THE QUADRO 2021 MANUAL

PART 5

THE TRAFFIC INPUT TO QUADRO

Contents

Chapter

1. NETWORK DESCRIPTION

1.1 The QUADRO user needs to define the characteristics of the QUADRO network affected by the presence of the works, see Figure 1/1. The network elements required by the program are: the works site; the adjoining sections of main route upstream and downstream of the site, as far as the junctions where diverting traffic is modelled as leaving and rejoining; the next adjacent upstream section on the main route, as far as the next major junction; and the diversion route. This network must be specified separately for both directions of travel. All jobs between points A and B can be modelled in a single QUADRO run. However, separate QUADRO networks must be defined for jobs on other parts of the network being assessed.

1.2 For the purposes of the model, all diverting traffic is assumed to follow a single route, as the diagram shows for one direction of travel. The other direction may be modelled with a different diversion route having the same or different end points.

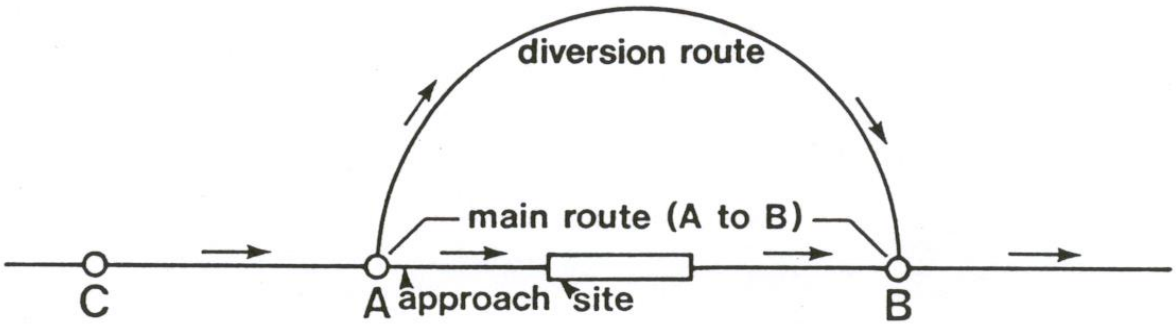


Figure 1/1: Basic Elements of the Network

Diverting traffic leaves the main route at point A, follows the entire diversion route, and returns to the main route at point B. In practice, of course, whereas some traffic will divert in this way, some will leave at A and re-assign the remainder of its trip, not returning to the main route. Other traffic will re-assign the first part of its trip, join the diversion route at some point and continue via B. Other traffic will travel by a substantially different corridor, or at a different time, or will be suppressed. As a proxy for all these possibilities, the model makes the simplifying assumption of continuity of flow both in space - that is, all traffic proceeds right through the network, and in time - that is, traffic demand is unaltered by the presence of the works. The model also ignores any second order diversion effects, that is, traffic already using the diversion route remains on it, despite any increases in journey time. If the specification of the diversion route is particularly problematic, defining the route by means of a 'maximum queuing delay' relationship, see Chapter 2, may be helpful.

Main Route Without Works

1.3 The main route is treated as a single link joining junctions A and B. It is assumed to be of consistent layout and to have no significant flow variations along it. In some circumstances (when queues are long enough) the model calculates journey times along part of the main route upstream of junction A. If this occurs the model assumes as a simplification that the characteristics are as for AB. (Junction C is significant in the Incident Sub-Model only, see paragraph 1.10**).** The user is required to specify the length AB (and AC), and to input road class and selected geometric characteristics for AB, which QUADRO uses to calculate a speed/flow relationship, following methods identical to those presented in Part 5 of the COBA Manual. The road classes are listed in Table 1/1.

Road Class	Description
1	Rural single carriageway
2	Rural all-purpose dual 2 lane carriageway
3	Rural all-purpose dual 3 or more lane carriageway
4	Motorway (urban or rural), dual 2 lanes
5	Motorway (urban or rural), dual 3 lanes
6	Motorway (urban or rural), dual 4 or more lanes
7	Urban road, Non-central, single or dual carriageway
8	Urban road, Central, single or dual carriageway
9	Small town road, single or dual carriageway
10	Suburban Main Road, single carriageway
11	Suburban Main Road, dual carriageway

Table 1/1: QUADRO Road Classes

Classes 1 to 6 are used for all-purpose roads and motorways that are generally not subject to a local speed limit. Classes 7 and 8 are used for roads in large towns or conurbations subject to 30 mph (48 kph) speed limits only. Class 9 is used in small towns or villages for routes subject to a 30 mph (48 kph) or 40mph (64 kph) speed limit. Classes 10 and 11 are used for major suburban routes in towns and cities that are generally subject to a 40 mph (64 kph) speed limit. QUADRO works with average speeds, which are not permitted to exceed the specified speed limit. As a simplification cost calculations are performed using a single weighted average speed for all vehicle categories.

Main Route With Works

1.4 The site is defined by its type (that is, number of lanes open, and form of traffic control), length, and position relative to junction A on the main route. Whereas the main route itself is assumed to have the same characteristics in both directions, the site need not have. The direction directly affected by any obstruction is termed **the primary direction**. The other direction is termed **the secondary direction**. For each direction the site is located by the distance from the point of departure of the diversion in that direction (A in Figure 1/1) to the start of the site in that direction. This section is termed the **approach**. The corresponding section beyond the site to the point of return of the diversion is termed the **after section**. The definition of **site length** depends on the type of road and the form of layout being used. For dual carriageways the **length required is that suffering a reduction in width, that is, from start of coning to end of coning.** On single carriageways, two types of layout can be modelled. If there is shuttle working, (that is, a single lane controlled by fixed message signs, the priority rule, stop-go boards, or signals), **the site length is the distance between the stopping points,** whether these are specifically signed or not, at either end of the site (for example, for signals the length will on average be the distance between the signal heads plus 0.03km). The other method of operation does not involve shuttle working; either two lanes are open (one in each direction), or one direction is open and the other closed, in which case all the traffic in that direction diverts. In these cases the site length is again defined by the section suffering reduced width. The form of layout is specified for each direction of travel by the works type, as defined in Table 1/2.

Works Type	Description
0	No lanes open in this direction
1	One lane open in this direction
2	Two lanes open in this direction
3	Three lanes open in this direction
4	Four lanes open in this direction
5	Five lanes open in this direction
9	Shuttle working
add 10	if layout features contra-flow working, for example, works type 12 indicates 2 lanes open in contra-flow

Table 1/2: QUADRO Works Types

1.5 In the case of dual carriageway works, and single carriageway work without shuttle operation, the site length used in the main delay model is in fact longer than the value defined above and input by the user. This allows for there being a significant effect on traffic speeds in the approaches to the start of the traffic management layout. On dual carriageways the input site length is increased by 30 percent, up to a maximum of 0.6km. On single carriageways without shuttle operation there is a fixed 0.03km increase.

1.6 The program calculates journey times in the approach to the site and the after section using the main route speed/flow relationship. For the site itself a journey time relationship or speed flow relationship is automatically selected according to the road class and works type. Tables 1/3 and 1/4 summarise the relationships used. Those for motorway and dual carriageway works are based on relationships produced in 1988 (Ref 5.1). The relationship for shuttle working sites is derived in Chapter 10. In all cases a constraint is applied so that, even for main routes with particularly poor geometry, the speed in the site cannot exceed the speed elsewhere on the main route (excluding any queue). The main route (without works) speed/flow relationships are set out in more detail in Part 5 of the COBA Manual.

<u>Journey Time Relationships for Works Sites in QUADRO have the following general form:</u>

$$JT = K + K_1*Bendiness + K_2*Hilliness/2 + K_3*Flow$$

where: JT = journey time in minutes per km,
Bendiness is measured in deg/km, input on ROAD RURAL KEY 046,
Hilliness is measured in m/km, input on ROAD RURAL KEY 046,
Flow is veh/hr/standard (3.65m) lane,
K, K_1, K_2 and K_3 are constants dependent on Road Class, Works Type and Flow for light and heavy vehicles.

Road Class	1	2 & 3	2 & 3	3	4, 5 & 6	4, 5 & 6	5 & 6
Works Type	1, 11	1, 11	2, 12	3, 13 4, 14 5, 15	1, 11	2, 12	3, 13 4, 14 5, 15
Light Vehicles							
K	0.83	0.80	0.63	0.53	0.74	0.59	0.504
K_1	0.00083	0.00083	0.00054	0.00045	0.00083	0.00054	0.00045
K_2	0.0083	0.0083	-0.00136	-0.0011	0.0083	-0.00136	-0.0011
K_3 flow ≤880 >880# ≤1200 >1200#	 0.00007 0.00143	 0.00007 0.00068	 0.00007 0.00068	 0.000027 0.000523	 0.00007 0.00068	 0.00007 0.00068	 0.000027 0.000523
Heavy Vehicles							
K	0.83	0.80	0.82	0.659	0.74	0.71	0.588
K_1	0.00083	0.00083	0.00083	0.00072	0.00083	0.00083	0.00072
K_2	0.0083	0.0083	0.0083	0.0072	0.0083	0.0083	0.0072
K_3 flow ≤880 >880# ≤1200 >1200#	 0.00007 0.00143	 0.00007 0.00068	 0 0.00075	 0 0.00055	 0.00007 0.00068	 0 0.00075	 0 0.00055

\# applies to the excess of flow above 880 or 1200 veh/hr/standard lane.

Light vehicles are cars and LGVs.
Heavy vehicles are OGV1, OGV2 and PSVs.

Road Classes are shown in Table 1/1.
Works Types are shown in Table 1/2.

Minimum cut-off speed, 45kph, for all Road Classes.

These journey time relationships apply to both full contraflow (that is, all primary lanes cross central reserve) and partial contraflow layouts.

Table 1/3: Journey Time Relationships for Works Sites in QUADRO

<table>
<tr><th>Road Class</th><th>Works Type</th><th>Speed/Flow Relationship</th></tr>
<tr><td>1,10 and 7,8,9 (single c/way)</td><td>9</td><td>V = 17.5 - 15Q/1000 + 4.5L (see paragraph 10.3)

where: V = mean speed of all vehicles (kph)
Q = total flow (veh/hr)(<u>not</u> flow per standard lane)
L = site length (km)</td></tr>
<tr><td>7,8,9, 10,11 (single or dual c/way)</td><td>1,11, 2 or 12</td><td>Same as for the main route without works but with adjustments for reduced carriageway width, minimum speed cut-off and site speed limit. Carriageway widths and speed limits through the works are specified on WORKS-TYPE KEY 052.</td></tr>
<tr><td colspan="3">Minimum cut-off speeds: Class 7, 25 kph
Class 8, 15 kph
Class 9, 30 kph
Class 10, 25 kph
Class 11, 35 kph

Road Classes are shown in Table 1/1
Works Types are shown in Table 1/2

A full description of 'without works' speed/flow relationships can be found in Part 5 of the COBA manual.</td></tr>
</table>

Table 1/4: Speed/Flow Relationships for Works Sites in QUADRO

1.7 Defining the type of site automatically selects a default capacity as shown in Table 1/5 (Ref 5.2) or the user can overwrite these using locally observed values. The capacity is defined as the maximum throughput in pcu/hr (passenger car units per hour, see paragraph 7.1) when a queue is present at the site. There is also a facility to allow the capacity to vary on an hour-by-hour basis. This is to cover possible working methods involving extra lane closures at night, or opening an extra lane during peak periods or over busy weekends.

Road Class	Capacity (pcu/hr/standard lane)(1)
1(2)	1400
2 and 3	1800
4, 5 and 6	2000
7, 8, 9 and 10(2)	1400
11	1800

(1) number of lanes is specified on the Works Type input record, KEY 052.

(2) without shuttle working.

Table 1/5: Default Site Capacities

1.8 For single carriageway sites with shuttle working, the maximum discharge rate from a queue into the shuttle lane is required. The default for this is 1800 pcu/hr. As a simplification, QUADRO replaces this intermittent flow by a continuous but lower one. The expression for converting between these flows, which is dependent on the site length, is derived in Chapter 10. If the defaults are overridden by user-specified capacities, values up to and including 2500 pcu/hr are taken to imply a single lane open, higher values imply two (or more) lanes are open, reflecting typical observed capacity levels. User-specified capacities should be thoroughly researched and be based on long-term capacity observations (that is, ideally several full hour counts, and ignoring any periods without a queue present) at a site of similar geometry. **Narrow lanes** are being used at some locations in order to fully use the carriageway space available during roadworks. If the lane width is expected to be less than 3.0m then it is recommended that the above standard lane capacities be reduced by approximately 10-15% for use in QUADRO. Because QUADRO calculates queues deterministically results can be very sensitive to specified capacity, and in critical cases users may want to run a job with several capacity values to investigate this sensitivity.

Diversion Route

1.9 As for the main route, the diversion route is treated as a single link joining junctions A and B (in Figure 1/1). The route characteristics are represented by a single speed/flow relationship - that is, actual variations in flow and layout along the route are not included explicitly in order to simplify the assignment algorithm. The user is required to input the length of the route and to define a speed/flow relationship. The user must also input information on the traffic flow level on the diversion route in the absence of any diverting traffic. In practice, diversion is often likely to take place along one or more parallel routes, each composed of links with differing characteristics and basic flow levels. Chapter 2 explains these problems more fully. Different diversion routes may be specified for the two directions of travel.

Junctions and Incidents

1.10 QUADRO does not model junctions explicitly either on the main route or diversion route. However, some account may be taken of their effect on journey time by introducing an extra element to the diversion route speed/flow relationship. Part 7, Chapter 2, paragraph 2.24 presents a method for doing this. The user must, in effect, specify the locations - but no other characteristics - of three junctions on the main route, for each direction of travel. These are junctions A, B and C in Figure 1/1, which are located relative to the works site by the various section lengths. A and B are the start and end of the diversion route, and since the route may be 'notional', representing a number of diversion alternatives, these junctions also may not correspond to specific physical junctions (see paragraph 2.2). C is used as a method of limiting the queue resulting from incidents such as breakdowns or accidents within the site. In such cases the queue is allowed to build back as far as the next upstream junction beyond the start of the diversion route. Traffic is assumed to divert sufficiently to prevent a longer queue forming, and the user must specify the length AC.

1.11 QUADRO contains values for the average duration of incidents (that is, the time for which the carriageway is obstructed), with separate values for breakdowns and accidents. The values will depend on the location of the site and the level of provision for surveillance and recovery that is expected to be made. Studies suggest that at sites where good provision is made, the average duration of a breakdown can be 10 minutes, whereas if no special provision is made, 40 minutes is more realistic. Higher figures could be possible depending on communications and ease of access for the emergency and breakdown services. If no local data are available, suggested values taken from recent research (Ref 4.1) are shown in Table 1/6. Serious accidents can take a very long time to clear, but over 80% of accidents are damage only (see Part 4 paragraph 3.5), and unless local data are available the average accident duration should be set at 5 minutes longer than the average breakdown duration, see Table 1/6.

Type of Road	**Breakdown Duration (mins)**	**Accident Duration (mins)**
Motorway	25	30
Single and dual AP (without shuttle working)	40	45
Single AP (with shuttle working)	Incident delay sub-model does not run - see Part 4 paragraph 3.1	

Table 1/6: Default Breakdown and Accident Durations in QUADRO

Climbing Lanes on Dual Carriageway Roads

1.12 When an improvement scheme consists of adding a climbing lane to an existing road, an analysis of the delay costs during construction should be included in the economic appraisal. Also, a maintenance analysis for the road both with and without the climbing lane should be carried out to estimate the change in user delay costs and capital costs for future maintenance. These delays can be modelled in QUADRO. Link specific speed/flow relationships suitable for climbing lanes can be defined depending on the standard of dual carriageway being modelled, the local percentage of heavy vehicles, gradient of the uphill section and length of climbing lane. A method for preparing a link specific speed/flow relationship is given in Part 6 under the KEY 032 heading. QUADRO also allows the user to specify different accident information (if known) for the road with and without the climbing lane. Current standards (TD 9/93 DMRB 6.1) indicate that a gradient of 3% over a distance of 0.5km is expected to be the minimum that would justify a climbing lane on dual carriageways.

2. SPECIFICATION OF DIVERSION ROUTE

General Principles

2.1 The single diversion route used in QUADRO is intended to represent all possible diversionary behaviour. The program does not explicitly model early departure from the main route, late arrival on the main route (in these instances the driver re-assigns the last or first part of his trip, and so only uses part of the diversion route), strategic diversion (that is, re-assigning much or most of the trip to a different corridor), or retiming and suppression of trips. QUADRO assumes a fixed trip matrix.

2.2 The diversion route is represented in the model by a single link of specified length and speed/flow characteristics. It is the user's responsibility to define these characteristics so that the 'notional' diversion route within the program satisfactorily represents the real possibilities for diversion presented by the actual network. Wherever local knowledge of the likely routes and journey times is available, this should form the basis of the diversion route specification. The reality may consist of an obvious diversion via a single link of uniform quality, or it may comprise a heterogeneous set of links in series and parallel. Paragraph 2.5 contains advice on how to define a suitable single 'notional' route in such cases, but the user would be well advised to check the resulting estimated journey times against observed values if possible. QUADRO outputs journey speeds (and hence times) for the diversion route at various flow levels to facilitate such checking. The program was originally written for use in rural areas, and particular care should be exercised in urban areas - where there may be many possible alternative routes - that the specified diversion route reflects the possibilities offered by the surrounding network.

The Speed/Flow Relationship

2.3 The diversion route speed/flow relationship is defined by a free speed (V_0) and up to five flow/speed pairs. The points are specified as 'break points' between linear speed/flow slopes, and the final (that is, lowest) speed specified is taken as Vmin. Figure 2/1 illustrates the simplest and most complex relationships possible.

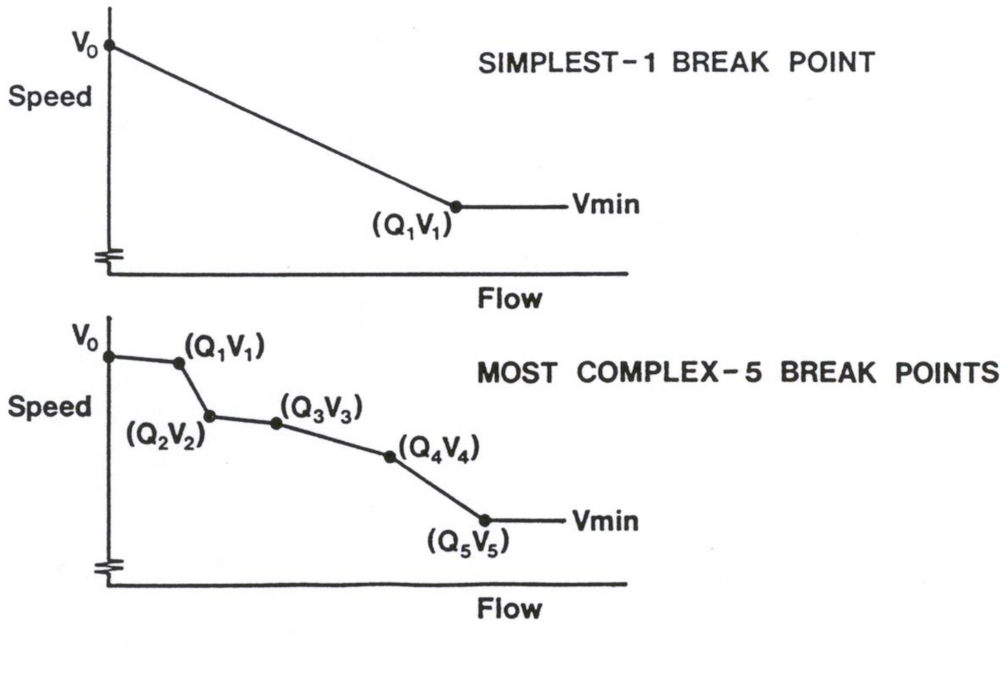


Figure 2/1: Possible Forms of Speed/Flow Relationship

The inclusion of up to five break points is to allow the user to take some account of differing characteristics on various parts of the diversion route. For example, congestion at junctions can be represented by a reduction in journey speed at appropriate flow levels. The only restriction on the use of the five flow/speed pairs is that as flow increases, speed must decrease (or stay the same).

The flow to be used in defining the relationship is **total one-way flow in veh/hr.**

The Warn Facility

2.4 To assist the user in identifying situations where unrealistic flows are diverted, the program accepts as input a flow level - the WARN level - coupled with the diversion speed/flow relationship. If diverted flows exceed this level, which is chosen by the user, a flag is set which appears in the program output as a Warning. The user should select a suitable level on the basis of knowledge of capacity restrictions on the route - for example, at junctions - or for policy reasons, such as a decision to limit flow levels through a sensitive area. If no WARN level is specified then the Warning flag will be set either when the minimum speed (Vmin) is reached or if the highest flow is reached.

Calculation of a Diversion Route Speed/Flow Relationship

2.5 Previous versions of the QUADRO user manual contained details of how to manually calculate the diversion route speed/flow relationship when combining links in series and in parallel. Corrections were also suggested to take account of junction geometric and junction overload effects. In 1987 the computer program QDIV (QUADRO DIVersion) was developed. This allows the QUADRO user to combine a number of links forming the diversion route avoiding error prone manual calculations.

2.6 An updated version of QDIV was issued at the same time as QUADRO which incorporates the most up to date link speed/flow relationships. It can also derive composite accident information which is needed to fully define the diversion route for eventual use in QUADRO. It must always be remembered that the results from a QDIV run should not be used in QUADRO without due consideration to the credibility of the calculated speed/flow relationship.

2.7 When the diversion route consists of a network of links in series and/or in parallel, it is recommended that the QDIV program be used. Instructions on how to use QDIV and data requirements are given in Part 7.

Maximum Queuing Delay

2.8 There will be occasions when the above methods for defining diversion routes are not appropriate. For instance, the main route may carry a large proportion of long distance traffic whose diversion opportunities cover a large area or, local traffic that becomes familiar with the level of delays expected at the roadworks might retime their journey to a different time of day, etc. These examples imply that drivers are ‘willing’ to be delayed for a certain time and then find alternative routes, etc., when their ‘maximum delay time’ is exceeded. QUADRO contains a facility whereby a ‘maximum queuing delay’ (MAX-Q-DELAY) time can be specified. This represents a measure of time that vehicles are willing to queue at the roadworks, not the overall additional journey time which will include the speed-flow difference along the main route itself. Some QUADRO assessments may need to be run for a range of maximum queuing delay times to test the sensitivity to traffic delay costs.

2.9 If MAX-Q-DELAY is used, it represents a fictive diversion route the journey time of which is defined as the time it takes to travel the length of the main route with works given a queue of length (and time) corresponding to MAX-Q-DELAY.

3. VARIATION IN TRAFFIC FLOW

3.1 If any site at the roadside is chosen and the traffic passing it is observed, it can be seen that the total number of vehicles varies from hour to hour, day to day, week to week and month to month. Not only does the total traffic flow vary in this way but also the proportion of the different types of vehicle which it contains. For example, the relative proportion of cars to goods vehicles is likely to be higher during peak hours than in other hours of the day. These observed variations will be specific to the site chosen; had another site been selected then the pattern of variation might well have been different. For example a road in a holiday area, with its high level of cars in summer, has a different pattern of variation from a road serving an industrial area on which the flow of both cars and goods vehicles might be much more even throughout the year.

3.2 There are, therefore, two broad types of variation which QUADRO should take into account:

i) variation of total hourly vehicle flow throughout the day;

ii) variation in vehicle type composition in each hour.

3.3 The operation of the road is dependent on the levels of traffic flow at different times of the day and is modelled using FLOW GROUPS (see Chapter 5) to represent the volumetric variation that occurs throughout the day. The SEASONALITY INDEX (see Chapter 4) of the network under consideration determines the level of flow in each flow group.

Day Types

3.4 The QUADRO model calculates user costs on a daily basis. Calculations are normally repeated for each of four different day types - Monday to Thursday, Friday, Saturday, Sunday - and are then factored up to the duration of the job in weeks. However, a single day run is also possible, and 'weeks' of less than the full seven days may be specified, for example, if there are to be no roadworks carried out at weekends. Within a day the basic modelling interval is normally one hour, and QUADRO uses a 24-hour flow profile for each direction of travel and each day type.

3.5 If locally observed data are available the user can specify these 24-hour profiles in full, varying the proportion of heavy vehicles from hour to hour if desired (although the split of light and heavy vehicles into individual vehicle categories on an hourly basis is not a user input), and specifying separate profiles for the diversion route. On the other hand, if there is minimal data available the user may input an estimated 12 or 16 hour two-way traffic count (observed or modelled) or a value of Annual Average Hourly Traffic (AAHT), for a given year. The program will use this input to generate hourly flows, applying built-in default 24-hour profiles.

4. NETWORK CLASSIFICATION AND SEASONALITY INDEX

4.1 Traffic statistics collected by the Department are categorised as follows:

i) Motorways;

ii) Built-up Trunk Roads (40 mph speed limit or less);

iii) Built-up Principal Roads (40 mph speed limit or less);

iv) Non Built-up Trunk Roads (speed limits above 40 mph);

v) Non Built-up Principal Roads (speed limits above 40 mph).

4.2 QUADRO contains default parameters which describe the average traffic conditions on roads falling into the above five categories and it is necessary to define the NETWORK CLASSIFICATION that best describes the scheme being assessed. The NETWORK CLASSIFICATION is used to call default values for SEASONALITY INDEX, Vehicle Category Proportions (Chapter 7) and E-FACTOR (Chapter 6), all of which can be overwritten by the user when local information is available.

4.3 The most important descriptor of annual traffic flow patterns is the SEASONALITY INDEX (SI) which is defined as the ratio of the average August weekday flow to the average weekday flow (Monday to Friday) in the neutral months, April, May, June, September and October (excluding periods affected by bank holidays). The SI defines the Flow Group Structure (Chapters 5 and 8) and M-FACTOR (Chapter 6), both of which can be overwritten if local information is available (this will usually consist of a whole years traffic count information). Research using STC Core sites indicated that a range of SI values are likely on each NETWORK CLASSIFICATION. Table 4/1 gives the range of SI values likely to be encountered on roads falling into each NETWORK CLASSIFICATION, values outside the ranges are possible.

Network Classification		**Range of Seasonality Index (SI) Encountered**	**Typical Values (Default)**
Motorway	(MWY)	0.95 - 1.35	1.06
Built-up Trunk	(TBU)	0.95 - 1.10	1.00
Built-up Principal	(PBU)	0.95 - 1.15	1.00
Non Built-up Trunk	(TNB)	1.00 - 1.50	1.10
Non Built-up Principal	(PNB)	1.00 - 1.40	1.10

Table 4/1: Network Classification and Seasonality Index

4.4 The SI of the network is used to determine the level of flow in each of the hourly flow groups (see Chapter 5). It is therefore important to obtain a good estimate of the SI applicable to the QUADRO network.

4.5 Ideally the Seasonality Index should be determined from long term ATC data. However a good estimate can be obtained by comparing three week continuous counts in August and late May/June or October.

4.6 At the early stages of scheme preparation, data to calculate the local SI value may not be available and therefore typical values may be used. These are given in Table 4/1 and are contained as defaults within the QUADRO program.

5. FLOW GROUPS

5.1 To take account of the variation in the level of traffic flow and its vehicle composition, the 8760 hours of the year are divided into different portions (numbers of hours) called 'FLOW GROUPS'. Each represents a different level of flow. The level of flow is much higher in the peak period than during the night. To take account of the variation in flow eight flow groups are used, four for weekdays and four for weekends, see Table 5/1. The level of traffic flow in each is determined from multipliers which are dependent upon the Seasonality Index (SI). This methodology was developed from the results of research undertaken in 1988 (Ref 5.3). The analysis was repeated using 1992 data from the STC automatic Core traffic census and the default parameters used to describe the flow group structure in the program are taken from this work. The method used to allocate the total flow into vehicle categories is described in Chapter 7.

5.2 The factors used to convert the AAHT to the total flow in each flow group are known as the Flow Group Multipliers. They are based on two-way traffic flows and were found to be independent of the Network Classification. The QUADRO program calculates the Flow Group Multiplier (FGM) based on the relationship FGM = d + n.SI . The default values for parameters d and n for each flow group are given in Table 5/1, these constants of Flow Multipliers can be changed using KEY 033, see Part 6. Figure 5/1 gives a pictorial representation of these straight line relationships illustrating how the Seasonality Index affects the flow levels in each flow group.

	Hourly Flow Group (HFG)	Number of Hours	Flow Group Multiplier for all SI Values
Weekdays	1	3132	0.446 - 0.159.SI
	2	2088	1.581 - 0.089.SI
	3	522	1.630 + 0.326.SI
	4	522	1.371 + 0.981.SI
Weekends	5	1248	1.187 - 0.554.SI
	6	832	1.078 + 0.072.SI
	7	208	0.744 + 0.894.SI
	8	208	- 0.178 + 2.146.SI

Table 5/1: Flow Group Multipliers

5.3 There are facilities within the program which enable the user to change the number of flow groups (maximum of 8) and the hours per flow group to reflect local conditions. However, before any change is contemplated, the Overseeing Organisation must be consulted so that verification of the methodology and base data used in determining these local values can be agreed. Where it is agreed that non standard values may be used it may still be necessary to produce a QUADRO evaluation using standard values as a sensitivity test.

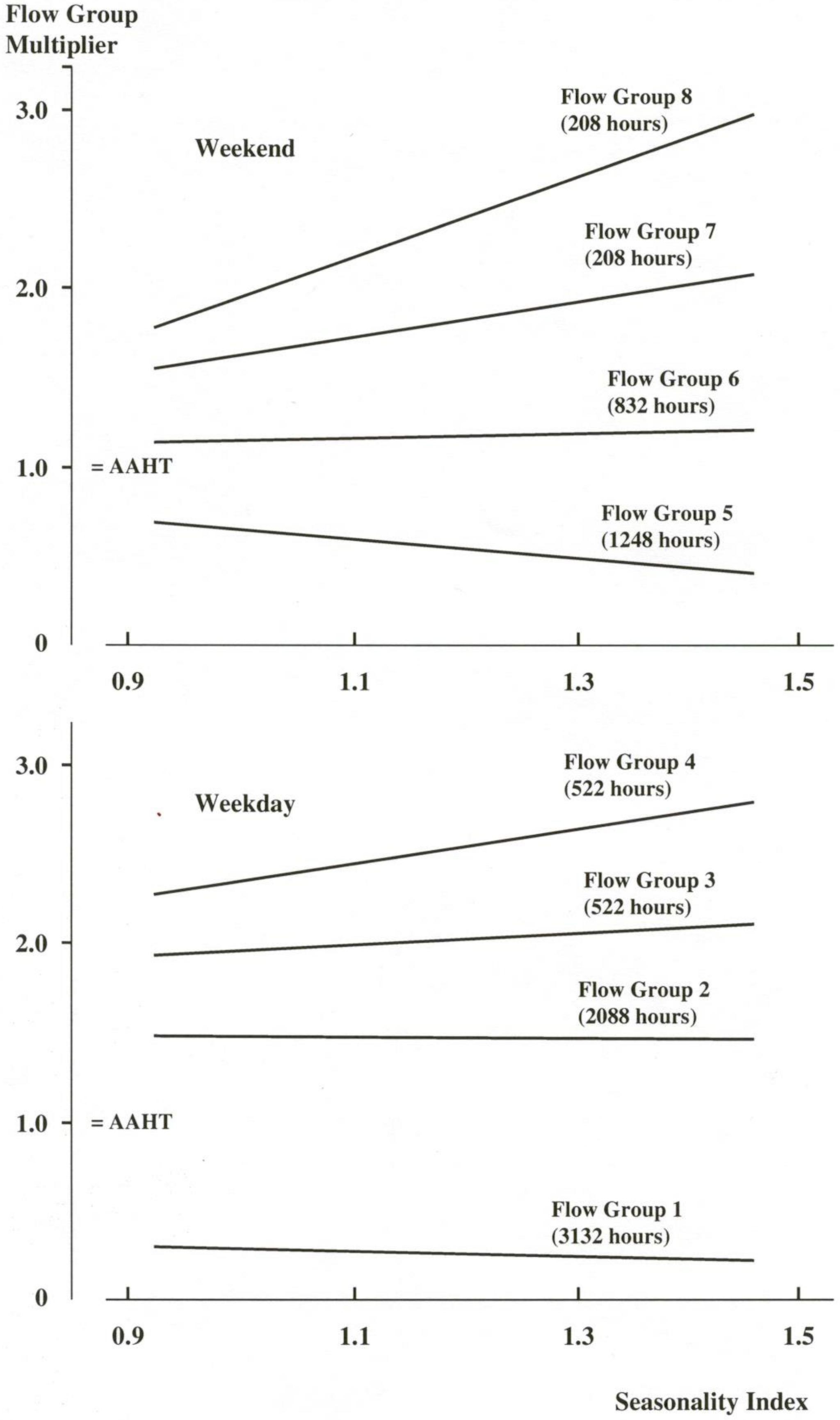


Figure 5/1: Variation in the Flow Group Multipliers with Seasonality Index

5.4 The 1988 research mentioned in paragraph 5.1 above also recommended hourly flow group allocations for each Network Classification. The variation between the five Network Classifications was found to be very small and therefore only one set of flow group allocations has been assumed in QUADRO, see Table 5/2. Table 5/2 also shows the assumed primary direction tidality factors applicable to all Network Classifications. The concept of directional flows and tidality is more fully explained in Chapter 6.

Hour of Day *	Mon-Thurs		Fri		Sat		Sun	
	Gh	Th	Gh	Th	Gh	Th	Gh	Th
1-7	1	.5	1	.5	5	.5	5	.5
8	2	.5	2	.5	5	.5	5	.5
9	4	.57	4	.57	6	.5	5	.5
10	2	.5	2	.5	6	.5	6	.5
11	2	.5	2	.5	7	.5	6	.5
12	2	.5	2	.5	8	.5	6	.5
13	2	.5	3	.5	8	.43	6	.5
14	2	.5	3	.5	8	.5	6	.5
15	2	.5	3	.5	7	.5	6	.5
16	2	.5	3	.5	6	.5	6	.5
17	3	.5	3	.5	6	.5	7	.5
18	4	.43	4	.43	6	.5	8	.57
19	2	.5	3	.5	6	.5	7	.5
20	1	.5	1	.5	6	.5	6	.5
21	1	.5	1	.5	5	.5	6	.5
22-24	1	.5	1	.5	5	.5	5	.5

* Hour Ending

Table 5/2: Hourly Flow Group Allocations (Gh) and Primary Direction Tidality Factors (Th) for All Network Classifications

6. SPECIFICATION OF DAILY FLOWS

6.1 Figure 6/1 summarises the alternative forms of flow and related inputs which can be accepted by QUADRO.

6.2 The user must supply basic information on level of flow on the main route and diversion route for each job. There are four methods of doing this (all flows are two-way):

i) Annual Average Hourly Traffic (AAHT) in a given year;

ii) a single 12-hour traffic flow (0700 - 1900) for a given year and month;

iii) a single 16-hour traffic flow (0600 - 2200) for a given year and month;

iv) a 24-hour- traffic flow for a given year, representing the time of year when the maintenance job is expected to be carried out.

User specified or default 24 hour flow profiles can be used with any of the above four methods.

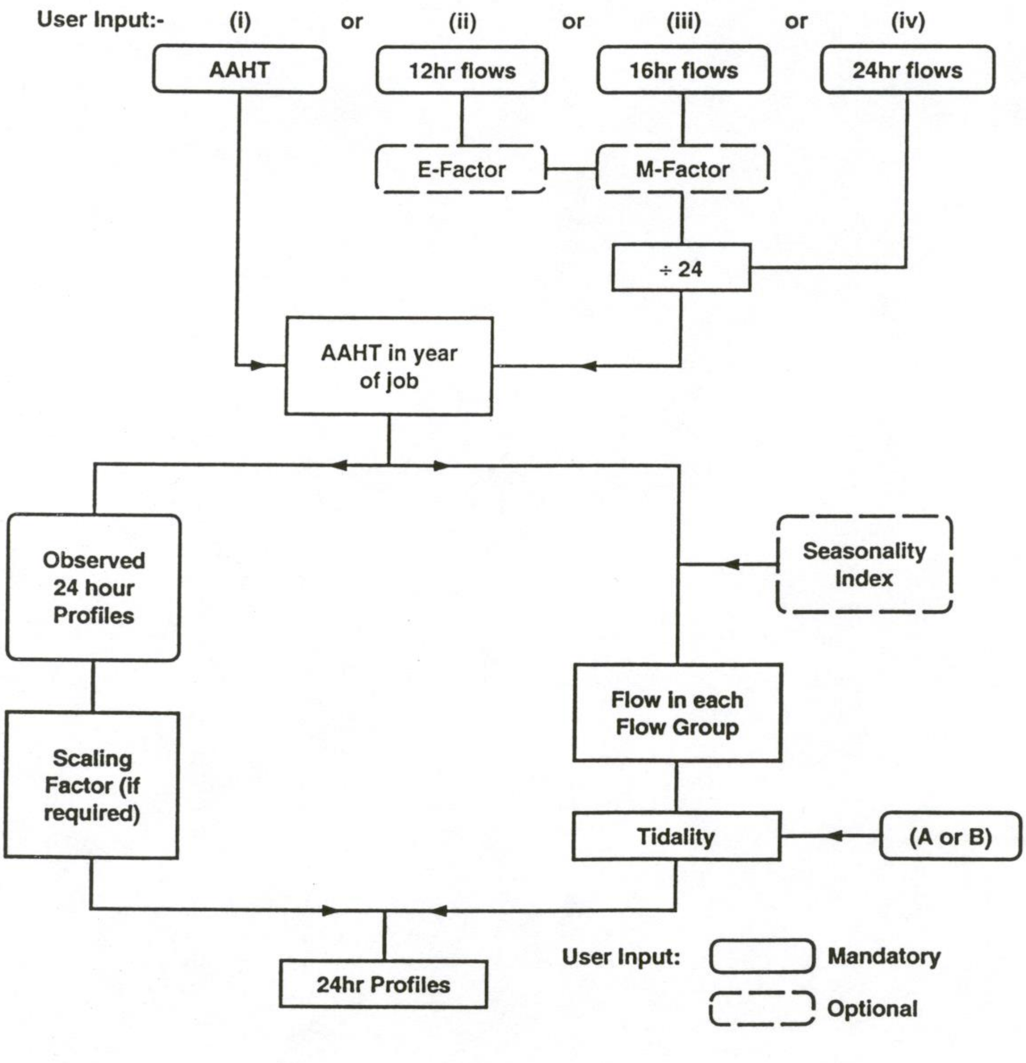


Figure 6/1: Possible Combinations of User-Supplied Data and Program Defaults

6.3 QUADRO converts user input flows to a value of AHT and then uses this to generate 24-hour flow profiles for each Day Type.

6.4 With method ii), the program applies an E-factor (for converting 12-hour to 16-hour counts) based on Network Classification together with an M-factor (for converting 16-hour counts into AADT and hence AAHT) based on Seasonality Index, see COBA Manual for full details. With method iii), the program applies the M-factor only to calculate AAHT. Where it is considered that the use of locally derived E and M-factors would be appropriate, the values chosen must be supported by a long term automatic traffic count. The results of these counts will need to be included in the economic analysis submission.

6.5 The fourth method is intended primarily for the user who is assessing an individual maintenance job in some detail, and who has detailed data for the time of the year when the maintenance job is to be carried out.

6.6 QUADRO only uses one set of flows for each job regardless of its duration. Therefore if substantial seasonal variations in flow are expected during a lengthy maintenance task, it may be desirable to treat it as several QUADRO jobs. In this case flows suitable for each period would need to be specified together with appropriate 24 hour profile data.

24-Hour Profiles

6.7 The basic time unit for traffic calculations in QUADRO is one hour, and so whatever method of specifying flow level is used, the program eventually requires a 24-hour profile of flows on the main and diversion routes for each Day Type. A set of default profiles will be generated by the program if any one of the above 4 methods of specifying flow level is used. These profiles are based on data from a sample of roads, and are designed to give typical hourly flows for all Network Classifications. The source of these profiles, and the way they are stored within the program, was outlined in Chapter 5. The profiles generate two-way hourly flows, which are subsequently disaggregated into directional flows.

6.8 However, the user may overwrite the program default profiles by specifying observed 24-hour profiles, for each Day Type. These profiles may be input as two-way flows or separate directional flows. In either case there is a choice of ways of expressing the profiles:

a) **if full seven-day weeks are being modelled:**

i) as actual hourly flows. In this case QUADRO checks that the sum of these hourly flows over the week (allowing for 4 of Day Type 1), equals 7 times the ADT - the ADT having been input or calculated by QUADRO from a 12 hr, 16 hr or AAHT input. If there is any discrepancy, all the flows will be scaled to remove it. The total flow input for each day appears in Phase 6 of the output so that errors and/or scaling can be checked for;

ii) deliberate use can be made of the scaling process. For example, if 24-hour profile data obtained in 1990 are to be applied to a job in 2000, the 1990 data can be entered directly. If a suitable 2000 flow is specified, all the hourly flows will be scaled appropriately;

iii) since the input values are not treated directly as flows, they can be proportions or percentages of the weekly total flow, or of the ADT. Note however, that proportions or percentages of the total daily flow for a given Day Type are not acceptable since the program cannot then generate different daily totals for different Day Types;

b) **if part-weeks are being modelled,** for example, single days or weekends, similar rules apply but the ADT is taken as the average over the specified days, rather than over the whole week.

An Example

6.9 ADT = 33000 veh. The table shows some of the two-way hourly flows input to the program, plus the daily totals for each Day Type.

Hour of the day	Day Type 1 (Mon-Thurs)	Day Type 2 (Friday)	Day Type 3 (Saturday)	Day Type 4 (Sunday)
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
16	3300	3800	1600	2900
17	3500	4200	1800	2600
18	3400	4200	1100	1900
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
Total	35000	42000	26000	23000

Now adding the daily totals to get a weekly total gives,

(35000 x 4) + 42000 + 26000 + 23000 = 231000

and factoring up the ADT to a whole week gives,

(33000 x 7) = 231000

so these hourly flows are compatible with the ADT and no scaling will take place. Note that if all the hourly flows are divided by 100, data input will be quicker and the result will be unchanged. Also, if the ADT is 39000 (representing a later year), each hourly flow will be factored by (39000 x 7)/231000 = 39/33.

If equivalent percentages are specified for the above flows, they will be:

Hour of the day	Day Type 1 (Mon-Thurs)	Day Type 2 (Friday)	Day Type 3 (Saturday)	Day Type 4 (Sunday)
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
16	10.0	11.5	4.9	8.8
17	10.6	12.7	5.5	7.9
18	10.3	12.7	3.3	5.8
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
Total	106.1	127.2	78.7	69.7

The appropriately weighted percentages sum to 700.0 over a whole week. With AADT = 33000, each figure is factored by (33000 x 7) / 700.0 to calculate the hourly flow.

6.10 If data are available, the user may specify separate 24-hour profiles for the main route and the diversion route. If no profiles are specified for the diversion route (that is, left blank on KEY 058), the main route profiles will be adopted. Data may be obtained from automatic traffic counters, averaging the counts over a suitable period to obtain representative profiles. If manual counts are used, estimates must be made for missing hours outside the count period.

Directional Flows and Tidality

6.11 The QUADRO model uses directional flows rather than two-way flows, since each direction of travel is modelled separately. If the program default 24-hour profiles have been used, or if the user has input two-way profiles, the flow for each hour must be disaggregated by direction. This split must take into account the tidal behaviour of traffic, that is, at some times one direction will predominate, and at other times the reverse direction. QUADRO takes account of two types of tidal behaviour. Firstly there is the familiar pattern of morning and evening commuter peaks. Secondly there are the Friday evening/Sunday evening peaks caused by weekend trips. In both cases it is possible to define an 'A' and 'B' tidality, or direction, where the 'A' (or 'Away') direction corresponds to the outward journey, that is, morning peak for commuters, and Friday evening for weekend trippers, and the 'B' (or 'Back') direction corresponds to the return journey. In order to relate these directions to the site geometry, the user must specify the tidalities for the primary direction through the site for Monday morning peaks and Friday evening peaks. The two-way flows are then converted, within the program, to directional flows by the application of 'tidality factors', where the tidality factor for a given direction is (directional flow)/(two-way flow). Thus for the direction carrying the greater flow, the tidality factor is greater than 0.5, and the factors for both directions add to unity. Table 6/1 shows how to select the tidalities for the primary direction.

WEEKDAY		
Direction carrying more traffic in Monday am peak	Monday am peak Tidality Factor	TIDALITY OF PRIMARY DIRECTION
Primary	>0.5	A
Secondary	>0.5	B
WEEKEND		
Direction carrying more traffic in Friday pm peak	Friday pm peak Tidality Factor	TIDALITY OF PRIMARY DIRECTION
Primary	>0.5	A
Secondary	>0.5	B

Table 6/1: Tidalities of Primary Direction Through Site

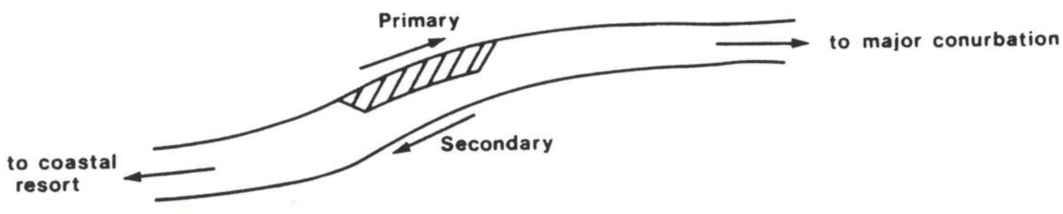
If not input to the program, the weekend tidality will be assumed to be opposite to the weekday tidality.

6.12 Having selected the tidality of the primary direction the program uses inbuilt tidality factors for each hour of each Day Type, for all Network Classifications, to convert all two-way flows to directional flows. These default values were tabulated in Table 5/2.

Tidality Examples

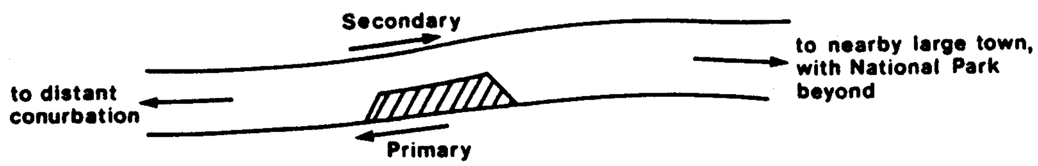
6.13 The following examples illustrate the tidality concept.

i)



On weekdays the predominant commuter movement is into the conurbation in the morning, and out in the evening. At weekends, traffic heads for the coast on Friday evening and returns on Sunday. The tidalities are: Weekday A, Weekend B.

ii)



On weekdays the local commuter traffic predominates, entering the large town in the morning, and leaving in the evening. At weekends, traffic from the conurbation to the National Park bypasses the town on Friday evening, and returns on Sunday evening. The tidalities are: Weekday B, Weekend B.

Vehicle Categories

6.14 The input of information concerning vehicle categories is discussed in Chapter 7. The default 24-hour profiles allow the proportion of each category to vary from hour to hour, but the tidality factors operate on all categories equally, so they do not introduce directional differences in category proportions.

7. VEHICLE CATEGORIES

Definition of Categories

7.1 The various types of vehicle on the road have different characteristics in terms of operating cost, growth, and occupancy. QUADRO uses the same categories as COBA. Some are illustrated in Figure 7/1, and are defined as:

Cars	**(CARS)** Including taxis, estate cars, 'people carriers' and other passenger vehicles (for example, minibuses and camper vans) with a gross vehicle weight of less than 3.5 tonnes, normally ones that can accommodate not more than 15 seats. Three-wheeled cars, motor invalid carriages, Land Rovers, Range Rovers and Jeeps and smaller ambulances are included. Cars towing caravans or trailers are counted as one vehicle;
Light Goods Vehicles	**(LGV)** Includes all goods vehicles up to 3.5 tonnes gross vehicle weight (goods vehicles over 3.5 tonnes have sideguards fitted between axles), including those towing a trailer or caravan. This includes all car delivery vans and those of the next larger carrying capacity such as transit vans. Included here are small pickup vans, three-wheeled goods vehicles, milk floats and pedestrian controlled motor vehicles. Most of this group are delivery vans of one type or another;
Other Goods Vehicles	**(OGV 1)** Includes all rigid vehicles over 3.5 tonnes gross vehicle weight with two or three axles Includes larger ambulances, tractors (without trailers), road rollers for tarmac pressing, box vans and similar large vans. A two or three axle motor tractive unit without a trailer is also included;
	(OGV 2) Includes all rigid vehicles with four or more axles and all articulated vehicles. Also included in this class are OGV1 goods vehicles towing a caravan or trailer;
Buses and Coaches	**(PSV)** Includes all public service vehicles and works buses with a gross vehicle weight of 3.5 tonnes or more, usually vehicles with more than 16 seats;

The program uses these categories for costing purposes. For traffic calculations, the only distinction is between light vehicles (cars, LGV) and heavy vehicles (OGV1, OGV2, PSV). The distinction applies to journey time and speed/flow calculations, and to site capacity (where one light vehicle = 1pcu (passenger car unit), and one heavy vehicle = 2 pcu).

Input of Vehicle Category Proportions

7.2 It is recommended that the user inputs local data for the proportions of the various vehicle categories in the traffic flow for the main route and diversion route separately. If no local values are specified, national average figures will be used. The national average proportions for 2002 by class of road are given in Table 7/1 and are held as defaults within the program.

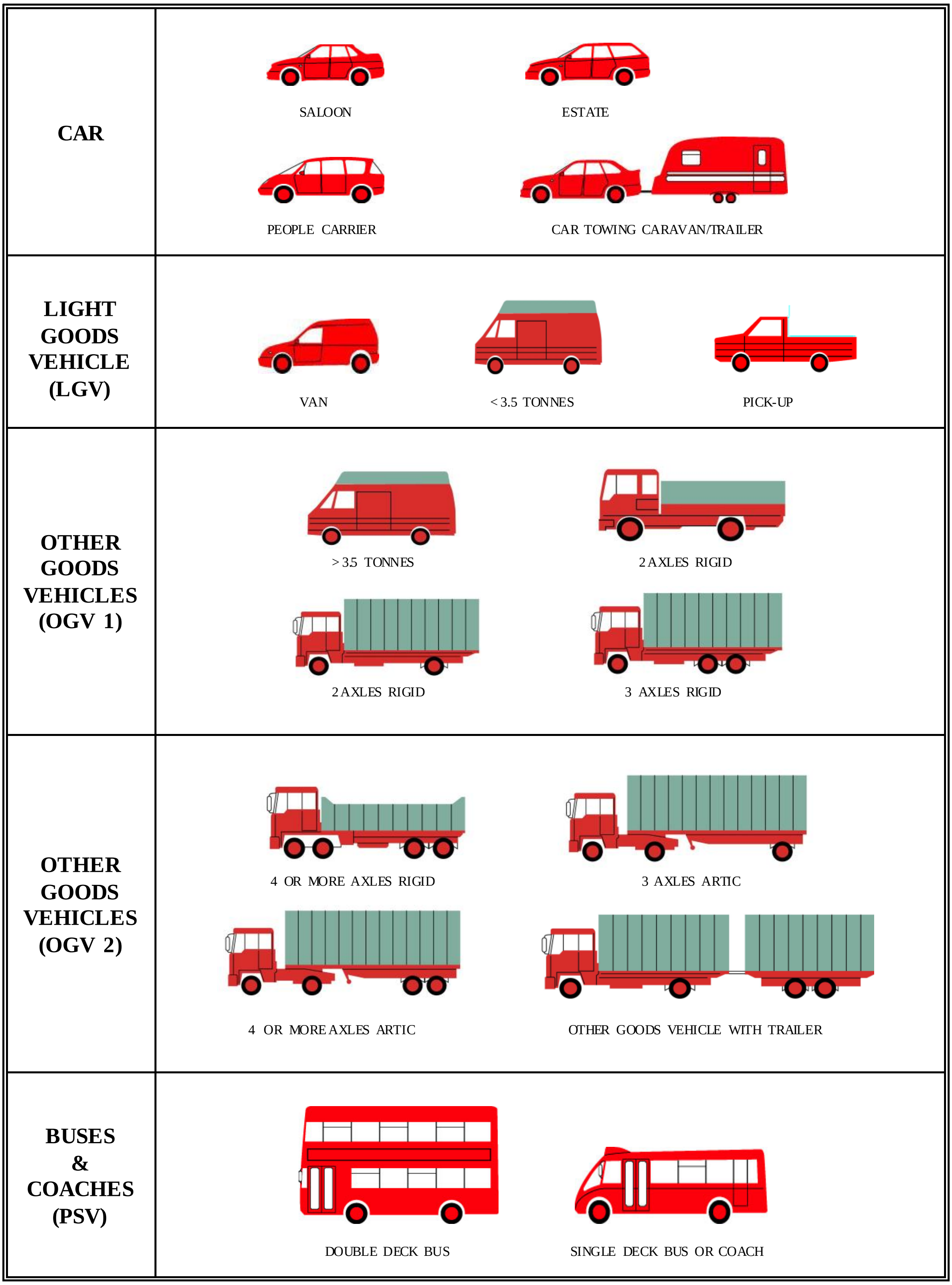


Figure 7/1: QUADRO Vehicle Categories

Class of Road	Cars	LGV	OGV1	OGV2	PSV
Motorway	0.762	0.107	0.041	0.085	0.005
Built-up Trunk	0.825	0.112	0.030	0.024	0.009
Built-up Principal	0.848	0.103	0.022	0.010	0.017
Non Built-up Trunk	0.787	0.110	0.038	0.059	0.006
Non Built-up Principal	0.826	0.113	0.031	0.022	0.008
Average All Roads (includes Minor Roads)	0.816	0.114	0.028	0.031	0.011

Table 7/1: Annual Average Vehicle Category Proportions by Class of Road (2002)

The program uses the specified or default proportions to calculate hourly proportions appropriate to the Network Classification.

7.3 Observed traffic proportions can be input to QUADRO as either 12 or 16 hour **weekday** values or as annual average **daily** (AADT) proportions. If either 12 or 16 hour weekday values are entered the program will convert them to AADT proportions as described below.

7.4 The proportion of traffic for each vehicle category (except cars) is estimated as follows:

estimated annual traffic proportion = A(I) x observed traffic proportion in a neutral month

where A(I) is the adjustment factor for each vehicle category. Defaults held in the program are given in Table 7/2. The traffic proportion for cars is estimated by subtracting from unity the sum of the estimated proportions for the other vehicle categories. When instructed by the Overseeing Organisation, A(I) factors can be redefined using the Basic Data KEY 023, see Part 6 Chapter 3.

Period of Neutral Month Weekday Count	Network Classification	Adjustment Factors A(I)			
		LGV	OGV1	OGV2	PSV
12 Hour (0700 - 1900)	MWY	0.86	0.80	0.84	1.19
	TBU	0.83	0.73	0.75	0.90
	PBU	0.83	0.73	0.75	0.90
	TNB	0.84	0.77	0.84	0.98
	PNB	0.84	0.77	0.84	0.98
16 Hour (0600 - 2200)	MWY	0.89	0.84	0.83	1.16
	TBU	0.89	0.81	0.79	0.92
	PBU	0.89	0.81	0.79	0.92
	TNB	0.89	0.82	0.83	0.89
	PNB	0.89	0.82	0.83	0.89

Table 7/2: Adjustment Factors to Estimate Annual Vehicle Category Proportions

Vehicle Category Proportions by Flow Group

7.5 First of all, the program will split the AADT proportions, either input directly or calculated internally, into weekday and weekend proportions. Research using STC Core sites has shown that the overall **weekday** vehicle category proportion is given by the AADT proportion multiplied by a factor ‘x’. Values of x contained within the program are given in Table 7/3. The traffic proportion for cars is estimated by subtracting from unity the sum of the calculated proportions for the other vehicle categories. When instructed by the Overseeing Organisation, x can be redefined by using KEY 030, see Part 6 Chapter 3.

Vehicle Category	x
LGV	1.12
OGV1	1.20
OGV2	1.20
PSV	0.97

Table 7/3: Values of 'x' used to Calculate Weekday Proportions

7.6 Secondly, the program will allocate vehicle category proportions to the total vehicle flow in each flow group. This is accomplished by means of vehicle category proportion correction factors. The defaults which are held within the program are given in Table 7/4. These were derived from an analysis of the STC automatic core traffic count sites, and although it is unlikely that the user will have sufficient data to develop local factors, they can nonetheless be changed by use of the Basic Data KEY 034, see Part 6 Chapter 3.

Flow Group	Vehicle Category				
	Cars	LGV	OGV1	OGV2	PSV
Motorways					
1	*	*	*	*	*
2	*	1.14	1.29	1.17	0.88
3	*	1.13	1.16	1.02	0.85
4	*	1.11	1.01	0.87	0.73
5	*	*	*	*	*
6	*	0.60	0.32	0.29	1.39
7	*	0.59	0.28	0.25	1.38
8	*	0.60	0.31	0.27	1.40
Built-up Roads					
1	*	*	*	*	*
2	*	1.14	1.44	1.22	1.12
3	*	1.12	1.31	1.08	1.09
4	*	1.10	1.04	0.87	0.98
5	*	*	*	*	*
6	*	0.62	0.39	0.30	0.84
7	*	0.64	0.43	0.30	0.88
8	*	0.67	0.45	0.29	0.86
Non Built-up Roads					
1	*	*	*	*	*
2	*	1.16	1.41	1.30	1.07
3	*	1.14	1.16	1.07	1.08
4	*	1.10	0.92	0.84	1.02
5	*	*	*	*	*
6	*	0.60	0.35	0.35	1.02
7	*	0.60	0.33	0.30	0.98
8	*	0.61	0.34	0.29	0.90

* Balancing Values

Table 7/4: Vehicle Category Proportion Correction Factors

7.7 The vehicle category proportions (except cars) in flow groups 2-4 and 6-8 are determined by applying the vehicle category proportion correction factors to the **annual average** vehicle category proportions. The proportion of cars is obtained by subtracting from unity the sum of the other vehicle category proportions. The proportions in flow groups 1 and 5 are obtained by a balancing procedure which ensures the correct total weekday and weekend flow of each vehicle category.

7.8 The following example shows the total vehicle flow and category proportions by flow group that the program will calculate for a road with a Seasonality Index (SI) of 1.10. Local vehicle category proportions should always be used when available.

(a) For example, if the **annual average** vehicle category proportions for the non built-up trunk road are, Cars 0.789, LGV 0.092, OGV1 0.055, OGV2 0.057, PSV 0.007.

(b) Using the ‘x’ factors given in Table 7/3, the **weekday** proportions are,

LGV = 0.092 x 1.12 = 0.103
OGV1 = 0.055 x 1.20 = 0.066
OGV2 = 0.057 x 1.20 = 0.068
PSV = 0.007 x 0.97 = 0.007
0.244
therefore, Cars = 1 - 0.244 = 0.756.

(c) Using the Flow Group Multipliers for a road with an SI of 1.10 from Table 5/1 and the Vehicle Category Proportion Correction Factors from Table 7/4, the program calculates the Total Vehicle Flow and Vehicle Category Proportions by Flow Group shown in Table 7/5.

Flow Group	Hours	Flow AAHT	% of Annual Flow	Vehicle Category Proportions				
				Cars	LGV	OGV1	OGV2	PSV
1	3132	0.271	9.69	0.770	0.090	0.050	0.088	0.003
2	2088	1.483	35.35	0.734	0.107	0.078	0.074	0.007
3	522	1.989	11.85	0.763	0.105	0.064	0.061	0.008
4	522	2.450	14.60	0.793	0.101	0.051	0.048	0.007
Weekday	6264		71.49	0.756	0.103	0.066	0.068	0.007
5	1248	0.578	8.24	0.803	0.086	0.048	0.053	0.009
6	832	1.157	10.99	0.898	0.055	0.019	0.020	0.007
7	208	1.727	4.10	0.903	0.055	0.018	0.017	0.007
8	208	2.183	5.18	0.902	0.056	0.019	0.017	0.006
Weekend	2496		28.51	0.872	0.064	0.027	0.028	0.008
Annual Average	8760		100.0	0.789	0.092	0.055	0.057	0.007

Table 7/5: Total Vehicle Flow and Vehicle Category Proportions by Flow Group for a Non Built-up Road with an SI of 1.10

Hourly Variations in Composition

7.9 The basic time interval for traffic and costing calculations in QUADRO is one hour, and either the national average or input vehicle category proportions are used to generate appropriate hourly composition figures, as shown above. However, if there are data available indicating unusual proportions of heavy vehicles at a site, or unusual variations through the day or night, then the proportion of heavy vehicles can be specified on an hour-by-hour basis for each direction (and for the main and diversion routes) separately, using KEY 058, see Part 6, Chapter 3. Such data will overwrite the values calculated by the program but no check is made for overall consistency. For costing purposes the flows of light and heavy vehicles will each be disaggregated into their categories.

Diversion of Heavy Vehicles

7.10 The light/heavy distinction is also made in one of the rules governing diversion, which can be varied by the user. By adjusting the heavy vehicle diversion factor (HVDF) the user can represent either the case where heavy vehicles are retained on the main route (HVDF=0) which may be desirable if the surrounding network has unsuitable roads, or the situation where heavy vehicles divert in the same way as light vehicles (HVDF=100, the default). Intermediate settings are also possible. For example, if there are 14% heavy vehicles on the main route and HVDF=50%, then there will be 7% heavy vehicles in the traffic flow that can divert. Settings of HVDF are automatically overridden if there are insufficient light vehicles to satisfy the basic diversion requirement of equalising the journey times on the main and diversion routes. Traffic calculations in QUADRO are made for one hour time periods, and HVDF can be set for each hour of the day.

8. VEHICLES IN WORK TIME AND VEHICLE OCCUPANCIES

8.1 Other Chapters have shown how QUADRO determines traffic flows for each hour in each direction of travel when the user cannot specify these directly from local observations and also how the hourly flows are then split into percentages of different vehicle types (lights and heavies). One further disaggregation is considered, namely the disaggregation of time spent in work and non-work mode for each vehicle type.

8.2 The latest National Travel Survey (NTS) showed that in an average week 12.1% of car mileage is in working mode, 25.5% is in commuting mode and 62.5% is in other non-working mode, see Part 2 Table 1/1 for values of time. These average percentages have been further disaggregated and Table 8/1 gives the average hourly percentages of time spent in the three modes for cars used in QUADRO for all Network Classifications.

Hour of Day *	Monday-Thursday			Friday			Saturday			Sunday		
	work	com	other	work	com	other	work	com	other	work	com	other
1-6	17.2	57.8	25.0	5.2	71.4	23.4	4.8	30.4	64.8	7.5	24.1	68.4
7	21.9	68.1	10.0	15.5	62.8	21.7	7.2	53.5	39.3	15.2	37.0	47.8
8	16.6	68.2	15.2	11.4	68.1	20.5	6.9	38.6	54.5	7.4	29.1	63.5
9	17.6	44.8	37.6	21.0	45.0	33.9	4.1	20.8	75.1	10.3	15.0	74.7
10-12	20.2	9.0	70.8	18.2	8.8	73.0	2.7	4.2	93.1	3.1	4.0	92.9
13-17	20.5	18.9	60.6	15.9	20.5	63.6	1.9	7.3	90.8	2.6	4.3	93.1
18-19	10.9	46.8	42.3	9.9	37.4	52.7	1.8	11.1	87.1	3.8	5.9	90.3
20-22	9.2	19.6	71.2	5.8	13.1	81.1	1.1	5.7	93.2	5.3	6.7	88.0
23-24	5.9	20.5	73.6	4.0	14.9	81.1	5.0	7.5	87.5	2.7	13.6	83.7

* Hour Ending

Table 8/1: Hourly Percentages of Time Spent in Work, Commuting and Other Non-Work Mode for Cars All Network Classifications

8.3 The latest NTS also provides data showing how car and LGVoccupancies per kilometre travelled varies from hour to hour throughout the week. Table 8/2 shows how these vary by QUADRO flow group.

	Flow Group								All Week Ave
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Working car	1.17	1.16	1.15	1.13	1.30	1.31	1.34	1.34	1.16
Non-work car									
Commuting	1.15	1.15	1.14	1.13	1.19	1.22	1.21	1.21	1.15
Other	1.79	1.82	1.79	1.71	1.98	2.13	2.15	2.15	1.91
Working LGV	1.20	1.20	1.20	1.20	1.26	1.26	1.26	1.26	1.26
Non-work LGV									
Commuting	1.46	1.46	1.46	1.46	2.03	2.03	2.03	2.03	1.59
Other	1.46	1.46	1.46	1.46	2.03	2.03	2.03	2.03	1.59

Table 8/2: Car and LGV Occupancies (per km travelled) by Flow Group

8.4 Car occupancy is assumed to remain unchanged as can be seen from Table 8/3. The occupancy of all other vehicle types should also be assumed to remain unchanged over time.

Range of Years	**Vehicle Mode**	**Rate of Change by Flow Group (% pa)**					
		1 & 2	**3**	**4 & 5**	**6 & 7**	**8**	**9 & 10**
2011 onwards	Working Cars	0	0	0	0	0	0
	Commuting Cars	0	0	0	0	0	0
	Other Cars	0	0	0	0	0	0

Table 8/3: Compound Annual Rates of Change in Car Occupancies (%)

8.5 Unlike cars, it was not possible to disaggregate the LGV percentages of working, commuting and other non-working time into hourly and daily values. The average work/commuting/other non-work split of 88%/2.6%/9.4% is used in QUADRO for all days of the week.

8.6 Other Goods Vehicles (OGV1 and OGV2) and Public Service Vehicles are considered to be always in working mode although some PSV occupants are in commuting and other non-work mode, see Part 2 Table 1/1.

9. TRAFFIC GROWTH

9.1 Whichever form of basic flow input is used, the program converts the flow from the data input year to a value appropriate to the year of the job. By default, this conversion uses national average factors consistent with the DfT road transport forecasts 2018 Scenario 1 (Ref 5.6), where a full account of the forecasts and basis of their derivation is contained. The forecasts, shown in Table 9/1, operate on each vehicle category separately so that the proportion of each vehicle category changes year by year. Historically, QUADRO has included 'Low' and 'High' traffic growth profiles. These have been replaced by a single 'reference' default growth profile. Table 9/1 gives actual annual growth over recent years and the National average forecast traffic growth profile expressed as annual percentage growth rates for each year up to 2041. Zero growth is assumed post 2050.

PERIOD (see note)	CARS	LGV	OGV1	OGV2	PSV
	ACTUAL GROWTH (% per year)				
1994	2.1	4.2	0.9	3.4	1.0
1995	1.8	2.7	0.8	4.5	5.0
1996	2.7	4.0	2.4	4.3	2.6
1997	1.5	4.9	0.4	3.7	1.6
1998	1.5	4.8	3.4	4.1	0.7
1999	1.5	1.3	1.5	0.2	-0.1
2000	-0.2	1.4	0.7	0.1	-2.1
2001	1.6	2.6	-1.3	-0.3	0.1
2002	2.7	2.6	1.5	1.0	-0.3
	GROWTH FORECASTS (% per year)				
RANGE OF YEARS					
2003 to 2010	-0.04	2.05	0.52	-2.64	-0.94
2011 to 2015	1.24	1.55	-0.34	0.51	-1.97
2016 to 2020	1.37	1.95	-0.02	-0.02	-1.82
2021 to 2025	0.97	1.04	0.06	0.06	0.00
2026 to 2030	0.84	1.07	0.20	0.20	0.00
2031 to 2035	0.85	1.36	0.36	0.36	0.00
2036 to 2040	0.72	1.27	0.40	0.40	0.00
2041 to 2045	0.62	1.00	0.38	0.38	0.00
2046 to 2050	0.55	0.76	0.35	0.35	0.00

NOTE: The 1994 growth factor is that used to convert a 1993 flow to a 1994 flow.

Table 9/1: National Reference Road Traffic Forecasts (annual percentage growth rates)

9.2 A local (scheme specific) traffic growth profile consistent with the National Road Traffic Forecasts should always be used if available. It is only necessary to specify factors for the periods corresponding to basic flow input years, and to future job years. Factors for other periods will not be used. In some circumstances the user may expect unusual growth at a particular site because of special local conditions, for example, a nearby development. In such a case the basic flow level expected for the year of the job may be estimated externally, and input (using one of the methods in paragraph 6.2) for the job year, without affecting other jobs by changing the growth factors.

10. SHUTTLE WORKING SITES, WORKS ON WIDE SINGLE CARRIAGEWAYS AND CONVOY WORKING

10.1 QUADRO requires site capacity to be constant over the one-hour period which is the basic modelling interval. At sites with shuttle working each direction experiences intermittent intervals of flow through the site, alternating with intervals of zero capacity. For the purposes of the model this pattern is represented by a continuous capacity. Similarly an average two-way speed/flow relationship is used. The following analysis is based on site observations and simulations carried out by TRRL reported in LR 1024 (Ref 5.4). The analysis is in terms of signal-controlled sites, but the relationship between red-time and site length has been adjusted to provide reasonable results over a range of lengths covering the use of both temporary traffic signals and stop-go signs, **up to a site length of 500m.**

Capacity

10.2 The following relationship has been derived between the all-red period, R (secs), at temporary traffic signals on single carriageways, and the site length, L (km), (defined in para 1.4)

$$R = -5.5 + 189L - 156L^2 \qquad ....(1).$$

A relationship has also been assumed between the green time, G (secs), at the signals, and the all red period:

$$G = 40 + 1.6R \qquad ....(2).$$

Taking the red/amber plus amber phases to be 10 seconds, then the cycle time, Cy, is given by:

$$Cy = 2G + 2R + 10 \qquad ....(3).$$

Site capacity is derived from the formula:

$$C = \frac{SG}{C_y}$$

where C is the capacity and S the saturation flow (both in pcu/hr). The saturation flow is the rate of discharge through the site during a green period when there is a queue maintained on the approach to the site. So, substituting equation (3),

$$C = \frac{SG}{2G + 2R + 10}$$

then substituting equation (2),

$$C = \frac{S(40 + 1.6R)}{90 + 5.2R}$$

and substituting equation (1),

$$C = \frac{S(31.2 + 302L + 250L^2)}{61.4 + 983L - 811L^2} \qquad ....(4).$$

The above expression is built into the program, with a saturation flow of 1800 pcu/hr, which it converts into a default whole-hour continuous capacity. The expression must be used externally to specify hourly whole-hour continuous capacities if the default is unsuitable.

Speed-Flow

A suitable speed/flow relationship must combine the speed of vehicles travelling through the site, with the delay inevitably incurred by some vehicles that have to wait because of the shuttle operation. Average delays per vehicle at various flow levels and for different site lengths, were obtained from the TRRL simulation referred to above. Journey times through the site were calculated for each site length assuming speeds of 43.9 kph for light vehicles and 38.2 kph for heavy vehicles, with 10% heavy vehicles. (These speeds are based on site observations.) The journey times and delays were added to get total average times through the site at various flow levels and for various site lengths. These total times were then converted back to average speeds through the site, which take account of the delay associated with shuttle working. The range of flows was from 100 veh/hr to 700 veh/hr, and of site lengths from 50m to 300m.

In order to obtain a speed/flow relationship, V(kph) a multiple regression was carried out of speed on flow and site length. At higher flows, particularly for larger sites, average speeds fall off rapidly with flow, and such values were excluded. The resulting expression was,

$$V = 17.5 - 15Q/1000 + 4.5L ,$$

where, Q is the one-way flow (veh/hr),
L is the site length (km).

This expression is used in QUADRO to calculate speeds in shuttle working sites.

Works on Wide Single Carriageway Roads

10.4 New single carriageway roads can have either 7.3m running width (S2) plus 1m hardstrips or 10.0m running width (WS2) plus 1m hardstrips. Normally S2 roads are maintained using a shuttle working traffic management layout. However, when a WS2 road needs maintenance a further traffic management option is available. The `Safety at Streetworks and Roadworks - A Code of Practice' booklet (Ref 5.5) states that two-way working may be operated where an unobstructed carriageway width of at least 6.75m past a roadworks site can be provided, below this width there may be problems for HGVs and PSVs. It goes on to say that two-way working should not be continued when the available carriageway width is less then 5.5m. When the works site is in the middle of the road, two-way traffic can be used provided a minimum width of 3.25m is maintained on each side of the site. However, where the traffic is expected to consist only of cars and other light vehicles this width may be reduced to 2.75m (desirable minimum) or 2.5m (absolute minimum). Together with prudent use of speed restrictions (which determine sideways clearances/safety zones), it should be possible to safely maintain a WS2 road whilst keeping two-way traffic running. QUADRO can model either shuttle working or two-way working on a WS2 road. If narrow lanes, that is, less than 3.0m width are proposed for works on WS2 roads then the site capacity used in QUADRO may need to be adjusted, see Part 5 paragraph 1.8.

Convoy Working

10.5 Lateral safety clearances have to be provided between the edge of the working space of a roadworks site and the edge of the part of the carriageway in use by vehicles. At sites where the carriageway width is so restricted as to prohibit the provision of the required lateral safety zone, traffic speeds must be reliably reduced to 10mph (16kph) or less. Convoy working is a method of working in which traffic is brought to a halt in advance of roadworks using traffic control and is then led through the site past the works by a works vehicle. Further details are given in Departmental Advice Note TA 63/97 (DMRB 8.4.5).

10.6 Convoy working cannot be specifically modelled in QUADRO. An appropriate speed/flow relationship would need to combine the speed of vehicles travelling through the site with the delay inevitably incurred by some vehicles that have to wait because of the convoy operation. It is suggested that the shuttle working speed/flow relationship can be used as a proxy for the convoy working relationship. Convoy sites should be coded as having a Works Type 9 on KEY 052 (single lane shuttle working) with a 16kph speed limit through the works for both primary and secondary directions.