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Committee of Transport Officials

TMH 17
Volume 1

South African Trip Data Manual

Version 1.0

September 2012

Committee of Transport Officials

TECHNICAL METHODS
FOR HIGHWAYS

TMH 17
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South African
Trip Data Manual

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Technical Methods for Highways:

The Technical Methods for Highways consists of a series of publications that are in the nature of manuals in which methods are prescribed for used on various aspects related to highway engineering. The documents are primarily aimed at ensuring the use of uniform methods throughout South Africa.

Users of the documents must ensure that the latest editions or versions of the document are used. When a document is referred to in other documents, the reference should be to the latest edition or version of the document.

Any comments on the document will be welcomed and should be forwarded to the publisher. When appropriate, such comments may be incorporated in future editions of the document.

Synopsis:

The purpose of this Trip Data Manual is to provide various traffic parameters required for the estimation of Engineering Service Contributions and for the undertaking of Traffic Impact and Site Traffic Assessments in South Africa. Various parameters are provided in the manual, such as trip generation rates, trip lengths and road construction cost parameters required for the estimation of engineering service contributions.

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1 Introduction

1.1 Background

The purpose of this Trip Data Manual is to provide various traffic parameters required for the estimation of Engineering Service Contributions and for the undertaking of Traffic Impact and Site Traffic Assessments. Various parameters are provided in the manual, such as trip generation rates, trip lengths and road construction cost parameters required for the estimation of engineering service contributions.

1.2 Data sources

The parameters provided in this manual were established using data and information obtained from various sources, including South African and international sources. The South African data are the result of a significant amount of effort by various individuals and organisations that collected and provided the data. These efforts are acknowledged with gratitude.

In spite of the above effort, however, the available local data are in some cases not sufficient to allow the estimation of traffic parameters with a high level of confidence. In such cases, the local data were supplemented by international information. In certain cases, judgement had to be applied in weighting or extrapolating information from the available sources of information.

Due to the lack of local information, authorities and practitioners are encouraged to conduct further surveys and to submit the data for use in future updates of this manual. A concerted and significant effort will be required to provide a reliable source of data required for the estimation of the required traffic parameters.

Even where there is a lack of locally available data, authorities must NOT allow the use of data collected at individual or specific developments for the determination of engineering service contributions and traffic impact assessments. The parameters must be determined on the basis of a scientific study of data obtained from a randomly selected sample of developments with adequate sample sizes. Studies based on observations at an individual or specific site may not be indicative of the potential traffic characteristics of a development.

Where data are not available in the manual for a particular land use type, consideration may be given to using data that is available for another land use that is likely to have the same traffic characteristics. Alternatively, international data sources may also be used if the traffic characteristics are likely to be applicable to local conditions.

1.3 Trip data tables

Various traffic parameters are provided in Appendix A to this manual. These parameters were derived from the various sources of data that were available locally and internationally. Detailed descriptions of the parameters are provided in the different chapters of this manual.

1.4 Trip parameter studies

Guidelines and requirements for the undertaking of trip parameter studies required for the estimation of different traffic parameters are provided in Appendix B. The parameters provided in this manual were derived using the methodologies described in this appendix.

Any data collected for inclusion in future editions of this manual must be collected in accordance to the requirements of the appendix. Forms are provided in the appendix that may be used for the data collection. The data should preferably be captured in spread sheets and submitted electronically for possible inclusion in future editions of this manual.

2 General Traffic Parameters

2.1 Traffic growth rates

Traffic growth rates are used for the estimation of future background traffic. These growth rates are normally only applied to background traffic counts.

The growth rate depends on the expected growth in the area in which the development is located as well as the degree to which approved but not yet exercised developments as well as latent rights in the area are taken into account in a traffic impact assessment.

Typical growth rates are provided in Table 1.1. These growth rates should be adjusted according to circumstances and the degree to which latent and other rights have been taken into account in the impact assessment.

2.2 Service flow rates

Service flow rates are required for the determination of engineering service contribution. The contribution depends on the road space required to serve traffic visiting a development. This space is broadly determined by first calculating the "amount of travel" by multiplying the trip generation of the development with half the average of trip lengths between the development and previous or next developments visited during trips (excluding travel on certain types of roads). The amount of travel is then divided by the typical service flow rate of a road to determine the lane-kilometre or roads required to serve the development.

The required service flow rate is determined by means of the following formula:

$$Q_T = \frac{N_L . Q_L}{2 \cdot F_{D1}}$$

Where:

- Q_T = Service flow rate of the road (veh per hour)
- N_L = Number of lanes on the road (e.g. 4 for a 4-lane road)
- Q_L = Service flow rate per lane (veh per hour per lane)
- F_{D1}, F_{D2} = Background traffic directional split F_{D1}:F_{D2} with $F_{D1} > F_{D2}$

Using the background directional traffic split implies that contributions are determined on the basis of the directional split for which roads are designed. This is an "average" split for all developments which does not take the directional characteristics of specific developments into account. It is not possible to determine such characteristics for individual developments and the formula is therefore based on the average split. Even if a development has a 50/50 traffic split at the entrance to the development, it does not imply that the same split would be maintained on the road network since outgoing traffic would not follow the exact same route as incoming traffic (particularly if there are more than one destination on a trip).

The parameters required for the above formula and service flow rate calculated by means of the above formula are provided in Table 1.2. The service flow rate was determined for a Level-of-Service D on typical Class 2 and 3 urban roads (TRB, 2000).

2.3 Heavy vehicle E80 axle equivalencies

Engineering service contributions are determined for the “capacity” and “strength” components of roads. The strength component provides for the cost of strengthening of roads to accommodate the E80 axle loads of heavy vehicles.

The number of E80 axle loads is established by multiplying the number of heavy vehicles with the average number of E80 axle loads per heavy vehicles. The number of heavy vehicles is derived based on the trip generation characteristics of a development and the percentage of trips that are made by heavy vehicles.

The average number of E80 axle loads per heavy vehicle can be expected to vary between different land uses since different land uses attract different types of heavy vehicles. Provision is therefore made for different E80 equivalencies for different land uses.

Heavy vehicles are classified in South Africa into three length categories, namely short, medium and long heavy vehicles (Schildhauer, 2005). The average number of E80 axle loads per vehicle for the three categories are provided in Table 1.3. Also provided in the table is a typical composition of the three heavy vehicle classes on urban roads. An average number of E80 axle load per heavy vehicle is also given in the table for this typical composition.

2.4 Heavy vehicle lane distribution

Roads are designed to carry a certain number of E80 axles over its lifetime. The normal practice is to construct all lanes of multilane roads for the required pavement strength although heavy vehicles tend to concentrate in the slow lane.

Not all heavy vehicles, however, concentrate in the slow lane and there is some distribution over other lanes of the road. The typical percentage of heavy vehicles using the slow lane is therefore used in determining the unit cost rate for the strength component of the engineering service contribution. Typical percentages of heavy vehicles travelling in the slow lanes of roads are provided in Table 1.4.

2.5 Normal and Abnormal Days

Daily traffic patterns may vary significantly on different days of the year. In South Africa, differentiation is made between two basic classes of traffic patterns, namely those counted on normal and abnormal days. Normal days are days of the year during which traffic patterns tends to be stable and where these patterns are not affected or influenced by abnormal or exceptional events.

Abnormal days are days on which the traffic patterns deviate from normal days due to events such as schools and public days (including influenced days). Although abnormal, these days can be predicted from published information on school and public holidays.

Exceptional days are normal days on which some unpredictable event occurred that affected the traffic pattern. These include events such as road closures, construction, accidents and adverse weather conditions.

Abnormal days can be identified by means of definitions provided in Table 1.5 (Papenfus and Van As 2010). Days that are not abnormal can be assumed to be normal but care is required to ensure that unpredictable events have not occurred which could affect the traffic counts.

3 Road Construction Cost Parameters

3.1 Introduction

A number of parameters are provided in this chapter for establishing road construction cost rates required for the determination of engineering service contributions. The cost rates required to estimate costs are not provided in this manual but will be published and updated annually by municipalities. This chapter only covers the parameters required to determine the cost rates as well as the methodology for establishing the cost rates.

3.2 Road design standards and quantities

Construction cost rates required for determining engineering service contributions are based on road design standards and quantities typical of Class 3, 4 and 5 roads in urban areas. The design standards and quantities used for this purpose are provided in Tables 2.1a and 2.1b. The quantities provided in the tables have been determined for a 1 km length of road (of each Class).

Standards and quantities are provided for the following items in the tables:

- Road reserve area (hectare)
- Road pavement area (m^2)
- Pavement layer areas (3 million E80 axles)
- Pavement layer areas (10 million E80 axles)
- Kerb lengths (m)
- Sidewalk areas (m^2)
- Public transport facilities (bus stops)
- Grade separation structures (No)
- Traffic signals (No)

Provision is made for two pavement designs, one designed for 3 million and the other for 10 million E80 axles. The difference in costs between the two designs is used to determine the “strength” component of the engineering service contribution. The cost of the capacity component is determined by subtracting the strength component from the total cost. The strength component is then used to determine the cost rate of accommodating 10 million E80 axles over a design life of 20 years.

3.3 Cost components

The cost components that are used in establish construction cost rates are summarised in Table 2.2. Once rates have been established for each cost component, the rates can be multiplied with the quantities provided in Table 2.1 to determine a total cost per km of road (for different road classes).

Only cost components that are normally associated with well-planned and designed roads are taken into account when determining cost rates. Costs resulting from inadequate infrastructure planning and reservation of land for infrastructure provision are not taken into account. The costs could have been prevented if adequate planning had been in place and land had been reserved before development occurred. Cost items such as relocation of engineering services and demolition of structures are therefore not taken into account in determining cost rates.

The cost components summarised in Table 2.2 are the following:

a) **Land value**. Land values are established and provided by land valuators of a municipality. The land values must be determined as the typical or average values of land at the time townships are established or when new roads are typically constructed. The land value is typically that of farm land with development potential.

b) **Accommodation of traffic.** Items that are required to accommodate traffic during construction. However, excessive items required to accommodate traffic due to inadequate road network planning are not included.

c) **Earthworks.** A general cost component that includes items such as the following:

- Site clearing and grubbing.
- Mass earthworks (cut and fill).
- Importation and disposal of material.

The following items are not taken into account:

- Locating and uncovering engineering services.
- Removal of existing structures.

d) **Wearing Course.** Provision is only made for roads constructed with asphalt. Roads constructed with concrete or concrete blocks are not included.

e) **Base Course.** Foundation layer situated immediately below the wearing course. Constructed with imported material and normally stabilised.

f) **Subbase.** Foundation layer situated immediately below the base course. One or two subbase layers may be used. Constructed with imported material which may be stabilised.

g) **Subgrade.** Foundation layer situated immediately below the subbase. Constructed with in-situ material if such material is suitable, otherwise material is imported.

h) **Roadbed.** Situated below the foundation. Normally constructed with in-situ material if the material is suitable, otherwise material may have to be imported.

i) **Kerbs.** Concrete kerbs constructed along the edge of the road. Mountable or non-mountable.

j) **Sidewalk.** Cost rate includes all components involved in the construction of sidewalks, including preparation of the foundation.

k) **Guard rails and other safety devices.** Road safety devices such as guard rails.

l) **Stormwater drainage.** Only includes items required for the drainage of the road. Items required for the provision of a main stormwater structure is excluded (such items will be recovered by means of stormwater engineering contributions). Items such as trenching, pipes, culverts, channels, inlets, etc. are included.

m) **Public transport facilities.** Includes items such as bus shelters, pavements for the bus stops, etc.

n) **Grade separation structures.** A total cost is required for this component.

o) **Landscaping, finishing off and fencing.** Landscaping is included to the extent reasonably required for road provision. Landscaping aimed at purposes such as city beautification is not an engineering service and may thus not be included. Includes items such as vegetation, paving of medians and islands, etc.

p) **Road signs.** Provision and installation of road signs and markings.

q) **Traffic signals.** Provision and installation of traffic signals.

r) **Street lighting.** Street lights and electric cables.

s) **Other items.** Include items not covered elsewhere, such as service ducts.

t) **Preliminary and general items.** Cost provided as a percentage of the total constructed cost. Includes items such as the following:

- Preliminary, fixed and time related.
- Health and safety regulations.
- Engineer's accommodation.

u) **Professional services.** Cost provided as a percentage of the total constructed cost, including preliminary and general items. This percentage depends on the size of the project and a typical road construction project was therefore used to determine the percentage provided in the table.

The professional fees provide for all phases of the planning, design and supervision of a road project, including the following:

- Environmental Impact Assessment.
- Feasibility Study.
- Preliminary Design.
- Detail Design.
- Construction Supervision.

3.4 Cost Table – Land Values

Costing parameters will be published annually using tables similar to those provided in Tables 2.3 and 2.4. Table 2.3 is used for one of the major cost components, namely land values.

The municipality will establish regions in which land values are relatively homogeneous. The engineering service contribution will therefore differ from region to region depending on average land values in a region.

Land value is the average cost of land in a region at the time when a new township is established. Typically, the cost would that be of farm land with development potential. The land value costs are determined as the costs involved with the expropriation of land for purposes of road provision.

The following parameters will be provided in the land-value table:

a) Escalation factor applicable to land values. The escalation factor is based on the consumer price index. The following formula is used for determining the escalation factor:

$$I_L = \frac{I_{PCt}}{I_{PCo}}$$

In which:

I_L = Escalation factor for land
I_{PC} = Consumer Price Index (Historical metropolitan and other urban)

The suffix "o" denotes the base year when the base unit cost rate was determined while the suffix "t" denotes the year for which the cost rates are published. The consumer price index for the base year is determined as the average of the indices for the 12 months of the year. The index for the publishing year is determined as the average of indices for the most recent available 12 months.

b) Land values per region. The following is provided for each region:

i) Originally estimated land value per hectare for the region.
ii) Escalated value per hectare
iii) Cost per kilometre road. This is determined as follows:

Cost per km = Cost per ha x Road reserve width (m) / 10

iv) Cost per veh-km/hr for Class 3 roads, determined as follows:

Cost per veh-km/hr = Cost per km / Service flow rate Q_T

The table also provides space for a trip length adjustment factor that accounts for the size of the urbanised area. This factor is calculated using the formula given in Chapter 5 and parameters provided in Table 1.7.

3.5 Cost Table – Construction Cost

Table 2.4 is an example of a table that can be published annually for providing road construction cost rates required for determining engineering service contributions. The following information will be provided in the table:

a) Costing parameters – Class 3 roads, capacity and strength components:

i) The originally estimated construction cost per km road
ii) Escalation factor
iii) Escalated cost per kilometre road
iv) Cost rate per travel unit, obtained by dividing the escalated cost by:
   - For the capacity component, by the service flow rate (in units of veh-km/hr)
   - For the strength component, by the design number of E80 axles per day (as determined previously in this chapter)

b) Costing parameters – Class 4/5 Boundary roads:

i) The originally estimated construction cost per km road
ii) Escalation factor
iii) Escalated cost per kilometre road

c) Escalation factors, CPI and Production Price Indices provided at:

i) At the date of the construction cost estimate
ii) At the date of publication of the cost rates

The escalation factor is determined by means of the following formula:

$$I_K = 1 - X_{PK} + X_{PK} \cdot (X_{PL} \cdot \frac{I_{PCt}}{I_{PCo}} + X_{PM} \cdot \frac{I_{PMt}}{I_{PMo}} + X_{PF} \cdot \frac{I_{PFt}}{I_{PFo}} + X_{PP} \cdot \frac{I_{PPt}}{I_{PPo}})$$

In which:

I_K = Escalation factor for construction component
X_{PK} = Proportion of Construction cost subject to escalation
X_{PL} = Proportional value for Labour cost
X_{PM} = Proportional value for Materials (Civil engineering industry)
X_{PF} = Proportional value for Fuel
X_{PP} = Proportional value for Civil engineering plant
I_{PC} = Consumer Price Index (Historical metropolitan and other urban)
I_{PP} = Production Price Index for Civil engineering plant
I_{PM} = Production Price Index for Materials (Civil engineering industry)
I_{PF} = Production Price Index for Fuel (Diesel oil)

The suffix "o" denotes the base year when the base unit cost rate was determined while the suffix "t" denotes the year for which the cost rates are published. The price index for the base year is determined as the average of the indices for the 12 months of the year. The index for the publishing year is determined as the average of indices for the most recent available 12 months.

The costs rates required by Table 2.4 can be determining using cost estimates as provided in Table 2.5 and 2.6. These two tables provide details on the estimation of construction costs per km road for Class 3 and 4/5 roads respectively.

4 Trip Generation

4.1 Introduction

Trip generation is the amount of traffic generated by a development. A trip is defined as a single (one-directional) movement with either the destination or the origin of the trip at a development. The development is the destination when a person visits the development and an origin when the person leaves the development. Should a person both visit and leave a development, two trips are counted.

4.2 Average rates

The trip rates provided in this manual are average rates. The trip rates provided in the South African Trip Generation Rates (Department of Transport 1995) were provided as 75^{th} percentile values.

It is considered more reasonable to use average rather than 75^{th} percentile trip rates on the municipal street system which is used by a range of developments. The trip rates may vary between developments, but the total traffic on the street system is more related to the average trip rates than the 75^{th} percentile value.

The traffic on the access to a particular development, however, could vary from development to development. In such cases it could be more appropriate to use a lower or higher trip rate than the average.

4.3 Trip types

Trip generation fundamentally consists of four types of trips:

a) **Primary trips**, trips are new on the total road network. This is in contrast with the other types of trips that are already on the road network, although they could be new on segments of the road network.

b) **Pass-by trips**, trips that are attracted from roads *directly adjacent* to a development and from which direct access is provided to the development. These trips are made as intermediate stops on the *on the way* from an origin to a primary destination *without* route diversion (ITE, 2004). Pass-by trips are not new trips on the road network, but are trips turning in and out of accesses to the development. The trips should therefore not be deducted from the trip generation of the development – it is only the trip distribution that is affected.

c) **Diverted trips**, trips that are attracted from roads in the *vicinity* of the generator but which require a diversion to another road to gain access to the development. Diverted trips add traffic to streets adjacent to a site, but may not add traffic to other roads in the road network. The trips are similar to pass-by trips, except that they have to deviate to other roads to obtain access to the site. Diverted trips well tend to return to their original route and continue to their original destinations after visiting the development.

d) **Transferred trips**, trips that are already present on the road network and which are visiting similar developments near to the proposed development and which has the potential of transferring or switching their destination to the proposed development. These trips are different from pass-by and diverted trips in that trips are wholly transferred from one development to another.

Where available, information is provided on pass-by and diverted trips in the different trip tables provided in this manual. No information is available for transferred trips and such trips must therefore be estimated by means of other methods.

4.4 Daily trip generation rates

Daily trip generation rates and other associated traffic parameters are provided in Table 3.1. These parameters are intended for use in the determination of engineering service contributions. Peak-hour trip generation rates are provided in Table 3.3 – these rates are used in traffic impact and site traffic assessments. Trip generation adjustment factors are provided in a third table (Table 3.2) which are used both for establishing engineering service contributions and traffic assessments.

The following trip generation rates and parameters are provided in Table 3.1 for different land uses:

a) $AADT_D$, the Annual Average Daily Trip generation rate (per size unit), the estimated total in- and outbound traffic generated by one size unit of the development over one year divided by the number of days in a year.

b) The traffic factor F_{QD} used to convert the $AADT_D$ to an equivalent impact hourly flow rate for the development. It is a combined factor which accounts for factors such as the heavy vehicle generation as well as the traffic peaking characteristics of a development. The factor is determined using formulae provided in the *South African Engineering Service Contribution Manual for Municipal Road Infrastructure.*

c) Hourly Trip Rate (F_{QD} x $AADT_D$) which is the $AADT_D$ multiplied by the factor F_{QD}. This rate can directly be used in determining the engineering service contribution.

d) The percentage heavy vehicles P_{HD} (of $AADT_D$).

e) Number of E80 axles per heavy vehicle (E_{HD}), used for establishing the strength component of the engineering service contribution.

f) A size adjustment factor which is used to adjust the $AADT_D$ for the size of the development. The $AADT_D$ provided in the table is multiplied with the adjustment factor to provide the daily trip rate for a development of a particular size. The size adjustment factor is determined by means of the following formula:

$$\text{Size adjustment factor} = 1 + \frac{A}{1 + \frac{\text{sqm Size}}{B}}$$

In which A and B are parameters provided in the table and *sqm Size* is the size (GLA) of the development measured in units of m^2.

4.5 Peak-hour trip generation rates

Peak-hour trip generation rates and other associated traffic parameters and characteristics are provided in Table 3.3. These parameters are intended for use with traffic impact assessments. Where available, rates are provided for the following peak hour periods:

- Weekday AM peak hour (06:00 to 08:30)
- Weekday PM peak hour (16:00 to 18:30)
- Weekday Midday peak hour (11:30 to 14:00)
- Weekday Evening peak hour (18:30 to 24:00)
- Saturday Morning/Midday peak hour (08:30 to 14:00)
- Sunday Morning/Midday peak hour (08:30 to 14:00)

The following information is provided for each of the above peak hours where available:

a) Trip generation rate measured in units of trip ends per hour. It is the sum of in- and outbound traffic to or from a development during the peak hour.

b) Percent heavy vehicles, to and from the development during the peak period.

c) In/Out split, the percentage of trips entering and exiting the development during the peak period.

d) Peak hour factors (PHF) for:

i) Traffic entering and exiting the development.
ii) Traffic on the adjacent street network.

The peak hour factor is defined as the hourly volume divided by the peak 15-min flow rate within the peak hour, both measured in units of vehicles per hour.

i) Vehicle Occupancy, the number of persons per vehicle, including the driver of the vehicle.
ii) Percent pass-by and diverted trips, the percentage of the trip generation which is pass-by or diverted trips.

The pass-by and diverted trip factors provided in the table are subject to a maximum limit defined as a percentage of the background traffic at the intersection from which pass-by or diverted trips are attracted. This maximum percentage is provided in Table 1.6.

e) A size adjustment factor which is used to adjust various parameters provided in the table. The specific parameter is multiplied with the adjustment factor to provide the required parameter for a development of a particular size. The size adjustment factor is determined by means of the following formula:

$$\text{Size adjustment factor} = 1 + \frac{A}{1 + \frac{\text{sqm Size}}{B}}$$

In which A and B are parameters provided in the table and *sqm Size* is the size (GLA) of the development measured in units of m^2.

The trip generation rates provided in the different tables are mostly based on data that were collected locally at various types of land uses (a list of data sources are provided elsewhere in this manual). Where data were not available, the trip generation rates were based on those published by the ITE Trip Generation Manual (2004).

Only a limited amount of data is locally available on pass-by and diverted trips. The parameters provided in the tables were therefore mostly obtained from the ITE Trip Generation Manual (2004).

4.6 Heavy goods transport

Heavy goods transport has considerable impacts on the road network which requires a more accurate estimation of heavy vehicle trip generation than permitted by the use of average rates. For land-uses that require the transport of such heavy goods, the percentages heavy vehicles given in the various trip generation tables are provided only as approximate indicators and a more detailed analysis must be undertaken to determine the heavy vehicle trip generation of such land uses.

The land uses that typically require transport of heavy goods are Heavy Industrial/Manufacturing (Code 120) and Mining (Code 121), but there may be other developments that would require the transport of heavy goods. Examples of heavy goods include quarried or mined materials, heavy machinery and heavy products. Mined materials include sand, clay, kaolin, ores and minerals while heavy machinery include machinery used for mining, power generation and the production of goods. Heavy products include bricks, concrete products and refined metals and other similar goods.

The heavy vehicle trip generation of land uses that require transport of heavy goods must be derived by means of a detailed analysis of the planned heavy good production or consumption rates at a development. These rates can then be used to estimate the heavy vehicle trip generation rates for the development. Estimates will be required for both the daily and peak-hour trip generation of the development. This trip generation can also be based on observations that are made at other similar developments.

4.7 Vehicle ownership and transit availability

The trip generation rates provided in Tables 3.1 and 3.3 are applicable to areas with high vehicle ownership and where a low level of transit service is provided. For other areas, a lower trip generation rate can be expected. Trip reduction factors that can be used for such developments or areas are provided in Table 3.2. These factors can be applied to the trip generation rates provided in Table 3.1 as well as Table 3.3.

Typically, the vehicle ownership in areas with high levels of vehicle ownership varies between one to two vehicles per household. In areas with a low level of vehicle ownership, the majority of households (more than 50%) does not own a vehicle and relies on public transport for transportation. In areas with very low level of vehicle ownership, nearly all households (more than 90%) do not own a vehicle and rely on public transportation. The municipality will decide on which areas qualify as low or very low vehicle ownership areas.

The trip generation rates in low levels of vehicle ownership are currently relatively low or very low. It is, however, unlikely that the generation rates will remain at the current low level in the future. Provision must be made to accommodate such future growth and it is therefore necessary to predict likely future trip generation rates.

The reduction factors provided in the table are those that are considered reasonable for low vehicle ownership areas and areas with a high level of transit services. The factors have been established considering current trip generation rates in the different areas. It is unlikely that the trip generation rates will remain at current low levels, but at the same it is also unlikely that the rates will grow to those in high vehicle ownership areas. The reduction factors provided in the table provide for some reduction in trip rates, but not to the levels currently being experienced.

The transit reduction factors provided in Table 3.2 are applicable to developments that are located within a reasonable walking distance from a major transit node or stops on a major transit corridor. The municipality will decide on whether a particular development qualifies for this reduction.

4.8 Mixed-use development

For purposes of this manual, mixed-use developments are defined as developments in an area that consist of two or more single-use developments between which trips can be made by means of non-motorised modes of transport (such as walking). This has the net effect of reducing the vehicle trip generation in the area.

Some of the land-uses for which trip generation rates are provided already constitute mixed-use developments and the trip rate already provides for a reduced trip rate. An example of such a land use is shopping centres that could consist of other component land uses such as restaurants, cinemas, etc.

For land-uses which are not already included as a component of another land-use, an estimate may be made of the multi-use trips using the mixed-use reduction factors provided in Table 3.2. These reduction factors may be applied subject to the following two conditions:

a) The mixed-use developments must be located within a reasonable walking distance from each other.

b) The mixed-use reduction for a development may not exceed the available multi-use trips generated at the other adjacent or nearby developments.

4.9 Combination of reduction factors

The trip reduction factors provided in Table 3.2 for mixed-use development, vehicle ownership and transit nodes or corridors may be used in combination, in which case the following formula must be used to determine the combined reduction factor:

$$P_C = 1 - (1 - P_M) \cdot (1 - P_V) \cdot (1 - P_T)$$

In which:

P_C = Combined reduction factor
P_M = Reduction factor for mixed-use development
P_V = Reduction factor for vehicle ownership
P_T = Reduction factor for transit nodes or corridors

4.10 Peak-hour spreading

The trip generation rates provided in this manual may NOT be adjusted to account for the spreading of traffic demand during the peak period as a result of prevailing congested traffic conditions. The trip generation rate already accounts for some spreading of traffic demand as a result of factors such as variable working and travel times.

Allowing for spreading due to congestion does not reflect actual traffic demand and would exacerbate the existing congested conditions. Furthermore, spreading out of traffic demand due to congestion is a dis-benefit to users and must be assessed and evaluated as a negative traffic impact and a deterioration in level of service provided to road users.

5 Trip Length

5.1 Introduction

Trip length is an important parameter for the determination of engineering service contributions. The length of a trip is combined to determine the veh-km/hr of travel used for establishing the capacity component of the contributions. The trip length is also used in the determination of the strength component.

Trip length is the distance (in km) travelled between an origin and a destination. Where a trip is made to a multiple number of destinations, each leg of the trip is considered to consist of an origin and a destination.

Some limited data on local trip lengths are available for some land-uses, but the data currently do not adequately cover all land-uses. The available local data were therefore supplemented by international (USA) data to establish the trip lengths provided in this manual.

5.2 Average trip lengths

Average trip lengths are provided in Table 4 in this manual. The following information is provided in the table:

a) Average total trip length measured in km, between an origin and a destination.

b) Half trip length measured in km. Engineering service contributions are determined for half the trip length since the land use on the other side of the trip is responsible for the other half.

c) Half the trip length on Class 4 or 5 roads. This trip length is deducted from the trip length to determine the trip length on Classes 1 to 3 roads, for which contributions are determined. This deduction, however, is only made for two-lane Class 4 and 5 roads. For multilane Class 4 and 5 roads, only 50% of the trip length is deducted since the cost of providing the additional lanes must be covered by the trip length.

d) Percentage trip length on non-municipal roads, the percentage of the trip length not travelled on municipal roads (roads under the jurisdiction of the particular municipality).

e) Adjusted (half) trip length, the half trip length adjusted for travel on Class 4 and 5 roads as well as the percentage trip length on non-municipal roads. The adjustment is made as follows:

$$(L_D / 2) = (1 - P_N) \cdot (L_T / 2) - L_{45}$$

Where:

$L_D/2$ = Half adjusted average trip length (km)
$L_T/2$ = Half total average trip length from origin to destination
F_T = Adjustment for size of the municipality
P_N = Proportion travel on roads not under jurisdiction of municipality
L_{45} = Length of travel on Class 4/5 roads (subject to 50% reduction)

f) A size adjustment factor which is used to adjust the trip length for the size of the development. The trip length is multiplied with the adjustment factor to provide the trip length for a development of a particular size. The size adjustment factor is determined by means of the following formula:

$$\text{Size adjustment factor} = 1 - \frac{A}{1 + \frac{\text{sqm Size}}{B}}$$

In which A and B are parameters provided in the table and *sqm Size* is the size of the development measured in units of square metres.

5.3 Heavy goods transport

For land uses that require transport of heavy goods (such as Heavy Industrial/Manufacturing and Mining), the use of average trip lengths are inadequate and the heavy vehicle trip lengths must be derived by means of a detailed analysis,

The detailed analysis will require the identification of heavy vehicle origins and destination and routes that will be used by the heavy vehicles during the trips. The trip lengths must be adjusted for trips made on Class 4 and 5 roads as well as trips not made on roads under the jurisdiction of the particular municipality. Where the origin or destination of the trip is within the boundaries of the municipality, only one half of the trip length is required. Otherwise, the full trip length within the boundaries of the municipality must be used.

5.4 Trip Length Urban Size Adjustment Factor

For the determination of engineering service contributions, a factor is used to account for the impact of the size of the urbanised or developed area on trip lengths. Trip lengths in smaller urbanised areas can be expected to be shorter than those in urbanised areas. The adjustment is made by means of the following approximate formula:

$$F_T = 1 - F_{LA} \cdot e^{-A \cdot F_{LB}}$$

Where:

F_T = Adjustment for size of the urbanised area
A = Size of the urbanised area (km^2)
F_{LA}, F_{LB} = Parameters of the formula

The parameters required for the formula are provided in Table 1.7.

6 Locations and Land-uses

6.1 Development locations

Traffic parameters and characteristics may depend on the location of a development. Parameters such as trip generation and trip length can significantly depend on the location of a development.

A list and description of typical locations are provided in Table 5. The information currently provided in this manual are only applicable to developments located in suburban areas. When data become available for other areas, such data will be included in future editions of this manual.

6.2 Land-use types

Various traffic parameters and characteristics are provided in this manual for different types of land uses. Parameters such as trip generation and trip lengths depend significantly on the type and size of a land-use.

A list and description of the different land-use types for which traffic parameters are provided, are given in Table 6. It is important that this table should be studied carefully before a particular development is classified. Care should be taken to ensure that a land-use type is selected which would most closely reflect the traffic generating characteristics of a development.

6.3 Size units

The trip generation and other traffic characteristics of a development depend not only on the type of development but also on its size. Different size units are used in this manual, for example, “Gross Leasable Area (GLA)”, Dwelling Units”, “Rooms”, etc.

The size units used in the manual have been selected on the basis of the following considerations:

a) The most important consideration is that the size unit should be related to the extent of land-use rights that will be granted to a development. Such extent is normally defined in terms of some physical dimension of the development, such as area, number of units, etc.

b) There should be a direct causal relationship between the size unit and the trip generating and other characteristics of the development.

c) It should be possible to directly measure the size unit through a primary measurement and not derived from secondary data.

The following is a summary and definition of a number of the size units that are used in this manual:

a) **Gross Leasable Area (GLA)**. The GLA of a development is the total floor area designed for tenant occupancy and exclusive use (ITE, 2004). It is the area for which tenants pay rent and which produces income for the owner of the development. The GLA is normally measured in m^2 (square metres) and is typically measured between the centrelines of inner and outside walls.

Generally, the following areas are excluded from the definition of GLA:

- Open roof areas, verandas or balconies. Canopies erected on the street frontage of a shop.
- Parking areas.
- Malls, entrance halls and foyers at shopping centres.
- Accommodation for the lift room and other mechanical or electrical equipment required for the functioning of the building.
- Areas reasonably used in connection with the cleaning, maintenance and care of the building.
- Accommodation of the supervisor.

Storage space used by tenants is not included in the above list and is regarded as part of the GLA.

d) **Hectare (ha)**. The size of the property (development) in hectare (10 000 m^2).

e) **Dwelling Units**. The number of individual dwelling units in a development.

f) **Rooms**. The number of individual or separate rooms in a development. In situations where it is occasionally possible to combine two or more rooms into a single room, the rooms are counted separately.

g) **Beds**. The number of beds that will normally be provided in the development (assuming normal operations).

h) **Seats**. The number of seats that will be provided in a development for use by delegates (seats used by staff are excluded).

i) **Number of employees**. The maximum number of employees that will be employed at any time by the development.

j) **Students**. The number of students for which provision is made in a development.

k) **Workbays**. The number of individual work bays provided at a service facility.

7 Data Sources

The various traffic parameters provided in this manual are based on data obtained from the data sources listed below.

7.1 Trip Generation

Trip generation data were obtained from the following sources:

- Arup Consulting Engineers, Johannesburg.
- BKS Pty Ltd Consulting Engineers, Pretoria.
- Corli Havenga, Transportation Engineers, Pretoria.
- Gibb Africa Engineering Consultants, Pretoria.
- GOBA Consulting Engineers, Johannesburg.
- ITS Consulting Engineers, Pretoria.
- Jeffares and Green Consulting Engineers, Johannesburg.
- Karabo Consulting Engineers, Pretoria.
- Kwezi V3 Consulting Engineers, Pretoria.
- Louis Roodt, Pretoria
- SENA Consulting Engineers, Pretoria.
- SMV Civil Engineering Consultants, Pretoria.
- Tech IQ Consulting Engineers, Pretoria.
- Techworld Consulting Engineers, Pretoria.
- Tollplan, Toll road management, Engineering and Consulting, Pretoria
- Dr Pieter Pretorius, ITS Consulting Engineers, Pretoria.
- Hendrikus Swart, Endecon Ubuntu (Pty) Ltd Engineering Consultants
- Gert Potgieter, Mangaung Local Municipality
- Peter Purchase, EDS Structural, Civil and Transportation Engineers

7.2 Trip Lengths

Trip length data were obtained from the following sources:

- Citrus County, 2006, Impact Fee Study Draft Report, Tindale-Oliver & Associates, Inc. Lecanto, Florida.
- City of Albuquerque, 2004, Roadway facilities impact cost study, Summary Report, Tindale-Oliver & Associates, Inc., Tampa, Florida.
- City of Oviedo, 2006, City Of Oviedo Impact Fee Update Final Report, Tindale-Oliver & Associates, Inc. Tampa, Florida.
- Ghyoot VG, 1992, Feasibility analysis for proposed shopping centres with special emphasis on trade area demarcation. Doctor of Commerce (Business Economics) Thesis, University of South Africa, Pretoria.

- Indian River County Metropolitan Planning Organization, 2004, Update of the Traffic Impact Fee Ordinance – Cost Estimate Variables, Tindale-Oliver & Associates, Inc. Tampa, Florida.
- Johannesburg Road Agency, 2007, Trip length surveys in Johannesburg.
- Lake County, 2001, Lake County Transportation Impact Fee Study, Tindale-Oliver & Associates, Inc. Tampa, Florida.
- Tindale, SA, 1991, Impact Fees – Issues, Concepts and Approaches. ITE Journal, May 1991, pp 33-40.

8 References

City Council of Pretoria, 1998, Guidelines for Traffic Impact Studies, Pretoria.

City of Tshwane Metropolitan Municipality, Centurion Administrative Unit, Comprehensive Traffic Observations, Yearbook 2000, Pretoria.

Department of Transport, 1995, South African Trip Generation Rates – Second Edition, Report RR 92/228, BKS Inc, Pretoria.

ITE (Institute of Transportation Engineers), 1994, Manual of Transportation Engineering Studies, Washington D.C.

ITE (Institute of Transportation Engineers), 2004, Trip Generation, 7th Edition, Washington D.C.

ITE (Institute of Transportation Engineers), 2004, Trip Generation Handbook, 2nd Edition, Washington D.C.

JC De Vries, 2004, A methodology for establishing developer contributions to the provision of road infrastructure in urban areas, M.Eng Thesis, University of Pretoria.

NCHRP, 2001, Truck Trip Generation Data, A Synthesis of Highway Practice, National Cooperative Highway Research Program Synthesis 298, Washington D.C.

Papenfus AJ and Van As SC, 2010, Traffic Stratification System and Expansion Factors, Traffic volume and axle load information system, Revision of the South African Pavement Design Method, South African National Roads Agency Limited, Pretoria.

Schildhauer, C., 2005, South African Standard Traffic Data Collection Format, Version 2.00, Pretoria.

South African National Road Agency Limited, 2004, Traffic Count Yearbook, Mikros Traffic Monitoring, Pretoria.

Appendix A

Trip Data Tables

Table 1: General Traffic Factors

Table 1.1: Typical Traffic Growth Rates

Development Area	Growth rate
Low growth areas	0 - 3%
Average growth areas	3 - 4%
Above average growth areas	4 - 6%
Fast growing areas	6 - 8%
Exceptionally high growth areas	> 8%

Source: City Council of Pretoria (1998)

Table 1.2: Service Flow Rates – Class 3 Roads

Description	Data
Service flow rate per lane, Q_L pcu/hour/lane (Class I roads, LOS E)	1 135
Directional split (F_{D1})	55%
Number of lanes (N_L)	4
Service flow of road (Q_T veh/hour)	4 128

Source: Transportation Research Board, 2000, Exhibits 8-11, 10-7 and 16-7 (Class I Roads)

Table 1.3: E80 Axles per Heavy Vehicle

Heavy vehicle type	% Composition (*)	E80/HV (**)
Small Heavy Vehicles	76%	0.51
Medium Heavy Vehicles	20%	1.90
Large Heavy Vehicles	4%	3.49
Average number of E80 Axles per heavy vehicle (E_{HD})		0.90

Note: The percentage composition is a typical composition. It may vary depending on land-use.

(*) Source: Tshwane Metropolitan Municipality, Comprehensive Traffic Observations, 2000

(**) Source: South African National Road Agency Limited, 2004

Table 1.4: Lane Distribution of Heavy Vehicles

Number of lanes	Percentage HV in slow lane (*)
Two-lane	100%
Four-lane	90%
Six-lane	80%
Eight-Lane	70%

(*) Source: Derived from data collected by the South African National Road Agency Limited

Table 1.5: Abnormal Day Definitions

Abnormal days are defined as the following days of the year:

i) Public holidays.
ii) Days influenced by public holidays, as defined in the table below.
iii) School holidays in any province of the country, measured for the full duration of the holiday from the day upon which the school closes up to and including the day on which the school reopens.
iv) December recess, measured from the last seven days in November up to and including the first day schools reopen in January of the following year (in any province).

Weekday of Public Holiday	Days influenced by Public Holidays							
	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
Sunday			░	░	■	░		
Monday			░	░	░	■		
Tuesday			░	░	░	░	■	
Wednesday	■						░	■
Thursday	░	■	░	░	░			
Friday		░	■	░	░			
Saturday				■				

Public Holiday ■ Influenced Days ░

Source: Papenfus and Van As (2010)

Table 1.6: Maximum limit for pass-by and diverted trips

Description	Maximum
Maximum percentage of background traffic which may be included in pass-by or diverted trips	20%

Table 1.7: Trip Length Size Adjustment Parameters

Adjustment Parameter	Parameter
Parameter F_{LA}	±0.500
Parameter F_{LB}	±0.050

Table 2.1a: Road Design Standards and Quantities

Class 3 Roads

Description	Design data	Quantity per km road	
Road reserve width	32m Width	3.200	ha
Pavement (wearing course)			
Road Lanes	2 x (1000 - 2x5) x 7.8	15 450	m^2
Left-turn lanes	2 x 2 x 80 x 3.3	1 000	m^2
Right-turn lanes	2 x 2 x 110 x 3.3	1 450	m^2
Total Pavement		17 900	m^2
Pavement layers, 3 000 000 E80s			
Base Course	Area = Pavement	17 900	m^2
Subbase	Area = Pavement + 2 x 2 x 0.5 x 1000	19 900	m^2
Subgrade	Area = Subbase	19 900	m^2
Roadbed	Area = Subbase	19 900	m^2
Pavement layers, 10 000 000 E80s			
Base Course	Area = Pavement	17 900	m^2
Subbase, Upper	Area = Pavement + 2 x 2 x 0.5 x 1000	19 900	m^2
Subbase, Lower	Area = Subbase	19 900	m^2
Subgrade	Area = Subbase	19 900	m^2
Roadbed	Area = Subbase	19 900	m^2
Kerbs	2 x 2 x (1000-2x10)	3 920	m
Sidewalk	2 x 1.5 x (1000-2x10)	2 940	m^2
Public Transport Facilities	2 Per intersection	4	No
Grade separation	1 Grade separation per 100km road	0.005	No
Traffic signals	75% of traffic signals on Class 3 road	1.5	No

Note: Based on a four-lane road with 500m intersection spacing

Table 2.1b: Road Design Standards and Quantities

Class 4 Roads

Description	Design data	Quantity per km road	
Road reserve width	20m Width	2.000	ha
Pavement	9.0 x (1000-4x5)	8 820	m^2
Pavement layers			
Base Course	Area = Pavement	8 820	m^2
Subbase	Area = Pavement + 2 x 0.5 x 1000	9 820	m^2
Subgrade	Area = Subbase	9 820	m^2
Roadbed	Area = Subbase	9 820	m^2
Kerbs	2 x (1000 - 4x7.5)	1 940	m
Sidewalk	1 x 1.5 x (1000 - 4x7.5)	1 450	m^2

Based on two-lane road with 9.0m wide road widths

Class 5 Roads

Description	Quantity calculation	Quantity per km road	
Road reserve width	16m Width	1.600	ha
Pavement	7.0 x (1000-4x5)	6 850	m^2
Pavement layers			
Base Course	Area = Pavement	6 850	m^2
Subbase	Area = Pavement + 2 x 0.5 x 1000	7 850	m^2
Subgrade	Area = Subbase	7 850	m^2
Roadbed	Area = Subbase	7 850	m^2
Kerbs	2 x (1000-4x7.5)	1 940	m
Sidewalk	1 x 1.5 x (1000 - 4x7.5)	1 450	m^2

Based on two-lane road with 7.0m wide road widths

Table 2.2: Engineering Service Cost Components

Code (*)	Description	Unit of measurement
	Land value	Per Hectare
Accommodation	Accommodation of traffic	Per km Road
Earthworks	Earthworks	Per m^2 Pavement
Wearing	Wearing Course	Per m^2 Pavement
Base	Base Course	Per m^2 Pavement
Subbase	Subbase	Per m^2 Pavement
Subgrade	Subgrade	Per m^2 Pavement
Roadbed	Roadbed	Per m^2 Pavement
Kerbs	Kerbs	Per m Kerb
Sidewalks	Sidewalks	Per m^2 sidewalk
Guardrails	Guard rails and other safety devices	Per km Road
Stormwater	Stormwater drainage (road only)	Per km Road
PublicTransport	Public transport facilities	Per facility
Interchanges	Grade separation	Per interchange
Landscape	Landscaping, finishing off and fencing	Per km Road
RoadSigns	Road signs	Per km Road
TrafficSignals	Traffic signals	Per signal
StreetLights	Street lighting	Per km Road
Other	Other items	Per km Road
Prelim	Preliminary and general items	% of total cost
	Professional services	% of total cost

(*) Code may be used with a spreadsheet macro when undertaking road construction cost studies (Refer to Manual for Traffic Studies for Engineering Service Contributions and Traffic Assessments)

Table 2.3: Example of a Land Value Table for Engineering Service Contributions

Escalation Factors

Description	Year	CPI (I_{PC})	Esc Factor I_K	Average factors for year
Date of land-value estimation	2010	108.6		Land-value escalation based on the
Date of publication of cost rates	2007	89.8	1.209	Consumer Price Index

Land Values

No and Region		Estimated Value/ha	Escalated Value/ha	Class 1/3 road costs Cost per km	Veh-km/hr	Boundary road cost/km Class 4	Class 5	Trip length Adj factor F_T
		Road Reserve Widths/Veh-km/hr		32	4 128	20	16	
1	Region 1	R 1 500 000	R 1 813 500	R 5 803 200	R 1 406	R 3 627 000	R 2 901 600	100.00%
2	Region 2	R 1 250 000	R 1 511 250	R 4 836 000	R 1 172	R 3 022 500	R 2 418 000	100.00%
3	Region 3	R 1 000 000	R 1 209 000	R 3 868 800	R 937	R 2 418 000	R 1 934 400	100.00%
4	Region 4	R 500 000	R 604 500	R 1 934 400	R 469	R 1 209 000	R 967 200	100.00%

Land values are determined for farm land with development potential

Table 2.4: Example of a Construction Cost Rate Table for Engineering Service Contributions

Costing Parameters – Class 3 roads

Contribution Component	Veh-km/hr E80-km/day	Estimated cost per km	Escalation Factor I_K	Escalated cost per km	Cost Rate per Travel Unit
Capacity Component per Veh-km/hr	4 128	R 11 542 024	1.183	R 13 654 214	R 3 308
Strength Component per E80-km/day	3 044	R 1 501 028	1.183	R 1 775 716	R 583

Costing Parameters – Class 4/5 Boundary Roads

Boundary road class	Estimated cost per km	Escalation Factor I_K	Escalated cost per km	Cost Rate per km
Class 4 Boundary Roads	R 4 785 317	1.183	R 5 661 030	R 5 661 030
Class 5 Boundary Roads	R 3 457 608	1.183	R 4 090 350	R 4 090 350

Escalation Factors

Proportion X_{PP} subject to escalation	Labour X_{PL}	Materials X_{PM}	Diesel X_{PF}	Plant X_{PP}
0.85	0.30	0.30	0.05	0.35

CPI and Production Price Indices (Average for year)

Description	Year	CPI (I_{PC})	Materials (I_{PM})	Diesel (I_{PF})	Plant (I_{PP})
Date of construction cost estimate	2010	108..6	210.8	265.0	189.5
Date of publication of cost rates	2007	89.8	176.8	246.3	150.5

Information Sources: Production Price Indices

Statistics published by: Statistics South Africa

Consumer Price Indices (CPI) published in Statistical Releases P0141
- Average for the country

Production Price Indices published in Statistical Releases P0142.1
- Materials (Civil Engineering Industry)
- Fuel – Diesel Oil (Average for the country)
- Plant (Civil Engineering)

Web: http://www.statssa.gov.za/

Information also provided by:

The South African Federation of Civil Engineering Contractors

Web: http://www.safcec.org.za/Indices.Htm

Table 2.5: Example of Road Construction Cost Calculations

Class 3 Roads

Class 3 Roads - Capacity Component
Based on a four-lane Class 3 road with 500m intersection spacing

Description	**Unit**	**Rate (R/Unit)**	**Quantity (Units)**	**Cost (Vat Excl)**
Accommodation of traffic	Per km Road	R 150 000	1	R 150 000
Earthworks	Per m² Pavement	R 40	17900	R 716 000
Pavement (3 000 000 E80 Design)				
Wearing Course	Per m² Pavement	R 95	17900	R 1 700 500
Base Course	Per m² Pavement	R 65	17900	R 1 163 500
Subbase	Per m² Pavement	R 40	19900	R 796 000
Subgrade	Per m² Pavement	R 20	19900	R 398 000
Roadbed	Per m² Pavement	R 7	19900	R 139 300
Subtotal for pavements (3 000 000 E80 Design)				R 4 197 300
Subtract strength component for 3 000 000 E80s				-R 341 143
Kerbs	Per m Kerb	R 130	3920	R 509 600
Sidewalk	Per m² sidewalk	R 130	2940	R 382 200
Guard rails and other safety devices	Per km Road	R 30 000	1	R 30 000
Stormwater drainage (road only)	Per km Road	R 1 150 000	1	R 1 150 000
Public transport facilities	Per facility	R 120 000	4	R 480 000
Grade separation	Per interchange	R 30 000 000	0.005	R 150 000
Landscaping, finishing off and fencing	Per km Road	R 50 000	1	R 50 000
Road signs	Per km Road	R 150 000	1	R 150 000
Traffic signals	Per signal installation	R 300 000	1.5	R 450 000
Street lighting	Per km Road	R 550 000	1	R 550 000
Other items	Per km Road	R 120 000	1	R 120 000
Subtotal				**R 8 743 957**
Preliminary and general items	% of total cost		10%	R 874 396
Professional services and supervision	% of total cost		20%	R 1 923 671
Total construction cost per 1 km of road				**R 11 542 024**

Class 3 Roads - Strength Component
Based on a four-lane Class 3 road with 500m intersection spacing

Description	**Unit**	**Rate (R/Unit)**	**Quantity (Units)**	**Cost (Vat Excl)**
Pavement (10 000 000 E80 Design)				
Wearing Course	Per m² Pavement	R 95	17900	R 1 700 500
Base Course	Per m² Pavement	R 65	17900	R 1 163 500
Subbase, Upper	Per m² Pavement	R 40	19900	R 796 000
Subbase, Lower	Per m² Pavement	R 40	19900	R 796 000
Subgrade	Per m² Pavement	R 20	19900	R 398 000
Roadbed	Per m² Pavement	R 7	19900	R 139 300
Subtotal for pavements (10 000 000 E80 Design)				R 4 993 300
Additional for strength component for 7 000 000 E80s				R 796 000
Add strength component for 3 000 000 E80s				R 341 143
Additional for strength component for 10 000 000 E80s				**R 1 137 143**
Preliminary and general items	% of total cost		10%	R 113 714
Professional services and supervision	% of total cost		20%	R 250 171
Total strength component cost per 1 km of road for 10 000 000 E80s				**R 1 501 028**

Table 2.6a: Example of Road Construction Cost Calculations

Boundary Roads

Class 4 Boundary Roads
Based on two-lane road with 9m road widths

Description	Unit	Rate (R/Unit)	Quantity (Units)	Cost (Vat Excl)
Accommodation of traffic	Per km Road	R 25 000	1	R 25 000
Earthworks	Per m² Pavement	R 35	8820	R 308 700
Pavement				
Wearing Course	Per m² Pavement	R 50	8820	R 441 000
Base Course	Per m² Pavement	R 45	8820	R 396 900
Subbase	Per m² Pavement	R 40	9820	R 392 800
Subgrade	Per m² Pavement	R 20	9820	R 196 400
Roadbed	Per m² Pavement	R 7	9820	R 68 740
Subtotal for pavements				R 1 495 840
Kerbs	Per m Kerb	R 130	1940	R 252 200
Sidewalk	Per m² sidewalk	R 130	1450	R 188 500
Guard rails and other safety devices	Per km Road	R 5 000	1	R 5 000
Stormwater drainage (road only)	Per km Road	R 800 000	1	R 800 000
Public transport facilities	Per facility	R 120 000	0.25	R 30 000
Grade separation	Per interchange	R 30 000 000	0.000	R 0
Landscaping, finishing off and fencing	Per km Road	R 20 000	1	R 20 000
Road signs	Per km Road	R 25 000	1	R 25 000
Traffic signals	Per signal installation	R 300 000	0.25	R 75 000
Street lighting	Per km Road	R 300 000	1	R 300 000
Other items	Per km Road	R 100 000	1	R 100 000
Subtotal				**R 3 625 240**
Preliminary and general items	% of total cost		10%	R 362 524
Professional fees	% of total cost		20%	R 797 553
Total road construction cost per 1 km of road				**R 4 785 317**

Table 2.6b: Example of Road Construction Cost Calculations

Boundary Roads

Class 5 Boundary Roads
Based on two-lane road with 7m road widths

Description	Unit	Rate (R/Unit)	Quantity (Units)	Cost (Vat Excl)
Accommodation of traffic	Per km Road	R 25 000	1	R 25 000
Earthworks	Per m² Pavement	R 20	6850	R 137 000
Pavement				
Wearing Course	Per m² Pavement	R 50	6850	R 342 500
Base Course	Per m² Pavement	R 45	6850	R 308 250
Subbase	Per m² Pavement	R 40	7850	R 314 000
Subgrade	Per m² Pavement	R 20	7850	R 157 000
Roadbed	Per m² Pavement	R 7	7850	R 54 950
Subtotal for pavements				R 1 176 700
Kerbs	Per m Kerb	R 130	1940	R 252 200
Sidewalk	Per m² sidewalk	R 130	1450	R 188 500
Guard rails and other safety devices	Per km Road	R 0	1	R 0
Stormwater drainage (road only)	Per km Road	R 500 000	1	R 500 000
Public transport facilities	Per facility	R 120 000	0	R 0
Grade separation	Per interchange	R 30 000 000	0.000	R 0
Landscaping, finishing off and fencing	Per km Road	R 20 000	1	R 20 000
Road signs	Per km Road	R 20 000	1	R 20 000
Traffic signals	Per signal installation	R 300 000	0.0	R 0
Street lighting	Per km Road	R 250 000	1	R 250 000
Other items	Per km Road	R 50 000	1	R 50 000
Subtotal				**R 2 619 400**
Preliminary and general items	% of total cost		10%	R 261 940
Professional fees	% of total cost		20%	R 576 268
Total road construction cost per 1 km of road				**R 3 457 608**

Table 3.1: Daily Trip Generation Rates and Parameters

	Land Use	Size Units	Daily Trip rate $AADT_D$	Peaking Factor F_{OD}	Hourly Trip rate $F_{OD}.AADT_D$	Percent Heavy P_{HD}	E80 Axles Per HV E_{HD}	Size Adjustment 1+A/(1+sqm Size/B) Factor A	Factor B
100	**Industrial**								
110	Service Industry	100 sqm GLA	6.00	0.150	0.90	10%	1.34		
120	Heavy industry/manufacturing	100 sqm GLA	1.25	0.150	0.19	10%	2.35		
121	Mining	1 Employees	0.65	0.150	0.10	10%	2.35		
130	Industrial Area (Park)	100 sqm GLA	6.00	0.150	0.90	10%	2.35		
140	Manufacturing	100 sqm GLA	2.00	0.250	0.50	10%	2.35		
150	Warehousing and Distribution	100 sqm GLA	3.00	0.140	0.42	10%	2.35		
151	Mini-Warehousing	100 sqm GLA	2.50	0.100	0.25				
200	**Residential**								
210	Single Dwelling Units	1 D/Unit	4.00	0.225	0.90				
220	Apartments and Flats	1 D/Unit	2.75	0.225	0.62				
225	Student Apartments and Flats	1 D/Unit	1.25	0.225	0.28				
231	Townhouses (Simplexes and Duplexe	1 D/Unit	3.75	0.225	0.84				
232	Multi-Level Townhouses	1 D/Unit	3.25	0.225	0.73				
251	Retirement Village	1 D/Unit	3.40	0.110	0.37				
254	Old-Age Home	1 D/Unit	2.50	0.100	0.25				
260	Recreational Homes	1 D/Unit	3.00	0.100	0.30				
300	**Lodging**								
310	Hotel, Residential	1 Room	3.25	0.150	0.49				
330	Hotel, Resort	1 Room	6.00	0.100	0.60				
350	Guest House	1 Room	3.00	0.150	0.45				
400	**Recreational and Sport**								
430	Golf Course	1 Course	650.00	0.050	32.50				
473	Casino	100 sqm GLA	50.00	0.050	2.50				
480	Amusement Park	1 ha	250.00	0.050	12.50				
488	Sport Stadium	1000 Seat	100.00	0.050	5.00				
492	Health and Fitness Centre	100 sqm GLA	32.50	0.300	9.75				
500	**Institutional**								
520	Public Primary School	1 Student	2.00	0.400	0.80				
530	Public Secondary School	1 Student	2.00	0.400	0.80				
536	Private School	1 Student	2.00	0.400	0.80				
550	University / College	1 Student	1.90	0.110	0.21				
560	Places of Public Worship (Weekend)	1 Seat	0.65	0.085	0.06				
561	Places of Public Worship (Weekday)	1 Seat	0.60	0.085	0.05				
565	Pre-School (Day Care Centre)	1 Student	3.00	0.275	0.83				
566	Cemetery	1 Ha	6.00	0.050	0.30				
600	**Medical**								
611	Public Hospital	1 Bed	7.00	0.200	1.40				
612	Private Hospital	100 sqm GLA	16.50	0.110	1.81				
620	Nursing Home	1 Bed	2.25	0.110	0.25				
630	Medical Clinic	100 sqm GLA	40.00	0.150	6.00				
700	**Office**								
710	Offices	100 sqm GLA	8.50	0.250	2.12	5%	1.21		
713	Home offices and undertakings	1 House	25.00	0.250	6.25				
720	Medical consulting rooms	100 sqm GLA	55.00	0.135	7.43				
770	Business Centre (Park)	100 sqm GLA	10.00	0.150	1.50				
780	Conference Centre	1 Seat	1.00	0.300	0.30				

800	**Retail**								
812	Building Materials	100 sqm GLA	45.00	0.090	4.05	5%	1.32		
816	Hardware and Paint Store	100 sqm GLA	60.00	0.085	5.10	3%	1.32		
817	Nursery (Garden Centre)	101 sqm GLA	45.00	0.100	4.50				
820	Shopping Centre	100 sqm GLA	35.00	0.085	2.98	2%	1.32	6.000	3500
830	Bulk Trade Centre	100 sqm GLA	7.50	0.145	1.09	2%	1.32		
841	Motor Dealership	100 sqm GLA	30.00	0.100	3.00				
890	Furniture Store	100 sqm GLA	5.40	0.250	1.35	2%	1.32		
900	**Services**								
931	Restaurant, Quality (Sit-down)	100 sqm GLA	90.00	0.100	9.00				
932	Restaurant, Family (Sit-down)	100 sqm GLA	140.00	0.100	14.00				
933	Fast Food	100 sqm GLA	200.00	0.100	20.00				
946	Filling Station	1 Station	500.00	0.120	60.00	2%	1.32		
950	Vehicle Fitment Centre	100 sqm GLA	22.00						

Table 3.2: Trip Generation Adjustment Factors

			Percentage reduction for developments in areas with			
	Land Use	**Size Units**	**Mixed-use Development**	**Low vehicle Ownership**	**Very Low Ownership**	**Transit nodes or Corridors**
100	**Industrial**					
110	Service Industry	100 sqm GLA	5%	20%	30%	15%
120	Heavy industry/manufacturing	100 sqm GLA	5%	20%	30%	15%
121	Mining	1 Employees	5%	20%	30%	15%
130	Industrial Area (Park)	100 sqm GLA	5%	20%	30%	15%
140	Manufacturing	100 sqm GLA	5%	20%	30%	15%
150	Warehousing and Distribution	100 sqm GLA	5%	20%	30%	15%
151	Mini-Warehousing	100 sqm GLA	5%	20%	30%	15%
200	**Residential**					
210	Single Dwelling Units	1 D/Unit	10%	40%	70%	15%
220	Apartments and Flats	1 D/Unit	15%	30%	50%	15%
225	Student Apartments and Flats	1 D/Unit	25%	50%	80%	15%
231	Townhouses (Simplexes and Duplexes)	1 D/Unit	15%	30%	50%	15%
232	Multi-Level Townhouses	1 D/Unit	15%	30%	50%	15%
251	Retirement Village	1 D/Unit	5%	50%	80%	15%
254	Old-Age Home	1 D/Unit	5%	50%	80%	15%
260	Recreational Homes	1 D/Unit	10%	20%	30%	15%
300	**Lodging**					
310	Hotel, Residential	1 Room	20%	20%	30%	15%
330	Hotel, Resort	1 Room	20%	20%	30%	15%
350	Guest House	1 Room	20%	30%	50%	15%
400	**Recreational and Sport**					
430	Golf Course	1 Course	5%	0%	0%	0%
473	Casino	100 sqm GLA	5%	20%	30%	15%
480	Amusement Park	1 ha	5%	30%	50%	15%
488	Sport Stadium	1000 Seat	5%	30%	50%	15%
492	Health and Fitness Centre	100 sqm GLA	15%	20%	30%	15%
500	**Institutional**					
520	Public Primary School	1 Student	30%	50%	80%	15%
530	Public Secondary School	1 Student	30%	50%	80%	15%
536	Private School	1 Student	30%	50%	80%	15%
550	University / College	1 Student	20%	40%	60%	15%
560	Places of Public Worship (Weekend)	1 Seat	10%	50%	80%	15%
561	Places of Public Worship (Weekday)	1 Seat	10%	50%	80%	15%
565	Pre-School (Day Care Centre)	1 Student	5%	50%	80%	15%
566	Cemetery	1 Ha	0%	30%	50%	15%
600	**Medical**					
611	Public Hospital	1 Bed	0%	50%	80%	15%
612	Private Hospital	100 sqm GLA	0%	20%	30%	15%
620	Nursing Home	1 Bed	0%	50%	80%	15%
630	Medical Clinic	100 sqm GLA	0%	50%	80%	15%
700	**Office**					
710	Offices	100 sqm GLA	20%	20%	30%	15%
713	Home offices and undertakings	1 House	10%	20%	30%	15%
720	Medical consulting rooms	100 sqm GLA	10%	30%	50%	15%
770	Business Centre (Park)	100 sqm GLA	15%	20%	30%	15%
780	Conference Centre	1 Seat	10%	20%	30%	10%

800	**Retail**					
812	Building Materials	100 sqm GLA	10%	30%	50%	15%
816	Hardware and Paint Store	100 sqm GLA	10%	30%	50%	15%
817	Nursery (Garden Centre)	101 sqm GLA	10%	30%	50%	15%
820	Shopping Centre	100 sqm GLA	10%	30%	60%	15%
830	Bulk Trade Centre	100 sqm GLA	10%	30%	60%	15%
841	Motor Dealership	100 sqm GLA	5%	20%	30%	15%
890	Furniture Store	100 sqm GLA	5%	30%	50%	15%
900	**Services**					
931	Restaurant, Quality (Sit-down)	100 sqm GLA	10%	10%	15%	15%
932	Restaurant, Family (Sit-down)	100 sqm GLA	10%	30%	50%	15%
933	Fast Food	100 sqm GLA	10%	40%	60%	15%
946	Filling Station	1 Station	0%	0%	0%	0%
950	Vehicle Fitment Centre	100 sqm GLA	0%	0%	0%	0%

Table 3.3: Peak-hour Trip Generation Rates and Parameters

Size Adjustment Factor
1+A/(1+sqm Size/B)

110 Service Industry — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.90	0.90		0.90		0.15			
% Heavy									
In/Out	75:25	25:75		50:50		50:50			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

120 Heavy industry/manufacturing — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.50	0.70							
% Heavy									
In/Out	75:25	25:75							
PHF Dev									
PHF Street									
Veh Occupancy	1.80								
% Pass-by									
% Diverted									

121 Mining — **1 Employees**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate									
% Heavy									
In/Out									
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

130 Industrial Area (Park) — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.80	0.80				0.40			
% Heavy									
In/Out	70:30	25:75				30:70			
PHF Dev									
PHF Street									
Veh Occupancy	1.80								
% Pass-by									
% Diverted									

140 Manufacturing — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.60	0.60				0.30			
% Heavy									
In/Out	80:20	20:80							
PHF Dev									
PHF Street									
Veh Occupancy	1.50	1.50							
% Pass-by									
% Diverted									

150 Warehousing and Distribution **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.50	0.50				0.15			
% Heavy									
In/Out	60:40	45:55				65:35			
PHF Dev									
PHF Street									
Veh Occupancy	1.50	1.50							
% Pass-by									
% Diverted									

151 Mini-Warehousing **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.15	0.25				0.40	0.30		
% Heavy									
In/Out	60:40	50:50				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

210 Single Dwelling Units **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.00	1.00				0.50	0.50		
% Heavy									
In/Out	25:75	70:30				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

220 Apartments and Flats **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.65	0.65				0.35	0.35		
% Heavy									
In/Out	25:75	70:30				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

225 Student Apartments and Flats **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.20	0.30				0.15	0.15		
% Heavy									
In/Out	25:75	65:35				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

231 Townhouses (Simplexes and Duplexes) **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.85	0.85				0.45	0.45		
% Heavy									
In/Out	25:75	70:30				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

232 Multi-Level Townhouses — **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.75	0.75				0.40	0.40		
% Heavy									
In/Out	25:75	70:30				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

251 Retirement Village — **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.35	0.35		0.40		0.20	0.20		
% Heavy									
In/Out	40:60	50:50		50:50		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

254 Old-Age Home — **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.15	0.20		0.35		0.30	0.35		
% Heavy									
In/Out	65:35	40:60		50:50		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

260 Recreational Homes — **1 D/Unit**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.15	0.25				0.35	0.35		
% Heavy									
In/Out	65:35	40:60				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

310 Hotel, Residential — **1 Room**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.50	0.50		0.25		0.70	0.55		
% Heavy									
In/Out	60:40	55:45		50:50		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy	1.80	1.80							
% Pass-by									
% Diverted									

330 Hotel, Resort — **1 Room**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.30	0.40							
% Heavy									
In/Out	60:40	50:50							
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

350 Guest House **1 Room**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.45	0.45				0.25	0.25		
% Heavy									
In/Out	50:50	50:50				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

430 Golf Course **1 Course**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	40.00	50.00				80.00	80.00		
% Heavy									
In/Out	80:20	45:55				50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

473 Casino **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.85	5.00		3.25	6.25	3.00			
% Heavy									
In/Out	75:25	50:50		55:45	50:50	70:30			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

480 Amusement Park **1 ha**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.50	10.00				47.00	44.00		
% Heavy									
In/Out	85:15	60:40				60:40	45:55		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

488 Sport Stadium **1000 Seat**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate		150.00			270.00	170.00			
% Heavy									
In/Out		90:10			10:90	90:10			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

492 Health and Fitness Centre **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	5.00	9.50							
% Heavy									
In/Out	50:50	60:40							
PHF Dev	0.85	0.85							
PHF Street									
Veh Occupancy	1.10	1.30							
% Pass-by									
% Diverted									

520 Public Primary School — **1 Student**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.85	0.30		0.35					
% Heavy									
In/Out	50:50	50:50		45:55					
PHF Dev	0.55			0.55					
PHF Street									
Veh Occupancy	1.55			1.70					
% Pass-by									
% Diverted									

530 Public Secondary School — **1 Student**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.75	0.25		0.35					
% Heavy									
In/Out	50:50	50:50		45:55					
PHF Dev	0.55			0.55					
PHF Street									
Veh Occupancy	1.40			1.70					
% Pass-by									
% Diverted									

536 Private School — **1 Student**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.80	0.30		0.35					
% Heavy									
In/Out	50:50	50:50		50:50					
PHF Dev	0.55			0.55					
PHF Street									
Veh Occupancy	1.50			1.70					
% Pass-by									
% Diverted									

550 University / College — **1 Student**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.20	0.20		0.25					
% Heavy									
In/Out	80:20	30:70		30:70					
PHF Dev	0.65			0.65					
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

560 Places of Public Worship (Weekend) — **1 Seat**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.05	0.05					0.65		
% Heavy									
In/Out	55:45	50:50					55:45		
PHF Dev							0.65		
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

561 Places of Public Worship (Weekday) — **1 Seat**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.05	0.05							
% Heavy									
In/Out	50:50	50:50							
PHF Dev		0.65							
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

565 Pre-School (Day Care Centre) **1 Student**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.00	0.80		0.30					
% Heavy									
In/Out	50:50	50:50		50:50					
PHF Dev	0.65			0.65					
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

566 Cemetery **1 Ha**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.20	0.20		4.00		8.00			
% Heavy									
In/Out	70:30	35:65		75:25		50:50			
PHF Dev		0.65		0.65		0.65			
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

611 Public Hospital **1 Bed**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.50	1.45		1.50		1.00	1.00		
% Heavy									
In/Out	80:20	40:60		40:60		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

612 Private Hospital **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.65	1.50		1.60	1.70				
% Heavy									
In/Out	60:40	40:60		45:55	60:40				
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

620 Nursing Home **1 Bed**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.20	0.20		0.30		0.40	0.35		
% Heavy									
In/Out	70:30	40:60		40:60		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

630 Medical Clinic **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	6.00	6.00		4.20		7.80			
% Heavy									
In/Out	60:40	40:60		50:50		45:55			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

710 Offices — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	2.10	2.10				0.45	0.15		
% Heavy									
In/Out	85:15	20:80				55:45	55:45		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

713 Home offices and undertakings — **1 House**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	6.50	6.50		7.00					
% Heavy									
In/Out	85:15	15:85		50:50					
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

720 Medical consulting rooms — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	8.00	8.00		8.00		3.90	0.45		
% Heavy									
In/Out	55:45	45:55		45:55		60:40	50:50		
PHF Dev									
PHF Street									
Veh Occupancy		1.60		1.50					
% Pass-by									
% Diverted									

770 Business Centre (Park) — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.50	1.50							
% Heavy									
In/Out	85:15	20:80							
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

780 Conference Centre — **1 Seat**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.50								
% Heavy									
In/Out	90:10								
PHF Dev	0.75								
PHF Street									
Veh Occupancy	1.50								
% Pass-by									
% Diverted									

812 Building Materials — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	2.80		5.50			11.00	5.00		
% Heavy									
In/Out	65:35		45:55			50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

816 Hardware and Paint Store — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.15		5.20			12.00	10.00		
% Heavy									
In/Out	65:35		45:55			50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by			27%						
% Diverted			28%						

817 Nursery (Garden Centre) — **101 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.40	3.00	4.10			4.00			
% Heavy									
In/Out	65:35	30:70				45:55			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

820 Shopping Centre — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.60		3.40			4.50		6.000	3500
% Heavy									
In/Out	65:35		50:50			50:50			
PHF Dev						0.90			
PHF Street									
Veh Occupancy									
% Pass-by			13%			12%		1.950	48000
% Diverted			29%			38%			

830 Bulk Trade Centre — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	1.10		1.50	0.90		3.90			
% Heavy									
In/Out	70:30		40:60	45:55		50:50			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

841 Motor Dealership — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	2.20		2.30	5.10		2.20			
% Heavy									
In/Out	65:35		50:50	50:50		45:55			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

890 Furniture Store — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.20	2.10	0.50	1.30		2.50	1.00		
% Heavy									
In/Out	65:35	50:50	50:50	50:50		50:50	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

931 Restaurant, Quality (Sit-down) — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	0.75	11.80		9.80	9.00	11.00	9.00		
% Heavy									
In/Out	70:30	40:60		60:40	60:40	60:40	60:40		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by		39%							
% Diverted		30%							

932 Restaurant, Family (Sit-down) — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate		8.00			10.00	20.00	25.00		
% Heavy									
In/Out		65:35			70:30	60:40	50:50		
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by		38%							
% Diverted		23%							

933 Fast Food — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	45.00	50.00		30.00	55.00				
% Heavy									
In/Out	55:45	55:45		50:50	50:50				
PHF Dev									
PHF Street									
Veh Occupancy					1.65				
% Pass-by		52%							
% Diverted		25%							

946 Filling Station — **1 Station**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate									
% Heavy									
In/Out									
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

950 Vehicle Fitment Centre — **100 sqm GLA**

Description	AM Peak	PM Peak	Friday PM	Midday	Evening	Saturday	Sunday	Factor A	Factor B
Trip Rate	3.00	4.30				5.20			
% Heavy									
In/Out	65:35	45:55				50:50			
PHF Dev									
PHF Street									
Veh Occupancy									
% Pass-by									
% Diverted									

Table 4: Trip Lengths

	Land Use	Size Units	Total trip Length L_T (km)	Half trip Length $L_T/2$ (km)	Class 4/5 Half trip P_{45} (km)	Non-Municipal P_N (%)	Adj Trip Length $L_D/2$ (km)	Size Adjustment 1-A/(1+sqm Size/B) Factor A	Factor B
100	**Industrial**								
110	Service Industry	100 sqm GLA	12.00	6.00	1.25	50%	1.75		
120	Heavy industry/manufacturing	100 sqm GLA	15.00	7.50	1.25	50%	2.50		
121	Mining	1 Employees	15.00	7.50	1.25	50%	2.50		
130	Industrial Area (Park)	100 sqm GLA	15.00	7.50	1.25	50%	2.50		
140	Manufacturing	100 sqm GLA	15.00	7.50	1.25	50%	2.50		
150	Warehousing and Distribution	100 sqm GLA	15.00	7.50	1.25	50%	2.50		
151	Mini-Warehousing	100 sqm GLA	10.00	5.00	1.00	40%	2.00		
200	**Residential**								
210	Single Dwelling Units	1 D/Unit	8.50	4.25	1.00	40%	1.55		
220	Apartments and Flats	1 D/Unit	5.00	2.50	0.75	30%	1.00		
225	Student Apartments and Flats	1 D/Unit	3.00	1.50	0.60	20%	0.60		
231	Townhouses (Simplexes and Duplexe	1 D/Unit	7.50	3.75	1.00	40%	1.25		
232	Multi-Level Townhouses	1 D/Unit	7.00	3.50	1.00	40%	1.10		
251	Retirement Village	1 D/Unit	5.50	2.75	1.00	30%	0.92		
254	Old-Age Home	1 D/Unit	5.50	2.75	1.00	30%	0.92		
260	Recreational Homes	1 D/Unit	10.00	5.00	1.50	40%	1.50		
300	**Lodging**								
310	Hotel, Residential	1 Room	7.00	3.50	1.00	40%	1.10		
330	Hotel, Resort	1 Room	8.00	4.00	1.00	50%	1.00		
350	Guest House	1 Room	6.00	3.00	1.00	35%	0.95		
400	**Recreational and Sport**								
430	Golf Course	1 Course	13.00	6.50	1.00	45%	2.58		
473	Casino	100 sqm GLA	14.00	7.00	1.00	50%	2.50		
480	Amusement Park	1 ha	12.00	6.00	1.00	50%	2.00		
488	Sport Stadium	1000 Seat	12.00	6.00	1.00	50%	2.00		
492	Health and Fitness Centre	100 sqm GLA	5.00	2.50	0.75	30%	1.00		
500	**Institutional**								
520	Public Primary School	1 Student	4.00	2.00	1.00	25%	0.50		
530	Public Secondary School	1 Student	5.00	2.50	1.00	35%	0.62		
536	Private School	1 Student	5.50	2.75	1.00	40%	0.65		
550	University / College	1 Student	10.00	5.00	1.50	40%	1.50		
560	Places of Public Worship (Weekend)	1 Seat	6.00	3.00	0.80	35%	1.15		
561	Places of Public Worship (Weekday)	1 Seat	6.00	3.00	0.80	35%	1.15		
565	Pre-School (Day Care Centre)	1 Student	3.50	1.75	0.90	35%	0.24		
566	Cemetery	1 Ha	8.00	4.00	1.00	40%	1.40		
600	**Medical**								
611	Public Hospital	1 Bed	8.50	4.25	1.00	40%	1.55		
612	Private Hospital	100 sqm GLA	8.00	4.00	1.00	40%	1.40		
620	Nursing Home	1 Bed	7.50	3.75	1.00	35%	1.44		
630	Medical Clinic	100 sqm GLA	5.00	2.50	1.00	30%	0.75		
700	**Office**								
710	Offices	100 sqm GLA	9.00	4.50	1.00	35%	1.92		
713	Home offices and undertakings	1 House	7.00	3.50	1.00	35%	1.27		
720	Medical consulting rooms	100 sqm GLA	8.00	4.00	1.00	35%	1.60		
770	Business Centre (Park)	100 sqm GLA	10.00	5.00	1.00	40%	2.00		
780	Conference Centre	1 Seat	10.00	5.00	1.00	50%	1.50		

800	**Retail**								
812	Building Materials	100 sqm GLA	8.00	4.00	1.00	40%	1.40		
816	Hardware and Paint Store	100 sqm GLA	7.00	3.50	1.00	40%	1.10		
817	Nursery (Garden Centre)	101 sqm GLA	6.50	3.25	1.00	30%	1.27		
820	Shopping Centre	100 sqm GLA	10.00	5.00	1.00	40%	2.00	0.740	148000
830	Bulk Trade Centre	100 sqm GLA	10.00	5.00	1.00	50%	1.50		
841	Motor Dealership	100 sqm GLA	6.50	3.25	0.75	40%	1.20		
890	Furniture Store	100 sqm GLA	8.00	4.00	1.00	40%	1.40		
900	**Services**								
931	Restaurant, Quality (Sit-down)	100 sqm GLA	6.50	3.25	0.80	30%	1.47		
932	Restaurant, Family (Sit-down)	100 sqm GLA	5.50	2.75	0.80	30%	1.12		
933	Fast Food	100 sqm GLA	4.00	2.00	0.70	25%	0.80		
946	Filling Station	1 Station	5.00	2.50	0.50	40%	1.00		
950	Vehicle Fitment Centre	100 sqm GLA	8.00	4.00	1.00	35%	1.60		

Table 5: Development Locations

Rural area

An area with a rural character and which is not urbanised.

Town/Village

A relatively small urbanised area

Suburban Area (Large towns, cities or metropolitan areas)

Areas outside the central business district of a large town, city or metropolitan area.

CBD Area (Large towns, cities or metropolitan areas)

Central Business District, the economic centre or core of a large town, city or metropolitan area.

Table 6: Land-Uses and Size Units

100 Industrial

110	**Service Industries**	**100 sqm GLA**
	Service industries provide industrial services to the general public. Typical service industries include vehicle repairs, appliance and television repairs, etc.	
120	**Heavy industries/manufacturing**	100 sqm GLA
	The heavy manufacturing/industry land use covers developments where the primary activity is the conversion of raw materials or parts into products and where the materials or products have a heavy nature. Examples of this land use include brick manufacturing, machinery, metal, electrical power generation, etc. The land use also includes offices, warehouses and other facilities associated with the main activity.	
121	**Mining**	No of employees
	The extraction of raw materials, either from the surface or underground. Examples include sand, clay, stone, kaolin, ores, minerals and precious materials.	
130	**Industrial Area (Park)**	**100 sqm GLA**
	The industrial land-use includes industries that do not generally provide services directly to the general public. The industrial area or park may also contain related facilities such as services and warehousing. A small amount of retail may be included.	
140	**Light manufacturing**	**100 sqm GLA**
	The light manufacturing land-use covers developments where the primary activity is the conversion of raw materials or parts into products. Both materials and products must be of a light nature. Examples of this land use include clothing, food and furniture manufacturing. The land use also includes offices, warehouses and other facilities associated with manufacturing.	
150	**Warehousing and Distribution**	**100 sqm GLA**
	Warehouses are primarily used for the storage and distribution of materials, but may include office and other functions associated with such storage. Goods are often sorted and distributed from these warehouses.	
151	**Mini-Warehousing**	**100 sqm GLA**
	Mini-Warehousing contain a number of storage units which are rented for the storage of goods. These are typically "self-storage" facilities for use by the public.	

Table 6: Land-Uses and Size Units

200 Residential

210	**Single Dwelling Unit**	**Dwelling units**
	Single dwelling units are detached houses on individual erven. The units usually have individual accesses to streets.	
220	**Apartments and Flats**	**Dwelling units**
	Dwelling units located in one building. Buildings are normally multi-storied while dwelling units are relatively small in size.	
225	**Students Apartments and Flats**	**Dwelling units**
	Apartments and flats specifically targeted at students. This land-use may only be used when guarantees are given that the development will not be used by persons other than students.	
231	**Townhouses (Simplexes and Duplexes)**	**Dwelling units**
	Dwelling units typically provided in clusters or in complexes. Units could be detached or provided within one building structure. Parking is often provided within a communal area.	
232	**Multi-Level Townhouses**	**Dwelling units**
	Dwelling units provided in clusters in multi-level complexes. Individual townhouses can be provided on different levels. Individual townhouse could consist of one storey or could be multi-storeyed.	
251	**Retirement Village**	**Dwelling units**
	Dwelling units intended for senior adults. Dwelling units could be either detached or provided in one building structure.	
254	**Old-Age Home**	**Dwelling units**
	Provide living facilities and care for senior adults. They commonly have single rooms for residents and services including dining, housekeeping, care, medication administration and transportation.	
260	**Recreational Homes**	**Dwelling units**
	Single dwelling units located in holiday resorts. These dwellings are often second homes used periodically by owners or rented on a seasonable basis.	

300 Lodging

310	**Hotel, Residential**	**Rooms**
	Hotels provide sleeping accommodation and supporting facilities such as the reception area and dining rooms. Facilities that are mostly provided for hotel users are included in the trip generation rates.	
330	**Hotel, Resort**	**Rooms**
	Hotels primary serving tourists and persons on holiday. Typically located in holiday resorts.	
350	**Guest House**	**Rooms**
	Smaller lodging facilities with characteristics similar to a hotel, but which are provided in a building which has a residential character.	

Table 6: Land-Uses and Size Units

400 Recreational and Sport

430	**Golf Course**	**Courses**
	Trip generation rates for golf courses include facilities normally associated with such courses, such as a restaurant, lounge, etc.	
473	**Casino**	**100 sqm GLA**
	Casino establishments provide gambling facilities.	
480	**Amusement Park**	**ha**
	An amusement park contains rides, entertainment, refreshment facilities and picnic areas.	
488	**Sport Stadium**	**Seats**
	Sport stadiums may consist of one or more sport fields surrounded by seats for spectators.	
492	**Health and Fitness Centre**	**100 sqm GLA**
	Health and Fitness Centres focus on individual fitness or training. Typically they provide exercise facilities, gymnastic equipment, locker rooms and small refreshment facilities.	

Table 6: Land-Uses and Size Units

500 Institutional

520	**Public Primary School**	**Students**
	Public primary schools typically serve students for the first half of their school education.	
530	**Public Secondary School**	**Students**
	Public secondary schools typically serve students for the last half of their school education.	
536	**Private School**	**Students**
	This land-use includes schools for all ages of students.	
550	**University / College**	**Students**
	This land-use includes universities, technicons and colleges.	
560	**Places of Public Worship (Weekend)**	**Seats**
	Places of public worship which normally operate on weekends (e.g. Saturdays or Sundays).	
561	**Places of Public Worship (Weekday)**	**Seats**
	Places of public worship which normally operate during the week (e.g. Friday).	
565	**Pre-School (Day Care Centre)**	**Students**
	A facility where care is provided for pre-school age children. The facilities include classrooms, offices, eating areas and playgrounds.	
566	**Cemetery**	**Ha**
	Place of burial. Size measured in units of hectares.	

Table 6: Land-Uses and Size Units

600 Medical

611	**Public Hospital**	**Beds**
	An institution where public medical care is provided. The land-use includes related facilities normally associated with hospitals, including doctor consulting rooms, pharmacies and other medical services.	
612	**Private Hospital**	**100 sqm GLA**
	An institution where private medical care is provided. The land-use includes related facilities normally associated with hospitals, including doctor consulting rooms, pharmacies and other medical services. The consulting rooms are those used by doctors whose primary duty is to provide health care at the hospital. Other rooms must be treated as medical consulting rooms..	
620	**Nursing home**	**Beds**
	A facility whose primary function is to care for persons who are unable to care for themselves. Care is mostly provided by nursing staff and by visiting doctors. Traffic is primary generated by employees, deliveries and visitors and not by residents.	
630	**Medical Clinic**	**100 sqm GLA**
	A facility at which limited diagnostic outpatient care is provided. No prolonged in-house medical or surgical care typical of hospitals is provided.	

700 Offices

710	**Offices**	**100 sqm GLA**
	This land-use includes developments at which affairs of businesses, commercial or industrial organisations are conducted.	
713	**Home offices and undertakings**	**Houses**
	This land-use includes all home office undertakings, such as small businesses, professional firms, hair-dressers, etc.	
720	**Medical consulting rooms**	**100 sqm GLA**
	Medical consulting rooms are facilities at which medical practitioners may be consulted on an appointment basis, with no or limited provision for hospitalization. Pharmacies are not included.	
770	**Business Centre (Park)**	**100 sqm GLA**
	Business centres are facilities serving a range of mixed land-uses, such as offices, banking facilities, light industries and warehousing.	
780	**Conference Centre**	**Seats**
	A conference centre provides conference facilities. The land-use may include associated land uses, such a dining facilities, dining rooms, etc.	

Table 6: Land-Uses and Size Units

800 Retail

812	**Building Materials**	**100 sqm GLA**
	A building material centre is a free-standing facility that sells building hardware and materials. May include a component of hardware and paint sales.	
816	**Hardware and Paint Store**	**100 sqm GLA**
	Hardware and Paint Stores are generally free-standing facilities at which only hardware and/or paint is sold. May include a very small component of building material.	
817	**Nursery (Garden Centre)**	**100 sqm GLA**
	A nursery or garden centre is a free-standing facility at which items are sold to the public.	
820	**Shopping Centre**	**100 sqm GLA**
	A shopping centre is an integrated (mixed-use) group of commercial establishments that operate as a unit. May include small components of other land uses, such as restaurants, hardware and paint shops, etc.	
830	**Bulk Trade Centre**	**100 sqm GLA**
	Bulk trade centres are generally free-standing commercial facilities at which goods are sold in bulk to either the public or to businesses.	
841	**Motor Dealership**	**100 sqm GLA**
	A motor dealership is a location at which either new or used vehicles are sold. May contain a limited component of vehicle parts sales.	
890	**Furniture Store**	**100 sqm GLA**
	A shop at which furniture is exclusively sold.	

Table 6: Land-Uses and Size Units

900 Services

931	**Restaurant, Quality (Sit-down)**	**100 sqm GLA**
	This land-use consists of high quality, full-service restaurants with lower turnover rates. This type of restaurant typically requires reservations.	
932	**Restaurant, Family (Sit-Down)**	**100 sqm GLA**
	This land use consists of sit-down restaurants with higher turnover rates. These are typically family restaurants and reservations are often not required.	
933	**Fast Food**	**100 sqm GLA**
	Facilities that sell take-away food. Table services are not normally provided, but limited facilities are sometimes available. Include drive-through facilities.	
946	**Filling Station**	**Stations**
	Filling Stations at which the primary business is the fuelling of motor vehicles. Related facilities such as a convenience shop, service facilities and a car wash are not included.	
950	**Vehicle Fitment Centre**	**100 sqm GLA**
	Vehicle Fitment Centres specialise in the fitment of vehicle parts such as exhausts, tyres and radios.	

Appendix B

Trip Parameter Studies

Note: Trip Parameter Studies are undertaken when parameters required for the purposes of this manual must be determined. These studies are not required for traffic impact or site traffic assessments.

B.1 Road Construction Cost Studies

B1.1 Introduction

Road construction cost studies are undertaken to establish the construction cost rates required for the calculation of engineering service contributions. These cost rates are based on road design standards and quantities typical of Class 3, 4 and 5 roads in urban areas as described in the Data Manual. Use is made of a reduced set of cost components for the estimation of the cost rates.

The cost rates must be obtained from priced bills of quantities for road projects in accordance to the procedure described in this chapter. Such bills of quantities are normally available in spreadsheet format which significantly simplifies the studies required to establish the cost rates. A spreadsheet is available that can be used for the collection and submission of the cost data.

B1.2 Road cost data

Road cost data may be collected by means of the form provided in Table 1.1. A separate form must be used for each road project.

The data required for the form must be obtained from priced bills of quantities for urban road projects. Since such bills of quantities are normally available in spreadsheets, the data should rather be collected by means of spreadsheets.

A spreadsheet RoadCostData.Xls is available that can be used for collecting as well as the analysis of data. The data that is required by this spreadsheet is similar to that shown in Table 1.1.

The table consists of a number of main data entry areas, as following:

a) Project data:

- i) Project description.
- ii) Year in which the project costs were obtained.
- iii) Name of city/town or area where the project is located.
- iv) Road classification (Classes 2 to 5).

b) Quantities that is required for determining unit cost rates:

i) Road length (km), the total length of the road along the centreline.
ii) Area of the wearing course (m^2) for the road.
iii) Area of the base course (m^2) for the road.
iv) Area of the subbase (m^2) for the road.
v) Area of the subgrade (m^2). Zero if none.
vi) Area of the roadbed (m^2). Zero if none.
vii) Length of kerb (m). Zero if no kerbs.
viii) Area of pedestrian sidewalks (m^2). Zero if none.
ix) Number of bus stops. Zero if none.
x) Number of interchanges. Zero if none.
xi) Number of traffic signals. Zero if none.

c) Priced bill of quantities

i) Cost code (more information below)
ii) Item number
iii) Item description
iv) Measuring units
v) Quantity
vi) Unit rate
vii) Total amount

d) Calculated unit cost rates

i) Cost code
ii) Cost rate per cost code (total cost divided by the quantity in (b) above)

The spreadsheet contains software (in the form of a macro) that can be used to accumulate the cost items from the bill of quantities for each of the cost codes. The accumulated costs are divided by relevant quantities to determine unit cost rates for each cost component.

A list of cost codes are also provided in Table 1.1. Each row of the bill of quantities must be tagged with one of the cost codes. In a spreadsheet, this can readily be done by copying the code and pasting it to one or more rows of the bill of quantities. This process involves some effort, but it can be undertaken relatively easy. It is, however, important that the appropriate cost code be used to tag the different rows. The software provided in the spreadsheet will accumulate cost data using the tags.

The cost code “NotApplicable” is used to tag those items in the bill of quantities that are not applicable or which should not be included in the cost rates. It is important to exclude items that would not normally form part of road construction or which cost may be excessive (or possibly too low). More information on items that should not be included is provided in the Data Manual.

The following cost codes are available:

Cost Code	Description	Quantity for cost rate determination
Accommodation	Accommodation of traffic	Road length (km)
Earthworks	Fill and cut	Wearing course area
Wearing	Wearing course	Wearing course area
Base	Base course	Base course area
Subbase	Subbase	Subbase area
Subgrade	Subgrade	Subgrade area
Roadbed	Roadbed	Roadbed area
Kerbs	Kerbs	Kerb length
Sidewalks	Pedestrian sidewalks	Sidewalk area
Guardrails	Guardrails and other safety devices	Road length (km)
Stormwater	Stormwater, including culverts/bridges	Road length (km)
PublicTransport	Public transport facilities	No of bus stops
Interchanges	Interchanges	Number of interchanges
Landscape	Landscaping	Road length (km)
RoadSigns	Road traffic signs	Road length (km)
TrafficSignals	Traffic signals	Number of traffic signals
StreetLights	Street lighting	Road length (km)
Other	Other costs (not classified)	Road length (km)
Prelim	Preliminary and general items	
NotApplicable	Cost item not applicable, excluded	

B1.3 Road cost data analysis

The analysis of the road cost data can be undertaken by means of a form similar to that provided in Table 1.2. This analysis, however, can be simplified by means of software provided in another spreadsheet RoadCostBase.Xls. This spreadsheet can be used to accumulate cost data from various RoadCostData.Xls spreadsheets and to analyse the accumulated data. This spreadsheet will scan through other spreadsheets and extract the data that are required for the analysis.

Table 1.2 shows only a portion of the form that is required for the analysis. Additional columns are provided in the spreadsheet, one for each of the cost codes listed in the previous section. At the bottom of the form, a summary is provided of the cost rates obtained from each of the cost data spreadsheets.

The following data, provided at the top of the form, are calculated from the road cost data obtained for each individual project:

a) Minimum cost rate for any project
b) Median cost rate for all projects
c) Maximum cost rate for any project

The cost rate that is used for the determination of engineering service contributions is entered in the "adjusted" row. The rate would normally be selected as the median, but the rate may require adjustment depending on the degree to which the road projects in the list are representative of road projects in general.

A row is also provided as part of the spreadsheet that contains formulae that will automatically round off the rates to an accuracy which is acceptable for the determination of engineering service contributions. This row can be manually overwritten if required.

B1.4 Price Escalation

The road construction cost rates are escalated by means the method described in the Data Manual. A form similar to that provided in Table 1.3 may be used for this purpose. This form is also included in the RoadCostBase.Xls spreadsheet.

The escalation must be based on price indices published monthly by *Statistics South Africa* (available from the http://www.statssa.gov.za/ website). The information is also made available by the *South African Federation of Civil Engineering Contractors* (on their http://www.safcec.org.za/ website).

The following price indices are used for the determination of the escalation factors:

a) Consumer Price Indices (CPI), Average for the country
b) Materials, Civil Engineering Industry
c) Fuel – Diesel Oil, Average for the country
d) Plant – Civil Engineering

Table 1.3 shows entries for the above indices for a number of years. The RoadCostBase.Xls spreadsheet contains entries from 2000 to the most recent year.

The price indices can show significant monthly variation. For this reason, the average annual index for a particular year is used rather than the index for a particular month. These annual indices are determined as the algebraic average for a year.

The financial years of municipalities start on the 1st July of each year. However, the indices for a financial year are usually not available on the date the cost rates must be published. The average indices shown in Table 1.3 are therefore calculated from April in the previous year to March in the financial year. The base year rates, however, are determined for the calendar years.

The following proportions are used for the determination of escalation factors:

Prop X_P subject to escalation	Labour X_L	Materials X_M	Diesel X_F	Plant X_P
0.85	0.30	0.30	0.05	0.35

Table 1.1: Road construction cost data submission form

Road Construction Cost Data						
Road Project						
Beg Fin Year (1 Jul)		**City/Town**	**Calculated total costs**			
Road class (2 to 5)			**Cost Codes**	**Total cost**	**Cost Codes**	**Total cost**
Road length (km)		**Notes**	Accommodation		PublicTransport	
Wearing (m^2)			Earthworks		Interchanges	
Base (m^2)			Wearing		Landscape	
Subbase (m^2)			Base		RoadSigns	
Subgrade (m^2)			Subbase		TrafficSignals	
Roadbed (m^2)			Subgrade		StreetLights	
Kerb (m)			Roadbed		Other	
Sidewalk (m^2)			Kerbs		Prelim	
Bus stops (No)			Sidewalks			
Interchanges (No)			Guardrails			
Traffic signals (No)			Stormwater		NotApplicable	

Instructions:
1) Enter project name, Year number, Road class and Quantities above
2) Copy and paste priced bill of quantities to space below
3) Copy and paste applicable Cost Codes to Column 1
4) Do not include excessive items which do not normally form part of road construction

Cost Code	**Project Data (Priced bill of quantities)**					
Select from list	**Item**	**Description**	**Unit**	**Quantity**	**Rate**	**Amount**

Table 1.2: Example unit cost rate calculations (Class 2/3 roads)

Cost Code	Accom-modation	Earth-works	Wearing	Base	Sub-base	Sub-grade	Road -bed	Kerbs	Side-walks	……	Prelim
Rounded	R 150 000	R 40	R 95	R 65	R 40	R 20	R 7	R 130	R 130		10%
Adjusted	R 150 000	R 40	R 95	R 65	R 40	R 20	R 7	R 130	R 130		10%
Minimum	R 67 078	R 30	R 67	R 59	R 24	R 7	R 3	R 123	R 110		8%
Median	R 111 824	R 40	R 104	R 69	R 42	R 13	R 5	R 139	R 110		11%
Maximum	R 852 986	R 224	R 132	R 134	R 63	R 28	R 15	R 201	R 196		17%
Lynnwood Road	R 852 986	R 224	R 104	R 102	R 42	R 28	R 15	R 139	R 196		
Van Ryneveld	R 111 824	R 38	R 67	R 69	R 63	R 19	R 12	R 140			10%
Nellmapius 1	R 94 453	R 30	R 125	R 61	R 38	R 13	R 4	R 123	R 110		8%
Nellmapius 2	R 197 081	R 40	R 132	R 134	R 42	R 13	R 5	R 124	R 110		12%
Lenchen Extension	R 67 078	R 78	R 69	R 59	R 24	R 7	R 3	R 201			17%

Table 1.3: Example Cost Escalation Factors

Annual Average Escalation Factors

Cost components and proportions					
		Prop X_P subject to escalation:			0.85
		Labour X_L	Mat X_M	Diesel X_F	Plant X_P
		0.30	0.30	0.05	0.35
Year end		CPI	Avg Production Price Indices		
Year	Mnt	Wgt Avg	Materials	Diesel	Plant
2010	3	108.6	210.8	265.0	189.5
2007	12	89.8	176.8	246.3	150.5
2007	12	89.8	176.8	246.3	150.5

Monthly Escalation Factors

Date		CPI	Production Price Indices		
Year	Mnt	Wgt Avg	Materials	Diesel	Plant
2000	1	60.4	97.0	75.1	95.3
2000	2	60.4	97.7	79.9	97.4
2000	3	60.9	97.7	88.4	97.4
2000	4	61.6	98.0	92.5	97.4
2000	5	61.9	99.1	90.0	98.7
2000	6	62.3	99.2	91.5	98.7
2000	7	62.8	100.6	94.1	99.2
2000	8	63.1	102.7	101.7	102.4
2000	9	63.3	103.1	111.1	102.4
2000	10	63.6	101.2	122.2	102.4
2000	11	63.6	101.3	129.5	104.0
2000	12	63.8	101.8	123.9	104.7
2001	1	64.5	103.7	117.7	104.7
2001	2	64.6	103.6	114.1	108.2
2001	3	65.1	103.7	111.8	108.2
2001	4	65.4	103.7	112.1	108.2
2001	5	65.6	105.1	116.7	112.2
2001	6	65.9	105.0	116.3	112.2
2001	7	66.1	107.9	116.1	112.2
2001	8	66.0	108.4	116.1	114.3
2001	9	66.1	108.6	116.0	114.3
2001	10	66.1	108.8	118.3	114.3
2001	11	66.4	108.7	117.9	119.8
2001	12	66.8	108.9	115.4	119.8

Notes

1. Average values used rather than midpoints because factors vary significantly during the year (month to month).
2. Average values for financial years from July to June. Due to unavailability of indices, the average values are determined from April to March.

Information Sources

Statistics published by: Statistics South Africa

- Consumer Price Indices (CPI)
  - Published in Statistical Releases P0141
  - Average for country
- Production Price Indices
  - Pblished in Statistical Releases P0142.1
  - Materials (Civil Engineering Industry)
  - Fuel - Diesel Oil (Average for country)
  - Plant (Civil Engineering)
  - http://www.statssa.gov.za/

Information also provided by:

- South African Federation of Civil Engineering Contractors
  - http://www.safcec.org.za/

B.2 Trip Generation and Length Studies

B2.1 Trip studies

Trip generation and length studies are undertaken with the purpose of estimating the following traffic parameters.

a) Short-term count based parameters (2 to 24 hours)

   i) Peak-hour trip generation rate
   ii) Percentage in/out split
   iii) Percentage heavy vehicles
   iv) Peak-hour factors (15-minute counts)
   v) Background peak-hour factors
   vi) Vehicle occupancies (persons per vehicle, including driver)
   vii) Parking rates
   viii) Pedestrian/cyclist counts

b) 7-Day (or longer) traffic count based parameters

   i) AADT Daily trip generation rate
   ii) Traffic factors for engineering service contributions

c) Interview surveys

   i) Trip length
   ii) Pass-by and diverted trips

Where possible, studies should be undertaken for all the above parameters for a particular land use. The studies may, however, only be undertaken for a subset of the parameters, depending on available resources.

B2.2 Sites for trip studies

The selection of sites for trip generation studies is critical for establish representative trip generation parameters for a particular land use. The use of inappropriate sites could lead to either an under or overestimation of trip generation rates.

The following are a number of requirements for <u>selecting sites</u> for trip generation and length studies (ITE, 2004):

a) *Occupancy*. The site must have a reasonable full occupancy (at least 85 percent of the size at the time of the study) and must be economically healthy.

b) *Maturity*. The site must be mature (two years or older) and located in a mature and fully developed area.

c) *Congested conditions*. Trip generation studies should not be undertaken in areas that are experiencing high levels of traffic congestion. Studies under such conditions would tend to underestimate the trip generation of a development.

d) *Construction*. There should be no on-site construction or construction of roadways surrounding the site.

e) *Isolated sites*. A particularly important requirement is that it must be possible to isolate the site for the following purposes:

   i) All parking must occur on the site. Parking on other sites will result in an underestimation of the trip generation rate for the development.
   ii) Except if it is the purpose to study mixed-use developments, there should be limited ability for pedestrians to walk to the site from adjacent or nearby developments.
   iii) Entry and exit point to the site must be clearly identifiable and must not be shared by other developments.
   iv) There must be no through traffic.

f) *Survey*. The site must be suitable for undertaking the traffic counts and traffic surveys required for the studies. Space must be available for undertaking the traffic studies. Care should be taken to prevent double counting of vehicles.

g) *Site information*. Information must be available on aspects such as the land use type and size of the development.

h) *Permission*. The permission of the owner or manager of the site must be obtained.

Trip generation studies for a particular land use must be undertaken at a minimum of <u>three</u> different developments, although a minimum of <u>five</u> sites are preferred. If the trip rate is related to the size of the development (such as shopping centres), a minimum of <u>ten</u> sites are required.

The collected data must be carefully investigated for <u>outliers</u>. Should outliers be present, then the sites must be re-evaluated to determine whether they are representative of the general population of sites. The sites should not be taken into account if they are found not to be representative of developments in general.

B2.3 Street counts

Where possible, counts should also be undertaken on the <u>street</u> immediately adjacent to the development. The peak hour trip generation should preferably be based on the peak hour of the adjacent street and not of the development. Where a street count is not available, it is assumed that the peak hour of the development corresponds with that of the adjacent street.

The count on the adjacent street will also allow the determination of typical peak hour factors on streets adjacent to developments of a particular land use. These factors are important in the analysis of the traffic impact of a development.

B2.4 Normal/Abnormal days

Differentiation is made between traffic surveys on normal and abnormal days. Normal days are days of the year during which traffic patterns tends to be stable and where these patterns are not affected or influenced by abnormal or exceptional events.

Abnormal days are days on which the traffic patterns deviate from normal days due to events such as schools and public days (including influenced days). Although abnormal, these days can be predicted using the methodology provided in the Data Manual.

Exceptional days are normal days on which some unpredictable event occurred that affected the traffic pattern. These include events such as road closures, construction, accidents and adverse weather conditions.

The traffic surveys would normally be undertaken on *normal days*, but the surveys should be undertaken on abnormal days when a land use specifically focuses on abnormal days (e.g. holiday resorts). Care should be taken to ensure that surveys are not undertaken on exceptional days.

B2.5 Short-term traffic counts

The duration of a short-term count can vary from about 2 hours to not more than 24 hours. The counts are typically undertaken manually on an access to a development, normally using one or two persons per access to the development, depending on the traffic volumes at the accesses.

Where resources are available, it would be preferable to undertake a turning movement count at the access intersection to the development. The count on the street network is then used to determine the background (street) peak-hour factor.

Although it is preferable to undertake a traffic count for at least 12 hours, the count should at least cover the peak periods for the development. The duration of a count should therefore not be less than 2 hours to cover 30 minutes before and after the peak hour. The count must be of sufficient duration to ensure that the peak hour was correctly identified.

The traffic counts should be undertaken in 15-minute intervals. These intervals are required to identify the peak hour period. The counts can then also be used to determine 15-minute peak-hour factors.

The counts must also differentiation between in- and outbound directions. This is required to determine directional splits. Alternative, when the count is undertaken at an access intersection, turning movement counts will be required for this purpose.

The counts should also differentiate between light and heavy vehicles. The classification can be based on the number of tyres on a wheel. A heavy vehicle is one that have dual tyres on at least one axle (or wheel) while light vehicles will only have single tyre wheels.

The count can be undertaken using a form similar to the following (an intersection count would require more columns for the different turning movements):

Trip generation traffic count

Development:	
Address:	
Access location	
Date of count	

15-minute period	Inbound direction		Outbound direction	
	Light veh	Heavy veh	Light veh	Heavy veh

B2.6 Long-term traffic counts

Long-term traffic counts are undertaken for a period of seven days (but preferably 14 days) and are undertaken using electronic equipment. At least one such count should be obtained per land-use category, while a similar background street count is also required.

The long-term counts can be used to determine trip generation rates for a larger range of time periods. The counts are also required for estimating the Annual Average Daily Trip generation (AADT) for a development. The counts are also used to determine traffic factors required by the engineering service contribution methodology.

Similarly to short-term counts, the counts should also be undertaken in 15-minute intervals (access counts must also differentiate between in- and outbound directions). Where possible, the heavy vehicles should be classified as light (or short), medium and heavy (or long).

B2.7 Vehicle occupancy

Vehicle occupancy is the number of persons (including driver) in a vehicle. Although occupancy is not an essential parameter, it should be surveyed when resources are available.

For the vehicle occupancy survey, a random sample of vehicles is selected and a count made of the number of persons (including the driver) in the vehicle. The sample is deemed random when the first next vehicle is selected immediately after the information of a previous vehicle has been recorded on the form.

The survey can be undertaken using a form similar to the following:

Vehicle Occupancy Survey

Development:	
Address:	
Access location	
Date of survey	

Time (hh:mm)	No of persons	Direction In/Out		Time (hh:mm)	No of persons	Direction In/Out

B2.8 Pass-by and diverted trip studies

Pass-by and diverted trip studies are undertaken by means of interview surveys. These surveys must be undertaken on the site itself but could also be undertaken on the entrances and exits to and from the site.

In order to identify whether a trip is a pass-by or diverted trips, the following questions must be asked:

a) Is this development the primary destination of the trip or an intermediate stop? This question will identify whether the trip is a primary or a non-primary trip.

b) If the trip is non-primary, the question must be asked whether the intermediate stop was made from the street adjacent to the development (at the access) or whether it required diversion from another road or street not passing by the development. This will identify whether the trip is a pass-by trip or a diverted trip.

The sample size per peak or time period should not be less than 30 interviews, although a larger sample size of 100 interviews or more per peak period would be preferred.

The pass-by/diverted trip survey can be undertaken using a form similar to the following:

Pass-by/Diverted Trip Survey

Development:	
Address:	
Access location	
Date of survey	

Question 1	Is this development the primary (main) destination of your trip or an intermediate stop?
If the answer of Question 1 is “intermediate”, continue with Question 2. Otherwise stop.	
Question 2	Were you travelling on the street adjacent to the development (Pass-by trip) or did you had to divert from another road or street that is not adjacent to the development (Diverted trip)

Time (hh:mm)	P: Primary X: Intermed	P: Pass-by X: Diverted		Time (hh:mm)	P: Primary X: Intermed	P: Pass-by X: Diverted

B2.9 Trip length studies

Trip length studies are also undertaken by means of interview surveys. The studies, however, are significantly more extensive compared to pass-by and diverted trip studies. The studies can be combined in one survey, but will require significantly more resources.

The trip length study must be undertaken at a development with a particular land use. Road side surveys may not be used for this purpose since such surveys are biased towards longer trips. Trip lengths obtained from a sample of road side surveys can be significantly longer than actual trip lengths (in many cases twice as long).

The trip length data should preferably be collected by means of a large scale map of the area. The scale should be large enough to allow the exact identification of the trip origin or destination as well as the route that were followed during the trip. It should also cover most likely origins and destinations of persons that will be visiting the development. When the survey is undertaken near to the boundary of the municipality, the map should also include the adjacent municipality or municipalities.

It is important that the map should differentiate between the following three groups of road classes:

a) Class 1 to 3 roads.
b) Multilane Class 4 and 5 roads.
c) Two-lane Class 4 and 5 roads.

It is only necessary to mark the Class 1 to 3 roads and Multilane Class 4 and 5 roads on the map. Roads that are not marked are two-lane Class 4 and 5 roads.

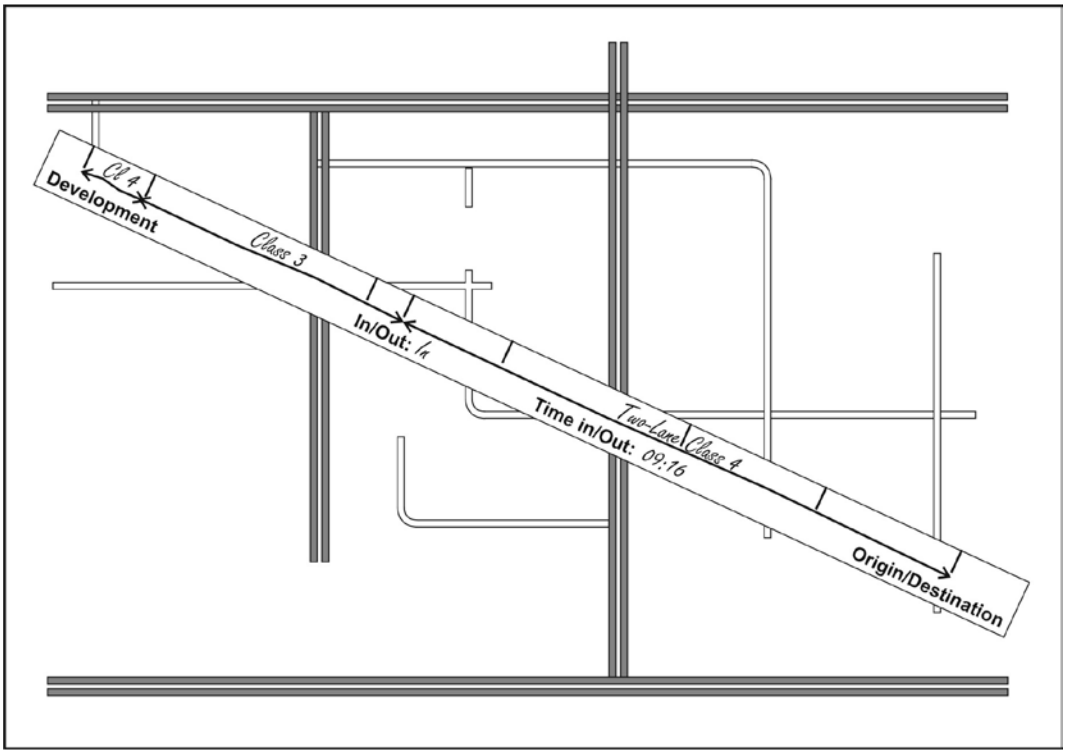
The map should also show the boundaries of the urbanised areas of the municipality (areas in which townships have been established). The maps must also show national and provincial roads located in the area.

Information can be collected on both the inbound and outbound trips. For the outbound trip, it is important to check whether a respondent will be able to provide reliable data on the trip to be undertaken. It is not necessary to record the times accurately.

One possible method for collecting the trip length data is to obtain the specific address of the origin or destination and to list some or all of the street names along the trip. This data can then be used afterwards to determine the route and measure the trip length of the data.

An alternative method is to measure the trip length during the interview. This measurement can be made using narrow strips of paper. The positions of the origins and destinations are marked on the strip of paper together with the length of each section of road along the trip. The strip of paper is also used to indicate a) the class of road, b) whether it is a provincial or national road and c) whether the road is located outside the municipality. The actual travel distance can be scaled off afterwards from the paper strips. An example of the methodology is shown in the figure below.

The sample size for trip length surveys should be obtained from not less than 30 interviews, although a larger sample size of 100 interviews or more would be preferred.



Example map-based trip length survey

B2.10 Pedestrian/cyclist counts

The current version of the Data Manual does not include any data on pedestrian or cyclist trip generation of developments. This information may become important in future, and provision is therefore made for the collection of such data. The required data is similar to that for short-term traffic counts and must be recorded similarly.

B2.11 Parking demand studies

A trip generation study can readily be expanded to include a parking demand study. The parking study would normally require counts over a longer period than that required for the trip generation study, while a count of parked vehicles may also be required.

Parking accumulation can be obtained from in- and outbound traffic counts or from a count of parked vehicles. A possible shortcoming of using traffic counts is that the counts must be undertaken very accurately to prevent an accumulation of errors. A count of parked vehicles is more accurate, but the survey requires a relatively large survey team. The count of parked vehicles must also be taken very quickly at the end of a time interval, preferably within a short period of one or two minutes. In such a short period, one person can only count a relatively small number of parked vehicles.

Unless a traffic count can be started very early when all parking spaces are empty, a count of parked vehicles must be undertaken at the start of the survey. A similar count should also be undertaken at the end of the survey. This second count can be used for testing whether the traffic counts contained any serious errors.

At developments where parking spaces are reserved for specific use by tenants, a count of parked vehicles will be required to differentiate between reserved and unreserved parking. Such a count should be undertaken regularly during the survey, preferably every hour.

B2.12 Trip data submission forms

Several forms are provided in this chapter that may be used for capturing data collected during trip studies. A spreadsheet TripRateData.Xls is also available that can be used for this purpose.

The available data submission forms are shown in Tables 2.1 to 2.5, as follows:

Table 2.1: Development information

The first form, shown in Table 2.1, is used for capturing data about the development. The following information must be entered on this form:

- Data Source – Person and organisation that provided the data
- Development name – Name of the development for which data are provided
- Development address – Street address of the development
- City/Town – The city of town in which the development is located
- Location code – Rural, Town, Suburban or CBD
- Mixed-use level – Low or high levels of mixed-use (walking trips)
- Vehicle ownership – High, Low or Very Low level of vehicle ownership
- Public transport – Low or high levels of public transport.
- Congestion – Indication of whether congestion in the area may affect the study
- Number of accesses (vehicular, delivery and pedestrian)
- Number of parking spaces (on-site, off-site and on-street)
- Reserved number of parking spaces (on-site, off-site and on-street)
- Primary land use (code, size, size occupied, size units and description
- Mixed land uses (optional, same data as for primary land use)

Space is also provided in the form for information on whether or not the following traffic counts were undertaken as part of the study:

- In/Out vehicle count
- In/Out pedestrian count
- In/Out on-street count
- Interview survey

Information is also required on whether the traffic counts are cumulatively or not as well as the duration of the traffic count intervals. The preferred interval duration is 15 minutes, but data collected in 60-minute intervals can also be entered.

Table 2.2: Vehicular trip generation traffic count

The form provided in Table 2.2 can be used for the collection of vehicular trip generation traffic counts (as well as parking accumulation). The following data are required:

- The date of the traffic count. Several counts can be entered sequentially in the table, but each new count must start with a new date. The date is only provided on the first row of the count.
- The end time of the count (at the end of the interval).
- In- and outbound traffic count. If traffic counts are undertaken at several accesses, the sum of the counts at the different accesses must be provided.
- Heavy vehicle count, total in- and outbound. Differentiate between short, medium and long trucks if data are available.
- Vehicle occupancies (persons per vehicle) for in- and outbound directions. The sample size together with the calculated vehicle occupancy must be provided.
- Parking occupancy (number of occupied spaces) at the end of the time interval. Differentiate between unreserved and reserved parking.

Table 2.3 Pedestrian/Cyclist count

Pedestrian and cyclist counts can be provided in Table 2.3. Space is provided for the following counts:

- The date of the traffic count. Several counts can be entered sequentially in the table, but each new count must start with a new date. The date is only provided on the first row of the count.
- The end time of the count (at the end of the interval).
- In- and outbound pedestrian count. If counts are undertaken at several accesses, the sum of the counts at the different accesses must be provided.
- In- and outbound cyclist count. If counts are undertaken at several accesses, the sum of the counts at the different accesses must be provided.

Table 2.4 Adjacent street traffic count

Traffic counts on the adjacent street can be provided in Table 2.4:

- The date of the traffic count. Several counts can be entered sequentially in the table, but each new count must start with a new date. The date is only provided on the first row of the count.
- The end time of the count (at the end of the interval).
- Traffic count in two directions of travel on the adjacent street.

Table 2.5 Interview survey data

The following interview survey data can be provided in Table 2.5:

- The date of the traffic survey.
- Time of arrival at the development.
- Time when the person will be departing from the development.
- Trip type (Prim, Pass, Div)
- Inbound and outbound trip lengths

The trip types may be one of the following:

- Prim – Primary trip
- Pass – Pass-by trip
- Div – Diverted trip

The following information is required for the trip length:

- Half the total trip length (km) - the total trip length divided by two
- Half the Class 4/5 trip length (km)
- Trip length outside the boundaries of the municipality (if available)
- Trip length on national/provincial roads (if available)

B2.13 Trip data analysis

The analysis of the trip data must be undertaken by means of software since regression analysis (including nonlinear regression analysis) must be undertaken to determine the required trip rates and other related parameters. For this purpose, two spreadsheets TripRateBDat.Xls and TripRateBase.Xls are available to accumulate trip data from various TripRateData.Xls spreadsheets and for the analysis of the accumulated data.

The TripRateBase.Xls spreadsheet contains a database of all accumulated data, but the accumulation is undertaken by the TripRateBDat.Xls spreadsheet. The only data required by TripRateBDat.Xls is the names of the data spreadsheets that must be accumulated.

The analysis of the trip data is undertaken by means of the TripRateBase.Xls spreadsheet. This spreadsheet contains several spreadsheets with accumulated data and calculated trip rates.

The summarised data are provided in the following spreadsheets:

a) BaseNme – A list of names and organisations of persons that have submitted data for inclusion in the Data Manual.
b) BaseGen – Summary trip generation data derived from vehicular counts.
c) BasePed – Summary pedestrian generation data derived from pedestrian counts.
d) BaseLen – Summary trip length data derived from interview survey data.
e) BasePrk – Summary parking rate data derived from counts
f) BaseTrf – 7-Day traffic pattern data derived from 7-day traffic counts.

Other data required by the software are provided in the following spreadsheets:

- ParmDat – Average number of E80 axles per heavy vehicle
- LandUse – Land-use codes, descriptions, units and base sizes

Trip parameters calculated by the software are given in the following spreadsheets:

- CalcGen – Trip generation rates and other associated parameters
- CalcPed – Pedestrian generation rates and other associated parameters
- CalcLen – Trip length and other associated parameters
- CalcPrk – Parking rate parameters
- CalcTrf –Equivalent traffic impact factors for engineering service contributions

Outputs from the analysis are provided in the following spreadsheets:

- LandCode – Land-use codes, descriptions, units and base sizes
- TripParm – Daily and other trip generation results
- TripFact – Trip reduction factors
- TripRate – Trip generation rates and other results
- TripLeng – Trip lengths and other results
- ParkRate – Parking rates

Various macros are provided in the spreadsheet for the analysis of the data. The results of this analysis are stored in the calculated trip parameter spreadsheets. In these spreadsheets, two rows of data are provided for each land use, namely:

- “Used” parameters – The parameters that must actually be used in output sheets
- “Calc” parameters – The parameters calculated by the software

In situations where a “used” parameter is not provided, the “calc” parameter will be given in the output spreadsheets. The “used” parameters can be used to overwrite the calculated parameter in situations where data are inadequate and must be based on other local and international trip rate data.

All parameters are determined as “average” parameters obtained from regression analysis (described in the next section). The only difference is parking rates that are determined as the 85th percentile value of rates measured at the different developments (ITE Parking Generation, 2004). In determining this percentile value, the developments are weighted according to their sizes.

B2.14 Regression analysis

The trip generation rates and other parameters are determined by means of weighted regression analysis. Linear regression is used when a size adjustment factor is not required. For land uses where the trip rate depends on the size of the development, the parameters must be estimated by means of nonlinear regression analysis.

The nonlinear regression analysis is undertaken by means of the following search procedure:

a) Minimum and maximum values for the size adjustment parameters are assumed

b) Two values of the parameters are selected between the minimum and maximum values (at points 1/3 and 2/3 between these values)

c) The sum of squared errors is determined for each of the two midpoint values and the minimum sum of squared errors determined. If the minimum is at the 1/3 point, then the maximum value is made equal to the 2/3 point. Otherwise, the minimum value is made equal to the 1/3 point.

d) Steps b) and c) are undertaken until sufficient accuracy has been obtained.

The results of the regression analysis are provided as trip rates (and other parameters) in the “calculation” spreadsheets. The results of the regression analysis can be overwritten in this spreadsheet in situations where there is inadequate data (“used” vs “calc” data). The final results are provided in the different output files as well as graphs showing the regression relationships.

The regression analysis is undertaken for the following dependent and independent variables for the various trip rates and parameters:

Parameter	Dependent variable	Independent variable
Trip generation rate	Number of trips (in plus out) at development	Size of the development
Percent heavy vehicles	Number of in plus out heavy vehicles	Number of trips generated by the development
Percent short, medium and long	Number of in plus out heavy vehicles of a type	Number of in plus out heavy vehicles
In-/Outbound split	Total number of inbound trips at development	Number of trips generated by the development
Peak hour factor (PHF)	In plus out flow rate (veh/hour) during peak 15-minute period	Number of trips generated by the development
Vehicle Occupancy	Total number of persons in vehicles (all trips)	Number of trips generated by the development
Percent pass-by or diverted trips	Percent pass-by/diverted trips multiplied by development size	Size of the development
Trip length	Trip length multiplied by the size of the development	Size of the development (square metres)
Trip length components	Length of trip component	Total (half) trip length

Table 2.1: Development particulars

Development particulars - Trip Generation and Trip Length Data

Data Source	
Dev name	
Address	
City/Town	

Location code		Rural, Town, Suburban, CBD Location
Mixed-use (walk)		Low/High mixed-use development (walking)
Vehicle ownership		High/Low/Very low vehicle ownership
Public transport		Low/High public transport
Congestion		No/Yes - Congestion in area may affect trip generation rates
Weight		Weight given to development in statistical analysis (Zero to ignore)

	Vehicle	Delivery	Pedestrian	
No of Accesses				Vehicular, delivery, pedestrian accesses

	On-site	Off-site	On-street	
Parking Spaces				On-site, off-site, on-street No of parking spaces
Reserved spaces				Reserved parking spaces

Primary Land-Use	Code	Size	Size occup	Size units	Description

Land-Uses for Mixed-Use Developments	Code	Size	Size occup	Size units	Description

Traffic counts	Type	Time Int	
In/Out veh count			N=None, C=Cumulative, T=Non-cumulative
In//Out Pedes			Cumulative counts must start with zero
Street count			15 or 60 Minute counts (15-minute preferable)
Interview survey			No/Yes interview survey undertaken

Table 2.2: Vehicular trip generation traffic count

Trip generation traffic count

Count	Time	Traffic count		Heavy veh count				In Veh Occup		Out Veh Occup		Park Occup	
Date	End	In	Out	In+Out	Short	Med	Long	Samp	Per veh	Samp	Per veh	Unres	Res

Table 2.3: Pedestrian/cyclist count data

Pedestrian/Cyclist count					
Count	Time	Pedestrians		Cyclists	
Date	End	In	Out	In	Out

Table 2.4: Adjacent street traffic count data

Adjacent street traffic count			
Count	Time	Street Count	
Date	End	Dir1	Dir2

Table 2.5: Interview survey data

Interview survey data									
Survey	Time	Time	Trip	Half trip lengths		Class 4/5 Roads		Outside	Prov/Nat
Date	Arrv	Dept	Type	In/Outbound	Half Len	Multi-lane	Two-Lane	Munic	Roads