CALCULATING TRANSPORT EMISSIONS

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Section 1. Calculation of Transport Emissions

1.1 Objective

The objective is to derive a representative figure for emissions for each small area (Parish, Census output area or ward). This will be based on emissions from roads passing through the area.

Other possible models could be considered, which might have more bearing on emissions caused by residents of an area, but these probably do not account for the district total. Some traffic is resident's travel, and other traffic is passing through.

It is important to recognise that the figures presented here represent transport emissions occurring in an area, as opposed to transport emissions caused by an area; be it by residents or businesses.

The calculation has to be based on available data. It is assumed that emissions from a road are proportional to:

- The length of road
- Traffic flows on the road
- Emissions rates by vehicle type for the road type.

So if emissions for a length of road can be established, then emissions for the areas it passes through can be assigned according to the proportion of road length passing through the area.

The method adopted for calculating flows and emissions in outline is as follows:

1. Where a road has a Dft traffic count associated with it, this is used for the flow – if a count for the reference year (2017) is available, then this is used, otherwise the latest before the reference year is used. This covers all motorways and A roads.
2. If a road is not typical, but has no count available, then an estimate is made based on assumptions about turning movements from links with known counts.
3. Motorway and A road emissions are published as totals so an emissions rate per vehicle kilometre for each vehicle type can be calculated for each vehicle type and road type (A or M).
4. We assume Minor roads have the same emissions rate as A roads.
5. Emissions and road lengths from atypical minor roads are then calculated, leaving a residual amount of emissions and road lengths to be apportioned between the remaining roads.
6. Weightings are applied by road function to the remaining roads, from which vehicle kilometres and AADF for each residual road type can be calculated. The result of these calculations is then added as pseudo counts to the TrafficCounts table.
7. Emissions are calculated for each link based on AADF, Emissions rates and road length.
8. Road links are intersected with areas and emissions are summed to give transport emissions for each area.

1.2 District level emissions figures

An overall figure for transport emissions is available for Teignbridge for 2017 from GHG emissions statistics. For transport this figure is broken down by:

Category	Emissions kt CO_2e
Road transport – A roads	317.6
Road transport – Motorways	20.9

Road transport – Minor Roads	72.3
Diesel Railways	4.4
Transport other	1.8

Diesel Railways and Transport other are small compared with Road Transport and cannot reasonably be allocated to smaller areas.

The rest of this document will focus on Road Transport.

1.3 District level fuel consumption figures

As well as the emissions breakdown for GHG emissions there is data on energy consumption by vehicle type at local authority level. This breaks down as follows:

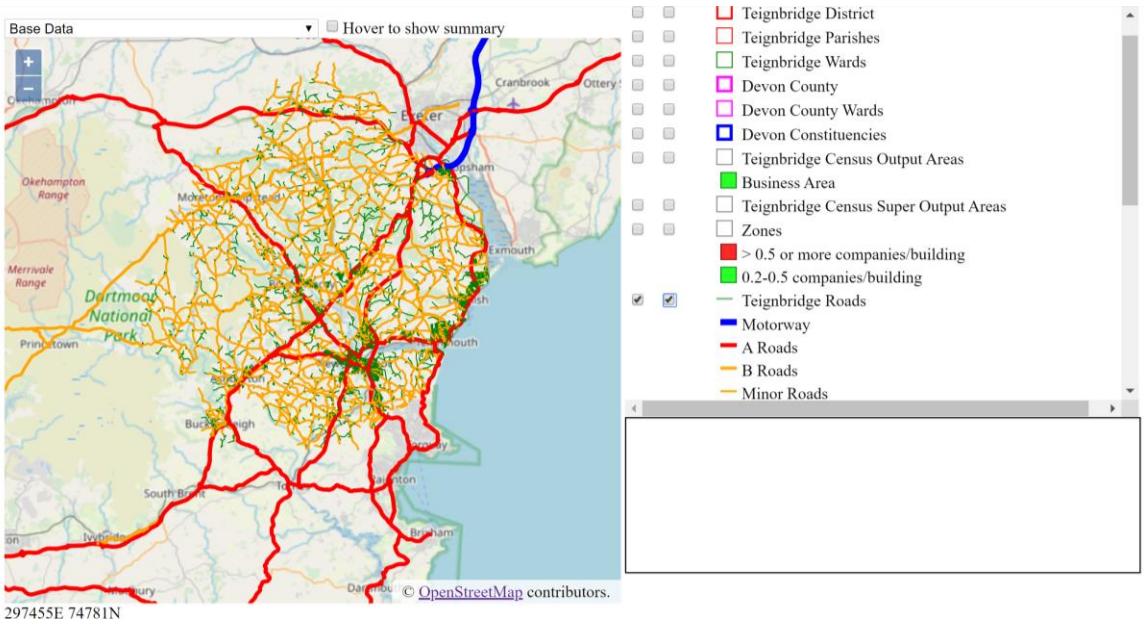
Teignbridge	Motorways	A roads	Minor Roads	Total
Buses	35	1,373	1,038	2,446
Diesel Cars	2,051	28,862	7,548	38,461
Petrol Cars	1,482	30,058	8,047	39,586
Motor Cycles	19	397	210	626
Diesel LGVs	1,228	19,255	4,145	24,629
Petrol LGVs	35	558	151	743
HGVs	1,445	15,572	778	17,796
Total	6,294	96,075	21,917	124,286

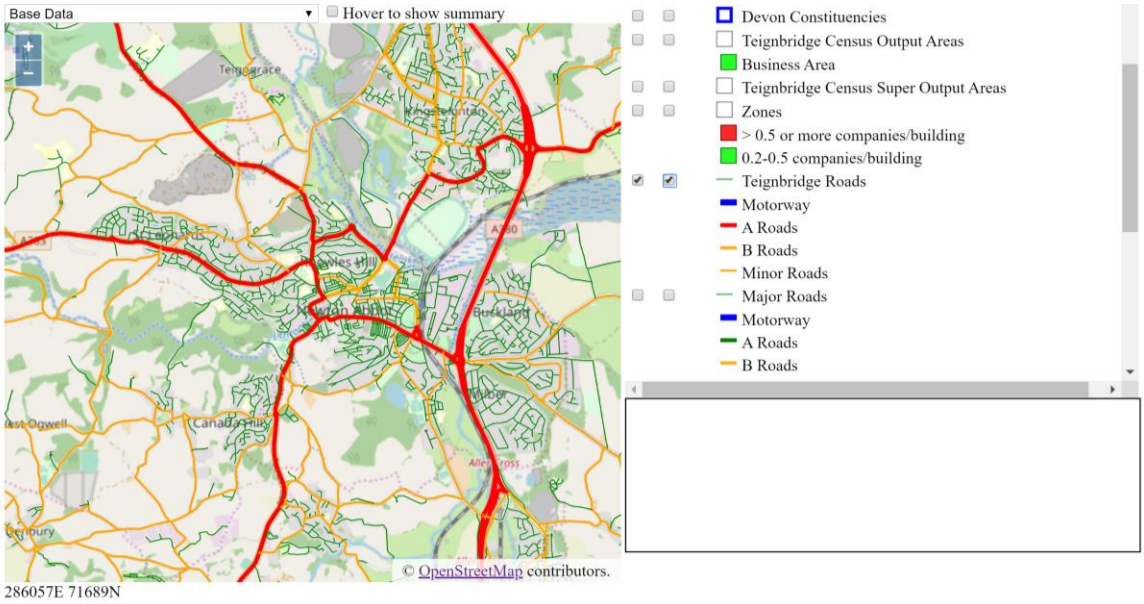
Units in the above table a ktOe (kilotonnes of oil equivalent)

We know emissions by each road type, as well as fuel consumption, so can work out an approximate value for emissions if we assume that emissions are proportional to fuel consumption.

1.4 OS Open Roads

This is a detailed road network, which contains all roads in Teignbridge:





Each link in the network has attributes including:

- Road Number
- Class
- Function
- Startnode
- Endnode

Class has sensible values for Motorways, A and B roads

For each link the length intersecting the district boundary has been calculated, and is stored in the district_length attribute. The total of district_length is shown in the table below.

Function has useful values below that:

Function value	Consumption Category	Kilometres	Notes
Motorway	Motorway	2.67	This is estimated from the major road network (see below), which excludes slip roads
A Roads	A Roads	148.20	Ditto
B Roads	Minor Roads	83.87	
Minor Road	Minor Roads	1060.66	These are roads that go somewhere but aren't classified as A, B or M
Local Road		418.49	These are typically estate roads
Local Access Road		18.17	
Restricted Local Access Road		441.39	
Secondary Access Road		10.81	

Start and End nodes can be used to trace through the network.

1.5 DfT traffic counts

DfT traffic counts are available on Motorways and A roads from 2000 to 2018. They are also available for some B roads, but not necessarily for such a wide range of dates.

A simplified road network is also available from DfT which covers the A and M road network. Each link in this network is a simple straight line, which isn't good enough to determine which areas a road passes through.

Traffic counts are expressed as Annual Average Daily Flow (AADF)

Dft Traffic counts are broken down by the following vehicle types:

- Pedal cycles
- Two Wheeled Motor Vehicles
- Cars and Taxis
- Buses and Coaches
- LGVs
- HGVs

The following mapping between fuel consumption figures and traffic counts is proposed:

Fuel Consumption Vehicle Category	Traffic Count vehicle category	Notes
Buses	Buses and Coaches	
Diesel Cars	Cars and Taxis	Diesel and Petrol consumption are added together to translate AADF to emissions
Petrol Cars		
Motor Cycles	Two Wheeled Motor Vehicles	
Diesel LGVs	LGVs	Diesel and Petrol consumption are added together to translate AADF to emissions
Petrol LGVs		
HGVs	HGVs	

Using this mapping calculate fuel consumption by traffic count vehicle category and road type:

Combined consumption				
Teignbridge	Motorways	A roads	Minor Roads	Total
Buses and Coaches	35	1,373	1,038	2,446
Cars and Taxis	3,533	58,919	15,595	78,047
Motor Cycles	19	397	210	626
LGVs	1,263	19,813	4,296	25,371
HGVs	1,445	15,572	778	17,796
Total	6,294	96,075	21,917	124,286

We have emissions totals for each road type and consumption, so can derive a conversion factor from consumption to emissions:

Teignbridge	Motorways	A roads	Minor Roads	Total
Emissions	20.9	317.6	72.3	410.8
Consumption	6,294	96,075	21,917	124,286
consumption to emissions factor	0.00332	0.003305761	0.00329882	0.003305

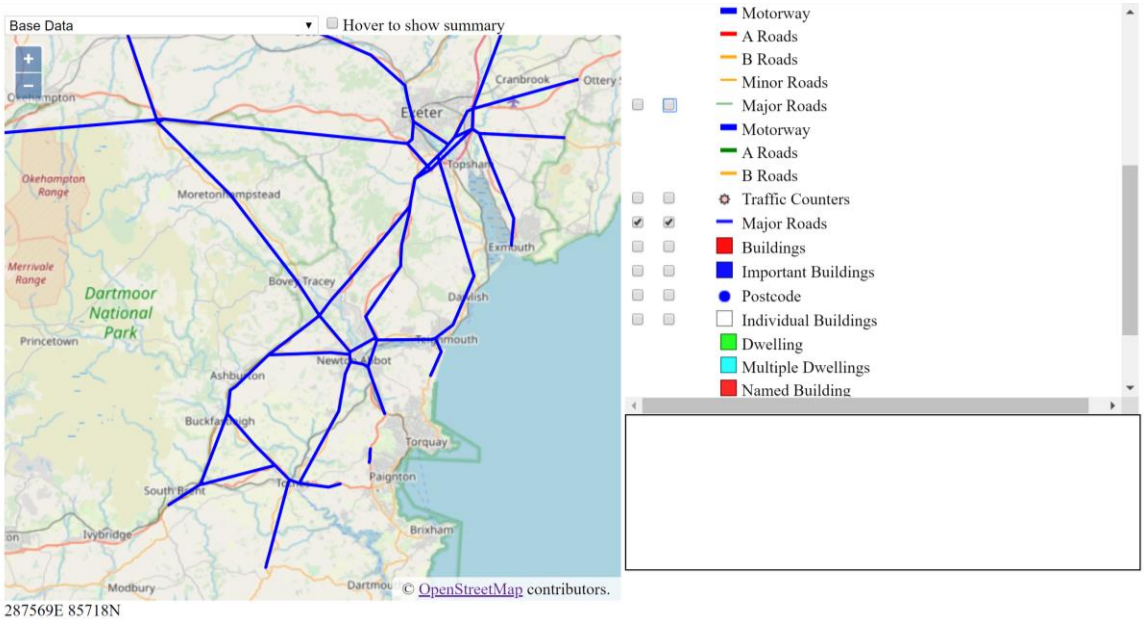
This conversion factor can then be used to derive emissions for vehicle type by road type:

Emissions by vehicle and road type				
Teignbridge	Motorways	A roads	Minor Roads	Total
Buses and Coaches	0.12	4.54	3.42	8.08
Cars and Taxis	11.73	194.77	51.44	257.95
Motor Cycles	0.06	1.31	0.69	2.07
LGVs	4.19	65.50	14.17	83.86
HGVs	4.80	51.48	2.57	58.84
Total	20.9	317.6	72.3	410.8

We now need lengths for each road, so that vehicle kilometres can be derived for each vehicle type and road. We then derive emissions / km for each vehicle type on each road type from emissions divided by vehicle kilometres. The lengths of road will be distorted if we include slip-roads, both links of dual carriageways and so on. These mainly occur on the major road network, this means that for Motorways and A Roads we will assign the shape from the detailed network, but only using one link for each part.

1.6 Adding shape to the major road network

The major road network downloaded from DfT is comprised of straight links which are each associated with a traffic counter. Only the start and end points of these links are geographically accurate:

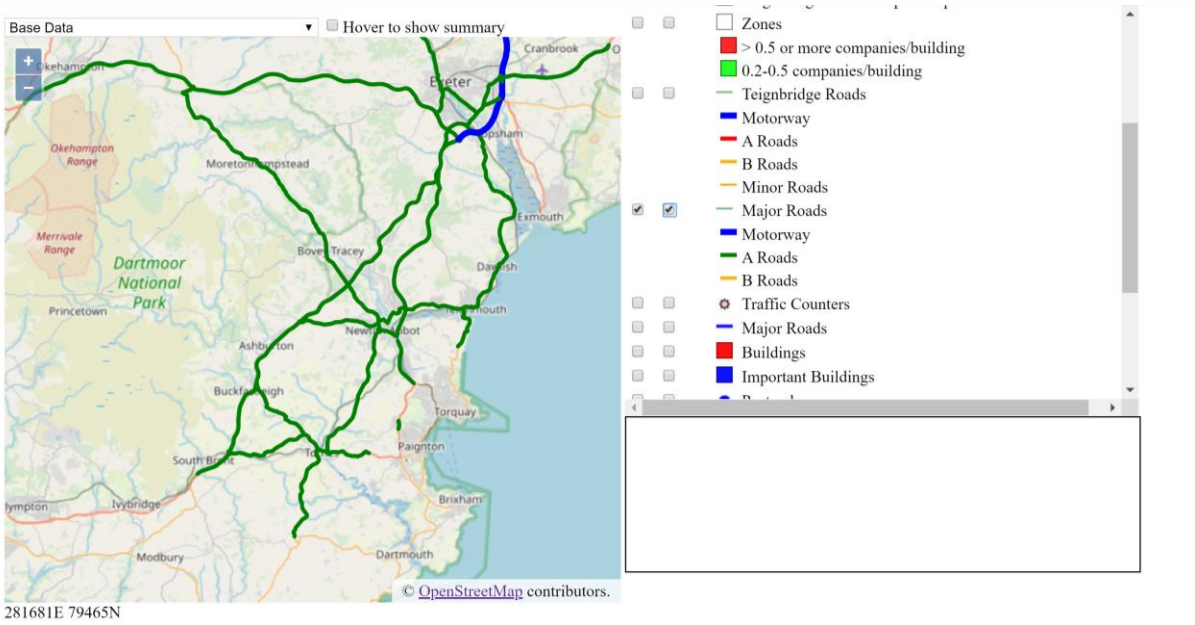


In order to be useful for assignment to smaller areas the shape of the detailed OS network needs to be assigned to each link in the above network. This is done by script assignCountersToRoadlinks.js.

- The nearest node in the OS network to the end of each major network link is found.

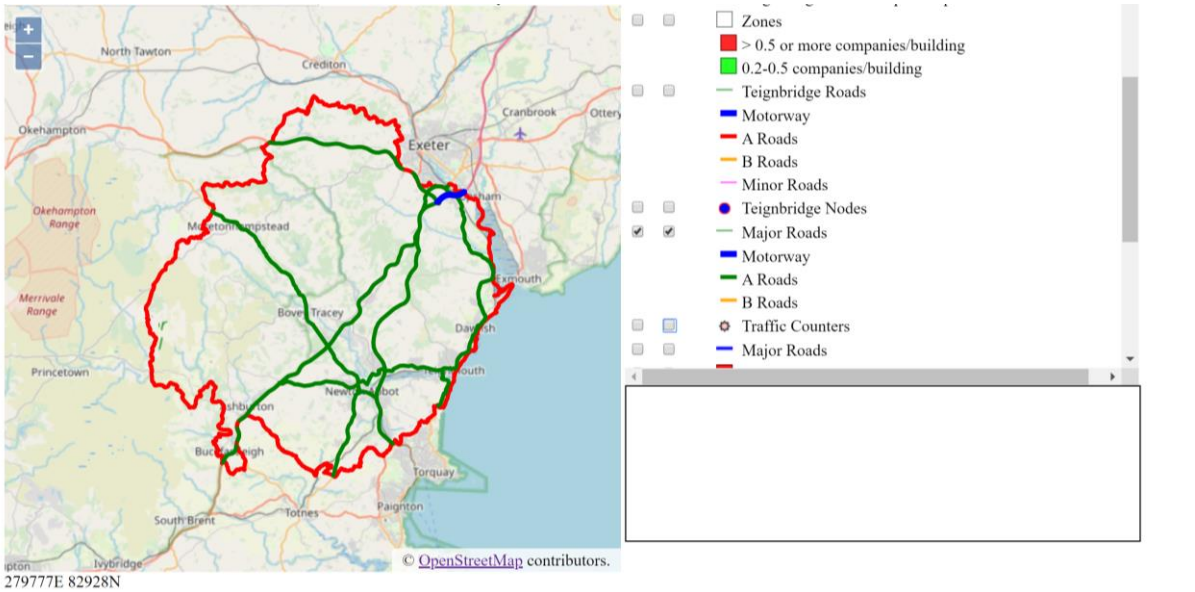
- Links for B Roads are added, these are identified by pairs of nodes in the detailed road network, as these roads are not in the major road network.
- A spanning tree from each major network start node is constructed, using a link cost function based on link length. This cost function multiplies the length by 10 if the link's road name does not match the major road name; this allows the trace to pass through small sections of road with different names (for example where the A381 crosses the A380). The trace stops when the end node of the major network link is found.
- The set of links in the spanning tree whose road name matches on the route from start to end node is then extracted.

This results in a major road network with shape:



281681E 79465N

The network shown above includes a buffer 5km outside Teignbridge, so that major road links spanning the boundary can be reconciled to the detailed network. The network now needs to be clipped at the Teignbridge boundary, so that overall lengths are correct:



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The major road network uses a single link from the detailed road network to represent both directions of travel, this avoids double counting, but means that there are many links that are not used.

Each link from the detailed road network that is used to construct the major road network is assigned a counter ID and count year. Motorways, A and B road links that are not used are assigned counter 0, which has no flow for any vehicle type.

1.7 Emissions per vehicle kilometre for each road type and vehicle type

To work this out we need accurate road lengths for each type of road, which for major roads are provided by the Major Roads network, and for minor roads network by the detailed road network.

This gives:

Teignbridge	Motorways	A roads	B Roads	Other roads	Minor Roads	Total
Lengths for each road type	2.67	148.21	83.88	1949.53	2033.41	4217.70

The table above is used for information only, it is used for checking, but is not used directly in the following calculation.

We need emissions / vehicle kilometre for each road type and vehicle type. We can do this using traffic counts for major roads, but need to make some assumptions for minor roads.

1.8 Assigning traffic counts to the road network

We have seen that a large proportion of Teignbridge's road traffic is on the major network, for which we have:

- traffic flows by vehicle type
- fuel consumption by vehicle type
- district emissions for motorways and A roads

We can therefore work out a figure for A Road and Motorway emissions for each area from these. We can also use counters where these exist for B Roads.

For this we need annual vehicle kilometres for each vehicle type.

These figures are stored in table TeignbridgeVehicles

Table TeignbridgeVehicles vehicle kilometres by road type and vehicle type

class	VEHKM buses and coaches	VEHKM cars and taxis	VEHKM two wheeled motor vehicles	VEHKM lgvs	VEHKM hgvs	VEHKM pedal cycles
A Road	5891650	1049862579	9183383	223383419	65956528	1052880
B Road	976650	87082796	759564	11427116	2070368	748808
Motorway	155175	69718549	396233	16186040	6305577	0
Unknown	2816	457028	0	31830	19436	0
Residual	4088756	190214601	3467024	36905461	1218900	0

The relevant portion of this table is shown below inverted:

Vehicle kilometres per year = SUM(AADF * km)			
Teignbridge	Motorways	A roads	Total
Buses and Coaches	155175	5891650	6046825
Cars and Taxis	69718549	1049862579	1119581128
Motor Cycles	396233	9183383	9579616
LGVs	16186040	223383419	239569459
HGVs	6305577	65956528	72262105
Pedal Cycles	0	1052880	1052880
Total	92761574	1355330439	1448092013

From this we can calculate emissions per vehicle kilometre for each vehicle and road type by dividing each cell in the emissions per vehicle type by road type by these values, which are stored in table TransportEmissionsRates, which gives an emissions rate for each road types and vehicle.

Emissions by vehicle and road type kg/veh/km		
Teignbridge	Motorways	A roads
Buses and Coaches	0.74902658	0.770439452
Cars and Taxis	0.16825421	0.185522697
Motor Cycles	0.1558699	0.14290849
LGVs	0.25900073	0.293205456
HGVs	0.7611315	0.780481991

In practice this table is now calculated as part of the SQL server workflow, as accurate major road lengths are also derived as part of that workflow. The values for A Roads are slightly lower than in the first version of this document due to greater data accuracy.

Appendix 2 – Note on derived emissions figures to cars and motorcycles discusses possible reasons for higher than expected car and motorcycle emissions.

These can then be applied to vehicles on each link of the major road network and on B Roads.

The A Road emissions rate is assumed for all minor roads.

Traffic flow Estimates are derived for B Roads individually as described in the following section. These then give vehicle kilometres for B roads, from which emissions are derived. The totals for B Road emissions are then calculated. Residual Road emissions are then calculated from Minor Road emissions minus B road emissions.

Intersecting the major road network with each area will then give emissions from motorways and A roads for each area.

1.9 B Road traffic

There are a few traffic counters on B roads, these have significantly higher flows than the above:

Road Number	B3192	B3193	B3387	B3193	B3193	B3193	Averages
Location description	Teignmouth to Haldon	Kingsteignton	Bovey - Haytor	Finlake	North of Finlake	Doddiscombe	Without B3192
Year	2009	2009	2009	2008	2018	2018	
Buses and Coaches	13	46	29	6	14	8	20.6
Cars and Taxis	6287	2272	1734	1745	1618	833	1640.4
Motor Cycles	53	55	14	15	40	18	28.4
LGVs	1196	346	181	359	397	214	299.4
HGVs	54	23	28	182	33	15	56.2

These also exhibit significant variation between counters, so assuming an average even excluding the B3192 is likely to introduce quite a lot of error. There are relatively few B roads in Teignbridge, these are as follows:

Teignbridge B roads		
Road Number	Counters	Where
B3192	1	Teignmouth to Haldon
B3193	4	Kingsteignton to Dunsford
B3212		Exeter to Postbridge via Moretonhampstead
B3387	1	Bovey - Widecombe
B3352		Through Ashburton
B3380		Through Buckfastleigh
B3344		Bovey - Chudleigh Knighton - Chudleigh
B3195		Exeter Rd - Kingsteignton
B3195		The avenue Newton Abbot
B3195		Halcyon Road - Abbotsbury Road Newton Abbot

Local knowledge tells us that there is a lot of variation between these, so some of these deserve individual treatment. Where there are traffic counts (even old ones), these should be used instead of estimates. In some cases inferences can be made from nearby traffic counters, for example B3195 the Avenue Newton Abbot could be inferred from A381 East Street and A381 Torquay Road.

Devon County Council have done many traffic counts and show the locations of these on an interactive map , however, there is a charge of £145 for each count and the interactive map throws an exception if you try to get details of a location. This cost is not within our resources.

Clearly B roads in towns like Newton Abbot and Kingsteignton have very different characteristics from those in more rural areas.

A summary of B road exceptions is as follows:

Road Number	From	To	Year	CounterID	buses_and_coaches	cars_and_taxis	two_wheeled_motor_vehicles	LGVs	HGVs	pedal_cycles	Notes	Location Description
B3195	A381	Queen St	2017	10	306	18276	238	3025	352	129	Estimated from counters on A381	Station Road
B3195	Queen St	A383	2017	11	306	18276	238	3025	352	129		The Avenue
B3195	A382	A383	2017	12	73	8361	143	1834	170	5	Estimated from counters on A382, A381	Halcyon Road, Kingsteignton Road
B3195	A380	Strap Lane	2017	13	41	6832	0	522	292	0	Estimated from counters on A380	A 380 to Strap lane Kingsteignton
B3195	Strap Lane	B3193	2017	14	15	3498	13	531	158	0	Estimated from split at Strap lane junction	Through Kingsteignton
B3195	B3193	A383	2017	15	38	4634	40.5	704	169.5	67	Estimate 50% of counter 996221 + section north	
Strap Lane	B3195	B3193	2017	16	40	6490	0	452	276	0	Estimated from split at Strap lane junction	Between RAB towards Chudleigh
B3193	B3195	Strap Lane	2009	996221	46	2272	55	346	23	134	Earlier Count	
B3193	Strap Lane	B3344	2017	17	40	6490	0	452	276	0	Strap Lane	
B3193	B3344	Bridford M	2017	946925	9	1503	32	421	27	125		Teign Valley
B3193	Bridform M	B3212	2017	946919	8	845	18	202	14	21		
B3192	A379	A380	2009	946915	13	6287	53	1196	54	6		
B3212	Exeter	B3193	2009	950869	35	1003	15	76	16	5	Assume same as later counter on B3212	
B3212	B3193	Moretonha	2009	950869	35	1003	15	76	16	5	Assume same as later counter on B3212	
B3212	Moretonha	Postbridge	2009	950869	35	1003	15	76	16	5	Counter on district boundary near Postbridge	
B3387	Widecomb	Bovey	2009	969125	29	1734	14	181	28	4		
B3344	Bovey	B3193	2017	19	29	1734	14	181	28	4	Equal to Widecombe	
B3344	B3193	B3913	2017	18	40	6490	0	452	276	0	As 10	Chudleigh Knighton to Chudleigh
B3344	B3193	A38	2017	20	31	4987	0	31	249	0	10 minus teignvalley traffic	Chudleigh
B3352			2017	21	33	3833	25	455	123	22	Average urban B road	Ashburton
B3380			2017	22	33	3833	25	455	123	22	Average urban B road	Buckfastleigh

Where B Road emissions have been estimated, a calculation is done (in a spreadsheet) based on assigning flows into and out of the B Road based on measured or estimated flows on nearby traffic counters. Some examples of this method of analysis are detailed in Appendix 1 – Detailed B road calculations.

A record of the start and end nodes for each of these B road sections has been made, these are in the Blinks tab of the transport emissions spreadsheet, and are imported to the minorRoadCounters table in the database. The tracing process used for major roads has been extended to trace these links, this identifies the detailed network links between start and end nodes, and assigns a count number to them. Where an existing count point does not exist a pseudo count point is generated to hold the estimate, these are numbered starting from 10 up to 22. The lowest real count point number is 6023.

B Road emissions are summarised in the following table:

B Road Summary		
Vehicle Type	Emissions kt CO2e	Vehicle Kilometres
Buses and Coaches	0.752449691	976650
Cars and Taxis	16.1558352	87082796
Motor Cycles	0.108548144	759564
LGVs	3.350492761	11427116
HGVs	1.615884939	2070368
Total	21.98321073	102316494

These emissions are deducted from the minor road emissions given in the GHG reporting figures to give residual road emissions:

Calculation of residual emissions			
Vehicle Type	Minor Road Emission	B Road Emissions	Residual Emissions
Buses and Coaches	3.4235822	0.752449691	2.6711325
Cars and Taxis	51.4449612	16.1558352	35.2891260
Motor Cycles	0.6928661	0.108548144	0.5843179
LGVs	14.1713754	3.350492761	10.8208827
HGVs	2.5672151	1.615884939	0.9513301
Total	72.3000000	21.98321073	50.3167893

1.10 Emissions for Residual Roads

Residual roads are minor roads that are not B roads

Residual Roads do not have traffic counts, so these need to be estimated. It is proposed that this estimate is based on:

- Length of link
- Weighting by function of link
- A road emission rates for vehicle types.

We have already calculated emissions rates by vehicle type for A roads and make the assumption that emission rates for other roads are the same. We also have annual emissions for each vehicle type, so can estimate vehicle kilometres for each type, by dividing emissions by emissions rate for each vehicle type:

Veh Type	Minor Road Emissions kt	Emissions rate -kg/km	Emissions rate kt/km	veh km	Annual flow = veh km/length	Daily flow (AADF)
Buses and Coaches	2.67	0.77043945	7.70439E-07	3467024.536	1778.391272	4.8723049
Cars and Taxis	35.29	0.1855227	1.85523E-07	190214602.1	97569.53974	267.31381
Motor Cycles	0.58	0.14290849	1.42908E-07	4088755.907	2097.304979	5.746041
LGVs	10.82	0.29320546	2.93205E-07	36905461.46	18930.4546	51.864259
HGVs	0.95	0.78048199	7.80482E-07	1218900.822	625.2285098	1.7129548

An initial estimate of AADF has been made by dividing veh km by total length of residual roads * 365

The total length of residual roads is about 1950km.

Each minor road link is assigned a count_point_id as follows:

Count Point ID	Road function
1	B Road (not currently used)
2	Minor Road
3	Local Road
4	Local Access Road
5	Restricted Local Access Road
6	Secondary Access Road

Counts for each vehicle type are added based on the calculation method described above for residual roads.

Minor roads will have more traffic that local roads and access roads. To account for this weights are applied:

Weights	
ROAD FUNCTION	WEIGHT
Minor Road	4
Local Road	1
Local Access Road	1
Restricted Local Access Road	1
Secondary Access Road	1

These weights are then applied to road lengths to get the weighted total length for residual roads

Weighted Total Length			
ROAD FUNCTION	WEIGHT	Length	Weighted Length
Minor Road	4	1060663.83	4242655.33
Local Road	1	418489.98	418489.98
Local Access Road	1	18171.46	18171.46
Restricted Local Access Road	1	441386.64	441386.64
Secondary Access Road	1	10816.62	10816.62
		1949528.54	5131520.03

The flows for each road function are given by:

$AADF_{vf} = VEHKM_{vf} * Weight/Weighted\_Total\_Length$

(v is vehicles and f is road function).

This gives the following flows for residual road types.

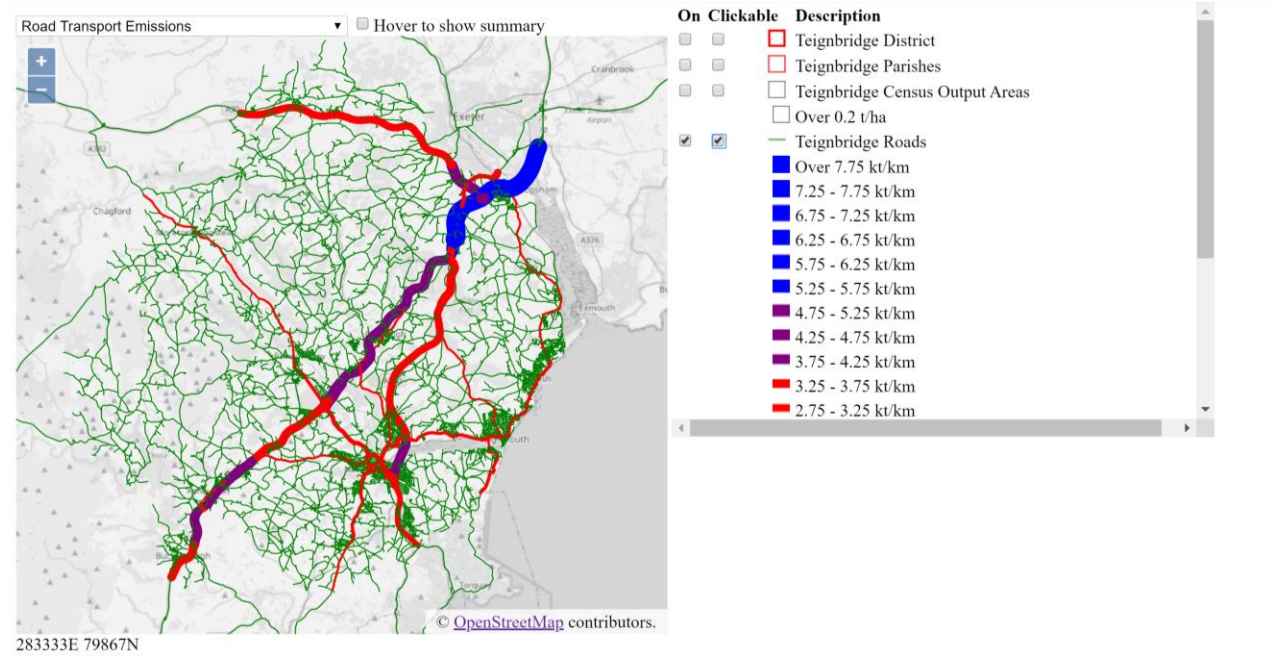
AADF for residual roads						
Road function	Pedal Cycles	Two Wheeled Vehicles	Cars and Taxis	Buses and Coaches	LGVs	HGVs
Minor Road	0	7	406	8	78	2
Local Road	0	1	101	2	19	0
Local Access Road	0	1	101	2	19	0
Restricted Local Access Road	0	1	101	2	19	0
Secondary Access Road	0	1	101	2	19	0

Note that counts have been truncated, which will lead will mean that the emissions total for residual roads will not add up to the emissions from which they are derived. For this reason a correction is applied to individual road emissions derived from estimated flows to arrive at the right emissions total.

This completes the calculations of traffic flow and emissions.

1.11 Presentation of results

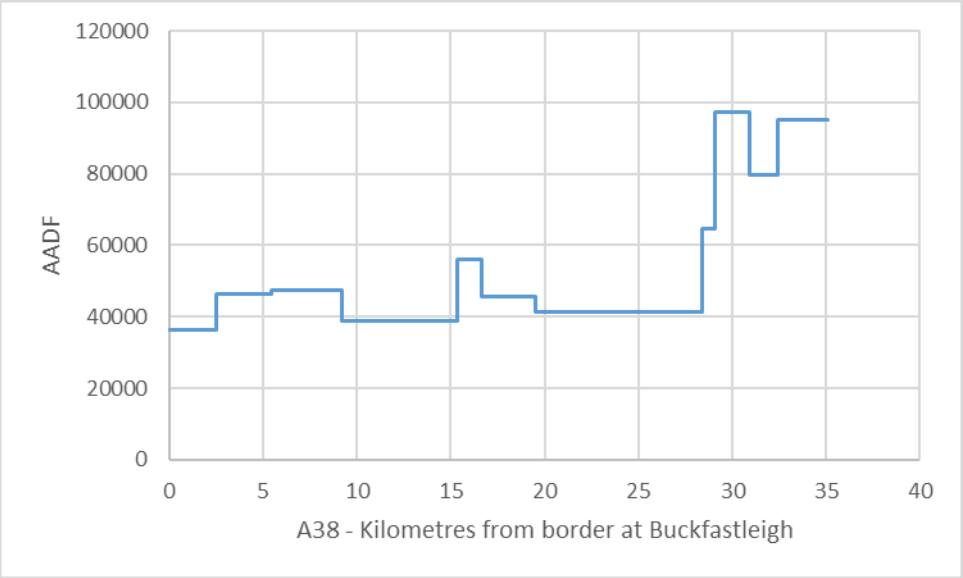
So a map can now be produced showing emissions per kilometre:



Above roads are shown with thickness proportional to emissions per kilometre. Blue above 5.25kt/km, Purple 3.75 to 5.25 kt/km, red 0.25 to 3.75 kt/km, others in green. Emissions not calculated outside the district.

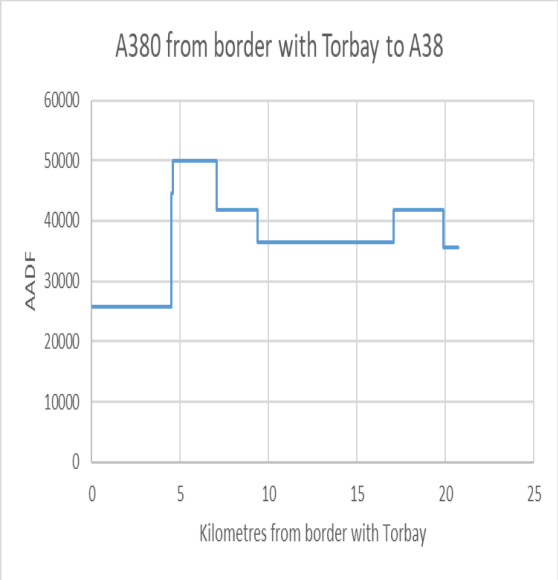
This presentation shows that a significant part of the traffic is local on the A38, A380 and possibly the lower section of the M5, but does not help in quantifying what is generated locally.

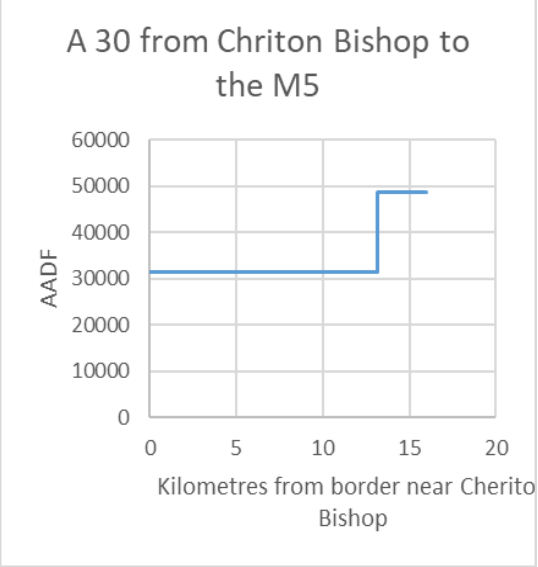
1.12 Flows along principal routes feeding into Exeter and the M5



There is clear evidence of additional local traffic between Ashburton and the A383; A382 and Chudleigh Knighton / Chudleigh. A large increase between the A380 and A379 and from the A30 Eastwards. Traffic volume increases slightly between Buckfastleigh and Haldon Hill.

Traffic on the first section of the A380 from Torbay is noticeably lower than further towards Exeter. The section between the A381 (Penn Inn) and the A383 (Kingsteignton) is noticeably heavier and local. Clearly local traffic has been picked up between Kingsteignton and the A38.





The A30 is much simpler. Traffic beyond the A377 Alphington is probably long distance as there are only a few villages on the route out of the district. The A377 traffic is almost certainly to Exeter.

1.13 Assigning emissions to areas such as Parishes and Output Areas

An initial attempt was made using OA_PARISH, which is the intersection of parishes with outputareas. This was useful in identifying some errors in the OA_PARISH lookup table, but proved to be inaccurate because OutputAreas do not cover features list estuaries, which can have bridges.

Instead separate features have been created as basic building blocks:

- PARISH_ROAD which is the intersection of parishes with the detailed road network.
- OA_ROAD which is the intersection of OutputAreas with the detailed road network.

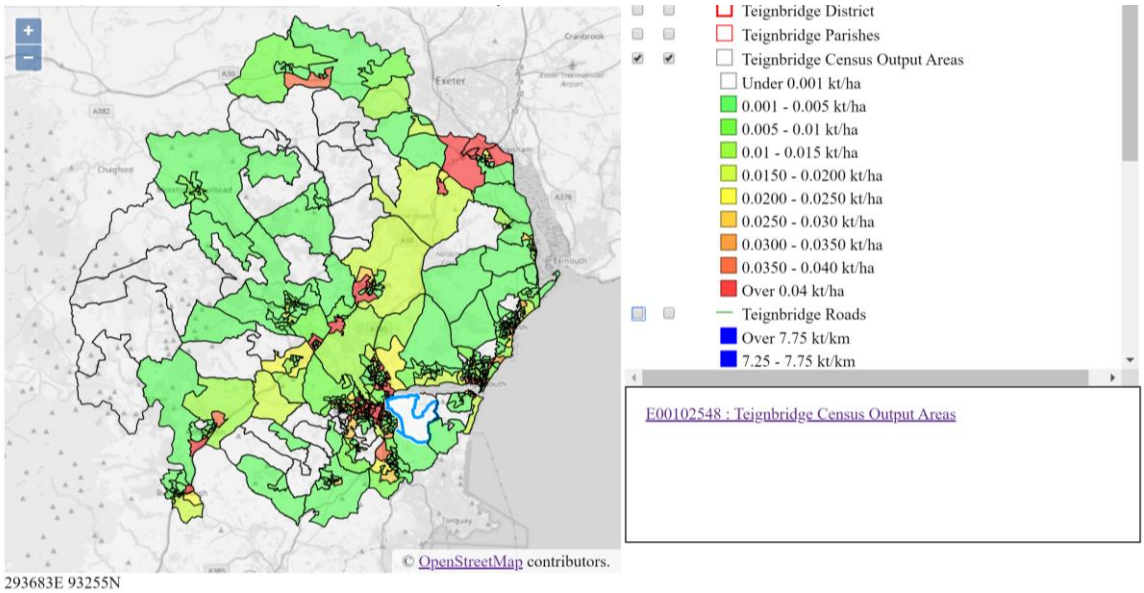
For each link:

- The length of intersection is multiplied by AADF and vehicle emissions rate for each vehicle type to give emissions for each vehicle type.

Emissions for each vehicle type are summed across the area.

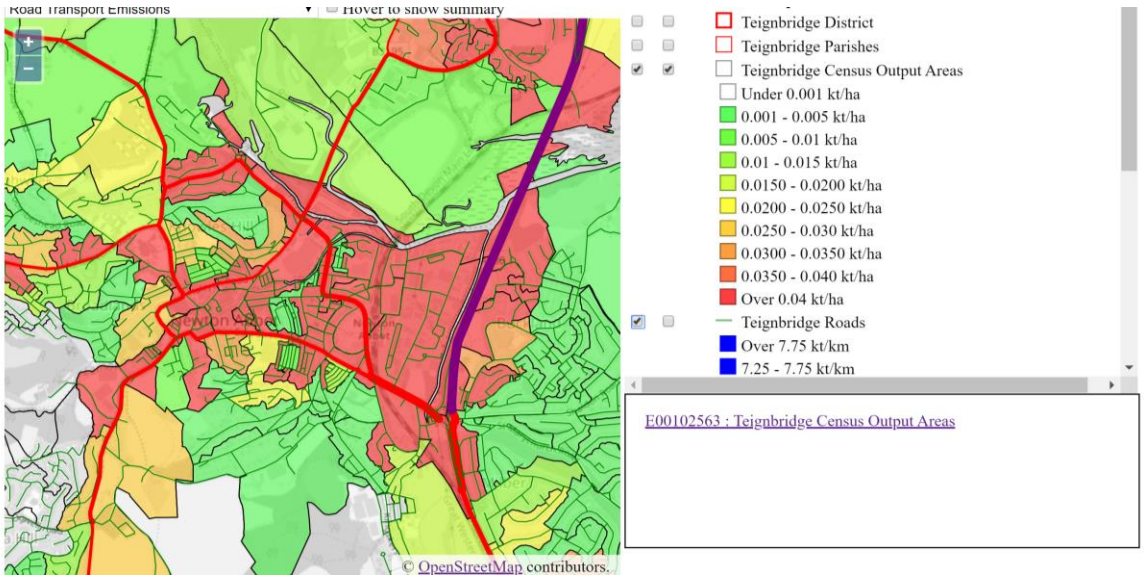
Total emissions are calculated.

This enables a map showing emissions/hectare to be produced:



The reder an area is the worse it is. Red tends to concentrate around trunk roads, road junctions and town centres.

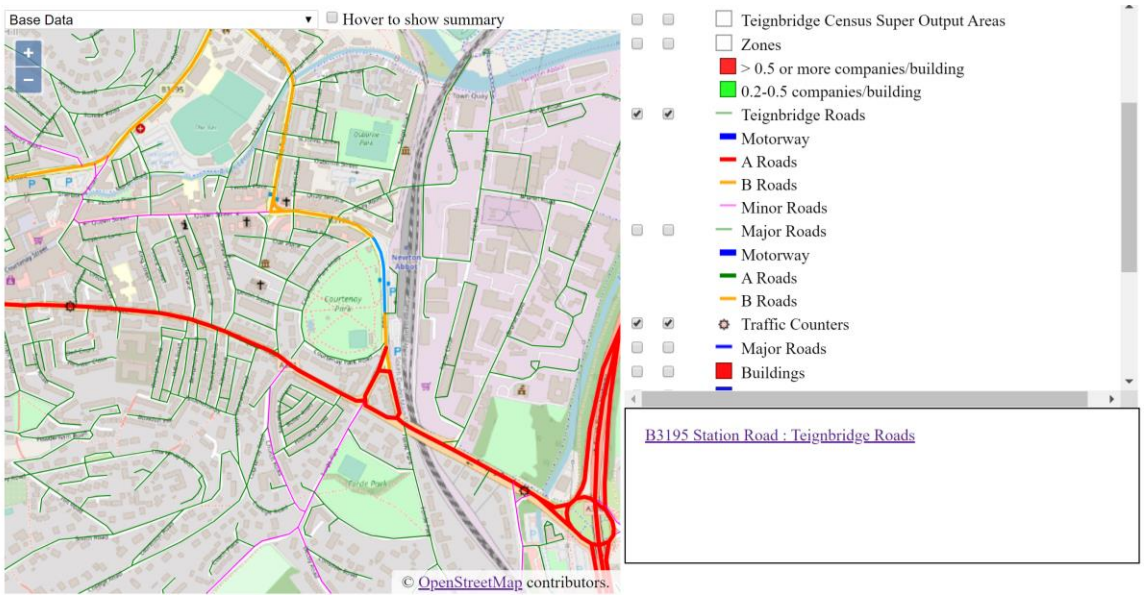
The worst emissions are around the M5, but Newton Abbot centre is also fairly bad.



Section 2. Appendix 1 – Detailed B road calculations

So what follows is a best estimate on an individual basis:

2.1 B3195 Newton Abbot – The Avenue and Station Road



Traffic in the highlighted section by Cortenay Park is related to traffic at the counters at A381 Torquay Road and A381 East Street. There are the following possible vehicle movements:

B3195 Newton Abbot			Variable
From	To	Flow%	Name
A381 East Street	A381 Torquay Road	25%	AB
A381 East Street	B3195	75%	AC
A 381 Torquay Rd	A 381 East Street	50%	BA
A 381 Torquay Rd	B3195	50%	BC
B3195	A 381 East Street	10%	CA
B3195	A 381 Torquay Rd	90%	CB

The flow% are estimates based on personal knowledge of the junction.

It should be possible to get bi-directional flows for the counters, if these are available we can write a set of equations that can be solved:

Let the flow on the measured roads be:

Counter Position	Direction	Variable
A381 East Street	East	AE
A381 East Street	West	AW
A381 Torquay Rd	East	BE
A381 Torquay Rd	West	BW

Then

AE = BA + CA

AW = AB + AC

BE = BA + BC

BW = CB + AB

We have 6 variables and 4 equations, so there are a number of solutions to this within bounds that will now be defined.

The bi-directional counts at this junction for 2017 are:

Bi-Directional Counts 2017									
Counter Pc	Direction	Variable	CounterID	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A381 East S	East	AE	8324	29	7595	168	1647	172	23
A381 East S	West	AW	8324	25	7544	159	1571	124	26
A381 Torq	East	BE	27045	165	16339	227	2634	444	141
A381 Torq	West	BW	27045	177	17743	221	2937	346	100

Unfortunately the A381 Torquay road counter is placed to the west of the junction with Brunel Road, significant numbers of vehicles turn into/out of Brunel Road. The counter also does not count vehicles going north from Sainsbury's. It is assumed that these uncounted movements reduce traffic at the B3195 A381 junction by 20% to 80% of the values above. If we do not do this the calculated traffic volume is unfeasibly high for the road. (it is higher than the A roads that surround the town).

Assume that 20% more of the traffic at 27045 turns onto Brunel estate than goes towards Decoy and Sainsbury's

Reduce A381 Torquay Rd traffic to account for turn difference at Brunel and Sainsbury's							Factor	80%	
Counter Position	Direction	Variable	CounterID	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A381 Torquay Rd	East	BE	27045	165	13071	182	2107	355	113
A381 Torquay Rd	West	BW	27045	177	14194	177	2350	277	80

The minimum flow on the B3195 occurs when no vehicles turn from A381 East St to B3195 North and no vehicles turn from B3195 South to A381 East St Westbound. This gives:

Lower Bound of B3195 flows - all vehicles from A381 East St go to A381 Torquay Rd, all vehicles on A381 East St come from									
Movement				buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A381 East St to A381 Torquay Road				29	7595	168	1647	172	23
A381 Torquay Rd to A381 East St				25	7544	159	1571	124	26
A381 Torquay Rd to B3195 North				152	6650	18	779	153	54
B3195 South to A381 Torquay Road				136	5476	14	460	183	90
B3195 minimum				**288**	**12126**	**32**	**1239**	**336**	**144**

The maximum flow on B3195 occurs when all vehicles on A381 Westbound come from B3195 Southbound and all vehicles on A381 Eastbound turn into B3195 Northbound, in this case assume that Brunel does not have the effect of reducing traffic, giving:

Movement			buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A381 East St to B3195 North			29	7595	168	1647	172	23
B3195 South to A381 East St			25	7544	159	1571	124	26
A381 Torquay Rd to B3195 North			177	17743	221	2937	346	100
B3195 South to A381 Torquay Rd			165	16339	227	2634	444	141
B3195 North max			206	25338	389	4584	518	123
B3195 South max			190	23883	386	4205	568	167
B3195 Max			**396**	**49221**	**775**	**8789**	**1086**	**290**

This is unlikely as this level of traffic is similar to the levels found on the M5.

The true picture lies between these positions, we introduce a flow split for each movement, which reflects what is likely in practice. We specify the split of eastbound traffic on A381 East Street to B3195 and A381 Torquay road, and the split from A381 Torquay road westbound to A3195 north and A381 East Street. These splits can be adjusted in the spreadsheet to arrive at reasonable values, constrained by all values must be positive, and turning from B3195 South to East Street being a difficult manoeuvre that is probably attempted by a small proportion of drivers.

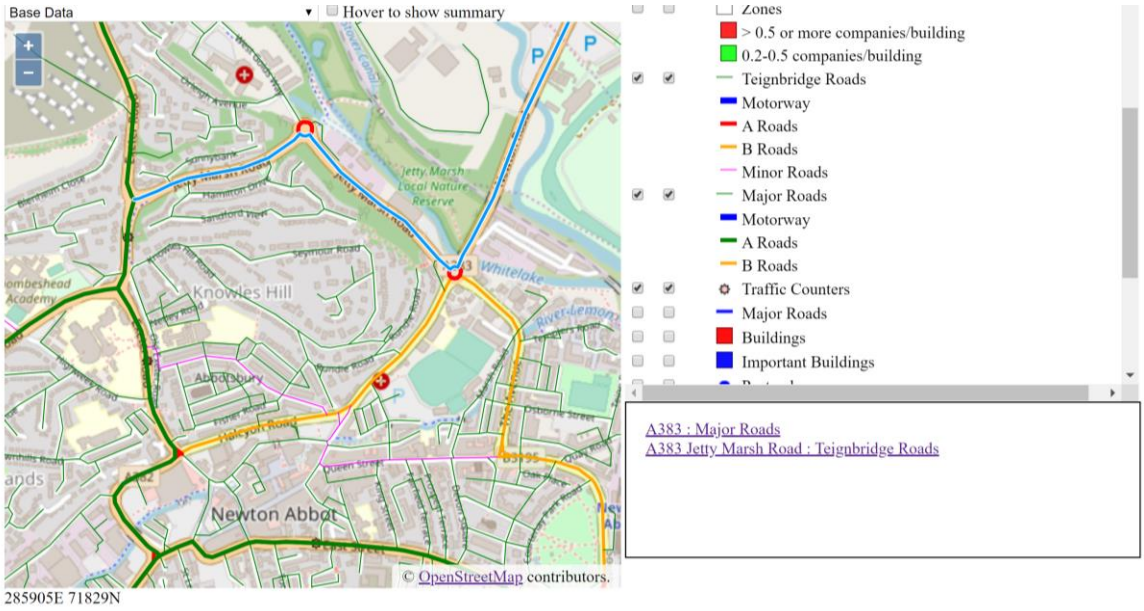
Likely split of manoeuvres									
Manoeuvre			Split	buses_and	cars_and_t	two_whee	LGVs	HGVs	pedal_cycl
A381 East St to B3195 North			10%	2.9	759.5	16.8	164.7	17.2	2.3
A381 East St to A381 Torquay Road			90%	26.1	6835.5	151.2	1482.3	154.8	20.7
A381 Torquay Rd to A381 East St			40%	25	5228.4	72.8	842.8	142	45.2
A381 Torquay Rd to B3195 north			60%	152	7842.6	109.2	1264.2	213	67.8
B3195 South to A381 East St				0	2315.6	86.2	728.2	0	0
B3195 South to A381 Torquay Rd				150.9	7358.5	25.8	867.7	122.2	59.3
B3195 North				154.9	8602.1	126	1428.9	230.2	70.1
B3195 South				150.9	9674.1	112	1595.9	122.2	59.3
B3195				**305.8**	**18276.2**	**238**	**3024.8**	**352.4**	**129.4**

Without the reduction at Brunel, there are about 25,800 cars and taxis on this section of the B3195.

This analysis shows that it is unwise to make general assumptions about flows based on road class alone!

2.2 B3195 – Newton Abbot – Halcyon Road and Kingsteignton Road

This joins the A382 near the cattle market and A383 by the fire station.



The highlighted section of road in the above is the A383 from the major road network, which is deemed to have uniform flow from the counter at Vicarage Hill in Kingsteignton. This is unlikely because there are a lot of retail outlets and the race course along this stretch of road; also the traffic on the B3195 The Avenue will have a significant impact. This suggests that Jetty Marsh will have more traffic than indicated by the Dft counter. The traffic on Kingsteignton Road and Halcyon way is quite heavy, but probably isn't as much as the Avenue, however, given that all this is within Newton Abbot for the purposes of estimating emissions it might be reasonable to estimate this stretch as equal to the Avenue. This would be reasonable, except that the flows on A383 and A382 sections that could contribute to this section of B3195 are all significantly lower than the estimate already given for Station Road. This is probably due to a combination of:

- The assumption that Brunel Road and Sainsbury's traffic cancels out is incorrect.
- Traffic going to the town centre not reaching these roads.

The positioning of the counter on A382 north of the junction with B3195 means that the flow on the section near ASDA will probably be higher than the count, but this can't be that much more because the counters on the A381 are not that high. There aren't good numbers to base this section on, so some assumptions are made:

- Traffic on the A382 section past ASDA is roughly the same in both directions.
- Traffic heading east at the lights by the cattle market splits 70/30 to stay on the A382.
- Traffic on B3195 in both directions is the same.

The flows at related counters are:

Section Halcyon Road and Kingsteignton Road for 2017								
	Counter	Direction	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A382 between A381 and A383	47938	North	94	8170	105	1444	129	16
		South	88	6562	89	1019	96	22
A381 East Street	8324	East	29	7595	168	1647	172	23
		West	25	7544	159	1571	124	26
A381 Totnes Road	78016	North	94	6798	126	1580	71	18
		South	88	6859	129	1623	67	11

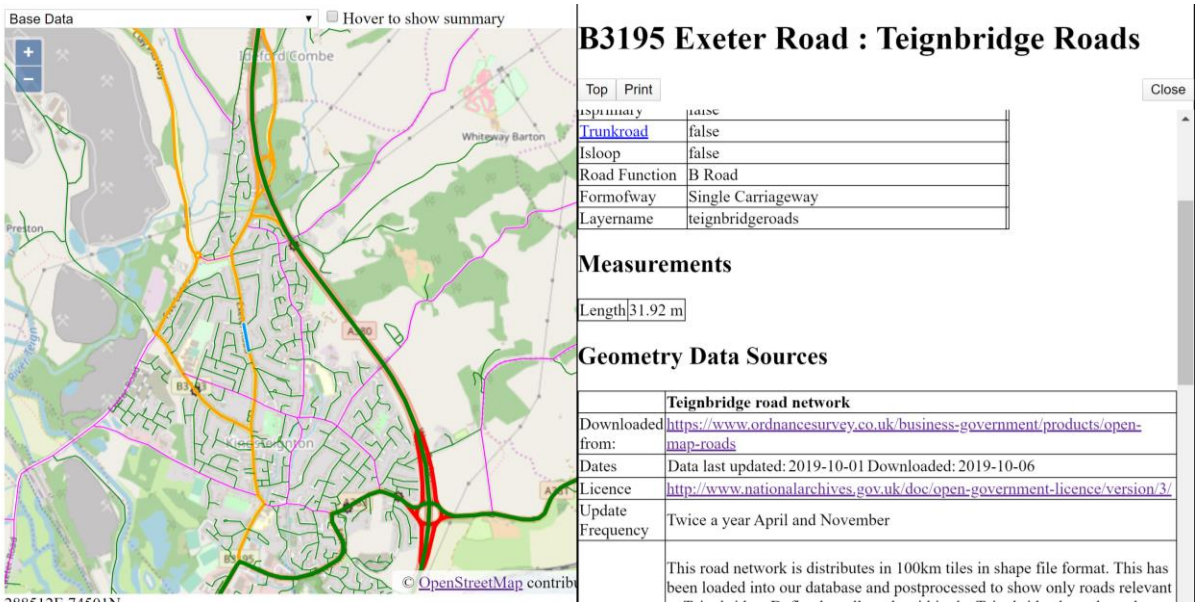
It is suspected that the traffic on the A382 section by ASDA is higher than the section to the north where the counter is. Next the traffic on this section is calculated based on the majority of traffic turning into the A382 from both directions of the A381:

Estimation of flows on A382 section by ASDA from A381 flows								
From	**To**	**Split**	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A381 East Street	A382	70%	17.5	5280.8	111.3	1099.7	86.8	18.2
A381 East Street	A381	30%	7.5	2263.2	47.7	471.3	37.2	7.8
A381 Totnes Road	A382	70%	65.8	4758.6	88.2	1106	49.7	12.6
A381 Totnes Road	A381	30%	28.2	2039.4	37.8	474	21.3	5.4
A382	East Street		0.8	5555.6	130.2	1173	150.7	17.6
A382	Totnes Road		80.5	4595.8	81.3	1151.7	29.8	3.2
A382 North by ASDA			83.3	10039.4	199.5	2205.7	136.5	30.8
A382 South by ASDA			81.3	10151.4	211.5	2324.7	180.5	20.8
A382 Total by ASDA			164.6	20190.8	411	4530.4	317	51.6

These results can then be used to estimate B3195 Halcyon Road

Calculation of flows on B3195 using A382 and A382 by ASDA								
From	**To**	**Split**	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A382 South	B3915 East	20%	17.6	1312.4	17.8	203.8	19.2	4.4
A382 South	A382 South by ASD	80%	70.4	5249.6	71.2	815.2	76.8	17.6
A382 North by ASDA	A382 North	80%	66.64	8031.52	159.6	1764.56	109.2	24.64
A382 North by ASDA	B3195 East	20%	16.66	2007.88	39.9	441.14	27.3	6.16
B3195	A382 South by ASDA		10.9	4901.8	140.3	1509.5	103.7	3.2
B3195	A382 North		27.36	138.48	-54.6	-320.56	19.8	-8.64
B3195 East total			34.26	3320.28	57.7	644.94	46.5	10.56
B3195 West total			38.26	5040.28	85.7	1188.94	123.5	-5.44
B3195 Total			**72.52**	**8360.56**	**143.4**	**1833.88**	**170**	**5.12**

2.3 B3195 Kingsteignton



Traffic on the northern section by the junction with the A380 includes traffic from the B3193 joining and coming from the A380, this part can be estimated on counters on the A380 either side of the junction.

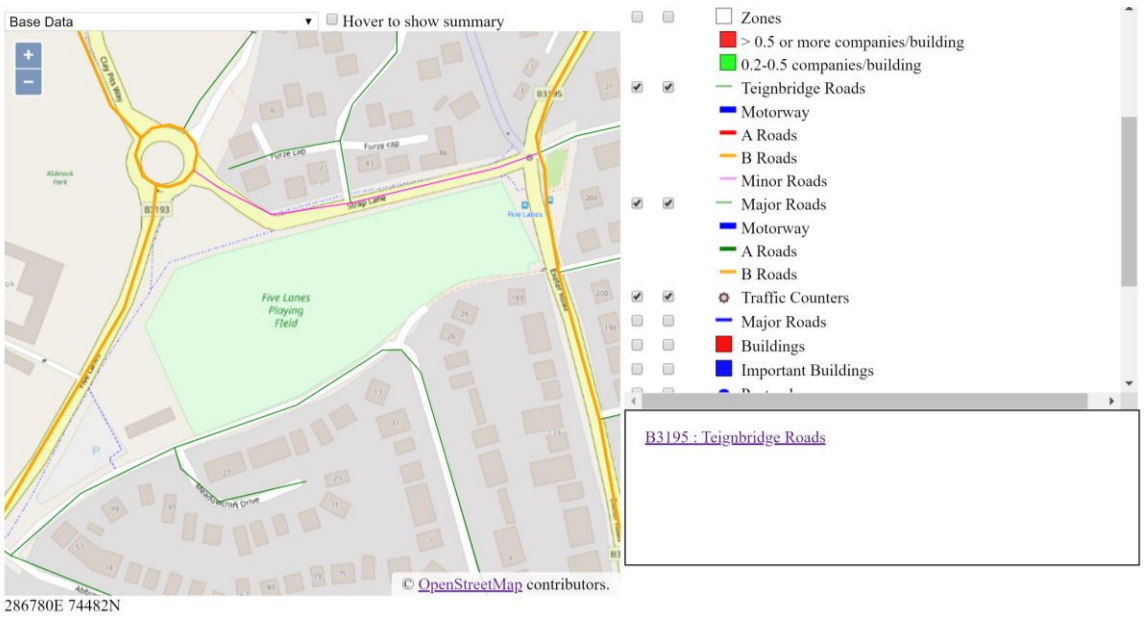
B3195 Kingsteignton								
Section	Counter	Direction	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A380 - A381 to B3195	7015	North	49	16359	170	3463	825	0
		South	66	17205	65	2743	841	0
A380 - B3195 to B3192	16977	North	53	14047	144	2807	638	0
		South	51	14911	162	2970	693	0

There are a small number of minor roads between these counters, the net effect of these is assumed to be negligible.

On this part are estimated as:

From	**To**	**Split**	buses_and	cars_and_t	two_wheel	LGVs	HGVs	pedal_cycl
A380 - A381 to B3195	A380	90%	44.1	14723.1	153	3116.7	742.5	0
	B3195	10%	4.9	1635.9	17	346.3	82.5	0
A380 - B3195 to B3192	A380	88%	44.88	13121.68	142.56	2613.6	609.84	0
	B3195	12%	6.12	1789.32	19.44	356.4	83.16	0
B3195	A380 -> B3192		8.12	925.32	1.44	193.4	28.16	0
	A380 -> A381		21.9	2481.9	-88	-373.7	98.5	0
B3195 North			30.02	3407.22	-86.56	-180.3	126.66	0
B3195 South			11.02	3425.22	36.44	702.7	165.66	0
B3195 Total			**41.04**	**6832.44**	**-50.12**	**522.4**	**292.32**	**0**

Note that some signs are negative in the above, these will be dealt with later by reducing cars and taxis. The negatives could be eliminated by increasing the splits towards the B3195, but this doesn't seem justified.



The estimate above applies to the section north of Strap Lane. The roundabout to the top left of the map joins strap lane with the B3193, which has recently been upgrade. It is suggested that most of the traffic connected with the A380 will use Strap Lane, rather than the section of the B3195 between Strap lane and the B3193 where it splits off further south.

2.4 Other B Roads

Where there are counters for a B Road this value has been used, even if it is from an earlier year.

Where there are no counters values have been estimated based on adjacent sections either with a counter, or where an estimate is available. Details are in the table below:

Road Number	From	To	Year	CounterID	buses_and_coaches	cars_and_taxis	two_wheeled_motor_vehicles	LGVs	HGVs	pedal_cycles	Notes	Location Description
B3195	A381	Queen St	2017	10	306	18276	238	3025	352	129	Estimated from counters on A381	Station Road
B3195	Queen St	A383	2017	11	306	18276	238	3025	352	129		The Avenue
B3195	A382	A383	2017	12	73	8361	143	1834	170	5	Estimated from counters on A382, A381	Halcyon Road, Kingsteignton Road
B3195	A380	Strap Lane	2017	13	41	6832	0	522	292	0	Estimated from counters on A380	A 380 to Strap lane Kingsteignton
B3195	Strap Lane	B3193	2017	14	15	3498	13	531	158	0	Estimated from split at Strap lane junction	Through Kingsteignton
B3195	B3193	A383	2017	15	38	4634	40.5	704	169.5	67	Estimate 50% of counter 996221 + section north	
Strap Lane	B3195	B3193	2017	16	40	6490	0	452	276	0	Estimated from split at Strap lane junction	Between RAB towards Chudleigh
B3193	B3195	Strap Lane	2009	996221	46	2272	55	346	23	134	Earlier Count	
B3193	Strap Lane	B3344	2017	17	40	6490	0	452	276	0	Strap Lane	
B3193	B3344	Bridford M	2017	946925	9	1503	32	421	27	125		Teign Valley
B3193	Bridform N	B3212	2017	946919	8	845	18	202	14	21		
B3192	A379	A380	2009	946915	13	6287	53	1196	54	6		
B3212	Exeter	B3193	2009	950869	35	1003	15	76	16	5	Assume same as later counter on B3212	
B3212	B3193	Moretonha	2009	950869	35	1003	15	76	16	5	Assume same as later counter on B3212	
B3212	Moretonha	Postbridge	2009	950869	35	1003	15	76	16	5	Counter on district boundary near Postbridge	
B3387	Widecomb	Bovey	2009	969125	29	1734	14	181	28	4		
B3344	Bovey	B3193	2017	19	29	1734	14	181	28	4	Equal to Widecombe	
B3344	B3193	B3913	2017	18	40	6490	0	452	276	0	As 10	Chudleigh Knighton to Chudleigh
B3344	B3193	A38	2017	20	31	4987	0	31	249	0	10 minus teignvalley traffic	Chudleigh
B3352			2017	21	33	3833	25	455	123	22	Average urban B road	Ashburton
B3380			2017	22	33	3833	25	455	123	22	Average urban B road	Buckfastleigh

Section 3. Appendix 2 – Note on derived emissions figures to cars and motorcycles

The consumption figures for motor cycles and to a lesser extent cars are surprisingly high.

Emissions by vehicle and road type kg/veh/km		
Teignbridge	Motorways	A roads
Buses and Coaches	0.74902658	0.770439452
Cars and Taxis	0.16825421	0.185522697
Motor Cycles	0.1558699	0.14290849
LGVs	0.25900073	0.293205456
HGVs	0.7611315	0.780481991

In 2009 government set targets for average new car emissions of 140g/km, in 2015 this target was revised to 130g/km. Figures in the table above are substantially higher than this.

The methodology for estimating emissions is described in section 10 of the following document:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/812146/Local_authority_C02_technical_report_2017.pdf

The mix of vehicles in the fleet is accounted for by:

- Traffic activity data – using DfT's national transport census
- ANPR data to identify make, model and age mix.
- Categorises the fleet using Euro emissions standard categories (Euro 1 to 6)
- Uses COPERT5 speed related emissions model, this includes a real-world year dependent correction factor to type approved CO2 emissions.

This methodology will derive worse emissions than new type approved emissions.

Traffic travels on roads with the heaviest traffic (M5, A38, A380, A30) at motorway speeds, which will increase emissions above the average. Older vehicles in the fleet will emit more than they did when new.

In 2009 AEA produced emissions curves by vehicle speed which have been used to estimate vehicle emissions by speed: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/4556/aeat-updated-vehicle-emission-curves.pdf. These curves are polynomials in terms of speed using terms up to the 6^{th} power of speed. Speeds on motorway and near motorway standard roads will also increase emissions.

This may explain emissions from cars, but not the figure for motorcycles. A possible explanation could be undercounting of motorcycles in traffic counts. This could be caused either by counters not registering, registering a different vehicle type or by inability to read a number plate.

This document discusses motorcycle undercounting.

http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(92)_FR.pdf

Why would traffic counts omit some motorcycles, but the fuel consumption figures not include these? This has not been explained.