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Technical note

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1 Introduction

1.1 This Technical Note forms Appendix A of the final Bromsgrove District Core Strategy – Infrastructure Delivery Plan and the Redditch Core Strategy – Infrastructure Delivery Plan – reports produced by Halcrow. The Technical Note sets out the development and assumptions used to develop the modelling tool used to assess and recommend transport infrastructure requirements to support housing and employment growth proposed through the Bromsgrove District Core Strategy and the Redditch core Strategy.

1.2 The Technical Note focuses on the modelling work used to assess the development assumptions put forward for Bromsgrove and Redditch Districts by Worcestershire County Council in 2012. Vehicle/Trip Generation Spreadsheet Highway models were developed for the AM and PM peak periods and development trip numbers were calculated for a 24 hour period in order to assess the number of trips made from proposed Core Strategy development sites by sustainable modes of transport. A commentary of each of the major sections of the spreadsheet gravity model is provided as part of this Technical Note through the use of model screenshots.

1.3 The Technical Note describes the development of the Spreadsheet Gravity Model used to assess the 'Core Development' Scenario and six 'Cross Boundary' scenarios. The 'Cross Boundary' scenarios include all of the development sites put forward through the 'Core Development' scenario and different combinations of additional sites on the north and west fringes of Redditch

2 Overview

2.1 To meet the transport infrastructure objective of the Bromsgrove District Core Strategy and Redditch Core Strategy a means of identifying transport infrastructure required to mitigate the adverse impacts of traffic generated by the proposed development was required. WCC and Halcrow agreed that the most appropriate tool that could be available within the programme to produce the IDP was a spreadsheet gravity model. The model is capable of

assessing the trip generation and distribution from a large number of development sites in the Bromsgrove and Redditch Districts and producing a forecast year assessment scenario.

2.2 The Technical Note summarises the modelling work undertaken to gather the data required to build such a model and the model development process based on the 2022 development assumptions. It describes the content of the gravity model and the relevant assumptions agreed between Halcrow and WCC.

2.3 The spreadsheet gravity model assigns vehicle trips between each of the proposed development sites in Bromsgrove and Redditch Districts to a number of destinations, either located in Bromsgrove or Redditch Districts or in the towns/cities located around the circumference of the Bromsgrove and Redditch area. The destinations were agreed with WCC. The assignment of the trips was based upon the population size and employment numbers of each of these origins and destinations. The trip distribution of all development trips in the gravity model was calculated in line with current WebTAG guidance (TAG Unit 3.5.6 Values of Time and Vehicle Operating Costs, August 2012). All trips were assigned a route between each of the origin and destination zones. The routeing was assumed a single, fixed, assignment.

2.4 The AM peak and PM peak gravity models provide a means to assess the number of development trips predicted to be on the strategic highway network in Bromsgrove and Redditch Districts. The development trips assignment result, when combined with the existing traffic data, allows the assessment of individual link and junction performance with the additional development traffic. Thus, the results provide an indication of areas of the highway network in receipt of greatest impact (in terms of capacity, journey times and performance) as a result of the developments assumptions for Bromsgrove and Redditch.

2.5 In addition, the 24 hour spreadsheet model provides a tool to forecast the number of trips made by sustainable modes of transport from development sites to assist the appropriate identification of infrastructure. Sustainable modes of transport include walking, cycling and public transport.

3 Development Assumptions

3.1 WCC provided Halcrow with a list of 'core' development sites for Bromsgrove District Council (BDC) and Redditch Borough Council (RBC) in 2012 (09/07/2012). See Figure 3.1 for a location plan of Bromsgrove and Redditch Districts.

3.2 Details of the six 'Cross Boundary' scenario tests and the associated development assumptions associated with those sites were supplied to Halcrow on 14/09/2013. Details of the 'Cross Boundary' scenario tests are shown on Table 3.1 and Figures 3.4 and 3.5.

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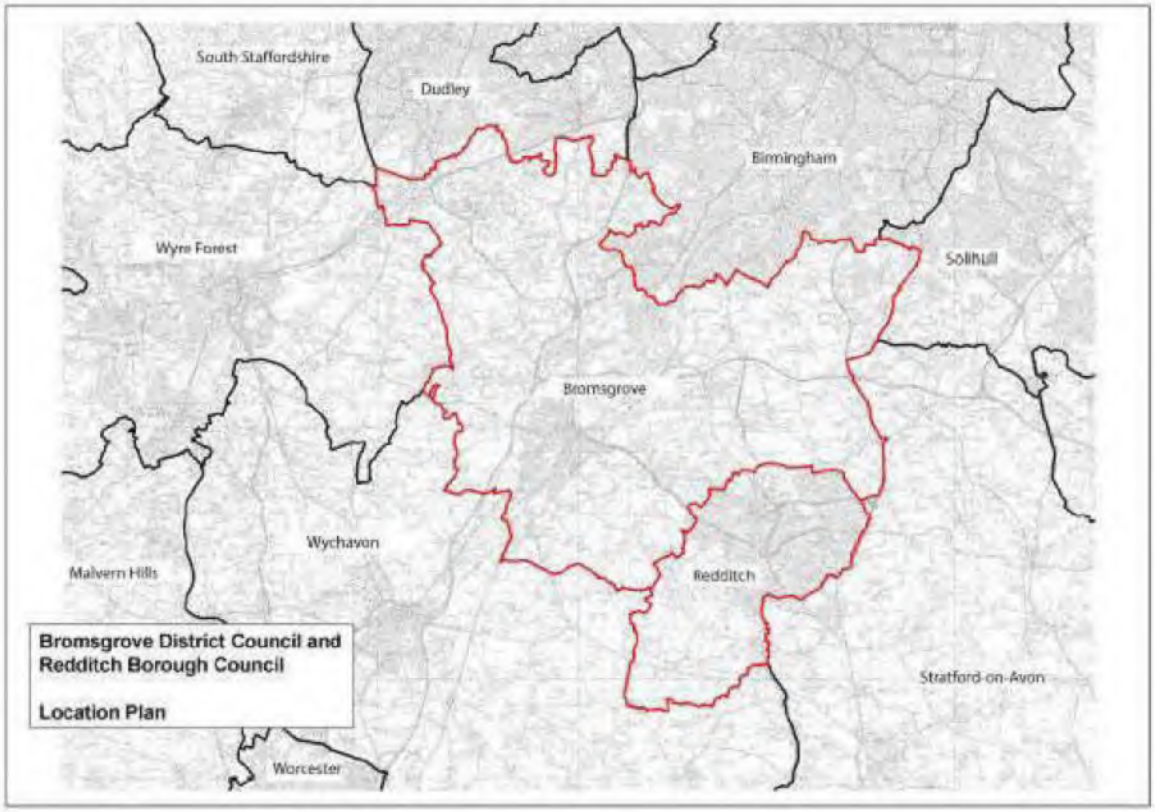
Figure 3.1 – Bromsgrove District Council and Redditch Borough Council Location Plan



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3.3 In order to keep the number of development locations to a manageable size, the individual sites were combined into 'clusters'. 'Clusters' were either taken as a single large development or as a combination of two or more development sites. The developments were grouped into 'clusters' based on their location in relation to the strategic road network, that being, 'clusters' loading onto the strategic road network at the same location/area were placed into a 'cluster' to represent that area. Large developments located away from, and likely to access the strategic road network away from, other development sites/clusters were not grouped with other development sites and were considered as a 'single site cluster'.

3.4 The designation of 'Clusters' was agreed between WCC and Halcrow. A detailed list of all the development sites proposed for Bromsgrove District Council and Redditch Borough Council and the designated 'clusters' is provided in Appendix D. The 'Clusters' are shown on Figures 3.2 to 3.3.

Figure 3.2 – Bromsgrove District Development Clusters – 'Core Scenario'

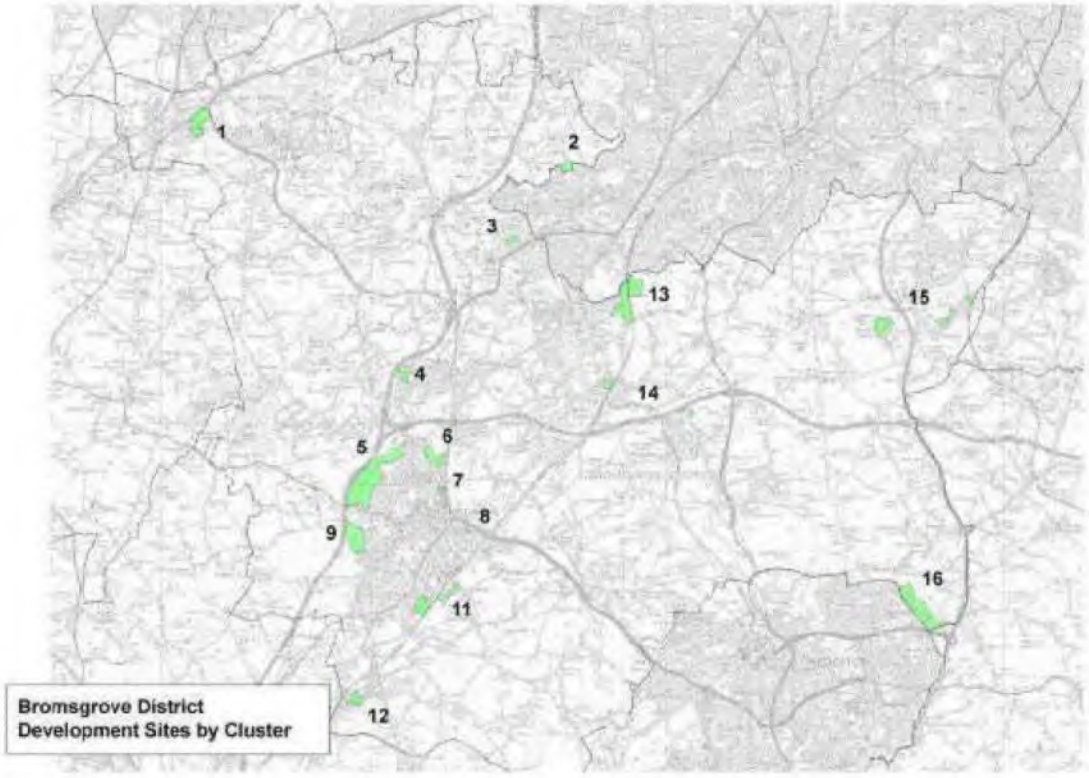

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Figure 3.3 – Redditch District Development Clusters – 'Core Scenario'

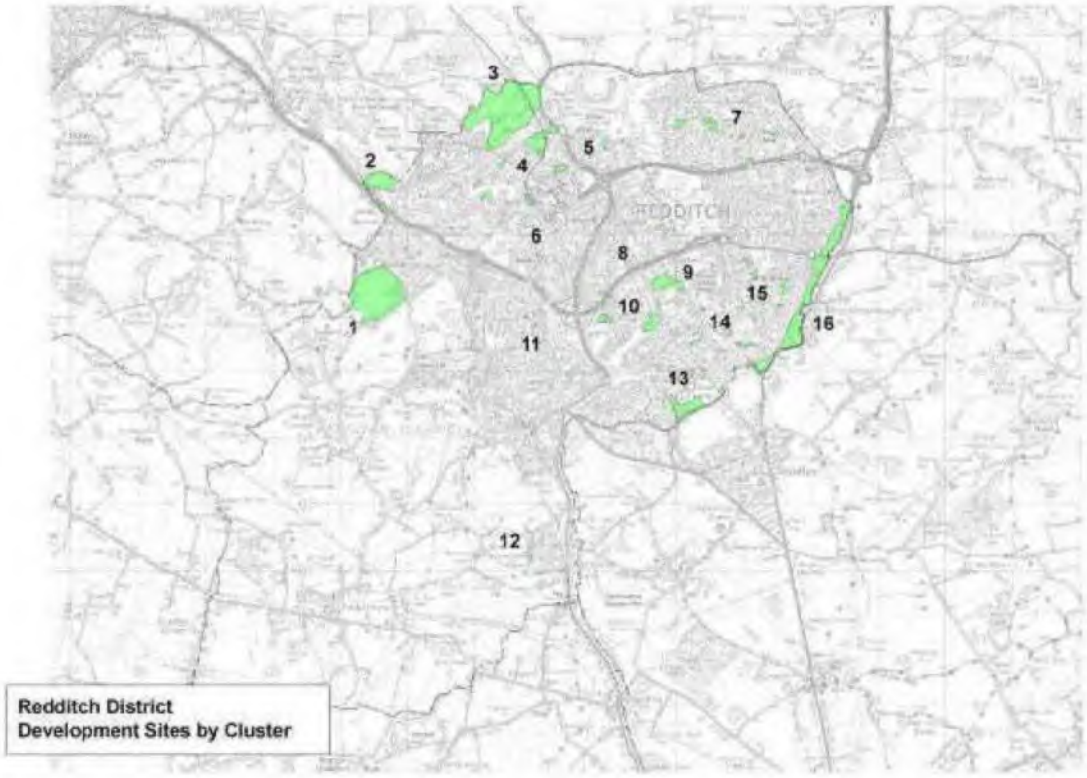

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Figure 3.4 – Bromsgrove and Redditch District – 'Cross Boundary Sites' – Site Locations

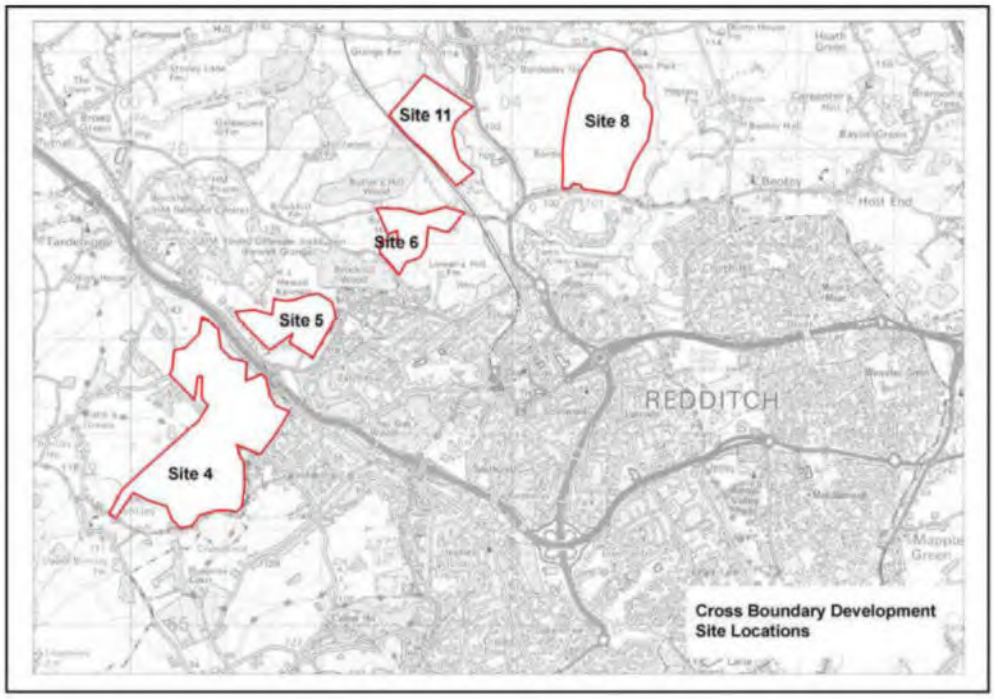
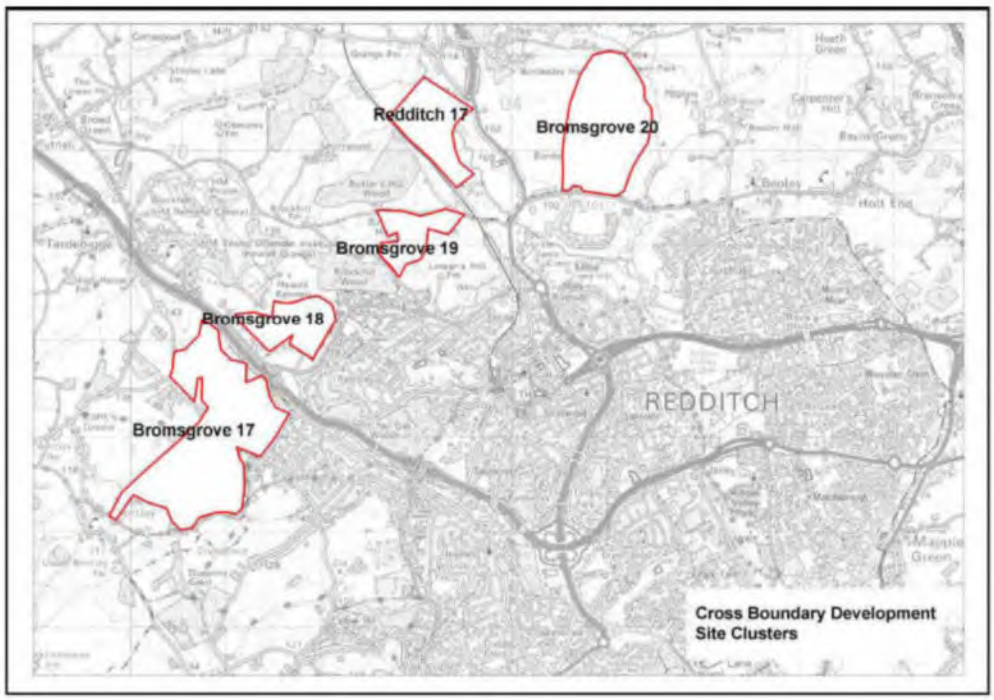


Table 3.1 - Bromsgrove and Redditch District – 'Cross Boundary Sites' – Site details

Scenarios	Residential Dwellings	Employment (ha)
1) Sites 4 & 5	3843	1.85
2) Sites 5, 6, 11 & 4 (Heyford only)	3229	1.85
3) Site 8	4053	3.7
4) Site 4& 5 *	3200	
5) Site 8*	3200	
7) Sites 4 & 6	3400	
8) Sites 6 & 8	3400	

Figure 3.5 - Bromsgrove and Redditch District Development Clusters – 'Cross Boundary Sites'



3.5 WCC also provided Halcrow with 'windfall' and 'commitment' figures for the two districts. The development being allowed for as windfalls and commitments was added to the Clusters included in the SWDP development allocations in order to reflect the magnitude of development planned for the area.

4 Phasing and Likelihood

4.1 The Bromsgrove and Redditch development assumptions were tested as an 'all development' scenario. That is, all sites were included in the modelling work to create one future year scenario.

4.2 This scenario was assessed against a 'Do- Minimum base case', as taken from observed ATC and Turning Count data from 2008-2012 in order to determine the impact of the specific Bromsgrove and Redditch proposed development growth.

4.3 An assessment of background growth and the relationship between the cumulative impact of development and background growth was considered. A means of comparing the calculated traffic flows from the gravity model against Tempro growth factors was developed and is discussed later in this Technical Note.

5 Trip Generation

5.1 The spreadsheet model includes functions to calculate the anticipated number of trips for all modes of transport and takes into account the geographical location of each of the sites in applying appropriate trip rates. Total (all modes) trip generation rates were sourced from the TRICS database. Table 5.1 shows the trip generation rates to be used for the residential development sites.

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Table 5.1 – Residential Trip Rates (all modes)

	Arrivals		Departures	
	AM Peak	PM Peak	AM Peak	PM Peak
Bromsgrove	0.235	0.636	0.837	0.377
Redditch	0.246	0.636	0.842	0.381
Hagley	0.250	0.724	0.820	0.372
Catshill	0.250	0.724	0.820	0.372
Barnt Green	0.279	0.760	0.926	0.382
Astwood Bank	0.279	0.760	0.926	0.382
Wythall	0.258	0.679	0.829	0.371
Longbridge	0.235	0.636	0.837	0.377

5.2 The functionality to test a range of multiple employment types within each of the modelled development 'clusters' was built into the Vehicle/Trip Generation model. As a result, a number of additional Vehicle Trip Rates were required and sourced from the TRICS database and are shown in Table 5.2.

Table 5.2 – Employment Trip Rates (all modes)

	Arrivals		Departures	
	AM Peak	PM Peak	AM Peak	PM Peak
B1 (Bromsgrove)	2.861	0.319	0.305	2.499
B2 (Bromsgrove)	0.915	0.240	0.512	0.685
B8 (Bromsgrove)	0.077	0.009	0.012	0.034
B1 (Redditch)	1.961	0.204	0.176	1.709
B2 (Redditch)	0.594	0.198	0.344	0.498
B8 (Redditch)	0.179	0.062	0.054	0.175
A3	2.444	10.286	0.889	9.714
A1	3.476	3.776	3.167	3.638
C1	0.424	0.78	0.825	0.529
A1	3.476	3.776	3.167	3.638
D2	0	4.582	0	4.335

5.3 The 'Cross Boundary' sites were applied the same trip generation factors as those sites put forward through the 'Core Development' Scenario.

6 Mode Split

6.1 The total number of trips from each of the development sites was calculated using the trip rates set out in Section 5. The trip totals were then distributed between the origins and destinations using the gravity model functions as set out in Section 7. Once the number of trips between origins and destinations were calculated, relevant mode split factors for that particular origin and destination pairing were applied to calculate the number of trips by each mode.

6.2 Census Journey to Work data was used as a reference for the percentage of trips by each mode between each of the origins and destination pairings.

6.3 The mode split factors applied for the origin and destination pairs are shown in Table 6.1.

Table 6.1 – Origin and Destination Mode Split Ratios

	Light Rail	Train	Bus	Taxi	Car Driver	Car Passenger	Motorcycle	Bicycle	On Foot	Other
Bromsgrove - Bromsgrove	0%	0%	2%	0%	54%	7%	0%	5%	32%	
Bromsgrove - Central Redditch	0%	0%	7%	0%	84%	5%	0%	2%	0%	2%
Bromsgrove - Outer Redditch	0%	0%	7%	0%	84%	5%	0%	2%	0%	2%
Bromsgrove - Central Birmingham	0%	14%	3%	0%	78%	2%	0%	1%	0%	2%
Bromsgrove - Outer Birmingham Conurbation	0%	14%	3%	0%	78%	2%	0%	1%	0%	2%
Bromsgrove - Worcester	0%	7%	6%	0%	75%	6%	0%	6%	0%	
Bromsgrove - other surrounding towns	0%	7%	7%	0%	75%	11%	0%	0%	0%	
Hagley - Birmingham/Dudley/Kidderminster/Worcester/Sandwell	0%	13%	4%	0%	79%	4%	0%	0%	0%	
Hagley - other surrounding townds	0%	10%	1%	0%	73%	12%	0%	4%	0%	
S Birmingham Conurb - Central Birmingham	0%	12%	4%	0%	77%	4%	0%	2%	0%	1%
S Birmingham Conurb - Outer Birmingham Conurb	0%	12%	4%	0%	77%	4%	0%	2%	0%	1%
S Birmingham Conurb - Other Surrounding Towns	0%	8%	7%	0%	77%	6%	0%	2%	0%	
S Birmingham Conurb - Other Surrounding Towns	0%	8%	7%	0%	77%	6%	0%	2%	0%	
Outer Redditch - Central Redditch	0%	0%	15%	0%	53%	8%	1%	4%	19%	
Outer Redditch - Outer Redditch	0%	0%	15%	0%	53%	8%	1%	4%	19%	
Central Redditch - Bromsgrove	0%	0%	5%	0%	79%	15%	0%	1%	0%	
Outer Redditch - Bromsgrove	0%	0%	5%	0%	79%	9%	2%	3%	0%	2%
Redditch - Central Birmingham	0%	22%	4%	0%	72%	2%	0%	0%	0%	
Redditch - Outer Birmingham Conurbation	0%	22%	4%	0%	72%	2%	0%	0%	0%	
Redditch - other surrounding towns	0%	0%	5%	0%	81%	10%	0%	4%	0%	

7 Trip Distribution

7.1 The trip distribution was calculated using the gravity model functionality. A gravity model uses data on the size of destination zones (population and employment data) and time and distance between origin and destination sites to assess the relative attractiveness of different locations.

7.2 The generalised cost functions, used by the gravity model to calculate the number of trips between all origins and destinations, were calculated according to WebTAG guidance. The population and employment numbers were calibrated to determine the number of trips between origins and destinations on the basis of relative attractiveness of different locations.

7.3 The WebTAG guidance equation used to distribute the development trips between origins and destinations calculates the generalised cost of trips through a function of the Value of Time and Vehicle Operating Cost. In order to inform these functions, the time and distance between all origins and destinations was taken from the Multimap website to ensure a consistent approach. As the distance and time functions were used to distribute the development trips around the network, to ensure consistency, the same method for obtaining the distance and time taken to route between all the origins and destinations was utilised.

7.4 An example of the assignment table of the origin and destination zones in the gravity model is shown in Figure 7.1.

Table 7.1 – Vehicle/Trip Generation Model Assignment Trip Matrix Example (Note: Numbers shown are for indicative purposes only)

Trip Assignment: Destination of Residential Trips in AM Peak

		DESTINATION						
ORIGIN	Total Trips	Bromsgrove Town Centre	Bromsgrove Technology Park	Bromsgrove Birmingham Rd	Bromsgrove Perryfields	North East Redditch Ravensbank	Longbridge	Redditch Town Centre
Bromsgrove - Cluster 1	324	3	1	4	0	1	10	5
Bromsgrove - Cluster 2	85	1	0	1	0	0	6	1
Bromsgrove - Cluster 3	57	1	1	2	0	0	7	1
Bromsgrove - Cluster 4	100	6	1	8	1	0	5	3

7.5 The origin zones are the series of 'clusters' made up of the development sites. These 'clusters' include either one large development site or a combination of smaller development sites.

7.6 The number of clusters by each district is as follows for the 'Core Development' Scenarios:

- Bromsgrove – 16 development clusters (Figure 3.2); and
- Redditch – 16 development clusters (Figure 3.3).

7.7 The 'Cross Boundary' Development Clusters were allocated into five additional clusters as shown on Figure 3.4. The destination zones are the larger populated towns within Bromsgrove and Redditch Districts and key attractors beyond the District boundaries but within reasonable journey time/commutable distance. These are shown on Figure 7.1.

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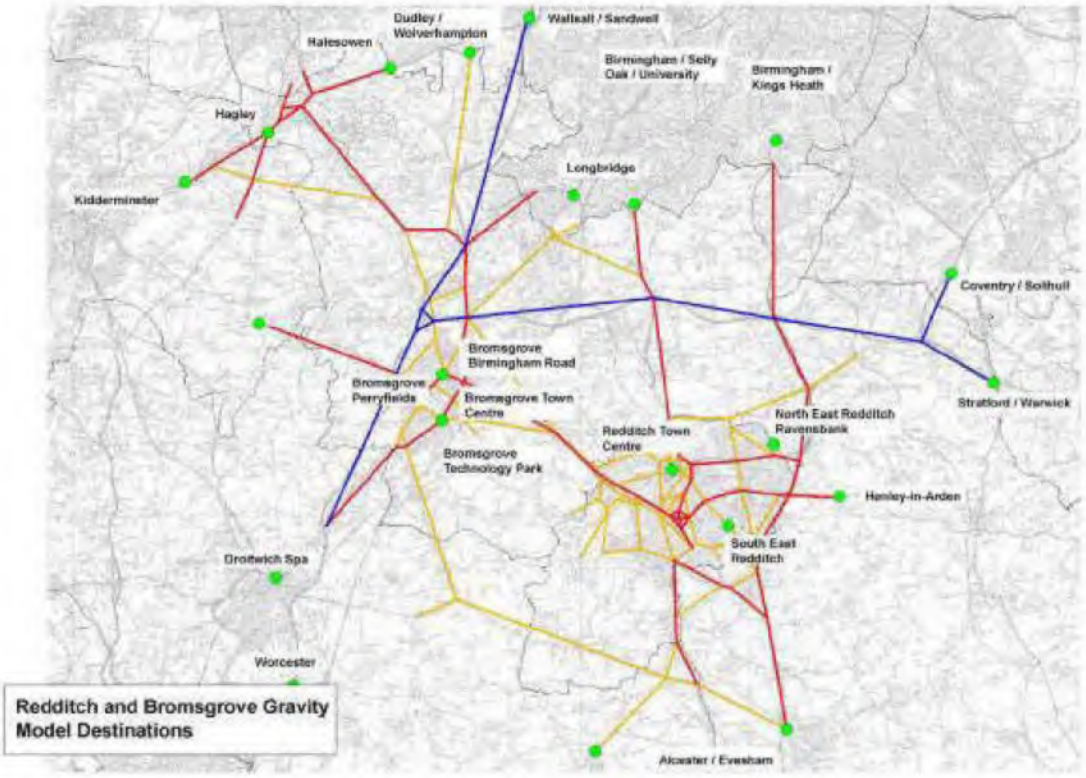
Figure 7.1 – Vehicle/Trip Generation Model Destination Zones



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7.8 Four trip distribution matrices were calculated for both the AM and PM peak models. The four trip matrices were for the following;

- Residential Site Departure Trips;
- Residential Site Arrival Trips;
- Employment Site Departure Trips; and
- Employment Site Arrival Trips.

7.9 The Bromsgrove and Redditch Core Strategy development clusters were referred to as 'origins', and the major population and employment centres within and surrounding Bromsgrove and Redditch Districts were referred to as 'destinations'. However, to accommodate the relevant trip rates, the origins and destinations were reversed in the trip matrices where necessary. The 'Departure' trip matrices have assumed the Bromsgrove and

Redditch Districts development sites are the 'origins', and the major population and employment centres within and surrounding Bromsgrove and Redditch Districts are the 'destinations'. The 'Arrival' trip matrices have assumed the major population and employment centres within and surrounding Bromsgrove and Redditch Districts are the 'origins' and the Bromsgrove and Redditch Districts development sites are the 'destinations'.

7.10 For the AM peak model, trips included in the Residential Site Departure Trip Matrix were calculated using the employment numbers trip attractor at their destinations as the appropriate balancing factor. The Employment Site Arrival Trip Matrix was calculated using the population number as a function of their origin as the balancing factor. For the AM peak 'counter movements', these being Residential Site Arrival Trips and Employment Site Departure Trips, an average of the population size and employment number functions was used to calculate the trip distribution.

7.11 For the PM peak model, the assumptions used in the AM peak model were transposed. That is, trips included in the Residential Site Arrival Trip Matrix were calculated using the employment numbers at their origin and trips included in the Employment Site Departure Trip Matrix were calculated using the population size of their destination. For the PM peak 'counter movements', these being Residential Site Departure Trips and Employment Site Arrival Trips, an average of the population size and employment number functions were used to calculate the trip distribution.

7.12 WebTAG guidance was applied to calculate a generalised cost for all trips between all origins and destinations based on Value of Time and Vehicle Operating Costs. For further information regarding the generalised cost calculations refer to WebTAG guidance (TAG Unit 3.5.6 Values of Time and Vehicle Operating Costs, August 2012).

8 Single, Fixed, Route Assignment

8.1 The trips between all origin and destination zones were calculated using the gravity model. The sum of all four trip matrices for each time period were summed up and applied to the strategic highway network in Bromsgrove and Redditch Districts. The highway links included, as agreed, between Halcrow and WCC are as shown in Figure 8.1.

8.2 The routeing pattern between origin and destination zones was based on an all or nothing assignement. That is, all trips between an origin and a destination will follow the same route on a single, fixed, assignment routeing pattern. Routes between all origins and destinations which make the journey in the reverse direction will be assumed to follow in same routeing pattern but in reverse.

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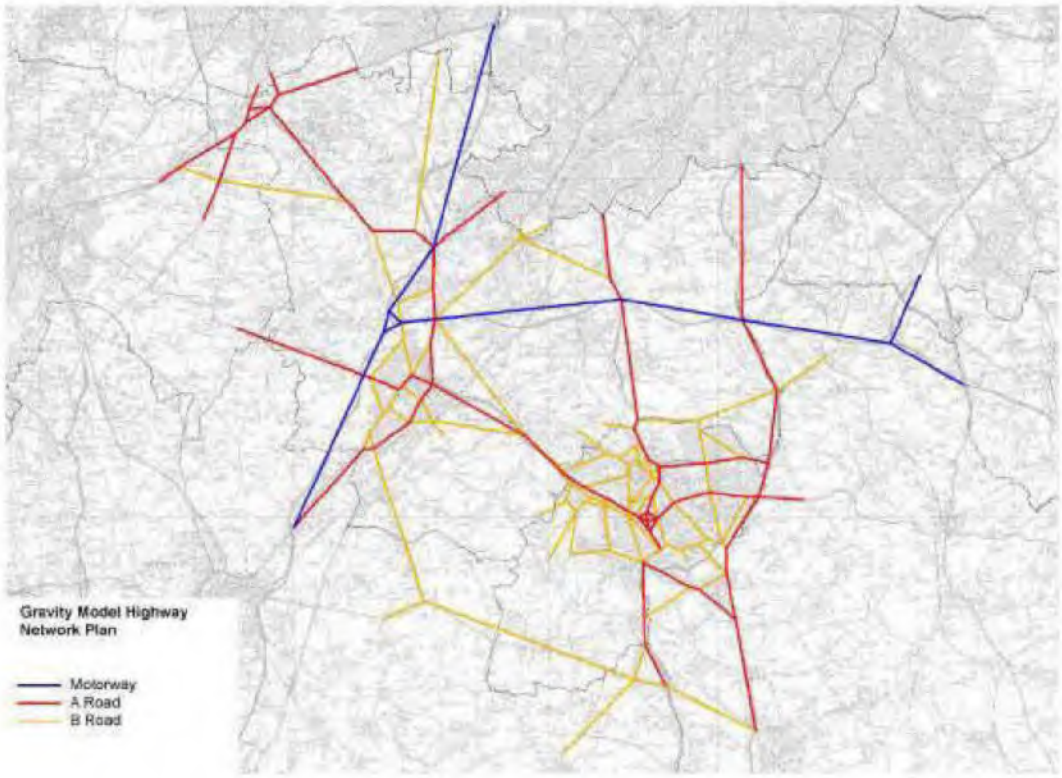
Figure 8.1 – Gravity model highway network



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9 Background Growth

9.1 Background growth for the AM and PM peak periods was considered through an analysis of Tempro Data. Tempro data provides a predicted background growth and is available for sub-areas within the area covered by the Bromsgrove and Redditch Districts, as shown in Tables 9.1 and 9.2.

9.2 Tables 9.1 and 9.2 also show, by way of example, selected main highway links from the spreadsheet model and the growth experienced on the links as a result of the assessment of impact of development traffic.

Table 9.1 – AM Peak Background Growth Analysis

AM Peak Background Growth Analysis			
Name	Tempro AM Growth Factor	Spreadsheet Gravity Model Network Link	Spreadsheet Gravity Model Network Growth
Bromsgrove	1.0410	A38 Birmingham Road (NB)	1.492
		Finstall Road (EB)	1.091
		Perryfields Lane (SB)	3.710
		Whitford Road/Fox Lane (NB)	1.919
Redditch	1.0009	A441 Birmingham Road (NB)	1.363
		B4497 Battens Drive (NB)	1.196
		A441 Evesham Road (Astwood Bank) (NB)	1.084
		B4184 Windsor Road (EB)	2.007

Table 9.2 – PM Peak Background Growth Analysis

PM Peak Background Growth Analysis			
Name	Tempro AM Growth Factor	Spreadsheet Gravity Model Network Link	Spreadsheet Gravity Model Network Growth
Bromsgrove	1.0470	A38 Birmingham Road (NB)	1.982
		Finstall Road (EB)	1.047
		Perryfields Lane (NB)	3.104
		Whitford Road/Fox Lane (NB)	1.199
Redditch	1.0202	A441 Birmingham Road (NB)	1.650
		B4497 Battens Drive (NB)	1.270
		A441 Evesham Road (Astwood Bank) (NB)	1.133
		B4184 Windsor Road	2.511

9.3 Comparing the two increase proportions it can be seen that the development related increase is greater than the TEMPRO increase. This means that the increase in demand as a result of Bromsgrove and Redditch development exceeds the TEMPRO increase. Increases contained in TEMPRO are largely a function of the summation of additional development, with a smaller proportion a result of, for example, longer journeys and mode change. Also, it is noted that the highway impact assessment work undertaken has focussed on the main routes. It is recognised that local routes will act as feeder routes to this network, and on these location routes (if the same analysis was undertaken) TEMPRO could, but not always, exceed development growth.

9.4 It is therefore considered, as this analysis was conducted at sufficient a strategic level, that the development traffic increases adequately reflect overall traffic increases.

10 Cumulative Impact

10.1 The cumulative impact of the development trips will be assessed at key junctions, as identified and agreed between WCC and Halcrow, using the Vehicle/Trip Generation model trip matrices and the result of applying these to highway network included in the model using the single, fixed, assignment process. The Vehicle/Trip Generation model outputs traffic flows for each of the links approaching the key junctions for both the AM and PM peak periods. A comparison of these link flows against current traffic flow data provides an indication of the anticipated future year performance of the junctions.

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10.2 A generic capacity was assumed for each junction type based on those used the development of the Worcester Transport Model. This capacity was included in the model to allow the comparison of the model flows against the capacity of the junction thus providing an indication of whether the junction will operate either below, at, or above capacity. Table 10.1 shows the assumed capacities applied across the network. These capacities were assessed with reference to the WTM.

Table 10.1 – Junction Capacities per Junction Type

Junction Type	Capacity
Priority Junction Mainline 1 Lane Approach	1200
Priority Junction Mainline 2 Lane Approach	2500
Priority Junction Give Way Approach 1 Lane	300
Priority Junction Give Way Approach 2 Lane	500
Signal Junction Mainline 1 Lane Approach	600
Signal Junction Mainline 2 Lane Approach	1000
Signal Junction Mainline 3 Lane Approach	1400
Signal Junction Give Way Approach 1 Lane	400
Signal Junction Give Way Approach 2 Lane	800
Roundabout Junction 1 Lane Approach	800
Roundabout Junction 2 Lane Approach	1200
Roundabout Junction 3 Lane Approach	1500
Roundabout Junction 4 Lane Approach	1800
Mini - Roundabout Junction 1 Lane Approach	400
Motorway Mainline 3 Lanes	5700

10.3 The requirement for a mitigation measure (scheme) was driven by the identification of junctions which are shown to operating at, or over capacity in the gravity model in the AM peak and PM peak periods, based upon the data parameters included in Table 10.1.

11 Concluding remarks

11.1 The Model developed provides an area wide assessment tool showing the transport impacts for Bromsgrove and Redditch Districts. This Technical Note has described the methodology adopted to build the Model and has noted the assumptions made during this process.

11.2 In terms of analysis of the highway network, the Vehicle/Trip Generation model was used to identify the junctions predicted to be under pressure as a result of the development proposals put forward for the Bromsgrove and Redditch areas. In order to further the design of any mitigation measures it is recommended that more detailed assessments are undertaken on a more local basis.

11.3 In terms of analysis of the sustainable modes, the model demonstrates requirements for walk, cycle and PT infrastructure and services to accommodate forecast demand and mitigate/limit impact of forecast vehicle trips generation.