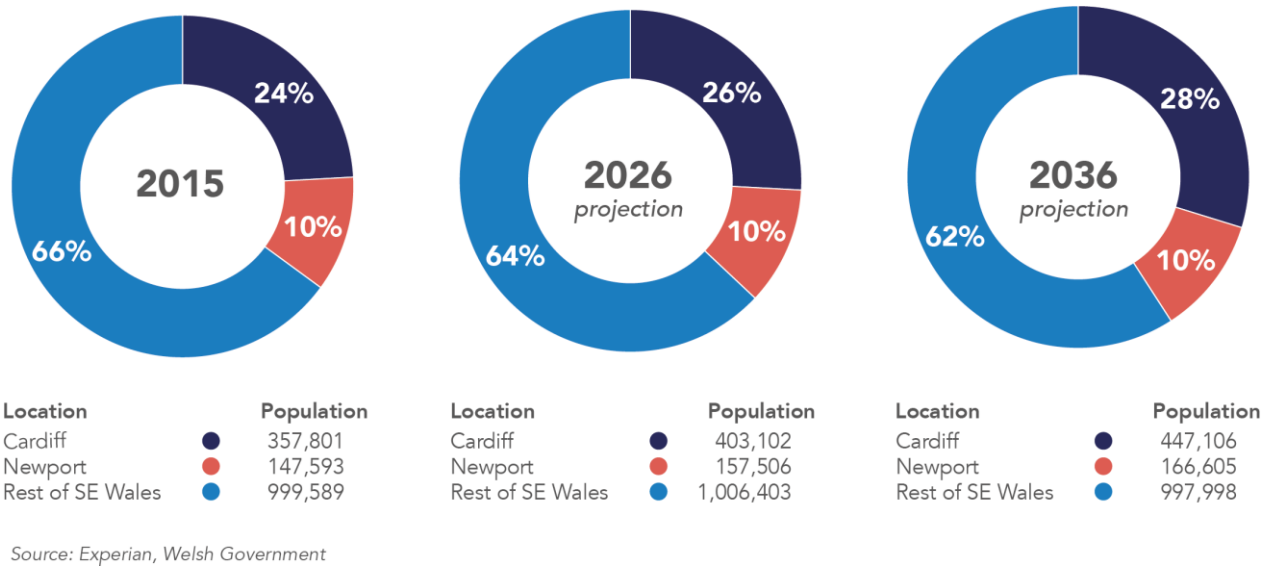

Figure 2.2: Population growth as percentage of population in South East Wales

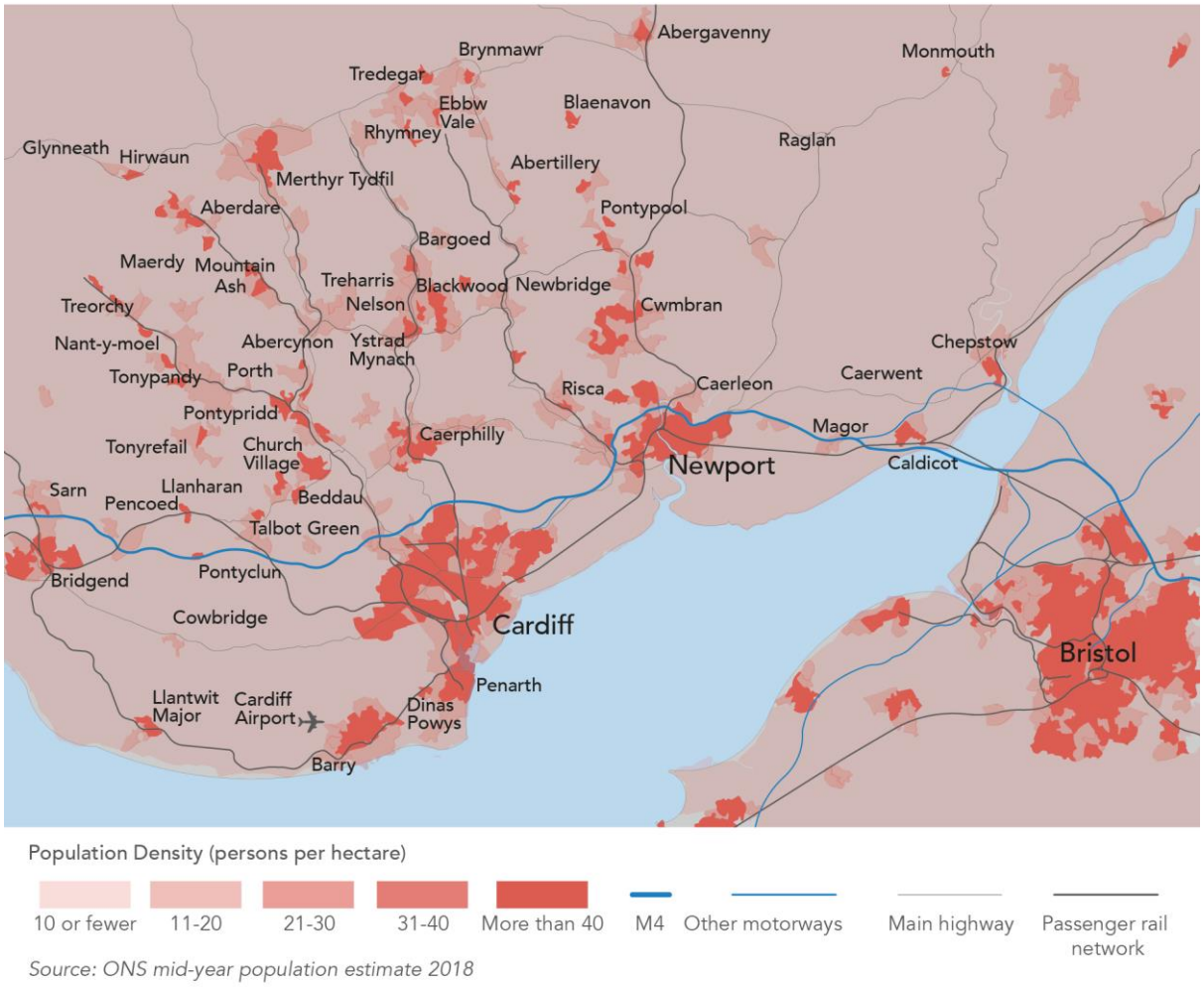

Figure 2.3: Population density across the region

Employment and jobs growth

2.5 We have identified that congestion on the M4 is related to commuter patterns. Employment trends therefore provide an indication as to where jobs growth may be and how this will affect people movements and volumes of traffic.

2.6 Putting the region into context, South East Wales dominates the Welsh economy. Cardiff alone produces 18% of the Welsh economic output (over £11.1 billion of Gross Value Added (GVA) per annum).[10]

2.7 Cardiff's labour market is by far the largest in Wales. Cardiff supports 13% of all jobs in Wales, while Newport's figure is 6%.[11] In South East Wales the number

[10] Source: ONS, 2018, Regional value added (balanced) by local authority in the UK

[11] Source: Business Register and Employment Survey 2018

of workers has increased by 19% since 2001. However, employment levels are not spread evenly throughout the region. Surrounding counties such as Rhondda Cynon Taf, Merthyr Tydfil, Torfaen and Caerphilly have unemployment levels higher than the Wales average.

2.8 Across England and Wales, employment is concentrated in cities.[12] As populations increase, we can expect more pressure on the transport system as people travel from residential areas to employment areas.

2.9 Employment density, defined as the number of employees per hectare, varies substantially across the region. The highest values are to be found in large urban areas. This is to be expected given that employment density is closely related to population density. Bristol has the highest employment density figure, which is comparable to central parts of Cardiff. Following these two cities, Newport and the Vale of Glamorgan record the next highest levels of employment density. All four areas have employment density figures significantly higher than the Welsh average. Areas to the north of Cardiff and Newport typically have employment density figures half that of Newport.

2.10 The employment density figures imply that Cardiff and Newport contain the highest density of employment opportunities, and as such attract workers either to live in these locations (indicated by the population figures) or to commute to these locations daily (as indicated by commuter flow figures). The figures in Cardiff are driven by the high number of jobs in and around the city centre. In Newport, the city centre also has the highest levels of employment density, but wider pockets of high employment density exist in several places outside the city centre. To the west of Newport, there is an area of high employment density centred around Imperial Park, and to the east of the city centre, a cluster of retail outlets contributes to a relatively high density. Both these areas have good highway links to the M4 but are served relatively poorly by public transport options; even with the South Wales Main Line running close by, there are no stations serving these two areas.

Recent trends in employment

2.11 Employment density matters as the cities are promoting themselves as employment centres via a range of policies. For example, the Central Cardiff Enterprise Zone has resulted in the provision of 52,000m^2 of new and

[12] Source: Centre for Cities 'What the geography of jobs in England and Wales tells us about the modern economy' 2016

redeveloped office space in the first three years of its operation.[13] We therefore expect an increasing proportion of the workforce will require access into city centres on a daily basis.

2.12 Current employment concentrations align with the three cities of Cardiff, Newport and Bristol. The growing service industry sector ('professional and other services' plus 'wholesale, retail, transport, hotel and food') dominates in city centres. UK-wide trends and local observations, such as the ongoing development of the Capital Quarter in Cardiff, suggest that service sector related employment in city centres will continue to grow.

2.13 The service sector across South East Wales, South West Wales and Bristol City combined employs 26% of the workforce, slightly less than UK average which stands at 33%.[14] Construction and production industries have been declining across South East Wales, in terms of their share of employment, especially in areas previously renowned for their coal mining and heavy industries. The decline of these industries coupled with the projected growth in service sector employment is likely to lead to more commuting from surrounding counties into cities such as Cardiff, Newport and Bristol with some of these journeys including the M4 corridor.

2.14 The story of the growing service sector is not all currently city-centre based. There are a significant amount of employment sites, including those in the service sector, located in 'out of town' locations, such as business parks in West Newport and North Cardiff. These areas are well located for ease of travel by cars using the M4. However, they offer a poor choice of alternative transport modes. Furthermore, services growth is also seen in well-connected towns such as Pontypridd and Cwmbran, although at a lesser scale than the cities.

Deprivation and access to public services

2.15 We have considered the relationship between access to transport and deprivation.

2.16 The region has considerable deprivation which varies within and across different local authority areas. At least half of residents of Rhondda Cynon Taf, Merthyr Tydfil, Caerphilly, Blaenau Gwent, Torfaen, Bristol, and Newport live in the two most deprived quintiles. Areas with higher levels of deprivation

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[13] Source: Business Wales: 'About Central Cardiff Enterprise Zone'

[14] Source: ONS, 2018, Annual Population Survey & Business Register Employment Survey (BRES)

normally have a greater proportion of non-car households.[15] Some of these areas of deprivation are also in areas with poor public transport links – for example there are no rail stations in East Cardiff or East Newport. This is described further in Part 3: Alternative Transport Options.

Cars and driving

2.17 Although the number of licensed cars has increased between 2013 and 2018, a significant proportion of households within South East Wales do not have access to a car, with many areas slightly above the Wales average of 22%.[16] Non-car households range from 15% in Monmouthshire to 27% in Newport.

2.18 Low car ownership can be due to good public transport – especially in cities. However, low car ownership levels combined with poor public transport services means that certain groups of people cannot access the growing jobs opportunities that are likely to be concentrated in cities. A lack of transport options will lead to sections of society locked out of a range of employment and other opportunities

2.19 There were almost 650,000 cars registered in South East Wales in 2018.[17] The number of cars is expected to continue to rise and the proportion of overall traffic in congested conditions is forecast to increase from 7% to between 8% and 16% by 2050. A continued reliance on car usage nationally and across South East Wales is likely to place even further strain on the current road network. In this context, it is worth noting that Newport has reported a 14% increase in car licences between 2013 and 2018, double the Wales average and higher than the England average (9%).

Land use developments

2.20 Specific commuting patterns have been identified as key causes of congestion on the M4. The topography of South East Wales and the industrial legacy shapes the pattern of development we observe today. Along the M4 corridor more land is being made available for development via allocations in Local Development Plans, especially around Cardiff and Newport.

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[15] Source: Welsh Index of Multiple Deprivation, 2019; English Indices of Multiple Deprivation 2019; Department for Transport, National Trip End Model,2015

[16] Source: Department for Transport, National Trip End Model, 2015

[17] Source: Department for Transport, Vehicle Licensing Statistics: 2018

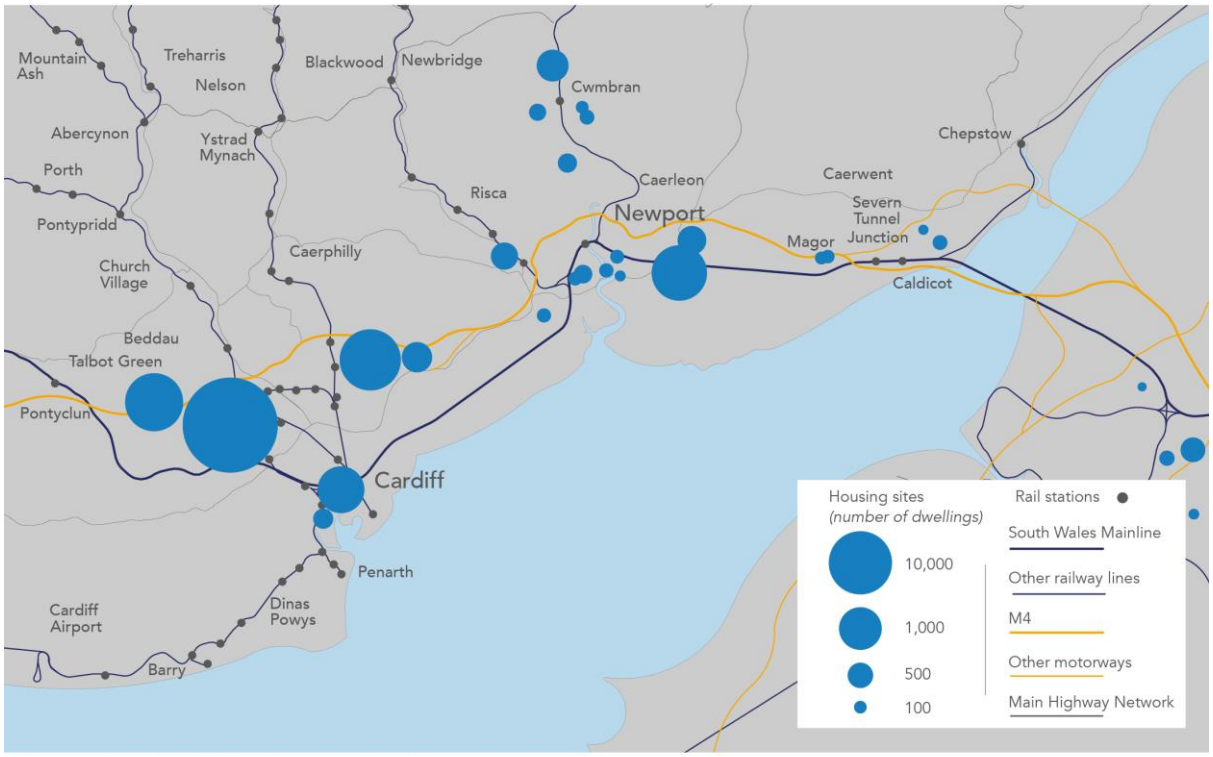
Future development patterns

2.21 Wales has an emerging hierarchy of national, regional and local plans, which set out spatial strategy and allocation of sites for developments at a local level. The bulk of development is expected to be in Cardiff and Newport.

2.22 Both Cardiff and Newport are planning for physical and economic growth. Cardiff's adopted Local Development Plan (2006 – 2026) plans for 41,000 dwellings and 40,000 new jobs. Newport's Local Development Plan (2011 – 2026) plans for 10,000 dwellings and an additional 7,400 jobs.

2.23 Given that Cardiff is projected to grow by one fifth over the next 20 years, it is unsurprising that there are a number of large residential allocations in Cardiff where building works have commenced in recent years. These are generally located in an arc across the northern fringes of Cardiff and at Llanwern, in the east of Newport. These locations are generally away from good public transport services, although some public transport improvements are planned for the sites being developed. On the whole, these sites are relatively close to the M4 and on the edges of built-up areas (Llanwern is an exception). The spatial distribution of planned major developments aligns with the top 10 origins and destinations for M4 journeys (see Figure 1.10 within Part 1: the M4 in South East Wales).

2.24 Figure 2.4 shows the locations for prospective housing developments, many of which are close to the M4 but not within proximity of existing railway stations either on the South Wales Main Line or any branch lines. The developments will be significant trip generators and travel is very likely to involve the motorway. These are considered reasonably foreseeable developments which includes sites that have already received outline planning permission at least.



Source: South East Wales Transport Commission

Figure 2.4: Prospective major developments in region

Housing market

2.25 House prices and the value of land determine where developers build and where people live.

2.26 Bristol has shown increasing housing prices and decreasing affordability. Its house prices are above average for a non-London UK city with a high housing cost to income ratio.[18] Cardiff house prices have risen relatively slowly but have become less affordable since 2017. Its house prices are roughly aligned with the average non-London UK city. Newport demonstrates stable house prices and affordability. It has below average housing costs and a lower housing cost to income ratio, meaning houses are more affordable for residents.

2.27 A high proportion of workers are priced out of adequate or desirable housing in Bristol, and to a lesser extent, Cardiff. However, these are the places with the highest number of employment opportunities. Unless housing within cities becomes more affordable, workers will continue to commute from more

[18] Source: Centre for Cities

affordable areas, and continue to put pressure on the existing transport infrastructure.

2.28 Furthermore, our analysis of M4 journeys suggests greater commuter movements towards Bristol in the morning from origins east of Newport, rather than in the other direction. House prices are less on average in South East Wales than in Bristol. The removal of the Prince of Wales Bridge tolls at the end of 2018 has made living in South East Wales and commuting into Bristol an even more attractive option, potentially exacerbating this commuter flow.

3. ALTERNATIVE TRANSPORT OPTIONS

3.1 Transport operates as a system and so it is important to understand the issues on the M4 in the context of the rest of the transport system in South East Wales. Decisions regarding how, when and why people travel are influenced by numerous factors. This part of our analysis:

- describes alternatives to using the M4 – rail, bus and active travel
- compares commonly taken M4 journeys to different modes
- reflects on the overall integration of the transport network

Rail

3.2 As a result of Wales' industrial legacy, South East Wales has a relatively dense network of existing and former railway lines, many of which would have been originally used to transport coal. Where lines remain today they provide passenger services as well as some freight movements. In other locations the track-bed has been converted to roads or paths.

Rail network

3.3 In South East Wales, the South Wales Main Line provides long distance services to the west (Swansea and beyond), east (Bristol, London and the south coast of England) and through to the Midlands and North of the UK via the Marches Line (which branches off at Newport) and Gloucester Line (which branches off at Severn Tunnel Junction).

3.4 All other railway lines in South East Wales are classed as the 'Valleys lines' providing local services in and out of Cardiff from the counties of Rhondda Cynon Taff, Caerphilly, Bridgend and Merthyr Tydfil to the north and along the coast in the Vale of Glamorgan.

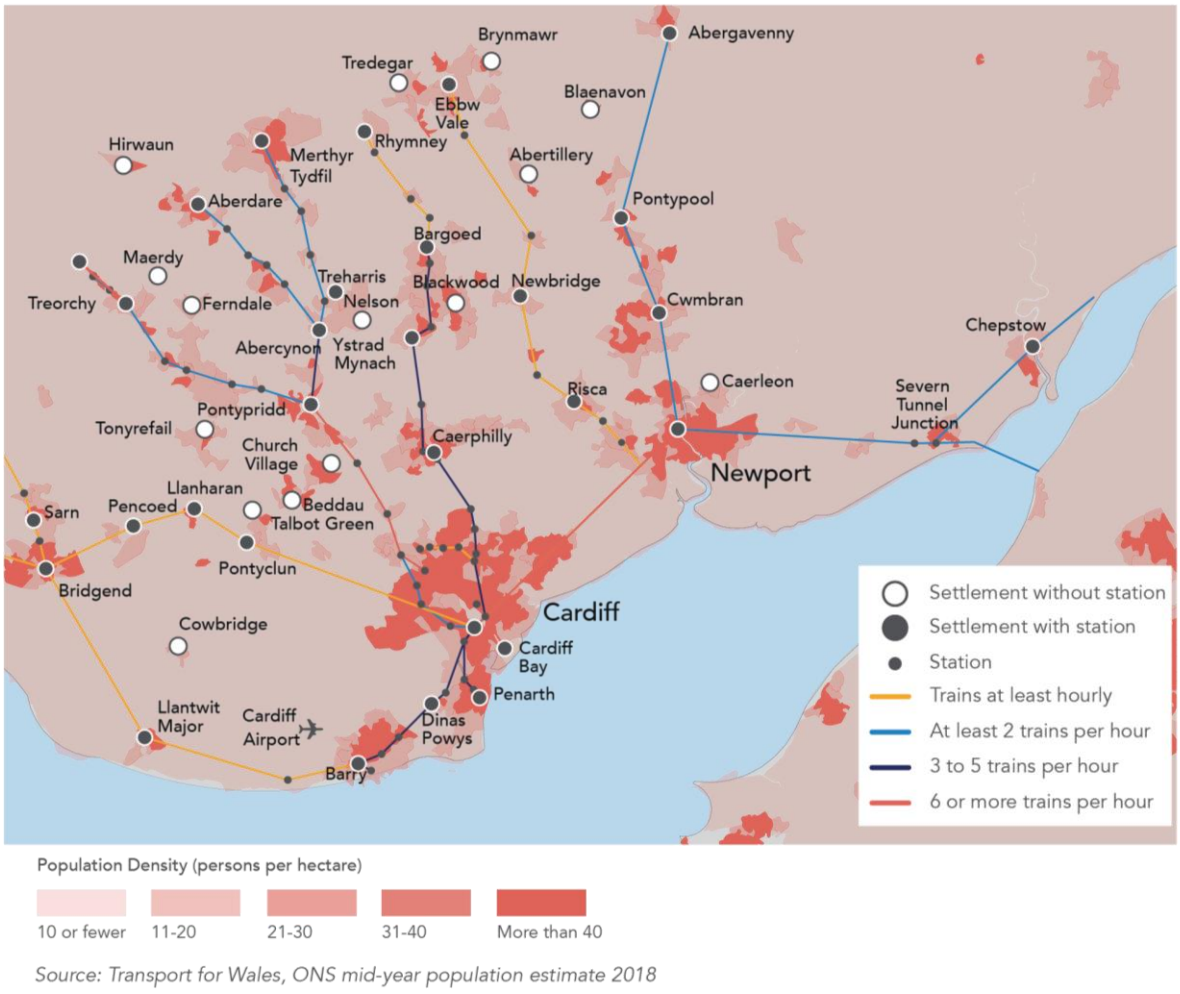
3.5 Consequently, there are a relatively high number of north-south services between Cardiff and villages and towns to the north and south, and between Bristol and the major settlements running west along the South Wales Coast.

3.6 However, this does not provide for the full range of people movements we observe. There is a lack of train services at the frequencies required for people travelling from smaller settlements and suburban areas of cities west to east through Wales and into the West of England. The rail network is based on a pattern of development implemented prior to the Second World War, and many post-war developments are not served by rail services, such as eastern and north-eastern parts of Cardiff and suburban areas of Newport.

3.7 While there is often a dense network of 'rails on the ground', many train services do not run at a sufficient frequency to act as a competitive alternative to car travel. Moreover, there are significant parts of the region with no rail service, often with high population densities. This can be seen in figures 3.1 and 3.2. For example, the railway line from Cardiff Central to Merthyr Tydfil is approximately 20 miles long and includes 14 stations. A similar distance from Cardiff Central to Bristol Parkway includes only six stations, three of these being on the English side of the Severn. Newport is particularly poorly served by rail, even after the re-opening of the Ebbw Vale branch in 2015.

Source: Transport for Wales

Figure 3.1: The rail network in South East Wales



Source: Transport for Wales, ONS mid-year population estimate 2018

Figure 3.2: Rail frequencies and population density

Rail patronage

3.8 Rail passenger numbers have increased year on year over the last twenty years, similar to other parts of the UK. Passenger numbers are highest on journeys between the largest cities; between Cardiff and Newport, Newport and Bristol, and Bristol and Cardiff. The next highest passenger figures recorded is on the Ebbw Vale line from Cardiff to Pye Corner, in West Newport.

Rail capacity

3.9 For the intercity services between Cardiff and Bristol, trains are over their seated capacity at peak times on a weekday morning. Conversely, the intercity services between Cardiff and Newport are under their seated capacity, even at peak times on a weekday morning or afternoon. This is due to the higher frequency of trains between Cardiff and Newport.

3.10 We note there is significant crowding on a number of key commuter services within the region, including:

- **Cardiff – Pye Corner – Ebbw Vale**. These services are crowded, with currently only one train per hour. Seated capacity at peak times in the afternoon for trains leaving Cardiff can be as high as 190%. We note that Ebbw Vale Town Station has recorded usage far higher than the projections prior to opening in 2015

- **Cardiff – Newport – Bristol Temple Meads**. There are only two trains per hour to and from Bristol Temple Meads. The four busiest routes on the South Wales Main Line are on this service. From Cardiff to Bristol Temple Meads, seated capacity at the peak times in the morning is as high as 172%. Although the current cascading of rolling stock is freeing up higher capacity services on this route

3.11 The degree of crowding suggests that there are more people who would like to use rail than are currently able. This is reinforced by the fact that car parks at key stations are often full in the morning peak period.

Governance

3.12 In late 2018, a new operating mechanism began in the Wales and Borders area. Branded as Transport for Wales (TfW), the service is run by KeolisAmey and took over from all previous services run by Arriva. Throughout this franchise period, it is expected that infrastructure developments such as electrification, new rolling stock and new stations will take place. There are also increases in service frequencies planned. Great Western Railway (GWR) operates high-speed services to London from South Wales, largely utilising overhead electric power from Cardiff to London. These trains stop at Bristol Parkway, and other services run by GWR go to Bristol Temple Meads.

3.13 We note and welcome the significant investment and development underway on the Cardiff and Valleys Lines. However, we do not expect this will greatly change the nature of the congestion problem on the M4.

3.14 Rail has the potential to move a significant number of people efficiently. However, rail is inherently inflexible due to its structure and less able to respond swiftly to changes in travel behaviour. Nevertheless, beyond the Cardiff and Valley Lines, investment in rail does not appear to have kept pace with potential demand.

Bus

3.15 Bus services in Wales are provided on a largely commercial basis with some revenue support for loss-making services, mainly in rural areas. The context is similar to that of England but with some regulatory differences.

3.16 In South East Wales, there are also two municipal operators, Cardiff Bus and Newport Transport, owned and managed by the respective local authorities. Private sector operators in the region include Stagecoach South Wales, First Cymru, New Adventure Travel (trading as NAT group) and Phil Anslow Travel.

Local bus network

3.17 A large number of local bus services are provided within Newport and Cardiff. The current bus network serves city centres, but often does not directly connect suburban housing to out of town employment areas. Travelling across cities can be difficult due to the legacy networks of radial routes – most routes within Cardiff and Newport travel into the city centre, with users often required to change buses, and possibly pay additional fares, to travel onwards. For example, in Newport there are no direct services travelling laterally from residential areas in East Newport to Celtic Springs Business Park in West Newport.

3.18 The lack of orbital bus routes – routes which circle the city centre – in Cardiff and Newport means that even short distances can prove problematic by bus. For example, travelling from residential areas of North East Cardiff to Cardiff Gate Business Park, also to the north of Cardiff, can only be achieved by travelling into the city centre first. In a similar way, travelling from residential areas in West Newport to the Imperial Park or Celtic Spring Business Park in West Newport also require a detour into the city centre.

Regional bus and coach network

3.19 Bus services between Cardiff and Newport are frequent. However, the journey normally takes over 45 minutes, which is time consuming compared to the car or train.

3.20 Figure 3.3 shows the main regional bus routes in South East Wales. Bus service frequencies vary by route and across the week, with a significant drop in frequencies at weekends. Figure 3.4 shows the frequency of services on the network in the context of population density. There are large built-up areas which do not benefit from good access to rail services, in particular eastern areas of Cardiff and suburban areas of Newport for whom bus services would be attractive.

3.21 Regional bus services generally provide long distance alternatives to long distance rail journeys. There are a high number of daily scheduled coach services between Swansea, Cardiff, Newport and Bristol, but these generally have much longer travel times than rail. Services provided by companies such as National Express and Megabus accommodate the needs of the occasional traveller but are not well suited for commuters. This is in part due to the city centre to city centre pick up and drop off points.

Source: Transport for Wales and Basemap Ltd

Figure 3.3: Regional bus network

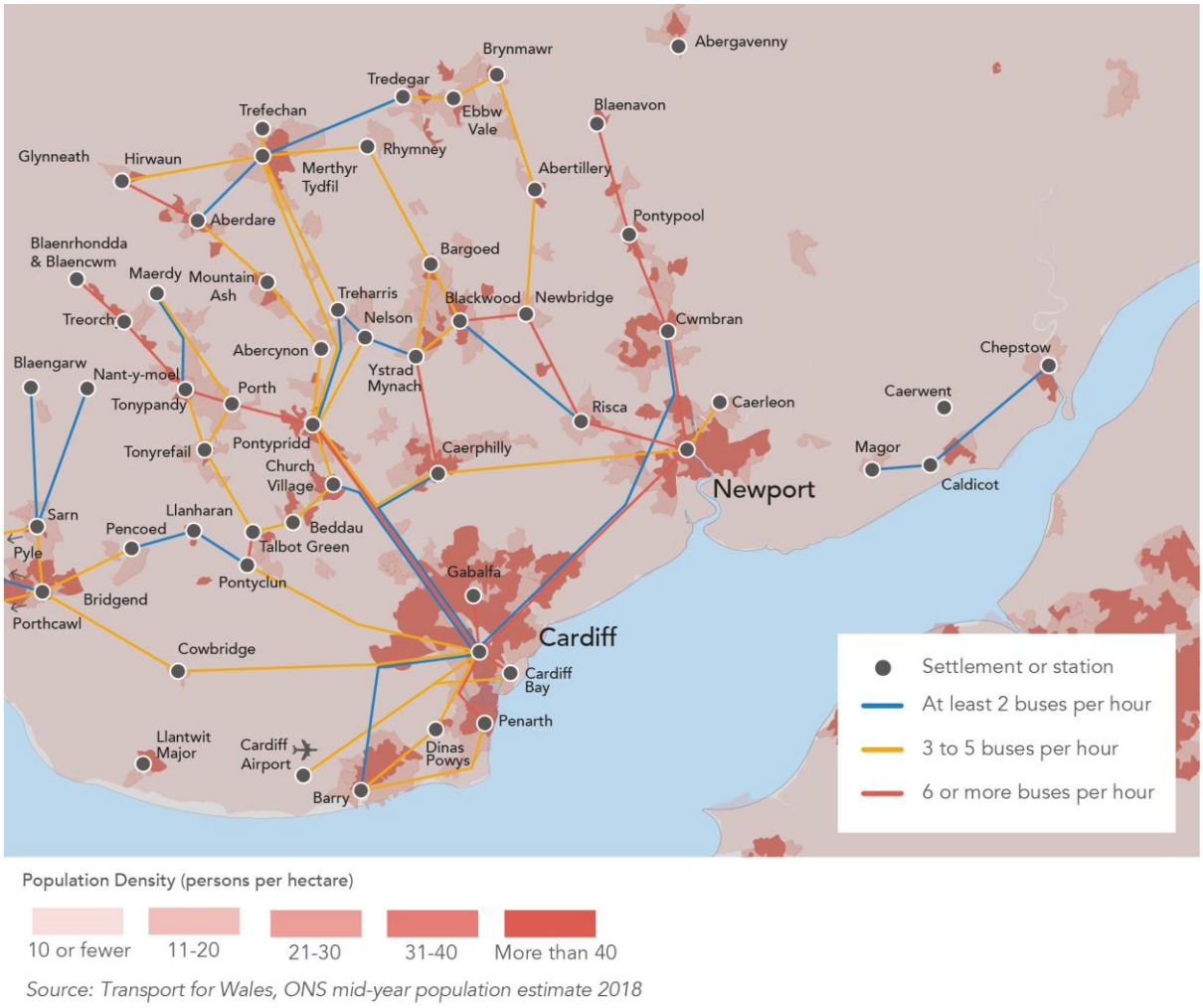


Figure 3.4: Bus service frequencies in South East Wales

Bus patronage

3.22 Although bus services may work well for some intra-city commuting, buses generally offer a poor service for commuting, especially for longer distances. As with most of the UK, demand for bus services has been falling, unlike rail use. This is despite an increased demand for travel. It is also noted the purpose of most bus trips is not commuting, more trips are made for other purposes such as shopping, leisure and education.[19]

[19] Source: National Travel Survey, Department for Transport

3.23 In South East Wales, bus use has remained stagnant. It is difficult to obtain specific data on bus passenger numbers due to commercial sensitivities. However, service providers are facing financial pressures.

Governance

3.24 Deregulation of bus services has resulted in a range of operators providing services, complicating the bus system for potential passengers in terms of the services available, frequency and ticketing options. There are some examples of bus services not coordinating with train timetables, so passengers face a lengthy wait for the next stage of their journey. We have also noted different bus companies scheduling their buses at the same time, so they are directly competing with each other, instead of complementing each other's timetables, so that a more regular service is provided.

3.25 It is notable that in London, where bus services are not deregulated, there is much higher use and demand than in most other parts of the UK. This is partially due to London's higher population density and initiatives such as road charging. However, London's through-ticketing initiative - linking high frequency bus services to local rail and underground services - does provide an easy to use, integrated public transport system for other cities to emulate.

3.26 We note that the Welsh Government's Bus Services Bill proposes new forms of bus regulation, providing local authorities with an improved range of tools to use in the planning and delivery of local bus services in their areas.

Active travel

3.27 Cycling and walking are key travel modes with important benefits in terms of decarbonising travel and improving wellbeing. We recognise it is not appropriate for long journeys, but it is important to remember that nearly every public transport trip will involve some element of active travel, usually walking. As such, it plays a critical 'first mile, last mile' role.

3.28 Local authorities have active travel maps which show the existing walking and cycle routes as well as proposed routes. The quality of active travel routes in the region varies greatly. While some are fully-segregated, hard-surfaced paths with clear cycle or walking demarcations, others are gravel paths with no demarcations or require users to share space with motorised traffic.

3.29 The most comprehensive traffic-free cycle route in the region is the Taff Trail, running north to south alongside the river. Most areas in the cities of Cardiff and Newport have very few traffic-free cycle routes. Advisory on-road routes are available but, as they avoid busy roads, they tend to be indirect and lead to longer than necessary journeys.

3.30 Cardiff Council, with support from the Welsh Government, is developing a number of traffic-free 'cycle super highways' to encourage more cycling in the city. These are expected to be implemented by 2022. There are also secondary cycle routes planned for 2027. Cardiff also benefits from an extensive and successful bike sharing scheme, Nextbike, with more than 50 stations located around the city.

3.31 In Newport, active travel routes are clustered around the city centres, along the River Usk, or along or close to the Southern Distributor Road (A48). There is no current direct route between the city centre and the Celtic Springs Business Park in the west, and routes to the east are situated alongside busy highways such as the A48. Overall, the active travel routes could be better connected and do not offer convenient direct routes between residential areas and employment areas.

3.32 Our analysis identifies that a high proportion of short journeys are made by car in Newport. This suggests the potential for significant increases in uptake of active travel if more cycle routes were available.

3.33 Between Cardiff and Newport there is no fully traffic-free cycle route. The focus for each local authority to date appears to have been to improve routes from suburban areas into city centres, rather than to provide traffic-free routes between local authority areas.

Integration of the transport network

3.34 If the public transport network is to well serve a wide range of needs, the different modes need to be considered as a single transit network. A number of elements are important, including aligned information, integrated ticketing, a coordinated timetable and seamless interchanges. This is far from the case in South East Wales.

3.35 There is a lack of alignment across the bus network as different tickets are needed for services provided by different operators. In some cases, bus operators have similar routes. Although together they may aggregate to a high frequency service, passengers will not necessarily benefit because bus operators reward loyalty, for example with discounted weekly and monthly fares.

3.36 We have found the interchange between train and bus is unintuitive and usually involves walking some distance. In Newport, the bus station is an 8-minute walk away from the rail station, and the route is not clearly signposted for anyone who arrives in Newport by train. Cardiff has been without a bus station since 2015. Buses to suburban areas of Cardiff can be caught at bus stops close to the rail station. However, the bus stops are spread over a few

different locations, so it is not clear to the occasional user or visitor where a bus departs from. At Severn Tunnel Junction Rail Station, bus connections are limited and the station is some distance from the main roads in the area and accessed via a narrow street. Furthermore, there is no facility for buses to turn around in front of the rail station building.

3.37 Station facilities vary widely across South East Wales and into Bristol. For example, both Bristol Temple Meads and Bristol Parkway have far greater bicycle storage capacity than any of the Welsh stations (over 400 spaces versus fewer than 100 at Cardiff Central).

3.38 The stations in South East Wales on the South Wales Main Line are located close to the town or city centre. Cycling to stations often requires the cyclist to navigate busy roads and Junctions, many of which currently lack traffic-free alternatives.

3.39 As the overall public transport system is disjointed in the sense that there are multiple train and bus operators. In respect of bus use especially, it is typical that tickets purchased for a service provided by one provider would not be accepted by another providing a service on the same or similar route. It is difficult for users to obtain information on travel options, especially when attempting to plan journeys across modes (bus and rail). Although the Traveline Cymru website does provide travel information across modes there is no facility to buy tickets or understand how much a journey would cost. The rail service is probably easiest to navigate as all services are listed online with live updates regarding any delays or cancellations.

Comparison of the M4 and the alternatives

3.40 We have assessed the public transport alternatives for the 'top 10' most common M4 journeys. This analysis is shown in Figure 3.5.

3.41 The table is based on journeys starting and finishing at a point roughly at the centre of each geographical area, and is therefore only a rough approximation of the 'average journey' between each origin and destination pair. It is likely to underestimate the journey time for bus and rail as it does not take account of travel required to and from a rail station or bus stop.

3.42 However, even approximate analysis clearly shows the alternatives generally perform worse than the private car in terms of journey time, and frequency.

3.43 For bus, each of the bus journeys take longer than car journeys using the M4. Most of the journeys require passengers to use more than one bus service to reach their destination and are infrequent.

3.44 For the rail alternative, some of the journey times are similar or quicker than the M4 equivalent (depending on the degree of congestion). However, the frequency of many journeys is poor.

3.45 Some of the rail journeys require passengers to use a bus for part of the journey. This accounts for the long rail journey times from Monmouthshire to Cardiff, for example. Most Monmouthshire residents would need to travel by bus to rail stations such as Chepstow or Newport before continuing their journey by rail.

3.46 The most popular origin and destination pair for M4 journeys is from Cardiff to West Newport. The rail service into Cardiff from Pye Corner in West Newport only runs hourly. For bus, the trip is over double the journey time. For journeys beginning in West Newport, passengers are unable to travel eastwards by rail from West Newport. The journey from West Newport to Bristol, involves catching a bus to Newport Central rail station. To complete the journey entirely by rail would mean a much longer journey, as passengers would first need to travel in the wrong direction to Cardiff to change trains.

3.47 Based on journey times and frequency of service alone, it is unsurprising that many travellers continue to make their journey by car rather than use current public transport options.

			Car	Bus		Rail	
Rank	From	To	M4 journey (min)	Bus journey (min)	Approx. frequency (min)	Rail journey (min)	Approx. frequency (min)
1	Cardiff	West Newport	20-30	80*	15	20	hourly
2	West Newport	Cardiff	25-55	80*	20	25	hourly
3	Greater Bristol	East Newport	35-45	85	hourly	45	30
4	East Newport	Greater Bristol	40-80	115	30	45	30
5	West Newport	West Newport	10-20	-	-	-	-
6	West Newport	Greater Bristol	40-85	135*	< hourly	70	30
7	Greater Bristol	West Newport	35-50	90*	< hourly	65	25
8	Cardiff	East Newport	30-40	70*	30	25	10
9	Monmouthshire	Cardiff	40-70	115*	50	100	40
10	East Newport	Cardiff	30-50	70*	30	30	10

** indicates interchange required*

Source: South East Wales Transport Comission calculations based on traveline.cymru and Google Maps. The approximate centre point of each sector was used to provide a rough estimate of journey times between each Origin/Destination, so journey times will differ as the start and end point is made more specific

Figure 3.5 Comparison of modal options for the top 10 M4 journeys, arriving by 9am on a typical weekday.

4. TRANSPORT MOVEMENTS IN SOUTH EAST WALES

4.1 Parts 1 and 3 of this report have described the current transport system in South East Wales, comparing the motorway with other transport options. To aid our understanding further, it is important to also analyse how people and goods are moving around the region. Studying these movements will tell us how well the current transport network is facilitating the journeys taking place. It also allows us to reflect on how those movements may change over time.

4.2 This part describes how people and goods are moving around the region. It demonstrates the role of the motorway in the regional transport context. There are important conclusions for travel within and between the three cities of Cardiff, Newport and Bristol.

4.3 Freight is given a specific discussion given the issues are quite different from the movement of passenger cars.

Analytical approach

4.4 We have used the South East Wales Transport Model to identify the patterns underpinning the main travel movements in South East Wales. Annex B describes the nature of the model in further detail. This analysis covers the M4, other roads, bus and rail. Active travel information is not available in this format.

4.5 The movements are best described by way of screenline analysis. A screenline is an imaginary line on map. The analysis measures the flow of traffic across each screenline. Screenlines allow us to estimate what travel is occurring between different parts of the region. By careful selection of screenlines, we can compile a representative picture of region-wide movements.

4.6 Figure 4.1 sets out the selected screenlines. A journey ‘counts’ if it crosses a screenline, no matter where it starts or ends.

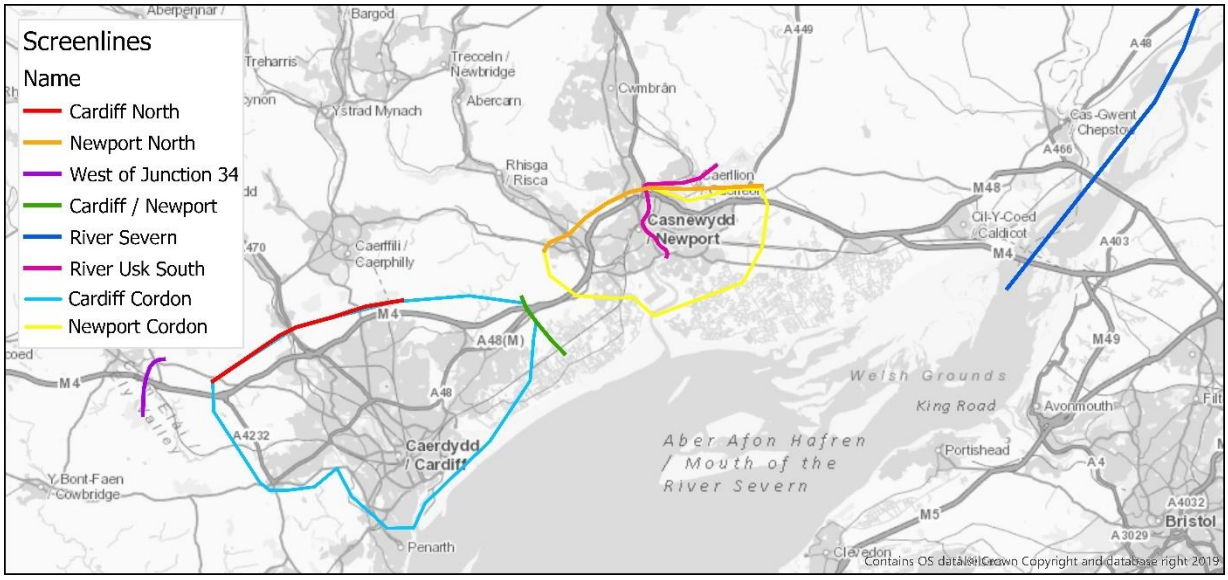


Figure 4.1: Screenlines in South East Wales

High-level findings

4.7 Figures 4.2, 4.3 and 4.4 summarise the high-level findings from this data analysis. They show estimates for the travel purpose, trip length and transport mode across each of the screenlines.

4.8 Figure 4.2 shows commuting is a very prominent travel purpose. Within the morning peak, commuting is clearly the largest journey purpose for all but one of the screenlines (River Severn). For the afternoon peak, journey purpose is more mixed, with non-business car journeys on a similar scale to commuting journeys. Again, the River Severn screenline shows a very different pattern with commuting levels far below car journeys for non-commuting and non-business reasons.

4.9 The Severn screenline also exhibits a markedly higher component of freight traffic – defined as both light goods vehicles and heavy good vehicles. Across other screenlines, journey purposes are broadly similar.

4.10 Figure 4.2 also reflects the traffic flows we see on the M4 - strong peak flows in the mornings and afternoons. On the M4, commuting generally involves 'lateral' journeys. In other words, journeys with origins and destinations to the east and west of each other. In addition, there is a significant amount of commuting into Cardiff from the north and south, and into Newport from the north. This traffic does not generally interact with the M4 but is just as large a flow of people.

4.11 Figure 4.3 shows that the majority of journeys are between 10 and 50 miles. These distances are measured 'as the crow flies'. These are medium length,

journeys that often travel across local authority boundaries. The majority of short trips are within Newport, or into and out of Newport and Cardiff. Very few of these trips involve the M4. Long journeys, defined as over 50 miles in length, are highest for the River Severn screenline.

4.12 Figure 4.4 shows that the most common transport mode, by a very large margin, is the car. This is no different from the rest of Wales and other parts of the UK. For rail, the share of travel is highest across the Severn. There is also markedly more rail travel into Cardiff than Newport, reflecting the relative provision of rail services and the location of stations. The share of travel undertaken by bus is highest in the inter-peak period, suggesting it is relatively under-used for commuting.

		AM Peak						Inter-Peak						PM Peak					
Screenline	Direction	Car - Business (%)	Car - Commute (%)	Car - Other (%)	LGV (%)	HGV (%)	TOTAL FLOW ACROSS SCREENLINE (vehicles/hour)	Car - Business (%)	Car - Commute (%)	Car - Other (%)	LGV (%)	HGV (%)	TOTAL FLOW ACROSS SCREENLINE (vehicles/hour)	Car - Business (%)	Car - Commute (%)	Car - Other (%)	LGV (%)	HGV (%)	TOTAL FLOW ACROSS SCREENLINE (vehicles/hour)
Cardiff North	NB	13	54	20	9	4	5,000	9	22	49	15	5	3,300	6	42	38	12	2	6,100
	SB	11	56	21	10	2	6,300	9	21	53	13	4	3,500	7	44	39	9	2	5,200
Newport North	NB	12	47	23	12	6	6,900	8	18	53	13	7	5,300	7	38	43	10	3	9,700
	SB	10	51	22	11	5	9,600	9	16	54	13	9	5,400	8	36	44	9	4	7,800
West of Junction 34	EB	17	50	15	13	5	6,100	16	18	42	15	10	3,500	12	42	36	7	3	5,100
	WB	16	51	17	9	6	5,300	15	20	42	14	9	3,400	13	40	35	9	2	6,400
West of J34 - **M4 only**	EB	20	46	12	15	7	4,100	20	16	34	16	14	2,200	15	40	33	8	4	3,200
	WB	19	48	14	11	8	3,400	19	19	36	15	12	2,300	17	39	33	10	3	4,200
Cardiff / Newport	EB	17	48	15	10	9	6,400	14	19	38	13	15	3,800	8	42	34	10	5	5,900
	WB	11	53	16	11	10	5,900	16	18	40	12	14	3,800	13	39	35	9	5	6,300
Cardiff / Newport - **M4 only**	EB	19	44	13	14	10	3,300	18	16	33	15	18	1,900	11	40	31	13	6	2,600
	WB	13	49	14	12	12	3,000	18	16	37	14	15	2,000	15	36	33	11	5	3,300
River Usk South	EB	15	40	24	12	8	7,600	12	14	52	12	11	6,100	8	34	45	8	4	8,300
	WB	10	47	23	12	8	8,300	12	14	53	12	9	6,100	12	31	44	10	3	8,200
River Usk South - **M4 only**	EB	23	37	15	13	12	3,000	20	13	35	14	18	2,300	14	34	36	10	7	2,800
	WB	13	47	14	14	12	2,900	22	12	36	14	16	2,200	22	26	36	11	6	3,000
River Severn	EB	26	24	14	19	17	3,800	19	5	32	18	25	2,600	17	13	37	18	14	2,600
	WB	20	35	16	15	14	3,200	15	7	42	18	19	2,700	19	15	40	18	8	4,400
River Severn - **M4 only**	EB	29	23	12	16	20	2,600	20	5	29	17	29	2,100	18	12	33	19	17	2,100
	WB	28	23	12	20	17	1,900	21	5	34	17	23	1,700	24	14	36	17	9	2,800
Cardiff Cordon	Inbound	10	57	20	10	3	14,500	10	19	52	13	5	7,600	8	43	40	8	2	11,100
	Outbound	12	51	21	10	5	10,700	9	22	50	14	6	7,600	6	43	39	9	2	14,200
Cardiff Cordon - **M4 only**	Inbound	15	56	16	10	3	3,300	16	20	45	15	5	1,600	11	46	37	6	1	2,300
	Outbound	17	54	17	9	4	2,300	14	23	41	15	6	1,400	10	45	34	9	2	3,300
Newport Cordon	Inbound	10	50	24	11	5	8,500	7	15	58	13	8	4,800	6	35	44	11	4	6,300
	Outbound	10	44	25	12	9	5,900	8	16	55	13	8	4,800	6	36	44	10	3	8,000
Newport Cordon - **M4 only**	Inbound	17	50	17	10	6	2,600	12	18	47	11	12	1,500	10	38	37	11	4	2,200
	Outbound	15	48	17	10	11	2,100	13	19	44	10	13	1,400	10	39	37	9	5	2,200

Source: South East Wales Transport Commission

Figure 4.2: Summary of trip purposes across South East Wales

Screenline	Direction	Trip length (miles): Less than 5	Between 5 and 10	Between 10 and 20	Between 20 and 50	Between 50 and 100	Over 100	Total 24hr flow across screenline (vehicles)
Cardiff North	NB	21%	26%	39%	13%	1%	0%	58,100
	SB	23%	26%	36%	12%	1%	0%	59,600
Newport North	NB	31%	22%	24%	15%	5%	3%	90,700
	SB	30%	23%	24%	14%	6%	4%	92,300
West of Junction 34	EB	4%	12%	37%	35%	8%	4%	59,300
	WB	3%	12%	37%	37%	9%	3%	59,500
West of J34 - **M4 only**	EB	0%	2%	30%	49%	12%	7%	37,500
	WB	0%	2%	33%	49%	12%	4%	39,400
Cardiff / Newport	EB	2%	15%	37%	30%	10%	6%	65,100
	WB	2%	15%	38%	30%	11%	4%	64,700
Cardiff / Newport - **M4 only**	EB	0%	5%	29%	40%	16%	10%	32,700
	WB	0%	7%	32%	39%	16%	6%	33,900
River Usk South	EB	34%	11%	18%	22%	9%	6%	97,400
	WB	35%	10%	18%	24%	9%	4%	97,600
River Usk South - **M4 only**	EB	1%	5%	19%	43%	19%	12%	36,500
	WB	1%	5%	19%	47%	20%	9%	35,000
River Severn	EB	0%	0%	12%	52%	22%	13%	39,700
	WB	0%	0%	14%	62%	17%	7%	43,400
River Severn - **M4 only**	EB	0%	0%	7%	54%	25%	15%	30,800
	WB	0%	0%	10%	62%	20%	8%	27,900
Cardiff Cordon	Inbound	24%	29%	32%	13%	2%	1%	131,700
	Outbound	22%	30%	32%	14%	2%	1%	131,300
Cardiff Cordon - **M4 only**	Inbound	1%	17%	45%	33%	3%	1%	28,200
	Outbound	0%	17%	46%	34%	3%	0%	27,100
Newport Cordon	Inbound	36%	24%	23%	12%	3%	1%	80,200
	Outbound	37%	23%	25%	11%	3%	2%	78,800
Newport Cordon - **M4 only**	Inbound	2%	15%	47%	31%	4%	1%	24,900
	Outbound	1%	17%	49%	26%	5%	2%	23,500

Source: South East Wales Transport Commission

Figure 4.3: Trip lengths across South East Wales

		AM Peak			Inter-Peak			PM Peak		
Screenline	Direction	Highway	Bus	Rail	Highway	Bus	Rail	Highway	Bus	Rail
Cardiff North	NB	91%	2%	7%	88%	5%	6%	81%	3%	16%
	SB	78%	4%	19%	85%	8%	7%	91%	3%	6%
Newport North	NB	93%	5%	2%	91%	7%	3%	93%	3%	4%
	SB	90%	6%	4%	89%	8%	3%	94%	4%	2%
West of Junction 34	EB	86%	3%	11%	86%	6%	8%	95%	1%	4%
	WB	85%	0%	14%	89%	2%	9%	88%	2%	11%
Cardiff / Newport	EB	84%	2%	14%	81%	3%	16%	80%	3%	17%
	WB	82%	3%	15%	82%	3%	14%	86%	4%	10%
River Usk South	EB	78%	4%	18%	83%	5%	12%	85%	3%	12%
	WB	85%	5%	10%	85%	5%	10%	88%	2%	10%
River Severn	EB	65%	1%	34%	74%	2%	24%	71%	1%	28%
	WB	85%	1%	19%	82%	1%	17%	85%	1%	15%
Cardiff Cordon	Inbound	79%	4%	17%	84%	8%	8%	89%	4%	7%
	Outbound	83%	5%	12%	85%	6%	9%	79%	3%	17%
Newport Cordon	Inbound	89%	7%	4%	90%	8%	2%	92%	5%	4%
	Outbound	82%	6%	12%	89%	8%	3%	93%	5%	2%

Source: South East Wales Transport Commission

Figure 4.4: Modal share across South East Wales

Findings by screenline

West of Junction 34 / Miskin

4.13 This screenline represents the main entry from the west of the region into Cardiff and further east. It is highly tidal; there are 15% more movements going east in the morning than west.

4.14 The majority of trips going eastbound and westbound across this screenline use the M4. Most are medium length journeys between 10 and 50 miles.

4.15 There is a high degree of interaction between Cardiff and local authorities west and north of Cardiff. These local authorities – Bridgend, Neath Port Talbot and Rhondda Cynon Taff – do not generally interact with Newport. This supports the observation that relatively little M4 traffic around Newport originates west of Cardiff.

Cardiff North

4.16 There is a strong tidal flow of travel from the north of Cardiff into the city. Around 43,000 trips are made across this screenline in each direction over the course of a typical day. This is a similar number to the trips into Cardiff from the west.

4.17 Around half of the trips are short journeys of 10 miles or under. The majority of the remaining journeys are under 20 miles. Over half of movements begin in the local authorities of Caerphilly and Rhondda Cynon Taff.

4.18 Compared to the regional average, a relatively high proportion of these trips are made by train. Rail services are used much more for commuting into Cardiff than for commuting north out of Cardiff.

Cardiff cordon

4.19 Consistent with the flows into Cardiff from the west and north, this screenline shows a significant tidal flow into Cardiff. While there is a high degree of 'in-commuting', it is worth noting the scale of travel is an order of magnitude below the degree of intra-Cardiff commuting.[20]

[20] Source: Cardiff's Transport White Paper: Transport vision to 2030

4.20 Travel generally involves medium length journeys. The longer the distance covered, the more likely that the M4 is used as the route into Cardiff.

Newport north

4.21 Around 90,000 trips are made across this screenline in either direction each day. This is around a third more vehicle movements than the Cardiff North screenline, despite the fact that more people travel into Cardiff than Newport. Furthermore, the Newport North cordon is mainly dominated by car whereas rail plays a more important role on the Cardiff North cordon. Proportionately a large share of inter-Newport travel is from the north.

4.22 There are many short trips across this screenline – over half of trips are below 10 miles. The analysis tells us that the vast majority of these are taken by car.

4.23 The single greatest movement across this screenline is from West Newport to West Newport. This, in part, explains the relatively high share of short-distance travel. Further north, Pontypool, Risca, Caerphilly Town and Cwmbran are all important origins, reflecting the fact that the counties of Torfaen and Caerphilly are significant trip generators.

Newport cordon

4.24 As with Cardiff, there is a high degree of in-commuting to the city. While the number of trips into Newport is around 60% of Cardiff, a similar absolute number use the M4 for the journey. Similar to the Newport North and River Usk South screenlines, there is a relatively high share of short journeys.

4.25 In terms of mode share, car makes up a higher proportion of trips than Cardiff, reflecting the differences in available rail services.

Cardiff / Newport

4.26 The screenline demonstrates the regional nature of travel in this area: over half of movements start or finish in Cardiff and over 40% start or finish in Newport. This is reflected in the length of trips, which are generally medium rather than long distance. Trips starting from Newport tend to originate close to the M4, but there is greater variation for Cardiff. Commuting is the single greatest trip purpose.

4.27 Cardiff and Newport are highly connected cities and a fifth of all movements across this screenline are between the two cities. While traffic on the M4 makes up no more than half of trips, this reflects the fact that a very significant number of road users join the motorway at Junction 29 and so travel on the A48(M).

River Usk south

4.28 This screenline gives us a sense of lateral movements across Newport between the east and west. Over a third of trips are under 5 miles, which reflects the high volume of lateral local trips between east and west Newport. Despite this, public transport use remains fairly low, reflecting the poor public transport links between the two. In particular, the inability to travel from west Newport into Central Newport by rail, and the lack of railway stations east of Newport.

4.29 Less than half of the movements take place on the M4, reflecting significant short movements within Newport on local roads and the A48. It can be seen the M4 is generally used for medium length and long distance journeys. This demonstrates the two different types of travel happening in a similar geographic area.

River Severn

4.30 This screenline captures cross-border travel along the M4, M48 and A48 into Gloucestershire and rail services to Bristol and Cheltenham. It exhibits quite different properties from the others. In particular, freight accounts for a much higher proportion of road traffic and the typical journey length is much longer. This screenline has the highest proportion of long distance journeys (over 50 miles) in the region.

4.31 Asymmetric flows in the morning and afternoon peaks suggest there are more people living in Wales and working in England than vice versa. Over half of movements start or finish in South West England; and over 25% start or finish in Monmouthshire. Trips from South East Wales are focused along the M4 and the A4042 (leading to the M4)

4.32 The share of travel on rail is the highest across any screenline, reflecting the good level of service on the South Wales Main Line that runs between South East Wales and the West of England and beyond.

The three cities

4.33 The cities of Cardiff, Newport and Bristol feature heavily in this analysis, demonstrating the fact that transport movements between and into these cities comprises a significant amount of traffic on the M4. This is unsurprising given the relative density of housing and employment in these areas.

4.34 Cardiff and Bristol act as bookends to a significant amount of the travel along the M4 between Junctions 29 and 23. Most eastbound journeys between Junctions 29 and 23 do not originate west of Cardiff. Similarly, most westbound journeys do not originate east of Bristol.

4.35 There is significant travel between each of the three cities. As the cities get larger, this is likely to increase. The greatest movements are between Cardiff and Newport, at around 27,600 journeys each day. Between Newport and Bristol, there are around 23,300 daily journeys. These journeys have increased as a result of tolls being removed, especially to East Newport. Between Cardiff and Bristol there are far fewer journeys, around 7,600, with a relatively high proportion of this traffic using the rail service.

Movement of goods

4.36 The movement of goods operates on the same infrastructure as the movement of people, principally the M4, other trunk roads and the South Wales Main Line. The two types of movements therefore interact. While freight comprises a minority share of transport movements, it is still very important to understand, not least because of the service it offers to the people and businesses of South East Wales.

Road freight

4.37 The M4 is the primary route for the movement of heavy goods vehicles in Wales, averaging more than double the number of HGVs per day compared to any other route.[21] It provides access along a key corridor of economic activity in Wales, servicing Cardiff, Newport and several major ports. As a result, it performs a variety of roles for the movement of goods. In particular, the motorway:

- provides access for transport operators moving goods between Welsh ports and the rest of the UK
- accommodates local and regional delivery and servicing activity between urban areas in South East Wales and industrial clusters in South Wales and neighbouring England
- acts as a strategic route for vehicles on long-distance journeys to and from Ireland, the rest of the UK and mainland Europe

Rail freight

4.38 While road carries the majority of freight in South East Wales, rail has a role to play within the corridor. This is mainly for servicing the traditional industries in

[21] Source: Welsh Government, Road Freight 2018

South Wales and their national and international markets. The most common types of cargo are steel, petrochemicals and coal (the latter is forecast to decline significantly due to coal-fired power station closures).

4.39 The South Wales Main Line from Swansea to Severn Tunnel is the primary route and there are multiple major freight operators. Demand is growing but there is still significant spare capacity in the system as around only 50% of available freight 'paths' on the mainline are utilised. A freight path is the opportunity to run a freight service at a particular time – these set an upper limit on rail freight.

4.40 The major ports within the M4 corridor are significant road and rail freight trip generators, in particular Port Talbot.

Freight traffic patterns

4.41 Relatively less data is available on freight movements than people movements. In particular, it is harder to gauge origin and destination patterns as there are often multiple stops in a single journey. We are also only able to approximate freight traffic by monitoring light goods vehicle (LGV) and heavy goods vehicle (HGV) movements. The majority of these vehicles will carry a cargo, but some will relate to servicing activity.

4.42 Overall, LGV and HGVs comprise between 15% and 30% of traffic on the road. It is often towards the lower end of the range in peak times and close to the higher end between the peaks. The proportion of freight traffic falls in peak times because the number of cars on the road increases. The absolute volume of freight traffic vehicles travelling along the motorway is relatively constant across the day.

4.43 The significant exception is the River Severn screenline where freight comprises up to 34% of traffic. This is considered to reflect the large number of distribution centres on the outskirts of Newport, Caldicot and Bristol. These specific locations in the east of the study area generate comparatively higher volumes of longer distance movements between South East Wales and the neighbouring South West of England, as well as to and from the English Midlands and beyond.

4.44 The nature of observed movements suggests freight movements by road within South East Wales comprise predominantly delivery and servicing activity for Cardiff and Newport. Long distance road freight is relatively small in volume, especially international 'land-bridge' traffic moving between the Republic of Ireland and Mainland Europe. As a result, HGV movements along the M4 are significantly higher between Cardiff and Bristol than between Cardiff and Pembrokeshire.

4.45 LGV and HGV traffic is overwhelmingly found on the M4 as there is a lack of alternative routes along the coastal corridor. The cost of the toll is a relatively low proportion of road freight operating costs, therefore its removal should not greatly increase HGV traffic.

ANNEX A: A TYPICAL JOURNEY ON THE M4 AROUND NEWPORT

A.1 The purpose of this annex is to tell 'the story of the road' through a narrative on a typical peak time journey in the morning and evening. It is designed to be read alongside the M4 Traffic Background Report

A.2 The first two narratives could be considered as the story of a commuter living in Wales and going to work in England; the latter two would reflect a commuter living in England and working Wales. The tidal nature of the motorway suggests there are significantly more of the former than the latter.

A.3 When the narrative talks about how the road 'performs', this is a reference to journey time reliability. In turn, journey time reliability refers to variance from average speed (a high variance means poor reliability, hence poor performance); the distribution is not symmetric and is unsurprisingly skewed towards lower speeds.

A.4 All vehicle flow numbers reflect average hourly flow during the peak period. At the end of each section, a summary table sets out the vehicle flows between Junctions and an approximate average speed and journey time reliability description in average conditions.

Eastbound – morning peak

A.5 Between Junction 29 (Castleton) and Junction 28 (Tredegar) is a good quality, but relatively short stretch of three-lane motorway that is not affected by steep gradients, tight bends, sections of missing hard shoulder or lane drops. This type of motorway generally copes well unless traffic volumes exceed 4,000 vehicles.

A.6 In the morning, peak hour that occurs generally between 7am and 8am, around 3,000 vehicles approach Junction 29 from the M4 north of Cardiff. There is then a very significant inflow from the two-lane A48(M) out of Cardiff to give a morning peak of 5,000 vehicles. Effectively, at this point, 5,000 vehicles are funnelled from five lanes to three lanes, less than a mile before Junction 28. As such, the road is heavily trafficked, average speeds drop below 60mph and there is poor journey time reliability. At Junction 28 (Tredegar), there is a significant traffic interchange, with more vehicles leaving than joining the motorway, accessing the A-roads to West Newport and local employment sites around Tredegar Park

A.7 Between Junction 28 (Tredegar) and Junction 27 (High Cross), the section of motorway is sub-standard, with a steeper gradient and tight bend travelling towards Newport. Whilst there is generally less traffic compared to the previous section of motorway, congestion problems are worse with average

speeds dropping to 40mph with very poor journey time reliability. Because of the sub-standard nature of this section of motorway, average speeds are typically limited to 60mph on this section even when traffic volumes are low during the middle of the day.

A.8 At Junction 27 (High Cross), traffic interchange, around 750 vehicles leave and join the motorway. There is therefore a similar amount of traffic on the motorway from Junction 27.

A.9 Between Junctions 27 and 26 (Malpas), the road performs similar to the previous section, with congestion problems.

A.10 At Junction 26, over 1,500 vehicles leave the motorway. This is a key motorway Junction for vehicles heading north to the eastern Valleys and south to Newport city centre. It is also the last opportunity for eastbound traffic to exit the motorway before Junction 24 (Coldra) as there are no eastbound off-slips at Junction 25A (Brynglas Tunnels) and Junction 25 (Caerleon).

A.11 There are only two lanes between Junction 26 and Junction 25A, which is frequently referred to as the Brynglas Tunnels bottleneck. Between Junction 26 and Junction 25A, average speeds are around 45mph and this section of the motorway generally sees good alignment and lane discipline.

A.12 At Junction 25A, the number of lanes increases back to three and a large number of vehicles join the road. This equates to around a 30% increase in traffic, taking the total number of vehicles using this section of motorway back to over 4,000 vehicles.

A.13 The partial Junction at Junction 25 allows traffic to join the motorway at this point, and this sees traffic increasing further to around 4,500 vehicles.

A.14 Average speeds increase over this section to around 55mph. This section of motorway has a very substandard alignment, with a tight bend, and a significant incline.

A.15 Junction 24 is a significant traffic interchange with more vehicles leaving than joining the motorway (around 1,500 vehicles leave). Only two lanes are available for traffic continuing east through this Junction resulting in a number of vehicles switching lanes taking place.

A.16 Between Junction 24 and Junction 23A (Magor), this section of motorway has 3 lanes and an average speed of 65mph. The number of lanes then reduce from three to two through Junction 23A but increase back to three thereafter. The lane drop at Junction 23A can cause traffic to try to avoid the inside lane on the approaching section, which can contribute to lower average speeds through this section.

A.17 At Junction 23A (Magor) there is another traffic interchange where slightly more vehicles leave than join the motorway and around 3,750 vehicles continue to cross the Prince of Wales Bridge into England.

From	To	Eastbound – morning peak		
		Peak flow	Trough average speed	Reliability
Junction 29	Junction 28	5,000	55	Poor
Junction 28	Junction 27	4,250	40	Poor
Junction 27	Junction 26	4,500	40	Very Poor
Junction 26	Junction 25A	3,500	45	Good
Junction 25	Junction 24	4,500	55	Poor
Junction 24	Junction 23A	4,250	65	Good

Figure A.1: Summary of M4 performance going eastbound in the morning peak

Westbound – evening peak

A.18 Around 4,250 vehicles approach Junction 23 on the M4 after crossing the Severn from England. There is moderate inflow of traffic from the M48 from Chepstow to give an evening peak flow of 5,000 vehicles around 4pm.

A.19 At Junction 23A the outflow is marginally higher than inflow leading to a flow of 4,750 vehicles between Junctions 23A and 24. The road performs poorly at this level of traffic flow with average speeds during the evening peak dropping to 45mph and a very poor journey time reliability. Friday evening peaks are significantly worse than other weekdays on this section with average speeds dropping as low as 30mph. Some of the congestion on this section is likely to be caused by queues extending from the next section of the motorway on the approach to Brynglas tunnels, and those switching lanes as the inside lane becomes a dedicated slip road for Junction 24 leaving only two lanes to continue westwards through this Junction.

A.20 Junction 24 is a significant interchange with a net inflow (1,500 vehicles joining compared to 1,250 leaving). This is due to traffic joining from the A449 (A40) dual carriageway, which is the main highway route from the Midlands and the North to South Wales. Between Junctions 24 and 25, the road performs poorly during the evening peak with speeds dropping to around 25mph on a typical weekday and around 20mph on a Friday. This reflects the fact this section of road has the worst alignment of the M4 corridor around Newport. Lane one is also likely to be underutilised on this section due to the lane drop from three to two lanes at Junction 25A.

A.21 At Junctions 25 and 25A the combined outflow is 1,250 reducing the number of vehicles to around 3,500 on the approach to Brynglas tunnels. Through the tunnel average speeds drop to around 40mph.

A.22 There is a significant net increase in traffic volumes at Junction 26, where the number of lanes on the motorway change from two lanes back up to three. Traffic volumes between Junctions 26 and 27 exceed 5,250 vehicles, which cause average speeds on this stretch to drop to around 50mph.

A.23 There is a small net decrease in traffic flow after Junction 27 leading to traffic volumes of 4,750 vehicles between Junctions 27 and 28. As a result, speeds are higher than on the previous section at around 60mph and journey time reliability is moderate.

A.24 There is significant interchange at Junction 28, with net inflow. This reflects A-road access to West Newport, parts of the Valleys via the A465, and local employment sites around Tredegar Park.

A.25 Between Junctions 28 and 29, peak flow is around 5,250. However, average speeds remain relatively high during this period at around 65mph.

A.26 There is significant outflow onto the A48(M) towards Cardiff at Junction 29 and around 3,000 vehicles continue on the M4 to cross the Severn into England.

From	To	Westbound – evening peak		
		Peak flow	Trough average Speed	Reliability
Junction 23A	Junction 24	4,750	45	Very poor
Junction 24	Junction 25	5,000	25	Very poor
Junction 25A	Junction 26	3,500	40	Poor
Junction 26	Junction 27	5,250	50	Poor
Junction 27	Junction 28	4,750	60	Moderate
Junction 28	Junction 29	5,250	65	Moderate

Figure A.2: Summary of M4 performance going westbound in the evening peak

Westbound – morning peak

A.27 In the morning peak hour that occurs generally between 7am and 8am, around 3,250 vehicles approach Junction 23 on the three-lane section of motorway from the Prince of Wales Bridge, with vehicles travelling towards Newport from England.

A.28 Again, a good quality three-lane section of motorway generally copes well unless traffic volumes exceed 4,000 vehicles.

A.29 At Junction 23, more vehicles then join the motorway from the M48 from Chepstow, increasing the traffic to 3,750 vehicles.

A.30 The number of lanes then reduce from three to two through Junction 23A but increase back to three thereafter travelling up to Junction 24 and the Brynglas Tunnels. The lane drop at Junction 23A can cause traffic to try to avoid the inside lane on the approaching section, but without any noticeable traffic congestion problems.

A.31 At Junction 23A, more traffic joins than leaves the motorway, resulting in a traffic volume of 4,000 vehicles between Junctions 23A and 24. Average speeds are generally in excess of 65mph.

A.32 At Junction 24 (Coldra) there is then is a significant traffic interchange with 1,500 vehicles joining compared to 1,000 leaving. Traffic wishing to continue westwards must switch from the inside lane which becomes dedicated off-slip for Junction 24.

A.33 Between Junctions 24 and 25, the motorway then experiences congestion problems with average speeds dropping to less than 50mph. The congestion problems and average speeds are exacerbated by the fact that this section has a very substandard alignment with a tight bend and increasing steepness in the road.

A.34 At Junctions 25 and 25A, around 1,250 leave the motorway, reducing the number of vehicles travelling on the M4 to around 3,250. However, the number of lanes then reduces from three to two on the approach to the Brynglas Tunnels. Through the tunnels, average speeds drop to around 40mph and journey time reliability is poor.

A.35 At Junction 26, the number of lanes on the motorway changes back from two lanes to three. However, there is a significant increase in traffic volumes with more traffic joining than leaving the motorway.

A.36 Traffic volumes between Junctions 26 and 27 exceed 5,000 vehicles, which contributes to the average speeds on this section being around 40mph.

A.37 There is then a further small increase in traffic after Junction 27, where more traffic joins the motorway again, leading to traffic volumes of 5,500 vehicles between Junctions 27 and 28. Average speeds are around 50mph and journey time reliability remains poor.

A.38 There is then another significant traffic interchange at Junction 28, with more vehicles leaving the motorway than joining, accessing the A-roads to West Newport and local employment sites around Tredegar Park.

A.39 Between Junction 28 and Junction 29, the traffic volumes reduce down to around 5,000 vehicles and average speeds are around 55mph travelling towards Cardiff.

A.40 There is a significant number of vehicles leaving the motorway onto the A48(M) towards Cardiff at Junction 29 and around 3,750 vehicles continue on the M4 heading towards Cardiff and beyond.

From	To	Westbound – morning peak		
		Peak flow	Trough average speed	Reliability
Junction 23A	Junction 24	4,000	65	Very good
Junction 24	Junction 25	4,500	50	Very poor
Junction 25A	Junction 26	3,250	40	Poor
Junction 26	Junction 27	5,000	40	Poor
Junction 27	Junction 28	5,500	50	Poor
Junction 28	Junction 29	5,000	55	Good

Figure A.3: Summary of M4 performance going westbound in the morning peak

Eastbound – evening peak

A.41 Around 3,000 vehicles approach Junction 29 from the M4 north of Cardiff. There is then a very significant inflow from the A48(M) out of Cardiff to give an evening peak of 5,250 vehicles around 4pm. At this point, the road has poor journey time reliability and the average speed drops to around 55mph. This is despite it being a stretch of motorway that is not affected by steep gradients, tight bends, sections of missing hard shoulder or lane drops. However, at Junction 29, five lanes carrying over 5,000 vehicles are reduced to three lanes less than a mile before Junction 28.

A.42 There is significant interchange at Junction 28, with net outflow. This reflects A-road access to West Newport, eastern parts of the Valleys via the A467, and local employment sites around Tredegar Park.

A.43 Between Junctions 28 and 27, peak flow drops sufficiently for road performance to improve. The trough average speed dips to around 50mph but there is still poor journey time reliability, indicating that the drop in speed is likely to be primarily associated with the sub-standard nature of this motorway section rather than the volume of traffic.

A.44 There is limited net change in traffic flow at Junction 27 with inflow and outflow broadly balanced at around 500 vehicles. Despite the marginal change in traffic flow the section of M4 between Junctions 27 and 26 performs slightly worse than the upstream section with trough average speeds of around 40mph and

poor journey time reliability. This may be cause due to an increased frequency of lane changes on this section as a result of the lane drop at Junction 26.

A.45 At Junction 26, there is a very significant net outflow, with over 1,750 vehicles leaving. This is a key motorway Junction for vehicles heading north to the Valleys and south to Newport city centre. It is also the last opportunity for eastbound traffic to exit the motorway before Junction 24, because there are no eastbound off-slips at Junctions 25A and 25. The high outflow could also be because traffic is seeking to avoid the Brynglas tunnel bottleneck.

A.46 Between Junctions 26 and 25A – the Brynglas tunnels – the road performs relatively well. Average speed is around 50mph and the distribution is skewed towards higher speeds, not lower speeds but there is still variability in the speeds. This reflects limited flow, good alignment and lane discipline.

A.47 At Junction 25A, a large number of vehicles join the road – a 30% increase in volume, taking flow to over 3,750 vehicles and then increasing further to around 4,250 vehicles after Junction 25. Between Junctions 25 and 24, the road performs moderately well with average speeds increasing to around 60mph, but with good journey time reliability. The relatively low speed reflects the fact this section of road has the worst alignment of the M4 corridor around Newport, whereas the good journey time reliability indicates that the section has sufficient capacity to carry the traffic volumes in the evening peak.

A.48 Junction 24 is a significant interchange with a net outflow (1,500 vehicles leave). Between Junctions 24 and 23A, the road performs well during the evening peak with high average speeds of around to 65mph.

A.49 There is moderate outflow at Junction 23 and around 2,750 vehicles continue on the M4 to cross the Severn into England.

From	To	Eastbound – evening peak		
		Peak flow	Trough average Speed	Reliability
Junction 29	Junction 28	5,250	55	Poor
Junction 28	Junction 27	4,750	50	Poor
Junction 27	Junction 26	4,750	40	Poor
Junction 26	Junction 25A	3,000	50	Poor
Junction 25	Junction 24	4,250	60	Good
Junction 24	Junction 23A	4,250	65	Very good

Figure A.4: Summary of M4 performance going eastbound in the evening peak

ANNEX B: TRAFFIC MODELLING

Introduction

B.1 Two transport models have been used for our analysis:

- the South East Wales Transport Model (SEWTM)
- the model developed for the M4 Corridor Around Newport (M4CaN) Project

B.2 Future analysis as part of the South East Wales Transport Commission will be undertaken using SEWTM.

B.3 This annex provides basic information on the two models, the differences between them and their use in the analysis. The remainder of this section is structured as follows:

- summary of the two models
- choice of the models for analysis
- note on differences between alternate modelling tools

Model summaries

South East Wales transport model

B.4 SEWTM is a multi-modal disaggregate transport model of the South East Wales Area. It comprises highway and public transport assignment models linked together by a policy-responsive variable demand model. It was built by a team led by Mott MacDonald between 2015 and 2017 and has a base year of 2015. The model is owned by Welsh Government, managed by Transport for Wales (TfW) and operated by a team led by Mott MacDonald.

B.5 SEWTM is focused on the Cardiff Capital Region, with a Fully Modelled Area (FMA) consisting of the ten South East Wales Local Authorities and Neath Port Talbot. The FMA is shown below in Figure B.1.

Source: Welsh Government

Figure B.1: SEWTM model area

B.6 The model has been built to provide a strategic analysis tool for assessing a wide variety of transport and policy interventions. In particular, its relative strengths are to:

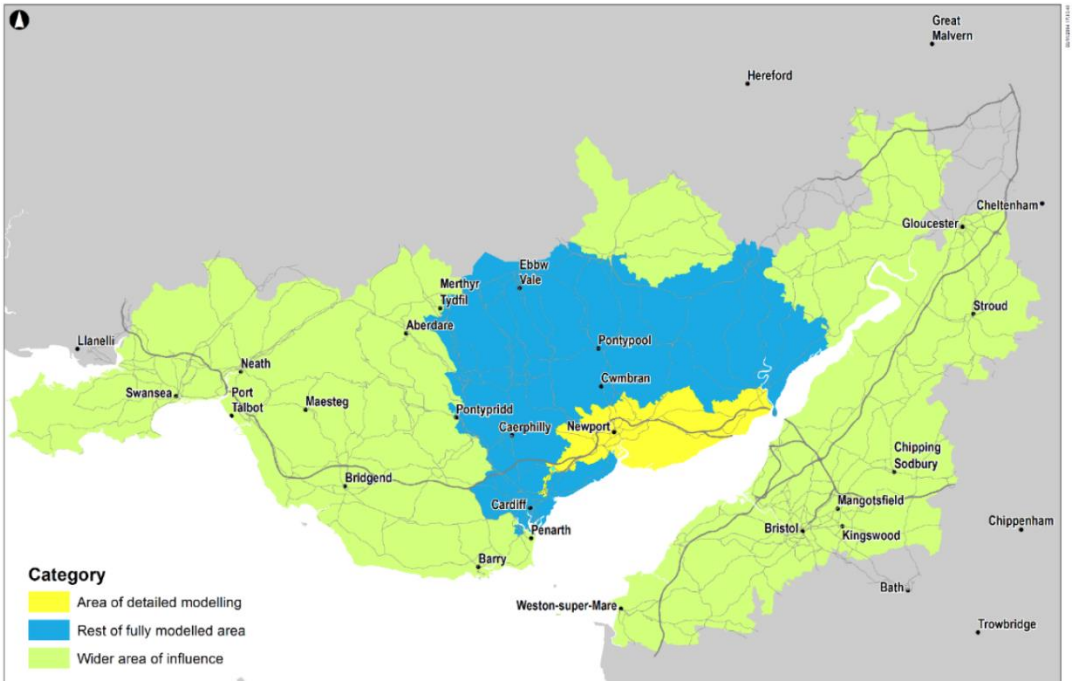
- understand the current travel patterns and the performance of the transport system
- project future travel patterns and conditions on the transport network
- assess the impacts of possible interventions in the transport system in a consistent manner
- assess the impacts of land use changes such as new housing developments and employment locations in a consistent manner
- provide inputs required for transport appraisals and business case development
- provide data required for development control work

B.7 The model has recently been updated to improve its functionality for use in forecasting the impact of transport and policy interventions arising from the Commission.

M4 corridor around Newport model

B.8 The M4 Corridor around Newport (M4CaN) model was developed by Arup in 2015, with a 2014 base year. The model was designed particularly to test the M4 Corridor around Newport Project.

B.9 The M4CaN model is particularly detailed for the area around Newport. The model area is shown below in Figure B2. The area shown in the red boundary in Figure B.1 is analogous to the smaller area shown as dark blue in Figure B.2. The M4CaN model does not extend as far west as SEWTM and its 'Area of Detailed Modelling' is also smaller. The area of the M4CaN model shown in green is the external area, the external area of SEWTM is the entirety of Great Britain.



Source: Arup

Figure B.2: M4CaN model area

B.10 The M4CaN model derives its response to the removal of the Severn Bridges tolls from the Severn Bridges Model, in which the M4CaN model is itself incorporated.

Key model feature comparison

B.11 Figure B.3 below illustrates the key features of the two models.

		M4CaN	SEWTM
Assignment Software Used		SATURN	VISUM
Model Base		May 2014	Neutral Spring Month 2015
Assignment Time Periods (Average Hour of Interval Shown)	**AM Peak**	08:00-09:00	07:45-08:45
	Inter-Peak	10:00-16:00	09:30-15:30
	PM Peak	17:00-18:00	16:30-17:30
	Off-Peak	-	18:00-07:00
Sources used for Highway Matrix Construction		• Mobile Phone Data (MPD) • Roadside Interviews (RSIs) • Synthetic Data • External data sources	• Mobile Phone Data (MPD) • Roadside Interviews (RSIs) • Synthetic Data • External data sources
Sources used for Matrix Construction – Additional Detail		• MPD was collected over 2 weeks in 2014 • RSIs were carried out at 27 locations • Synthetic Data was based on a Gravity Model that used External Sources: local RSI data, Journey to Work (JTW) and National Travel Survey Data • Other external data sources include: DfT Base Year Freight Matrices, Trafficmaster	• MPD was collected over 4 weeks in 2015 • RSIs were carried out at 5 locations • Synthetic Data was produced by demand model, utilising locally collected 2013 household surveys • External data sources include: Journey to Work (JTW), National Travel Survey data, DfT Base Year Freight Matrices, Trafficmaster
Public Transport Model		Bus and rail trips for East-West movements competing with the M4 are modelled in EMME and input to the Variable Demand Modelling (VDM) process	Public Transport assignments included within the VISUM model, and cover movements in the same study area as the highway model. Forecasts bus, rail and park and ride demand.
Sources used for Public Transport Matrix Construction		• MOIRA • Electronic Ticket Machine (ETM) • Passenger Counts • Rail Station footfall • TEMPro growth factors	• MOIRA • Electronic Ticket Machine (ETM) • Passenger Counts • Passenger Interviews • Boarding and Alighting Counts
VDM Method		Incremental using DIADEM software	Absolute model applied incrementally with custom four-stage discrete choice model
Source used for Forecasting Population and Jobs		**National Trip End Model (NTEM)**	**Experian Data**

Figure B.3: Key features of the two models

Application of models for analysis

Part 1

B.12 The M4CaN model underpins the following analysis in Part 1 of the report:

- M4 performance
- scale of Junction joiners and leavers in each direction in morning and evening
- top 10 origin-destination patterns
- journey lengths

B.13 Elsewhere in Part 1 of the report observed data has been used. in relation to the top 10 origin and destination patterns, the version of the model used represents a forecast scenario with the Severn Bridges Tolls removed.

B.14 The M4CaN model has been used to underpin this analysis because:

- summary analysis of various sections of the M4 was available from the M4CaN model at the outset of the Commission, and has therefore informed the Commission's initial views for some aspects
- the representation of traffic on the M4 in the M4CaN model more closely matches observed data than the existing version of SEWTM relating to route choice into England (ongoing updates to SEWTM will improve the model significantly in this regard)

Part 4

B.15 SEWTM underpins the screenline and mode analysis presented in Part 4 of this report. The M4CaN model has not been used to support analysis in this section.

B.16 SEWTM has been chosen as the analysis tool for this section due to its integrated and thoroughly tested public transport component, an element which is key to the analysis in this section. It is understood that an EMME-based public transport model is used to support the M4CaN model, but this is understood to provide significantly less functionality and analytical assurance.

Notes on comparing the outputs of different models

B.17 Any two transport models covering the same area will inevitably provide different results, even when both of those models are suitable to use. Differences in modelling results arise for a number of reasons. These include:

- different underlying data collection periods, travel patterns vary from day to day and from month to month, even where underlying trends are consistent
- differing model construction processes and model functionality
- differing model scenarios
- differing areas of focus and intended model uses

B.18 Both SEWTM and the M4CaN model have been built in accordance with the Department for Transport's Transport Analysis Guidance (TAG) and modelling best practice.

B.19 Model data from SEWTM and the M4CaN models have been compared to ascertain whether there are any fundamental differences in the representation of the transport network presented by the two models. Our view is that the most significant differences can be explained by the model scenarios presented (2015 base for SEWTM and forecast year without Severn Bridges tolls for the M4CaN) and that the choice of analysis tool does not change the conclusions reached in this report.