TSHWANE BRT LINE 1
FINAL PRELIMINARY DESIGN REPORT (VOLUME 1)

CONTENTS

1 INTRODUCTION

ARCUS GIBB was appointed by A-M Consulting Engineers (AMCE) for the preliminary design of the **Bus Rapid Transit (BRT) Line 1 Soshanguve to Pretoria CBD**, in order for the City of Tshwane to proceed with implementation of this line during the 2012/13 financial year. AMCE is appointed by the City of Tshwane as Programme Managers for the BRT project.

The preliminary design was completed in the absence of an approved operational plan. The City is in the process of re-developing an operational plan, including demand modelling, in parallel to the preliminary infrastructure design process. While this approach provides an opportunity to develop and tailor the operational plan, taking into consideration the outcome of the preliminary design process, it means that several key assumptions had to be made for the preliminary design to proceed.

The operational plan would normally specify key characteristics of the proposed system that influences the design of the required infrastructure, such as:

- the proposed network (routes) and station locations, and how it will be phased in over time
- the expected passenger demand
- Service design – what type of services will be provided to accommodate the demand – where are transfers and or feeder operations planned
- What type of buses would be used and frequency of services (system capacity requirements, station design, pavement design)

While it was hoped that the operational design and demand forecasting would progress to a stage where inputs can be obtained before the preliminary design is finalised, this was not possible. Therefore the preliminary infrastructure design proposed in this report will need to be reviewed once the operational plan is complete, prior to commencing the detail design.

The traffic impact assessment was also done in parallel to the preliminary design process, necessitated by the short project timeframe. The outcome of the traffic modelling resulted in recommendations for some changes to the completed preliminary design. Some of the proposed changes identified through the TRANSYT modelling that have not been incorporated into the draft drawings, has now been incorporated into the final drawings. The remaining changes should be done during the detail design process, once there is more finality regarding the operational design parameters, as some changes may not be necessary if a smaller BRT system is proposed than what is currently designed for.

This report supersedes the Draft Report issued for comment, dated 1 November 2011.

1.1 Project Background

The City of Tshwane (COT) developed a Strategic Public Transport Network (SPTN) for the City in 2005. The city's SPTN was developed within the overall framework of the SPTN developed by the Gauteng Province. The aim of the SPTN is, amongst others, to channel public transport services into focused high demand and frequency corridors, with feeder and distribution services serving these corridors. The main objectives of the SPTN are to:

- Establish a network that brings a reliable and frequent level of public transport service within acceptable walking distance.
- Establish focused and high frequency corridors where passengers are transported over longer distances, and where public transport enjoys priority over private transport.
- Provide interconnectivity between residential areas and main employment and business nodes, as well as between main nodes.
- Provide Tshwane with a permanent, recognizable public transport framework consisting of radial and circular routes.
- Provide nodes at the intersecting points of major routes where transfers can take place.

COT also undertook the preparation of an Integrated Transport Plan as is required by both the National Land Transport Transition Act (NLTTA), (Act 22 of 2000), sections 19 and 27, and the replacing Act, the National Land Transport Act (NLTA), (Act 5 of 2009), sections 32 and 36. This legislated Integrated Transport Plan (2006-2011) provides a stepping stone to long-term strategic vision for investing in the transport systems, infrastructure and networks in the city. It also re-iterates the objectives of the SPTN.

The ITP sets out the goals and objectives for transport in the City over the 5 year timeframe. It sets out the Transport Vision as follows:

"An integrated Transport System that meets the needs of all the people of Tshwane in a sustainable and affordable manner"

The four over-arching transport goals are:

- Improve accessibility and mobility provided by the transport system;
- Develop a transport system that drives economic growth;
- Improve the safety and security of the transport system; and
- Development of a transport system that reflects the image of the city.

Further the ITP states that:

- Higher priority must be given to public transport over private transport;
- Travel demand management measures should be used to discourage private transport; and
- Accessibility to public transport should be enhanced for those with disabilities.

The ITP then goes on to identify a number of objectives designed to achieve these goals and key amongst these is the development of a Bus Rapid Transit System

(BRT) which has the potential to address a number of these goals. The main objective of the BRT system is to design and construct a network of BRT Lines in the city providing a world class public transport for all residents of the City. The ITP's proposed BRT system consists of the implementation of eight individual BRT routes over the coming years, all accessing the Pretoria CBD, namely:

- Mabopane – CBD
- Mabopane – Menlyn
- Mamelodi – Menlyn – CBD
- CBD Circle
- Atteridgeville – Centurion
- Atteridgeville – Menlyn
- Mamelodi – CBD
- Mamelodi – Denneboom – CBD
- Mamelodi - Rosslyn

Subsequent to the completion of the 2006 – 2011 ITP, Mr Lloyd Wright of Viva Cities, developed a high level planning document "Tshwane Rapid Transit: Implementation Framework", dated May 2007.

This was followed by the development of an Operational Plan, completed in 2008 by Advanced Logistics Group.

The routes indicated in **Figure 1.1** was proposed and the City prioritised the implementation of Phase 1, the Mabopane to the CBD route.

Although parts of the proposed BRT routes run parallel to the Passenger Rail Agency's (PRASA) Priority A rail corridors, which is prioritised for upgrading and new rolling stock in the near future, the BRT Operational Plan argued that the passenger demand on the above corridors are such that they warrant both rapid rail and road services. The development of the full integrated BRT network is planned to take place over a series of phases, in order to match the available resources for planning and construction.

The City proceeded with and completed the preliminary design and environmental approval of the Mabopane to CBD route during 2008 - 2010. The route started at Mabopane Station, followed the R80, D F Malan Drive, Boom and Bloed Street, and Paul Kruger Street, ending at Pretoria Station. However subsequent review of the City's proposals by the funding agency, the National Department of Transport, resulted in a request for revisiting the planning. Key concerns were that the proposed route competes directly with the Mabopane to Tshwane Priority Rail corridor, stations along the R80 being inaccessible, and high costs.

A subsequent review by the City of Tshwane of the previous planning, resulted in the route being revised to start further south in Soshanguve, instead of in Mabopane, and to follow Doreen Road, Rachel De Beer and Mansfield Road, instead of the R80. The section of the route along Paul Kruger Street, from Boom Street to the Pretoria Station, remains the same. In addition to the revised route for Line 1, the City also decided to re-do the Operational Plan to address NDOT's concerns.

The National Department of Transport has made available funding for the implementation of the project and it is the City's intention to start implementation of the first section by 2012. Consequently, the preliminary design is urgently required to confirm the route, identify station locations and to determine likely cost of implementation, to confirm feasibility. If feasible, the City will proceed with detail design to enable construction to start in 2012.

However as noted in the introduction, the final route alignment and the relationship of Line 1 with the other routes are not yet finalised, as the operational plan is still being developed. The preliminary design of Line 1 has therefore been developed largely in isolation of the overall ultimate BRT system design and network of routes and services to be operated. It is strongly recommended that the operational plan be finalised and approved prior to the commencement of the detail design.

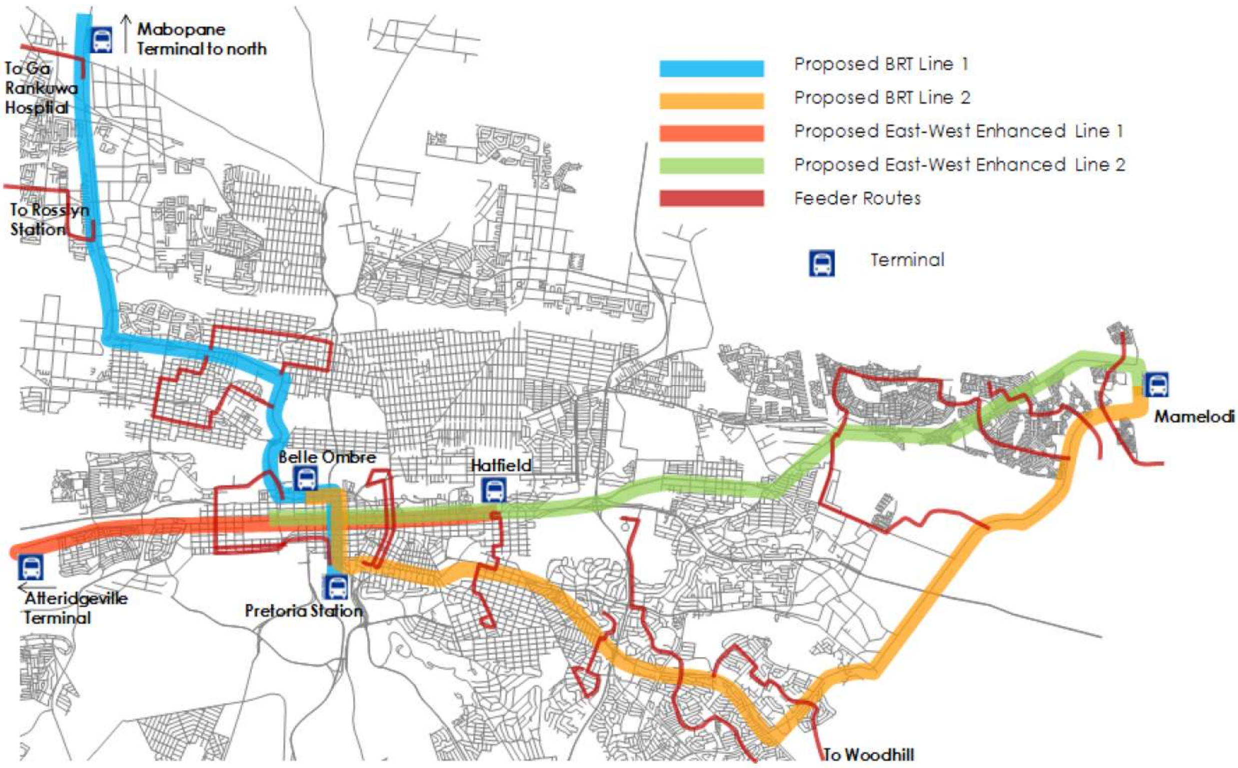


Figure 1.1: Proposed BRT Routes
Source: Tshwane Rapid Transit Operational Plan, September 2008

1.2 Scope of Work

The BRT Line 1 route is approximately 33km from the junction of M17/M20 Hebron Road to Pretoria Railway Station and comprises of the following sections:

- From M17/M20 Hebron Road Junction to Pretoria Railway Station via
  - M20 Rosslyn Road;
  - M20 Doreen Avenue;
  - R513 Brits Road;
  - R513 Rachel de Beer Road;
  - R101 Mansfield Avenue/Road; and
  - R101 Paul Kruger Street, terminating at Pretoria Station.

In addition the team has been tasked to include an extension of the line from the junction of M17 and M20 Hebron to the junction of M17 and Ruth First (M42/K4). This section has been included in the visual assessment but it was subsequently confirmed that the route would not extend this far north.

A further potential change to the route was proposed by Programme Managers during October 2011, namely that the service should start at the PRASA station (Kopanong) east of the intersection of Hebron and Doreen Roads. The design of the section of the M20 from the M17 up to Dorreen Road, was therefore put on hold, pending a decision on the final route alignment. The decision to proceed with this section has since been made and the design of this will be submitted as an Addendum to this report.

1.3 Preliminary Design Objectives

The preliminary design objectives can be summarised as follows:

- Prepare conceptual preliminary design drawings to determine what type of BRT infrastructure can be provided within the available constraints, or alternatively, what alternative solutions are available (options analysis);
- Preparation of preliminary cost estimate of the recommended option;

The preliminary design development includes the following components:

- Geometric design: topographical surveys, pavement condition survey and an assessment of utility or services information (including electrical and structures)
- A Traffic Impact Assessment, including detail traffic surveys, operational analysis of intersection capacity using appropriate modeling software (Transyt), and conceptual planning of an appropriate traffic signal system
- Environmental Assessment, including consideration of trees likely to be affected
- Road Safety audit by an independent traffic engineer or designer

The design philosophy includes both the widening of existing road and bridge infrastructure and the re-allocation of existing road space in favor of the BRT route, as appropriate. In addition one of the key requirements of the project is to maximise facilities for pedestrians and cyclists along the entire length of the scheme.

1.4 Report Structure

The report is structured as follows:

Ch	Description
1	**Introduction** – Provides an overview of the BRT Project.
2	**Methodology** – Discusses the process that was followed in carrying out this work.
3	**Land Use and Spatial Development Plans** – Contains a high level review of the known available proposed land use plans within the corridor.
4	**Existing and Proposed Transport System** – Contains a high level assessment of existing and future potential transportation demand in the corridor
5	**Selection of Routes and Station Locations** – Describes how the route and the location of the stations were determined
6	**BRT System Capacity** – sizing of system (line and station capacity) to accommodate operational requirements
7	**Traffic Impact Assessment** – discuss the quantification of the expected traffic impacts due to the implementation of the BRT system and potential mitigation measures to minimise negative impacts
8	**Structures Assessment** – identification of structural issues that may contribute to project cost
9	**Utilities Assessment** – assessment of services affected
10	**Environmental Scan** – identification of environmental issues that may require the design concept to be modified or could impact on implementation
11	**Geometric Design** – visual road condition assessment, design parameters, traffic loading and pavement design and BRT lane demarcation
12	**Cost Estimates** – preliminary design cost estimates
13	**Conclusions and Recommendations**

2 METHODOLOGY

The following provides an overview of the methodology, with more detail contained in the chapters following.

2.1 Data Collection

The following data was collected:

- Traffic counts
- Traffic signal settings
- Services information from Tshwane Departments
- As-built drawings of roads and bridges (where available)
- Planning reports for Rainbow Junction and other K-routes
- Visual road condition survey
- Available land use and spatial development plans

2.2 Selection of Station Locations

The preliminary design commenced with an overview of the route and the selection of station locations. GIBB has accepted the proposed route as a given since the overall network planning and prioritisation of the city-wide BRT system is being done by others, as part of a separate process. However minor deviations to the route, which is deemed to bring the route closer to passenger destinations en-route and are therefore likely to improve ridership, were identified.

Known land use and spatial development plans impacting on the route were reviewed to provide the overall strategic land use context, but detailed precinct – level plans that could materially influence station locations were not available.

Station locations were selected based on a combination of factors, namely:

- BRT Station spacing of 500m – 800m
- Site observations indicating areas of high pedestrian activity or areas, significant origins or destinations such as shopping centres, or areas where vacant land is available that could potentially be used as feeder areas or park and ride locations in higher income areas where walk distances are lower
- The current and potential future land use and accessibility on a pedestrian level within the 500m radius around the station
- Review of the traffic volumes, to place stations where traffic impact and vehicle pedestrian conflict would be minimised relative to other nearby alternative locations
- Geometric design constraints, for example horizontal curves, road reserve pinch points etc.

2.3 BRT Infrastructure Sizing

The project team faced the challenge of doing preliminary design without the operational plan being finalised.

An assessment and analysis of the existing and proposed BRT system demand is not part of the preliminary design scope as the operational design and demand modelling is done by others. However the team reviewed existing and known future planning to inform the design as far as possible. In the absence of an approved operational plan, the design does not yet take into account key operational aspects such as major transfer or feeder stations.

The service design and thus BRT system frequency is also not yet confirmed and the approach of sizing the infrastructure for maximum capacity, as a worst case scenario, was therefore adopted.

This includes provision of bypass lanes and stations with two independent docking areas with two bus bays each, where feasible. The design identified sections or locations where the above high capacity is not achievable. **It is critical to note that the preliminary design currently reflects the highest capacity facilities that can fit within the current constraints without major land acquisition. It does not represent the optimal design to cater for the forecasted passenger demand and service design, as this information is not yet available.**

The ultimate system capacity requirements may well be significantly less than the current design on some sections of the route. For example it may not be necessary to construct bypass lanes and double module stations at all station locations. Reduced system capacity could result in some cost savings.

2.4 Preliminary Design

The preliminary design was developed using topographical survey data (specified and provided by others), supplemented by aerial photography, where survey data was found to be insufficient.

As noted above, the preliminary design approach was to plan the highest capacity station that could fit within the space constraints of the given location. In the inner city locations, where space is at a premium, several alternatives were developed and considered. On the sections where a wide K-route road reserve is available, smaller station configurations were only considered at a few locations where the typical double module station could not fit due to site-specific constraints.

Typical design dimensions and cross sections are largely based on design dimensions specified by the Project Management Office, or adapted where required from Rea Vaya (City of Johannesburg) typical details.

A visual road condition survey was carried out. The visual assessment included the type of road usage, road and verge layout with approximate dimensions, street furniture and services as well as road surfacing type and road condition (surface defects and failure type if any). A centreline materials investigation is excluded from the scope of the Preliminary Design Phase and the road pavement structure is therefore not known at this stage.

In the absence of the operational design data, it was also necessary to make assumptions on the bus frequencies over the life cycle of the route in order to arrive at a suitable pavement design. The SA Mechanistic Design Method was used for the analysis and a similar pavement structure to the Johannesburg Rea Vaya System was selected.

A review of the major structures on the route was undertaken by experienced bridge engineers.

An electrical engineer assessed the impact of the preliminary design on street lighting and existing known electrical power supply.

The geometric design engineers assessed the impact of known affected services when estimating the project cost, but design of relocation of services is not deemed part of the preliminary design scope.

The cost estimate was prepared using quantities measured or estimated from the layout drawings and typical cross sections, and unit rates derived from recent relevant Civil Engineering Contracts, which includes construction rates from Johannesburg Rea Vaya contracts.

2.5 Environmental Assessment

An environmental specialist reviewed the proposed BRT planning to determine if either a Basic Assessment or a full Environmental Impact Assessment would be required, and the associated timeframes required for this.

2.6 Traffic Impact Assessment

A traffic model was developed to test the traffic impacts of the proposed BRT implementation on intersection performance.

TRANSYT was selected as it is an appropriate tool to test and optimise traffic signal designs on a corridor. Further, because it is a corridor model, it was deemed feasible to develop it within the extremely short timeframes of the project.

Normally, the traffic modelling is completed before commencement of preliminary design. However in this project, this task was done in parallel to the preliminary design, which means that some modelling outcomes result in the recommendation of design changes on designs that has already been completed. Where possible, this has been incorporated in the final planning drawings, in other cases, it was noted that it should be incorporated during the detail design stage.

It should further be noted that the BRT service frequency is not yet known and the modelling was therefore carried out using an assumed BRT frequency of 60 buses per hour on the entire route.

3 LAND USE AND SPATIAL DEVELOPMENT PLANS

The land use analysis is not part of the scope of works. Nevertheless, it was considered that a high level assessment of land uses within the corridor was essential to provide the overall land use context within which the BRT Line 1 is being planned. The documents reviewed include the following:

- City of Tshwane Metropolitan Spatial Development Framework
- North Western Spatial Development Framework
- Inner City Development Strategy
- Re Kgabisa Tshwane
- Rainbow Junction Traffic Impact Assessment Report

The purpose of this review was to identify the key areas for generating and attracting trips as well as areas planned for growth and development. This section of the report will therefore give a summary of the key land use issues identified which informed and provided input in the assessment of the route and stop locations.

However it should be noted that the above references, with the exception of the Rainbow Junction Report, are all relatively generic and at a high level, not to a detailed enough level to make a meaningful contribution to detail station location decisions. It is therefore recommended that a more detailed land use assessment be done to enhance the planning, as part of the operational plan.

3.1 City of Tshwane Metropolitan Spatial Development Framework

The Metropolitan Spatial Development Framework (MSDF) provides the overall spatial framework for the city and is structured around five concepts. The concepts are

- Smart Growth,
- Metropolitan Activity Areas,
- Movement System,
- The Urban Lattice and the,
- Environmental Structuring Concept.

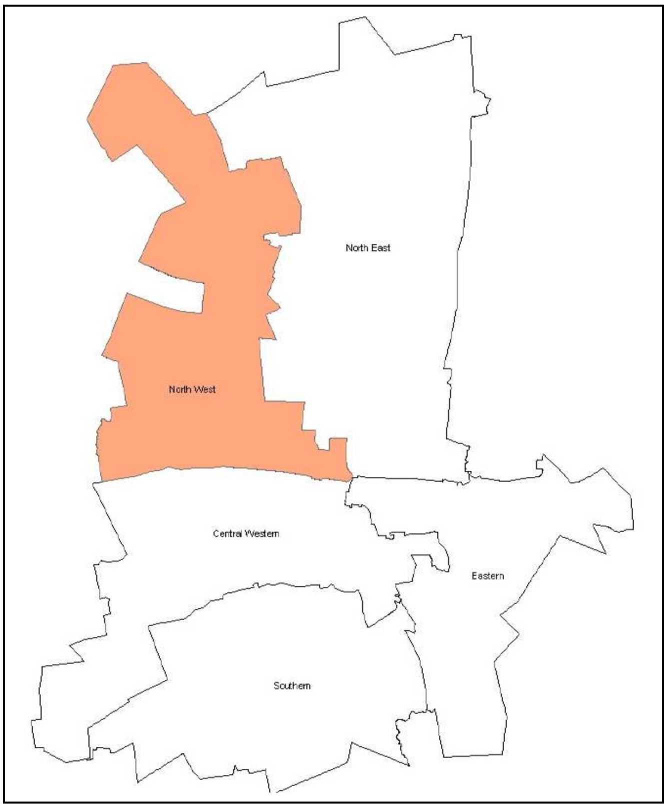
The MSDF describes the context and principles of these concepts, and also lays the foundation for the development of specific strategies to support the implementation of the MSDF.

The Tshwane City Strategy, which aims to influence the development path of the City over the next 20 years, has identified the area to the north of the CBD (over the Magaliesberg) as the “Zone of Choice” to serve as a focus area for strategic investments. The intention, amongst others, is to develop economic opportunities for the settlements to the north of the City, thereby reducing travel distance.

The City of Tshwane is further divided into five administrative planning regions as shown in **Figure 3-1** below. These are:

- North Western region
- Central Western region
- North Eastern region
- Eastern region
- Southern region

In 2007 CoT embarked on a process to compile five Regional Spatial Development Frameworks (RSDF's) for all the administrative planning regions of the metropolitan area. The RSDF's are inter-linked and also support the Tshwane MSDF, as well as the Tshwane City Development Strategy (CDS) and the Tshwane Open Space Framework (TOSF), and was approved by Council in 2008. The RSDF's applies the MSDF concepts on a regional scale and interprets the strategies on a spatial level. For the purposes of this project only the North Western Regional RSDF was reviewed.



Source: City of Tshwane North Western RSDF, 2007.

Figure 3-1: Locality of North Western RSDF

3.2 North Western Regional Spatial Development Framework

North Western Region is situated in the north-western part of the Metropolitan area, to the north-west of the CBD and to the west of the Wonderboom area.

It is accessible via:

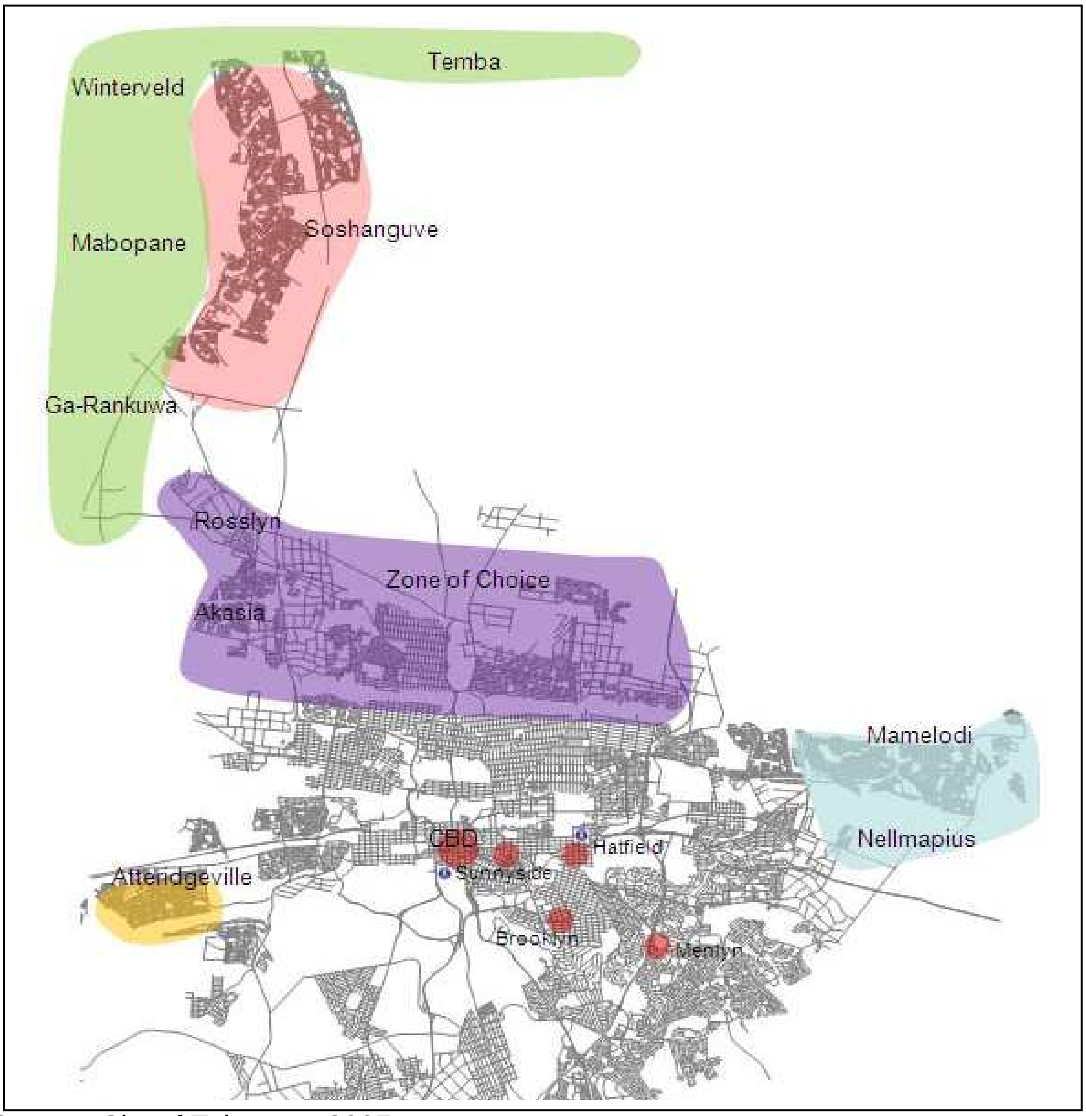
- The Mabopane Highway (PWV 9), which links the region with the central regions of the metropolitan area. This road provides a north-south linkage but does not continue further north to link the area beyond the municipal boundaries.
- The Platinum Highway (PWV 2) that links the region with the N1 freeway to the east and to the west links the area with Rustenburg and the Northwest Province. In general, regional accessibility within the area is poor although the PWV2 has improved the situation considerably since its construction.
- The link to the southern portions of Gauteng and the Tshwane Capital Core is poor and will only improve once the PWV 9 has been completed in the western side of Tshwane.
- The proposed east west link along the Zambesi, K14 and Rachel de Beer streets are seen as one of the most important links within the City.

3.2.1 Zone of Choice

The Zone of Choice is proposed in the RSDF as a strategic investment focus area in order to have a positive catalytic effect on development within the northern areas of Tshwane.

This area has the most potential for new development that will benefit most people in the North. The reason why this area has been identified as the Zone of Choice is related to its proximity to the Capital Core, existing infrastructure (such as the N4) and the momentum of existing developments such as the industrial area of Rosslyn.

Figure 3–2 provides a map showing the extent of the Zone of Choice. The area is defined as the Magaliesberg mountain range in the south, the western boundary is western boundary of the old Akasia area. The northern boundary stretches from the Rosslyn Industrial area along the southern boundary of the Onderstepoort nature area, the northern boundary of the Bon Accord Dam, and then along the Cullinan /Brits railway line. The eastern boundary stretches along the N1 from the railway line up the Magaliesberg.



Source: City of Tshwane, 2007

Figure 3-2: Extent and locality of the Zone of Choice

The Zone of Choice Strategic Development Framework is structured around the following focus areas of intervention:

(a) Focus Area I: Improvement of Access to the Zone Of Choice

- The extension of the PWV9 southwards;
- The construction of a freight (and passenger) airport in the North (north of the N4, Hall's Hill and the Doornpoort koppie);
- Efficient public transport is an absolute central element in the development of the North. This calls for the early establishment of a well-resourced Transport Authority and the conversion of freight lines to passenger rail (e.g. Hammanskraal);
- New rail connections;
- New multi-nodal interchanges on PWV9 road extension and
- Investment in bus transport and interchanges.

(b) Focus area 2: Platinum Corridor

- The new Platinum Highway (N4) currently does little for economic development in the sense that the high visibility and accessibility is not utilised to its full potential. It moves trucks through the area with speed and efficiency, but it acts as a barrier to local flows of people and commerce.
- The Platinum Highway has the potential to become the backbone of the development in the Zone of Choice. Access to the areas on both sides of the N4 must be provided.
- Businesses will gain an advantage by being close to and visible from the highway and its cross-roads. Over time, clusters of investment will bring new life along the road transforming it into a corridor of opportunity to support the local economy of Tshwane. The area between the Rosslyn and Onderstepoort on/off-ramps has the highest development potential as large strips of land are visible between these two off ramps.

(c) Focus area 3: Rainbow Junction

The proposed development consists of a number of different mixed use land uses and higher density residential developments along the Apies River. Other uses within the development include retail, commercial, sport related uses and hotel and conference facilities. The property is ideally situated for any large scale mixed land use development in terms of the overall City of Tshwane Metropolitan area.

(d) Focus area 4: Automotive Cluster (Development Zone)

The Automotive Cluster is a Blue IQ project initiated by the Gauteng Provincial Authority with the aim of concentrating automotive component manufacturers in one location. The City of Tshwane created the environment and actively participated by offering land incentives. The project was approved by cabinet in December 2001 as a five to eight year project which will see the development of approximately 130 ha to the east of the existing Rosslyn industrial area. Currently about 50% of the available 130 ha has been developed.

(e) Focus area 5: Metropolitan Urban Cores

Metropolitan Urban Cores have been identified within the Zone of Choice in terms of the Metropolitan Spatial Development Framework. In terms of North Western Region, the Akasia CBD and Pretoria North CBD have been identified as Metropolitan Cores. The Cores' roles in the future are to be the focus and highest concentration of residential, commercial, social, cultural and other urban activities. Higher density residential development should be encouraged specifically in and around the Metropolitan Cores.

(f) Focus area 6: Activity Corridors (Development Zone)

Activity Corridors are seen as an important element in the functioning of the: "Zone of Choice". Activity Spines take on a linear form and must be seen as an extension of the Metropolitan Cores as discussed in focus area 5. Higher concentration of activities must be encouraged along these routes. Special emphasis should be placed on the provision of higher density residential development along these corridors. The linear development may be single or mixed land use in nature. One of the main functions of the corridor is to join the three urban cores. The major activity corridors in the Zone of Choice can be defined as:

- The Zambesi, K14, Rachel de Beer/ Brits Road connecting the three urban cores with one another. The three urban cores are the Akasia CBD, Mabopane / Soshanguve Urban Core and Pretoria North CBD
- The Mabopane Centurion Development Corridor (MCDC) in the north, Brits Road/ Doreen and Heinrich Road.
- Daan de Wet Nel Avenue / K9 connecting the Automotive Supplier Park with the Zambesi, Brits Road Corridor.

(g) Focus area 7: Encourage Higher Density Residential Development

The Zone of Choice is one of the best locations for residential opportunities as part of the process of restructuring the City spatially. The areas along the Activity Cores / Streets and Metropolitan Cores are specifically suitable for development of higher density housing.

(h) Focus area 8: Enhancing the Natural Beauty of the Zone of Choice

The strong natural setting provided by the koppies and mountains at the entrances from the north and south into the Zone of Choice must be enhanced by making them more accessible to the public whilst at the same time protecting them against development. The total open space area should be managed as one area, with different themes along the route and marketed as a major tourist attraction.

3.2.2 Metropolitan Cores and Urban Cores

The RSDF re-iterates a number of Metropolitan Cores and Urban Cores as proposed in the City of Tshwane MSDF .The intention is to group economic, social and residential opportunities within these areas. The areas should also function as job opportunity clusters and should be supported through the provision of public transport and support services. The ones that are of significant to the BRT Line 1 are briefly summarized below.

- Akasia Urban Core - This node has the potential; to become the largest node in the region and the current retail area is about 70 000m². It accommodates higher order land uses such as retail and offices. The area is therefore indicated as a mixed use area. The inclusion of higher density residential will further strengthen the first order character of the node. The area to the north of the extension to Wonderpark is earmarked for mixed uses, including the existing offices, places of refreshment and community facilities although it is anticipated that this area will only be developed once the residential densification proposal to the north thereof has been initiated. High density residential development apartment buildings of between five and seven storeys are proposed to the north of First Avenue. The detailed proposals should preferably include provision of open space to create a linkage with the existing open space system as illustrated on the development framework. Lower densities should preferably be developed adjacent to existing residential areas. The area between Heinrich Street and Doreen Avenue should also be developed for medium to high residential development although extension of the retail component to include other forms of retail such as value retail and service industries should be allowed in close proximity to the existing Wonderpark Shopping Centre.

- Pretoria North Urban Core - This area consists of a large mixed use area. The focus of development in this node should be on *urban renewal* and the introduction of *higher density residential uses*. The area functions as a job opportunity cluster and should be supported through the provision of public transport and support services. The proposed strategy in Pretoria North and Akasia is to establish a secondary node to the West of Chantelle and the Orchards and allow complementary retail facilities adjacent to Wonderpark Shopping Centre. The extended Wonderpark Shopping Centre is expected to offer a wider tenant mix and act as a stronger draw card/catalyst for further development.

- Mabopane / Soshanguve Urban Core – The area surrounding the Mabopane Station accommodates a large retail component (± 80 000m²). The fact that this node is close to a station presents the opportunity to serve a very wide community, as most residents of the area are dependent on rail for daily transport. Future development in the node should be focused on social and community services to alleviate poverty and to ensure the possibility of public spending to emphasise development around the node.

- Rosslyn / Klerksoord - Rosslyn currently accommodates the automotive cluster, with a major focus on the export market. This is one of the Provincial Blue IQ projects and could result in numerous positive spin-offs for the region and the greater metropolitan area. The advantages of the investment in the area should be used in such a way so as to enable the creation of jobs for unskilled and semi-skilled workers. The development of workshops and commercially orientated land uses should be promoted. Klerksoord should be provided with proper infrastructure to encourage formal industrial development, focused on job creation. The areas between Rosslyn and Klerksoord as well as the area to the south of the PWV2 and north of the railway line and the Rainbow Junction area are indicated as mixed use areas. Future job opportunities are expected to take place along the proposed N4 Corridor Development as indicated on the Spatial Development Framework of North Western Region. These areas form part of a job opportunity belt connecting Rosslyn in the west with the proposed new Freight Airport in the east (Region 2). The mixed use areas are strategically located on main transportation axis' including rail infrastructure. The mixed use areas would be ideal to accommodate higher order land uses, which are supportive of the manufacturing sector and could include offices, high tech/ light industries, retail and conference facilities.

- Klip-Kruisfontein Urban Core - This is a proposed new node to the north of Rosslyn at the Klip- Kruisfontein station. It should have a strong focus on the creation of effective community facilities, although the provision of retail facilities and mixed uses are encouraged. Higher density residential development is also encouraged around this Urban Core. Recreational facilities also form part of future planning in this area around the quarry in the east.

Table 3-1 provides a summary of the future developments envisaged around these nodes.

Table 3-1: Future Developments proposed for the North West Region

Location	Proposed centre	Comments
R513 (Brits Road and Main Road - Heatherview	Neighbourhood Centre 2000 – 5 000m^2	To be developed depending on market conditions
Oribi Street and Willem Cruywagen Road – Eldorette	Neighbourhood Centre 2000 – 5 000m^2	To be developed depending on market conditions
Western end of First Street – Chantelle	Convenience centre 2 500 m^2	To be developed depending on market conditions
R566 (Garankuwa – Brits Road) and M17 Intersection	Community Centre 10 000m^2 to 30 000m^2	Future Node
Klipkruisfontein CBD	Convenience centre 15 000 m^2	Area has a shortage of retail space – to be located at major intersections
Soshanguve South and East	Convenience centre 2 500 m^2	Area has a shortage of retail space – to be located at major intersections
Soshanguve HH, PP, T, V, W – (northern quadrant of Soshanguve)	Convenience centre 2 500 m^2	Area has a shortage of retail space – to be located at major intersections
Winterveld	Convenience centre 2 500 m^2	Area has a shortage of retail space – to be located at major intersections

Source: City of Tshwane North West RSDF

3.2.3 Linear Activity Streets

The RSDF proposes that economic activities should be concentrated along the following streets in the North West Region, of relevance to the corridor:

- Parts of Emily Hobhouse
- Parts of Ben Viljoen
- Parts of Burger Avenue

3.3 Inner City Development Strategy (2006)

The Inner City Development Strategy (ICDS) provides the interventions into the spatial and physical environment of the Inner City, which is referred to as the Capital Precinct, which include, Capital Anchors, Government Boulevards, People's squares, and Government Clusters. The creation of the capital precinct is already largely driven by the Department of Public Works, through its recapitalisation of government buildings' project the Re Kgabisa Project which is discussed under **section 3.4** below.

3.3.1 Capital Anchors

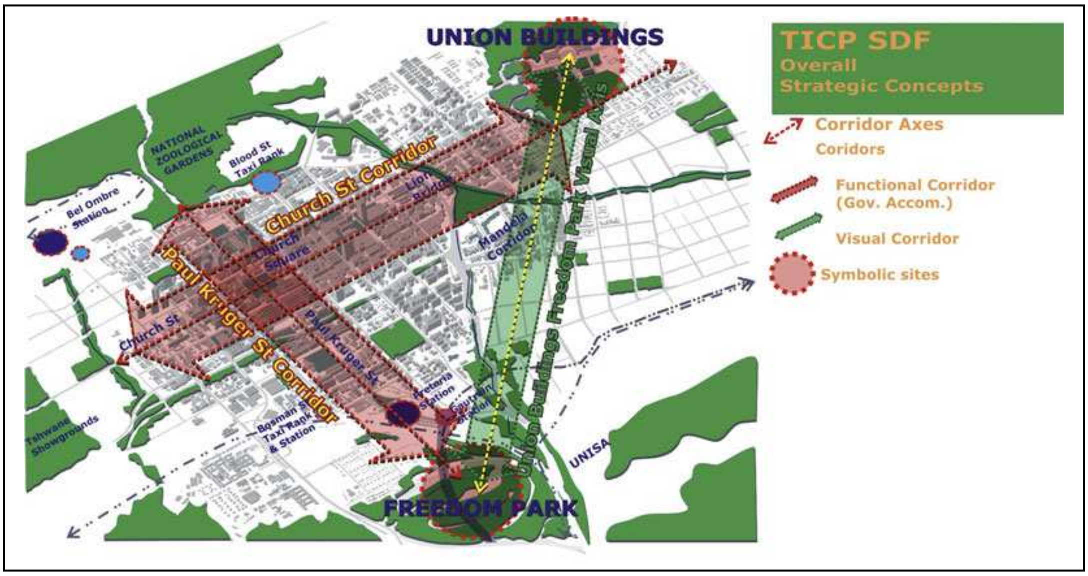
The following three main anchors have been identified:

- Church Square,
- The Union Buildings and
- Freedom Park.

3.3.2 Government Boulevards

The government boulevards provide a linkage between the three symbolic sites stated above. It is proposed that Church Street and Paul Kruger Street must form the main axis of the Capital Precinct, and will fulfil the role of **Government Boulevards.** They must be landscaped with trees, seating, street cafes and articulated to reflect the capital city image. The Government Boulevards links the three main Capital Anchors. A ceremonial entrance is also proposed from Church up to the Union Building.

Figure 3-4 shows the government boulevards to be provided between Church Square, Union Building and Freedom Park.



Source: City of Tshwane, Inner City development strategy, 2006

Figure 3-4: Proposed Government Boulevards

3.3.3 People's squares

It is proposed that government buildings should be **clustered** together around new public squares (**People's Squares**). The **People's Squares** should be developed as high quality public spaces celebrating our heritage, culture and freedom, each with its unique focus.

3.3.4 Government Clusters

The following seven government precincts/ clusters that make up the capital precinct have been identified in the inner city as:

- The Presidency,
- Mandela Corridor,
- Sammy Marks Square,
- Paul Kruger North,
- Church Square,
- Museum Park and
- Salvokop.

The ICDS indicates that the Inner City is in need of a dedicated public transport system for servicing the Inner City and its immediate surroundings. Destinations identified as important are Pretoria Station, Church Square, the National Zoological Gardens and the proposed Tshwane Crossing, reinforcing the Capital Circle. The proposed BRT Line 1 will serve the Pretoria Station, Church Square and the National Zoological Gardens.

3.4 Re Kgabisa (2005)

Re Kgabisa Tshwane is a programme led by the Department of Public Works and Public Service & Administration together with the City of Tshwane. The main purpose is to improve the physical working environment of national government departments and agencies within the inner city, as well as to improve public space and transport. There are 40 departments and agencies to be accommodated within the seven precincts – the Presidency, Mandela Corridor, Sammy Marks Square, Paul Kruger North, Church Square, Museum Park and Salvokop. The role of Tshwane is to provide suitable public infrastructure, as well as urban management of services, such as transport and security.

The main purpose of Re Kgabisa Tshwane is to ensure a long term accommodation solution for national Government department head offices and agencies within the inner city of Tshwane.

A Spatial Development Framework (SDF) has been developed to determine inner city development corridors and precincts within which the accommodation solution is to be located. The SDF sets out the principles and guidelines that assist the decision making process and guide the location as well as the nature of the accommodation.

3.4.1 Inner City precincts

The SDF has determined a series of precincts within which departments and agencies are to be consolidated and clustered. Seven precincts have been identified where departments can be clustered in terms of thematic concepts in terms of their roles and responsibilities and functional relations. These seven precincts, named after their location, are nominally,

- The Presidency,
- Mandela Corridor,
- Sammy Marks Square,
- Paul Kruger North,
- Church Square,
- Museum Park and
- Salvokop.

Figure 3-5 shows a schematic representation of the above seven precincts.

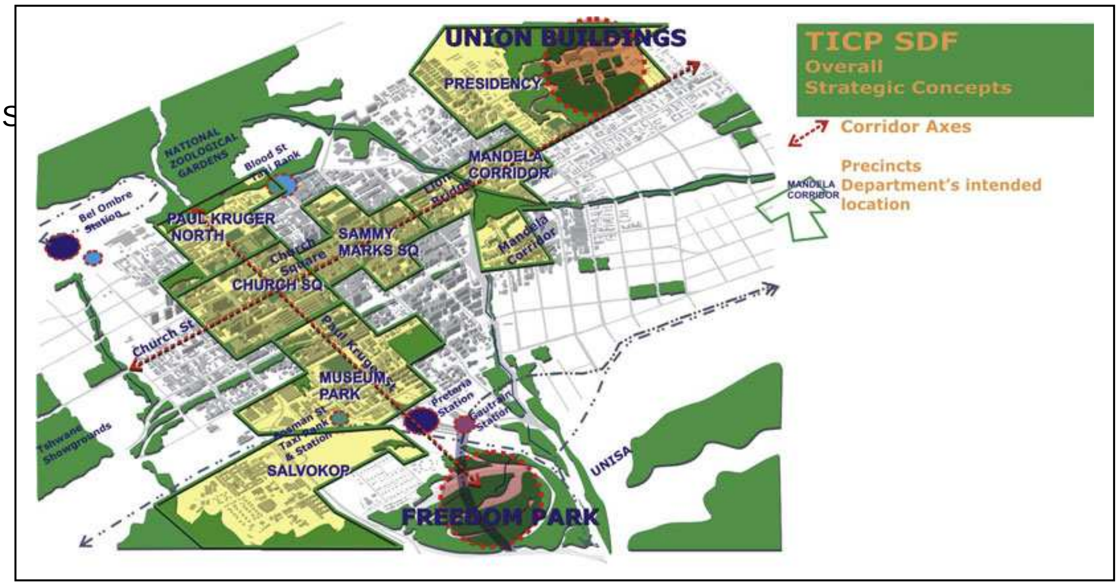
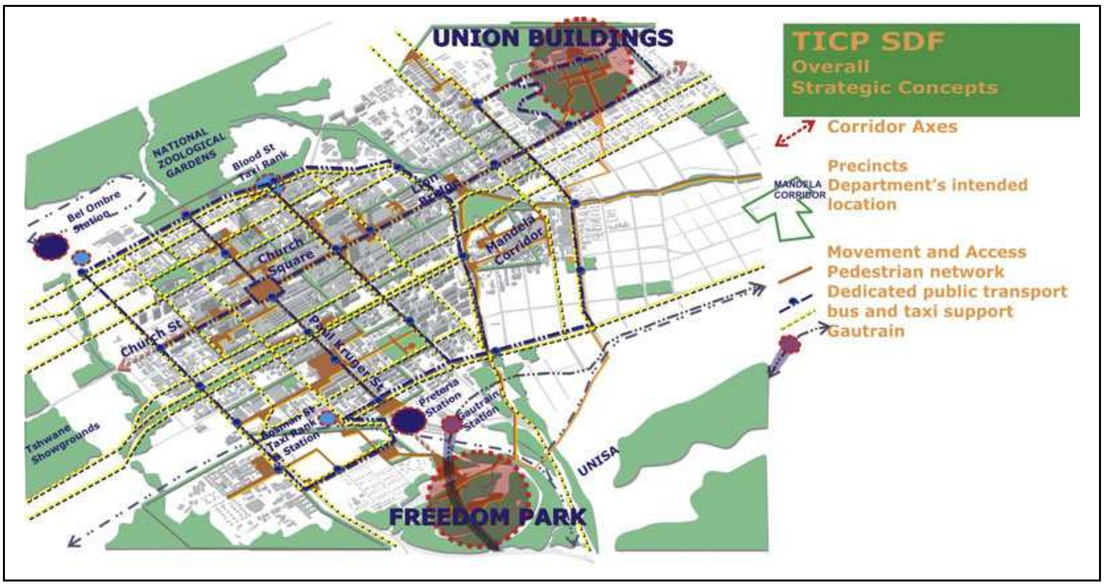


Figure 3-5: Inner City Precincts

3.4.2 Public Transportation Network

A core infrastructure spine to support the functional corridors and the precincts is proposed including a pedestrian and public transport spine in the forms of a dedicated right of way and pedestrian priority route along Paul Kruger and Church Streets linking the Gautrain Station through to The Presidency and in future to connect to Bel Ombre Station and the Bloed Street Taxi Rank. The proposed public transport network is indicated in **Figure 3-6** below. The network should be taken into account when feeder services for the BRT in the inner city is planned.

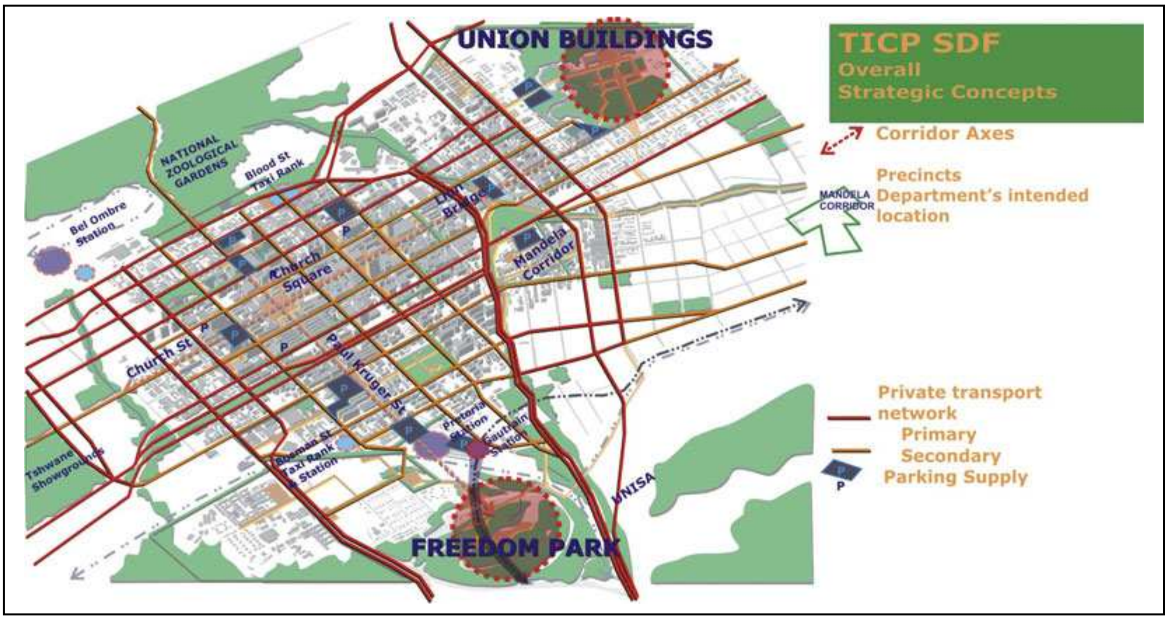


Source: City of Tshwane – ReKgabisa Report, 2005

Figure 3-6: Proposed Public Transport network

3.4.3 Private Transportation Network

Private vehicle traffic is adequately accommodated in the outer system of one-way couplets as shown in **Figure 3-7**. This will be complimented with increased parking provision at strategic locations associated with the pedestrian and public space improvements.



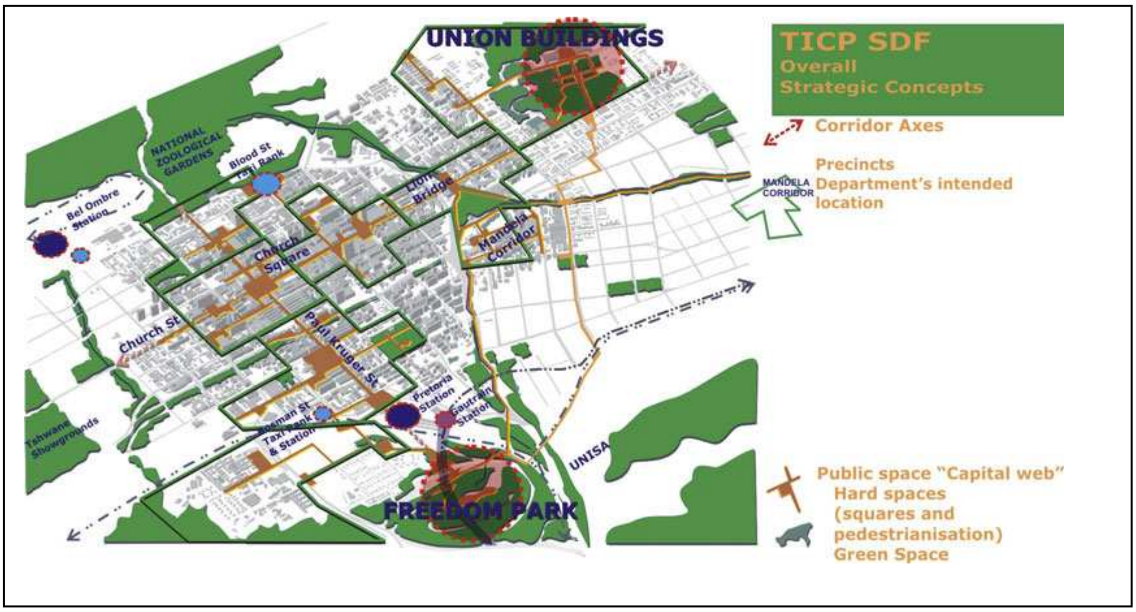
Source: City of Tshwane – ReKgabisa Report, 2005

Figure 3- 7: Private Transport Network

3.4.4 Public Space Network

The SDF includes a proposed public space network or "capital web" of pedestrian and public space (squares and parks) improvements that provide a positive public urban environment as shown in **Figure 3-7**.

The creation of a public space network supports and builds onto the core system of public transport, creating the core quality environment that directs the location of department accommodation and investment.



Source: City of Tshwane – ReKgabisa Report, 2005

Figure 3-8: The Proposed Public Open Space System

3.5 Land Use and Transport Integration

Generally, the issues identified in the land use documents reviewed were complimentary and provided a uniform picture of the goals and objectives for the City, key strategic land use areas and future development focus areas. These issues have been incorporated into the decision making process to define the proposed BRT Line 1 route and to identify the stop locations.

In summary the key outcomes of the land use review shows that key land use areas that will have an impact on the planning of BRT Line 1 include:

- Mabopane / Temba / Winterveld / Ga-Rankuwa
- Soshanguve
- Rosslyn / Akasia Industrial areas (including Wonder Park)
- Wonder Park Shopping Mall extensions
- Proposed Gauteng Automotive Cluster focused around Rosslyn
- Zone of Choice

In addition the urban regeneration project, Re Kgabisa, offers many synergies with a new emphasis on quality public transport, and pedestrian friendly open space. In line with the Re Kgabisa proposals this project is proposing dedicated BRT and Non-motorised transport lanes along Paul Kruger providing the necessary linkage between Church Square and Pretoria Station Intermodal Hub.

In conclusion, the proposed BRT Line 1 may be a catalyst for economic development along Soshanguve-Pretoria CBD corridor. A socio-economic study for this development corridor including the proposed BRT is required.

4 EXISTING AND PROPOSED TRANSPORT SYSTEM

An assessment and analysis of the existing and proposed transport demand on the corridor is not deemed to be part of the preliminary design scope, as this is dealt with in a separate work stream as part of the development of the operational plan.

However in the absence of the operational plan and demand forecasts, it was considered necessary to at least attempt to understand transport patterns on a high level, to provide insight into the potential nature and extent of the proposed BRT system.

4.1 Existing Transport Demand

4.1.1 Existing Modal Split

According to the 2006 -2011 City of Tshwane Integrated Transport Plan (ITP), the highest trip generators in CoT are Mamelodi/Eersterust, the Moot, Soshanguve, Mabopane/ Winterveld (over 60,000 trips in the morning peak period) as well as Temba, Garankuwa and adjacent provinces of Mpumalanga and North West (40,000 to 60,000 trips). The highest trip attractors, or employment areas, have also been identified as the Central Business District (over 100,000 trips in the morning peak period), Sunnyside, the Moot, and Rosslyn/Akasia, Pretoria East and Centurion. In addition to these trip attractors, a large number of trips are also attracted to external areas such as Ekurhuleni and Johannesburg.

In 2007 the City of Tshwane produced a report entitled Tshwane Rapid Transit: Implementation Framework. This study indicated that throughout the Tshwane area, there is currently very little integration between modes. The three main modes - minibus-taxi, bus and rail - all operate with different fare structures, fare technologies, and timetables. In addition, according to this study, overall private transport is currently at 59 percent of the total work trips in the City. The minibus-taxi is the dominant public transport mode at 17 percent of all morning peak work trips, with bus at 13 percent and rail at 11 percent. A total of 13 percent of all morning peak trips are on foot, with many of these walking trips encompassing substantial distances without the aid of adequate pedestrian infrastructure.

In 2008 the City of Tshwane carried out a household survey for all the five regions in the City. **Figure 4.1** shows the modal split (main mode) for all trip purposes on a typical weekday morning peak period (06:00 to 09:00) for each region based on the information provided in the survey report (2008).

The above figures show that car use is highest in high-income areas (with up to 70%) and lowest in low-income areas (as low as 14%). The BRT Line 1 is proposed to run in the North Western Region into the CBD. In this region most people currently use taxis (26%), 10% use buses whilst 8% uses rail.

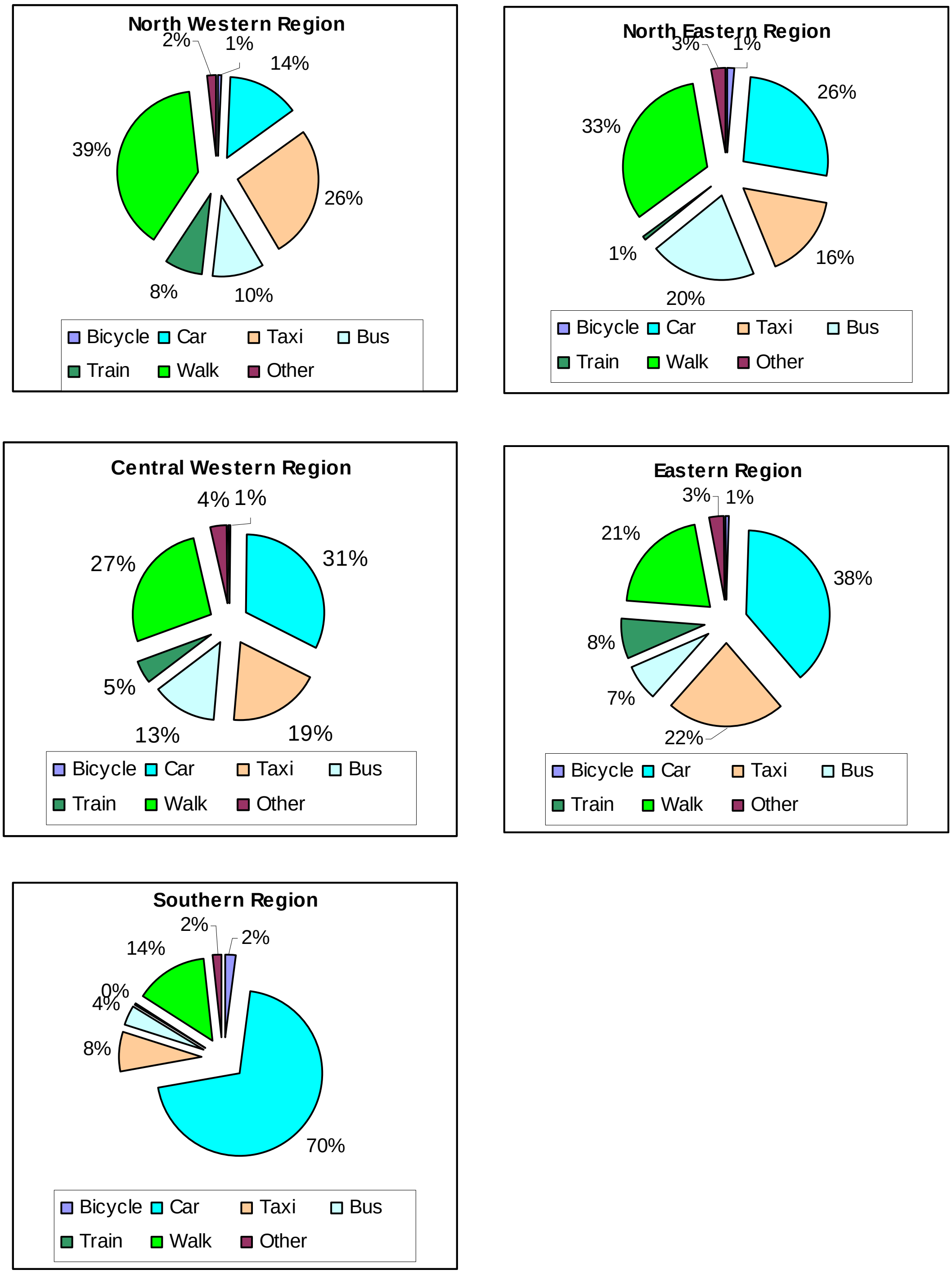


Figure 4.1: Mode Split by Region

4.1.2 Rail Transport

Commuter rail is an important passenger mode, especially during the peak periods. It is currently subsidised by the Government. The commuter rail system in Tshwane comprises four main radial routes into the city, from the north, south, east and west respectively. A short linking line, the Moot Link, connects the eastern and northern approach lines to form a ring around the CBD. Although no dedicated service operates on this ring, the provision of a service has been the subject of various studies. All routes approach the Pretoria Central station. Belle Ombre station, situated at the north end of the CBD is also a city centre terminus station.

Rail services are provided on the following four corridors:

- De Wildt - Mabopane - Belle Ombre - Pretoria, via Rosslyn, Mabopane, Soshanguve, Winternest, Hercules, Belle Ombre, Pretoria West;
- Rayton – Pienaarshoop – Pretoria, via Denneboom, Silverton, Koedoespoort, Rissik, Devenish;
- Saulsville – Pretoria via Atteridgeville, Kalafong, Pretoria West;
- Eerste Fabrieke – Hercules, via Denneboom, Koedoespoort, Queenswood, Villieria, Capital Park.

Table 4.1 shows the current morning peak period ridership for the principal rail routes. It is evident in **Table 4.1** that the Mabopane to CBD line is the busiest corridor on the network by a large margin, with as much as twice the ridership on the other corridors.

Table 4.1 Principal rail corridors

Route	Morning peak ridership
Mabopane – CBD	**9,000**
Mabopane – Pretoria North	**4,000**
Shoshanguve – CBD	**4,500**
Ga-rankuwa	**4,000**
Mabopane internal	**3,000**
Mamelodi – CBD	**4,500**
Mamelodi – Moot	**3,600**

Source: Tshwane Rapid Transit: Implementation Framework, 2008

Table 4.2 also gives the number of passengers embarking and disembarking during the period 06:00 – 08:00 at the stations along the De Wildt/ Mabopane to CBD railway line. Stations along the proposed BRT Line 1 Network are shown in bold.

According to the Tshwane Regional Rail Plan (2006) the Mabopane –Pretoria corridor is ranked as an A Corridor. It is the top priority corridor in the network region. An "A" corridor means that there is a clear case for rail and that rail is clearly more appropriate and cost effective than any other mode with passenger numbers at >20 000 – 30 000 passengers per hour). The corridor was also chosen as a demonstration corridor for the current PRASA rolling stock recapitalization project.

It should be noted that current capacity constraints on the Mabopane Line relate mainly to the severe shortage in operable rolling stock and not necessarily line capacity. The current poor levels of service resulted in a steady decline in ridership levels. The PRASA rolling stock recapitalization project includes capital budget provisions for relieving key rail junction bottlenecks that would prevent the service from achieving optimal capacity once the required new rolling stock has been procured.

Table 4.2: Number of passengers including transfers at stations: Peak Period 06:00 - 08:30

Station Name	Board	Alight	Total
Akasiaboom	2363	2372	4735
Barracks	396	1213	1609
Belle Ombre	413	4322	4735
Bosman Street	839	3738	4577
Daspoort	2203	4186	6389
De Wildt	1162	255	1417
Ga-Rankuwa	549	337	886
Golf	76	297	373
Hercules	777	2734	3511
Kopanong	3410	1139	4549
Lynross	50	225	275
Mabopane	11457	3251	14708
Medunsa	425	128	553
Mountain View	609	2263	2872
Pretoria	**17963**	**19690**	**37653**
Pretoria Noord	828	2669	3497
Pretoria West	2379	4679	7058
Rosslyn	**171**	**925**	**1096**
Schuttestraat	281	1449	1730
Soshanguve	**3104**	**1259**	**4363**
Taillardshoorp	1468	294	1762
Technicon Rand	99	667	766
Wintersnest	1909	3762	5671
Wolmerton	715	1975	2690
Wonderboom	**926**	**5255**	**6181**

Source: 2007/2008 Gauteng Rail Passenger Census

4.1.3 Bus Transport

The private bus operators providing services in the Tshwane area are principally working through interim contracts. Only the Atteridgeville and Mamelodi services are currently provided through tendered contracts. The bus routes are extensive covering most areas of Tshwane. However, the majority of the bus routes are from Mpumalanga (Former KwaNdebele) and Soshanguve / Mabopane and Hammanskraal to the central CBD. This is evident from the amount of subsidy that is currently being used in each of these areas as shown in **Table 4.3** which shows the current subsidised operators in CoT.

According to the Tshwane Rapid Transit Implementation Framework (2008) an estimated total of R 764 million was spent on operational bus subsidy in Tshwane during the 2006-2007 fiscal years, as shown in **Table 4.3**. This amount constitutes more than 77 percent of the total spent on bus subsidies in Gauteng. Pretoria City Transport (PCT) is subsidised by City of Tshwane, which annually covers the resulting operational deficit.

Table 4.3 Subsidised bus operators in Tshwane

Operator	Area served	Amount of subsidy for 2006-07 (Rand)
Putco	KwaMhlanga & Shoshanguve	R 458 million
North West Star	Mabopane & Hammanskraal	R 175 million
Atteridgeville Bus Service	Atteridgeville	R 35 million
Putco	Mamelodi	R 21 million
Pretoria City Transport	City and suburbs	R 75 million
	Total	**R 764 million**

Source: Tshwane Rapid Transit Implementation Framework, 2008

According to the Tshwane ITP (2006-2011) there are 121 000 passengers transported daily by the nine bus operators. In general utilisation is fairly high with the exception of the Pretoria City Transport (PCT) service. **Table 4.4** provides a summary of the route capacity utilisation per operator according to the 2005 surveys that were done as part of the development of the ITP.

Table 4.4: Route Capacity Utilisation per Operator

Operator	No. of Trips	Total Seats	Total Passengers	% Utilisation
Attridgeville Bus Services	117	7 020	6 250	89
NWS Batswana gare	**141**	**8 430**	**8 020**	**95**
NWS Bothlaba Tswana	**139**	**8 355**	**8 130**	**97**
NWS Thari	**74**	**4 440**	**4 170**	**94**
PUTCO Mamelodi	151	9 513	8 650	91
PUTCO Distribution	349	21 987	22 900	104
PUTCO Mpumalanga	475	30 006	31 900	106
PUTCO Ekangala	37	2 331	2 580	111
PUTCO Soshanguve	**620**	**39 060**	**33 450**	**86**
Pretoria City Transport	598	43 620	25 730	59
Total	2 463	174 762	131 170	86

4.1.4 Taxi Transport

In general, taxi routes in CoT follow a similar pattern as the bus routes in the City. The last current public Transport Record was done in 2003. **Table 4.5** provides a summary of the existing demand at the time. The city is currently in the process of updating this information.

Table 4.5: Minibus Taxi Surveys – 12 Hour (2003)

Description	Total
Number of Ranks	112
Number of Routes	462
Total Number of Vehicle Trips	22 359
Total Number of Passenger Trips	247 235
Total Number of Vehicle Trips (AM Peak)	6 368
Total Number of Vehicle Trips (PM Peak)	6 978
Total Number of Passenger Trips (AM Peak)	70 718
Total Number of Passenger Trips (PM Peak)	80 204

Source: City of Tshwane ITP, 2006-2011

4.1.5 Private Transport

The only recent published data on car ownership is the household survey that was carried out in 2008. According to the survey the majority (68%) of households in Tshwane do not own any vehicles. There were, however a few households owning one (15.2%) or two (11.1%) cars, bakkies or a minibus kombi. One percent (1.1%) of households had either one or two taxis or minibus kombis for business use as shown in **Table 4.6** below.

According to the household survey the data does not vary much from region to region. However, looking at the 2001 census data the peripheral suburbs had a lower car ownership rate per household compared to the more central and those to the south as shown in **Table 4.7**. This is probably still the case considering the existing modal splits as provided in **section 4.1.1.**

Table 4.6: % of households owning a car in Tshwane

Number of vehicles owned by households	Proportion of households owning a car/bakkie/ combi
0	67.6
1	15.2
2	11.1
3	4.6
4	1.0
5	0.3
More than 5	0.2

Source: City of Tshwane Household Survey, 2008

Table 4.7: Number of cars owned per household by Region

Sub Region	No of Cars owned per household
Temba, Winterveld, Mabopane, Garankuwa	**0.1**
Soshanguve	**0.2**
Akasia / Rosslyn	**1.5**
Rooiwal	1.1
Pretoria North	1.2
Moot	1.7
Mamelodi / Nellmapius	0.1
Pretoria East	1.8
Pretoria CBD	**0.3**
Pretoria West / Attridgeville	0.3
Centurion	1.4

Source: Census, 2001

In terms of tolling there are currently three sections of toll freeways in the Tshwane area, namely:

- The old N4 between Transoranje Road and the R511 (towards Hartebeespoort Dam)
- The N1 between the N4 east near the Proefplaas Interchange and Bela Bela (Warmbaths), and
- The new N4 Platinum Toll Road between the N1 and Brits

In addition, the Gauteng Freeway Improvement tolling system is currently being implemented and will start operating soon.

4.1.6 Conclusion

The demand for affordable passenger transport on the Mabopane/Soshanguve to Pretoria corridor is clear. The previous operational plan estimated that the Mabopane Line could carry up to 20 000 passengers per hour, but is not known how much of that number is current rail passengers, which may be served more efficiently by rail, if the level of services were to be improved to an acceptable standard.

Due to the spatial development legacy in the north-western quadrant, subsidised bus services from Hammanskraal, Winterveld, Garankuwa, and the Northwest Province, supplemented by taxi services, is a critical transport component and must be considered on a regional basis, and not a local Soshanguve catchment basis, when the operational plan is developed.

4.2 Future Transport Planning

4.2.1 Gauteng Strategic Road Network Review 2010 (SRNR2010)

The Gauteng Strategic Major Road Network was originally prepared in 1975 and although it was regularly updated, no comprehensive review had been undertaken. Previously the major road network comprised only Class 1 existing national and new “PWV route” freeways, and Class 2 major arterial roads identified as “K roads”. In addition, the major arterials in the inner city areas of Johannesburg and Tshwane were not included in the network.

The GSRN review study was divided into two phases. Phase 1 was completed in 2007 and a draft STN Consolidation Report dated 3, July 2007 was produced. Phase 2 was completed in May 2010. It incorporates the Class 1 freeways identified in Phase 1, reviews the existing and planned Class 2 routes and adds Class 3 roads that are of provincial, metropolitan and district importance to the GSRN. Class 3 roads are mainly the major arterials in the inner cities which were once not incorporated in the 1975 GSRN network.

The main objectives of the 2010 Phase 2 review were:

- A comprehensive merging of past, present and future initiatives with the outcomes of Phase 1
- A verification of the outcomes of Phase 1

- An identification of the components of the historical Class 1 and Class 2 road network no longer required
- An identification of additional components required to respond to land use trends and future integrated planning
- A re-assessment of the standards applicable
- An identification of the Class 3 network supporting and complementing the Class 1 and 2 network

Based on the above objectives the Gauteng Strategic Road Network (GSRN) 2010 Review produced three main deliverables:

- The Strategic Road Network map
- A Prioritization plan clearly indicating when each road must be implemented
- A review of Geometric Design Standards

The BRT Line 1 Route runs along the following Class 2 and 3 roads, as indicated in **Figure 4-1**:

Class 2:
- K217 (K4 - K216) – Soshanguve
- K216 (K216 – K63) – M17 Soshanguve
- K63 (K216 – K14) – Doreen Avenue
- K14 (K63 – M1) – R513/Rachel De Beer Street
- M1

Class 3:
- Mansfield Road
- Paul Kruger Street

The SRN provides a list of the following priorities for the Gauteng North Network:
- Top 20 class 1 routes – Existing national and new PWV freeways
- Top 30 class 2 routes – major arterials identified as K routes
- Top 40 class 3 routes – roads that are of provincial, metropolitan and district importance – D routes

The Top 20 class 1 routes that may have an impact on the BRT Line 1 are:
- PWV9 – divided into three sections, N1 to N14, K16 to N14, K16 Northwards
- PWV7
- PWV6

The Top 30 class 2 routes that have an impact on the BRT Line 1 are:
- K97 (PWV – K14)
- K16 (30th Ave – Baviaanspoort)
- K216 (PWV9 – K95)

There are some roads which are proposed but are not included in the top 30 priority:
- K8
- K14
- K6
- K217
- K16
- K95

Figure 4-1: Prioritised roads within the BRT Line 1 vicinity

The Top 40 class 3 routes that have an impact on the BRT Line 1 are:

- Link N4 West to PWV9
- Linvelt Avenue

However it is not clear in the report by when these new roads will be implemented.

4.2.2 Tshwane Integrated Transport Plan (2006 – 2011)

The Tshwane Integrated Transport Plan (ITP) identifies four over-arching Transport Goals:

- Improve accessibility and mobility provided by the transport system
- Develop a transport system that drives economic growth
- Improve the safety and security of the transport system
- Develop of transport system that reflects the image of the city

As has been stated in **Section 1.2,** the BRT Line 1 is one of the projects that have been identified in order to achieve the above mentioned goals. The following section summarizes transport planning projects that have also been proposed in the ITP and are of relevance to the planning of this BRT Corridor.

(a) CTMM Ring Rail Project

This project was started as a joint City Development and Urban Public Transport Project in 1999 and focused on the inner ring of rail in central CTMM with a view to encouraging development at the major nodal stations.

(b) The Proposed Re-instatement of the Hammanskraal – Pretoria Passenger Rail Service

A passenger service operated on this line up to October 1986, the service was terminated in favour of the bus services of the then 'Homeland' of Bophuthatswana, due to ageing and unreliable train rolling stock, amongst others. At this stage there is considerable pressure from the local residents to have the rail service re-instated, presumably due to rail fares being somewhat cheaper than the other modes.

PRASA and City of Tshwane conducted a Feasibility Study in 2010 for the reinstatement of the passenger service between Hammanskraal and PTA. The study concluded that the reinstatement of the service was feasible. However, the challenge at this stage was sourcing funding for upgrading the declining rail infrastructure (Signaling and structures) on the existing line. The other problem was a number of rail-crossing on that line which could pose danger to communities along the railway line should a frequent rail service be provided.

As part of the study, it was found that reinstatement of the (starter) service, through a diesel locomotive and track-authorisation (as a temporary signaling method) was feasible. However, this is also stalled by the availability of such rolling stock and a supporting business case.

According to the ITP, the outcome of the study was well received and supported by PRASA, who indicated that it would be taken forward through the support of TFR and existing internal channels in the next 5 year horizon.

(c) Pretoria Inner City Distribution

Transport in the inner city is geared to private transport, while public transport services and facilities are presently un-coordinated and not supporting the important status of the inner city. In recognition of the need to re-develop the inner city area, the Pretoria Inner City Integrated Spatial development Framework (ISDF) was developed.

This included an assessment of current public transport services and facilities and formulation of a master plan to co-ordinate and integrate all public transport services in the inner city. An overview of the ISDF has been provided already under **section 3.3.**

(d) The Pretoria North Public Transport Facility

This project evolved from a previous Council proposal for a medium sized soccer stadium in the vicinity of the Pretoria North railway station, the proposed light industrial and residential development between Lavender and Paul Kruger Streets. An investigation done by the CTMM indicated that the current public transport operations at Wonderboom Station should be relocated to the Pretoria North Station as part of a major road upgrading project to link Zambezi Drive in the east with Rachel de Beer Street in Pretoria North in the west.

Source: City of Tshwane 2010 priority Plans

Figure 4-2: Pretoria North Public Transport Facility

(e) Akasiaboom Intermodal Facility

The objective of this project is to implement the integration of the bus services from Ga-rankuwa with the rail services provided from Akasiaboom along the Mabopane corridor.

4.2.3 Tshwane Strategic Public Transport Plan (2005)

The concept of a Strategic Public Transport Network (SPTN) for the CTMM was launched in September 2005. The strategic public transport network is defined as the higher order of public transport roads within the network, requiring a high level of adjustment to suit and to favor public transport.

The following key infrastructure policy issues are recommended:

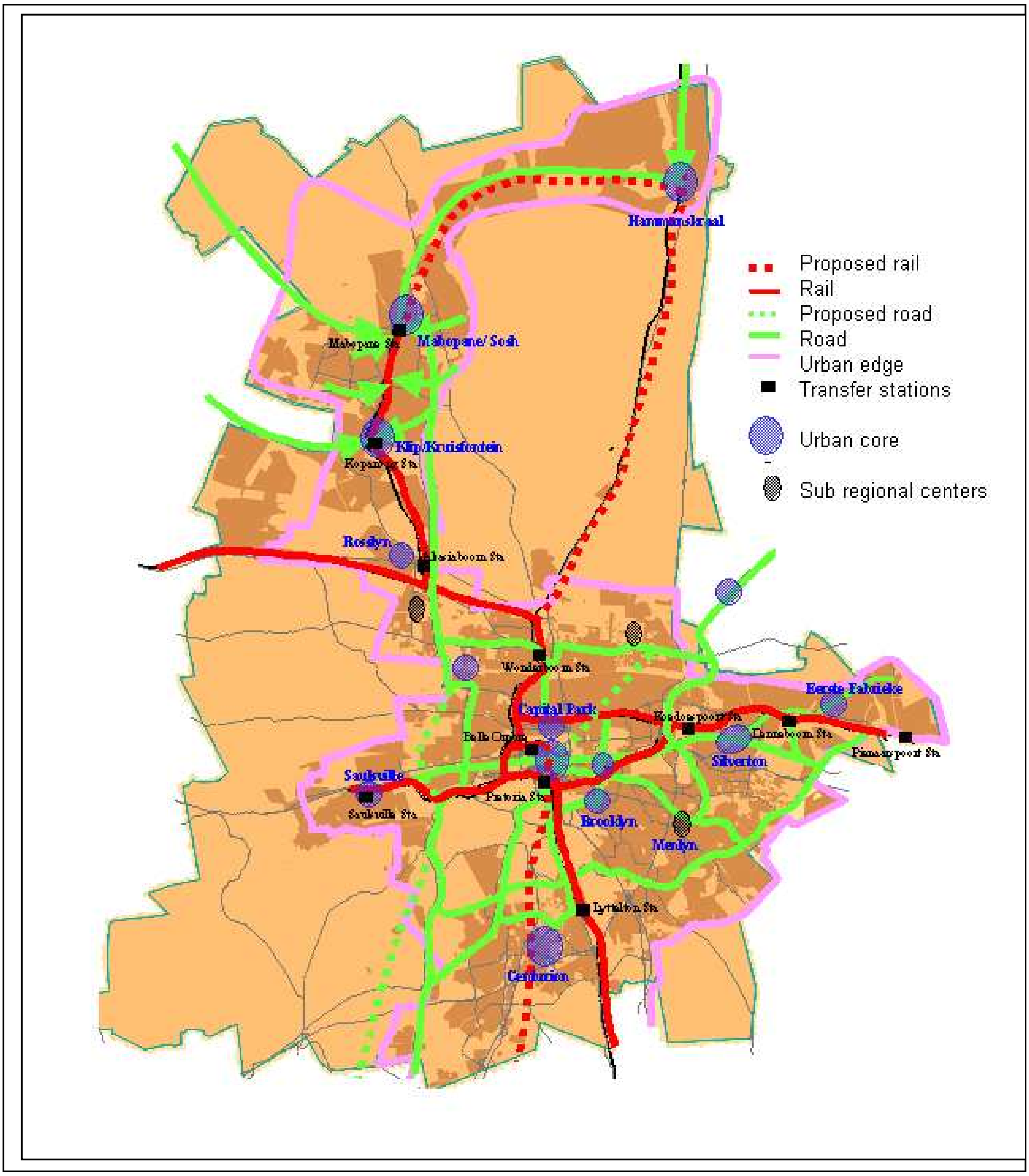
- The public transport system is to be designed for a minimum of 10 years, preferably 20 years
- As far as is possible proposed public transport priority measures will not reduce the current level of service of private vehicles, while an attractive viable alternative to private transport does not yet exist. Therefore existing capacity would not initially be converted to exclusive bus and taxi use
- More aggressive public transport priority strategies such as converting existing road space to exclusive public transport use are not ruled out, but these will be implemented at a stage when it has been demonstrated that a reliable, convenient and safe alternative to private transport exists
- Where additional capacity is added (e.g. construction of a new lane), this will be reserved for public transport only.
- Where additional capacity is created it will be adequate for the design period for public transport (should adequately cater for future public transport services), but need not be sufficient to maintain the current level of service of private vehicles up to the design year.

(a) Proposed SPTN Routes

he City of Tshwane with the strategic public transport plan commits itself to transform public transport within the city. The objectives of the network were defined as follows:

- A network that contributes to a reliable and frequent level of public transport service within acceptable walking distance of residents
- Establishment of focused and high frequency corridors where passengers are transported over longer distances, and where public transport enjoys priority over private transport
- Provision of interconnectivity between residential areas and main employment and business nodes, as well as between main nodes
- Establishment of a legible, permanent, recognizable public transport framework consisting of both radial and circular routes
- Development of nodes at the intersecting points of major routes where transfers can take place.

Figure 4-5 provides a map showing proposed network and nodes.



Source: City of Tshwane SPTN, 2005

Figure 4-5: City of Tshwane SPTN

(b) Proposed SPTN Nodes

The following primary and secondary nodes were identified as part of the SPTN.

Primary Nodes

- Mabopane Station,
- Belle Ombre Station,
- Denneboom Station and
- Pretoria Station
- Proposed Pretoria-North multi-modal facility

Secondary Nodes

- Hammanskraal,
- Rosslyn,
- Atteridgeville station,
- Denneboom station,
- Brooklyn and
- Menlyn.

4.2.4 Inner City Distribution System (1998)

The CBD of Tshwane has three major public transport termini:

- The Tswane train station, (now combined with a Gautrain station)
- The Belle Ombre Bus Terminus
- The taxi ranks at Bloed/Boom Street and at van der Walt Street.

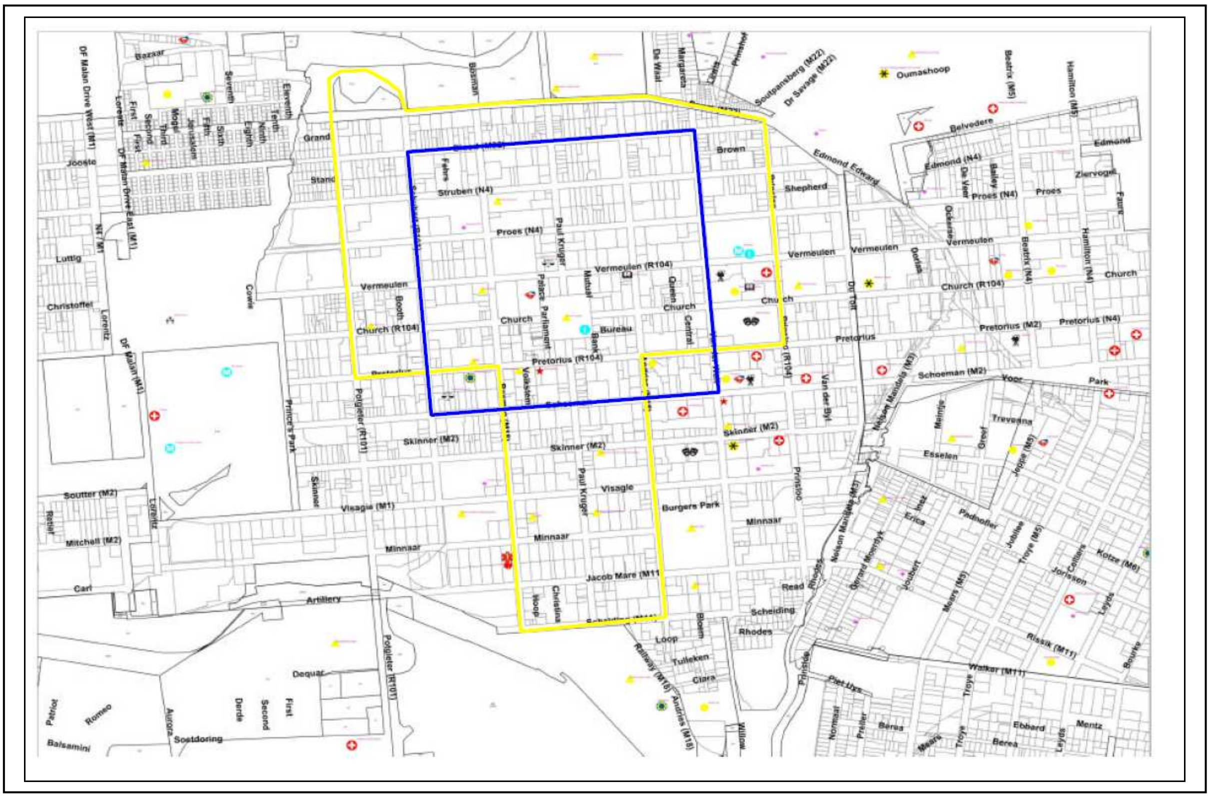
According to the Pretoria Inner City Distribution System, Draft final report, 1998:

- In 1996 an investigation was done to see what the viability of an "Inner City Distribution System" would be for Tshwane, as part of the "Four Cities Project". The conclusion was that although some commuters walked fairly long distances (up to 2 km) and that others said they were prepared to pay something for a distribution service, the actual demand for such a service was relatively low, and any such service would not be viable enough for the low amounts that people were prepared to pay (as most were from low income groups).

- A further transport study was done in 1998/99 on the public transport in the CBD as part of the then Pretoria Inner City Integrated Spatial Development Framework. In the report, a proposed mixture of guided and non - guided forms of transport (either light rail or bus) were suggested for the distribution of passengers between these termini and the inner city. Although this report was never formally adopted by Council, these broad proposals have found support within the CTMM.

An inner city distribution system of two interlinked routes to serve these termini and the inner city destinations was proposed as shown in **Figure 4-6**.

The project has previously been considered for implementation, but could not be implemented due to a lack of funding. The project forms part of the integrated transport plan for the city. The Inner City Distribution System (ICDS) will probably be part of the BRT feeder system eventually. However, the Gautrain CBD feeder route to Pretoria Station covers some of the areas proposed in the ICDS e.g. Paul Kruger, Visagie, Potgieter, Struben, Prinsloo, Visagie, etc. There is therefore a need to further integrate the BRT feeder service and the Gautrain feeder service to eliminate redundancy. This coordination is ongoing.



Source: Inner City Distribution System ,VKE, 1998
Figure 4-6: Proposed Inner City Distribution System

4.2.5 Gautrain Feeder and Distribution Routes

An extensive dedicated distribution system is provided for the inner city including Sunnyside. There are also proposals to extend these services to Arcadia serving a number of hotels in this area, the Union Building and various embassies.

Figure 4.7 presents a layout of the current dedicated feeder and distribution routes that were provided by the City of Tshwane. The following five routes are provided in the inner city:

- PD1 – services the inner city from Pretoria Station via Schubart, Proes, Van De Walt, Jacob Mare and Paul Kruger back to Pretoria Station.
- PD2 – services the Rietfontein and Mayville areas via Andries, Bloed, Voortrekker, Jeppe, Mears and Jacob Mare and Paul Kruger to Pretoria Station.

Figure 4.7: Gautrain and BRT Feeder and Distribution Routes in Pretoria CBD

- PD3 – services Technikon Rant to CBD via Rebecca, Mitchel and Paul Kruger to Pretoria Station
- PF2 – services Andeon, Booysens and Claremont area via Van der Hoff, DF Malan, Visagie and Paul Kruger to Pretoria Station
- PF4 – services the Sunnyside area via Leyds, Esselen, Visagie and Paul Kruger to Pretoria Station

In 2009/2010, with the planning of the BRT trunk route from Mabopane to Pretoria Station via R80, the planned Gautrain feeder routes and the planned BRT feeder routes were reviewed due to the duplication of services. The BRT Specialized Unit of the City of Tshwane and the Gautrain team resolved that the Gautrain feeder routes on the western side of Pretoria would be replaced by the BRT service, and that the Gautrain feeder service would initially focus on the Pretoria CBD and eastern side of the Pretoria CBD. This is currently ongoing but have not been finalized yet.

4.2.6 Rainbow Junction

Rainbow Junction Development is planned on the available space north of the Magaliesberg between Paul Kruger extension and the Apies River. It comprises of seven townships in Annlin West. A mixed land use development is envisaged consisting of residential, office, retail, hotel, industrial, motor related industries, filling stations, nursery and open space. According to the Pretoria North Station Modal Interchange Preliminary Design report, (2007) the total planned GLA of the development is 508 264 m^2.

Residential development will be the main trip generator during the morning peak hour and constitute about 27% of the total planned GLA. The other land uses will be the main trip attractors to the development during the morning peak hour and vice versa during the afternoon peak hour. As such there will be more trips attracted to the development than those actually generated by the development.

According to the Pretoria North Station Modal Interchange Preliminary Design report, (2007) the Rainbow Junction Development is expected to generate a total of 6 894 vehicle trips in the morning peak of which 2 272 originates from the development and 4 622 are attracted by the development. The expected number of vehicles generated in the afternoon peak is 10 049 of which 6 894 originates from the development and 3 617 are attracted by the development.

These vehicles trips will need to be accommodated on a road network of which most of the roads are currently operating at capacity during the peak. As such it is critical that Rainbow Junction be served by efficient public transport systems so that private vehicle trips are reduced as much as possible, minimizing the need for new road infrastructure.

A meeting was held with the Rainbow junction developers and the following issues were raised in terms of the current BRT Line 1 study:

- The developers strongly suggested that the proposed BRT route be reconsidered to better serve Rainbow Junction
- The developer therefore proposed that the proposed BRT Line 1 should run on Daan De Wet Nel and President Steyn, linking into the North South Spine road through the Rainbow Junction development, and not on Rachel de Beer
- Alternatively the BRT Line should run on R566 and continue on the North South Spine road through the Rainbow Junction development.

While it is agreed that it is important to serve Rainbow Junction well, the current proposed trunk route can still potentially do that if a well-developed public transport facility is developed from where a feeder service could operate that serves Rainbow Junction.

Central to the debate is the proposal to construct the K14 link through Rainbow Junction. This link is not on the priority list of the GSRNR (see **Section 4.2.1**) but will clearly make the development more accessible, and will also bring some relief on the north-south M1 link, due to the diversion of some east-west trips to the more direct route rather than via Lavender Road. However it will be extremely costly to implement, due to the structures affected and crossings of the Apies River, and it will likely not be justified if the section through Pretoria North remains a bottleneck. In particular, if BRT is implemented, the east-west capacity for mixed traffic on this route will be fairly limited. It is considered that the proposed K14 upgrading is only appropriate if land can be expropriated along Rachel De Beer to upgrade the route to the same Class 2 K-route standard of Rachel de Beer, east of Daan de Wet Nel Street, which is highly unlikely to happen in the near future.

Although these proposals have been raised they have not been taken into account in the current preliminary design study because the selection of the route does not form part of the current scope of work. These proposals require a high level strategic decision by the City of Tshwane Authorities and there are still uncertainties on when exactly this development will be implemented.

Based on the above issues the BRT project team proposes the following:

- That the BRT Line1 route be kept on Rachel De Beer Street

- Rainbow Junction is served by BRT at Station B20 at the proposed Wonderboom station modal interchange. A feeder and distribution service can be considered by the operational team to serve Rainbow junction along the North South spine. **Sheet 17** in **Volume 3** contains a schematic layout plan of a potential interim scenario at Station B20. The intermodal facility can be developed in such a way as to work in the interim while the proposed road network planned for Rainbow Junction is not yet in place, but to be adaptable to the future road network plans. Such as scenario has also been sketched out but is not included in this report. It should be noted that the proposal has taken the layout of the bus and taxi facility that was prepared by SSI Consulting Engineers as a given, but it may be possible to better integrate the facility if the layout is reconsidered in its totality. The preliminary design of the intermodal facility is not included in the current scope of work and will require substantial further engagement with affected stakeholders.

- Minimum upgrading be done on the section of this route (M1 from Jan van Riebeeck to Lavender Road), as it is proposed to be realigned in future when Rainbow Junction is developed and will therefore result in some abortive work.

4.3 Critical Transportation Issues

The issues identified in the various transportation documents reviewed provides insight into the current state of the transport infrastructure and broad transport patterns in the City of Tshwane.

Future projects planned by the City of Tshwane and provincial transport authority have also been identified. These issues need to be incorporated into the decision making process to define the proposed transport system when the operational plan is developed.

Currently, key unresolved issues impacting on the preliminary design include:

- The role of rail, which will impact on the demand and hence the system sizing
- Service design – location of transfer points, feeder and distribution services. In particular the potential role of Wonderboom intermodal facility may impact on the preliminary design, and linkage to the east of Pretoria
- Forecasted passenger demand for BRT, i.e. system capacity. It is not known whether the system will require bypass lanes or not. The current demand on the corridor and alternative routes (extracted from the preliminary indicative base year model) may not require a frequency in excess of 90 buses per hour, which is as a general rule of thumb the capacity of a system without bypass lanes. However, depending on the system design, it may be necessary to increase the system capacity in the inner city, where BRT services from other lines may merge. Significant restructuring of the transport services from areas remote from the corridor (e.g. Garankuwa), to force a feeder – trunk operation, may also increase ridership but increase transfers to passengers. It is critical to determine the likely ridership (order of magnitude) as soon as possible.
- Rainbow Junction planning and the role and timing of the proposed K14 link, which will provide a more direct link to the east of Pretoria via Zambezi Road, and provide some relief on the north-south M1 link as the result. This could potentially have a significant impact on the preliminary design approach for the BRT System in this area as it may result in the route along Rachel de Beer being reconsidered.
- There is need to update the comprehensive traffic study (which included EMME modeling) that was done previously for the Rainbow Junction Node, with a road network that includes the BRT system. The study should also address a feasibility study for the widening of Rachel de Beer Road with full BRT accommodation and the K14 link.

It is clear that the proposed BRT Line 1 has potential to address a number of the goals that were identified in the ITP and the SPTN. These goals among others include:

- Reduce public transport service backlog
- Expansion of the transport system
- Transport system easily accessible for tourists and visitors
- Support development of “Zone of Choice”
- Improve personal security of public transport system

5 SELECTION OF ROUTE AND STATION LOCATIONS

5.1 Route

A site visit was carried out on the 22nd of June 2011 along the CoT BRT Line 1 from Soshanguve to Pretoria CBD. The purpose of the site visit was to ascertain whether minor alternative route alignments/deviations could be proposed to better serve the passengers. Two minor route alignment alternatives are proposed.

5.1.1 Route Alignment Alternative 1 - Rosslyn

The first route deviation is indicated in **Figure 5-1**. Travelling from the north, the route turns left from Doreen Avenue into Piet Pretorius Street, left into Piet Rautenbach Street, left into R566 and from R566 it joins back into Doreen Avenue (right turn).

The main reason why an alternative alignment is being proposed is that most of the buildings along Doreen Avenue do not have direct access from Doreen Avenue. A more direct service into the Rosslyn Industrial area, a significant employment node, will reduce the walking distance for more people. At present there is an existing taxi rank along Pretorius Street which is a good indication of where people want to be.

Figure 5-1 also incorporates Google Earth StreetView images into the drawing further illustrating why an alternative is being proposed. Pictures were also taken on site to confirm the 2008 Google earth images, as shown **Figure 5-2**.

The advantages and disadvantages of the proposed alternative alignment, when compared to the current BRT Line 1 route alignment, are outlined in **Table 5-1**.

Table 5-1: Advantages and disadvantages of alternative alignment at Rosslyn

Advantages	Disadvantages
A more central route into Rosslyn Industrial Node is provided. Doreen Avenue skirts the area and does not offer any direct access for passengers into Rosslyn, since most buildings do not have direct access from Doreen Avenue	Potential increased journey time as the route deviate into Rosslyn.
The proposed station is within walking distance to the shopping mall and banks, police station, home affairs and city of Tshwane roads and storm water department.	Marginal additional route kilometres resulting in possibly additional capital cost or operational costs
Local services can run on the proposed alternative route and stop in Rosslyn, whilst express services can remain on the current route and do not need to stop. Because of the lower bus frequency, the local bus station do not need bypass lanes, resulting in potential lower construction cost	While it is possible to fit a station with bypass lanes on Doreen Avenue, between De Waal Street and Fred Otto, the road reserve is potentially too narrow to provide a median and safe staggered pedestrian crossing.

The alternative route alignment is deemed to have more advantages and is therefore proposed as the preferred option.

5.1.2 Route Alignment Alternative 2 – Wonderpark

The second route alignment deviation extends east from Doreen Avenue into 1st Avenue and then right into Heinrich Avenue and joins back into R513 (Rachel De Beer /Brits Road).

The key difference between the current BRT Line 1 alignment and the proposed route deviation is that the current BRT line 1 passes largely through vacant undeveloped land. Although proposals have been tabled to develop the land into residential townhouses, nothing has materialised so far. In addition there is no direct pedestrian access onto the houses along Doreen Avenue. In comparison, the proposed route deviation passes through a higher density residential area and the Wonderpark Shopping Mall offering passenger a convenient direct access to the mall, civic centre, hospital and a number of restaurants.

Figure 5-3 illustrates the route alignment alternative 2 as explained above. Pictures were also taken on site to confirm the 2008 Google earth images as shown **Figure 5-4**.

The advantages and disadvantages of the proposed alternative alignment, when compared to the current BRT Line 1 route alignment, are outlined in **Table 5- 2**.

Table 5-2: Advantages and disadvantages of alternative alignment at Wonderpark

Advantages	Disadvantages
Provides direct access to Wonderpark Mall Main Entrance, Civic centre, and Hospital	Physical constraint of a relatively narrow road reserve along Heinrich Avenue. However preliminary sketch plans indicates that the station would fit without the need to reduce the number of through traffic lanes.
A sidewalk/cycle lane already exist along Heinrich Avenue to the Mall	Wide median with trees – the trees would need to be removed at the station locations.
2 lanes per direction currently provided	The route is relatively congested with traffic to and from the Mall and while dedicated BRT lanes would ensure BRT traffic is not delayed, it is possible that private traffic levels of service may reduce
Local services can run on the proposed alternative route whilst express services could remain on the current route and do not need to stop. The local bus station in Heinrich Avenue would therefore not need bypass lanes.	

Figure 5-1

Figure 5-2

Figure 5-3

Figure 5-4

5.2 Station Locations

5.2.1 General Factors that influenced the placement of stations

The following general aspects influenced the proposed station locations:

- Station spacing: BRT stations are typically spaced 500 – 800m apart, to ensure that passengers are generally within 5 minutes' walk from the nearest station. However due to the length of the route (34 km), a longer station spacing was favored, to minimise excessive delays that would tend to make the service uncompetitive. Large sections of the route are relatively undeveloped, or developed at very low densities. The first iteration of station placements was done purely on optimal spacing, without considering location specific factors, with the exception of taking into consideration undeveloped sections (where no stations were placed). The 30 stations proposed result in an average station spacing of approximately 1.1km.

- In the second iteration, the site observations were used to move stations to areas where high pedestrian activity was observed, such as at larger bus and taxi stops and pick-up points, trip generators such as shopping nodes, or areas where vacant land is available that could potentially be used as feeder areas or park and ride locations in the higher income residential areas.

- The current and potential future land use and accessibility on a pedestrian level within the 500m radius around the station was also considered, to select the position where ridership is likely to be optimised (e.g. a location near a higher density town house development was favored over an area with single erven residential dwellings).

- The third iteration considered the traffic volumes:

    - Where possible, stations were placed at intersections where traffic volumes indicate that it may be feasible to create left-in, left-out access, in order to avoid right turning mixed traffic conflicting with the straight ahead BRT movement.

    - Where this was not deemed possible, but there was a choice between placing the station at a T-junction or a 4-way intersection, the T-junction was selected. In this instance, the stations were generally placed on the opposite side of the approach that requires a right turn, to enable the right turn lane to be provided in the "shadow" of the station.

    - Where stations had to be placed at 4-legged intersections, it was generally placed on the approach with the lowest conflicting right turn movements, and set back slightly to enable a right turn traffic lane to be maintained.

    - Although mid-block stations have the benefit of reduced intersection conflict, it requires an additional pedestrian signal to allow safe pedestrian crossing of two or more lanes, adding additional implementation and maintenance cost, increased complexity and potential increased delays to traffic. This option was generally not exercised. In most instances, a station access at an existing signalised intersection was preferred. Midblock locations also in many cases result in very limited pedestrian access to the station.

- The fourth iteration considered geometric design constraints, for example horizontal curves, road reserve pinch points etc.

- The final iteration has been done during the development of the preliminary design layouts, and considering the results of the traffic modeling, to minimise, where possible, traffic impact and the station's impact on existing services.

The initial assessment originally identified 30 stations, indicated in **Figure 5-5**. Due to the long route length, station delay will add a considerable amount of time to the trip, and the stations were therefore rationalised where possible, resulting in a reduction to 25 stations.

The proposed deviations are at Rosslyn and Karenpark. Stations 8A, 12A and 13A are alternative station locations, i.e. if Stations 8A, 12A and 13A are approved, Stations 8, 12 and 13 would be omitted and vice versa. A detailed motivation for these two route deviations were provided in the Interim Report submitted for comment, and the proposal has subsequently been accepted. The preliminary design for these two sections will be submitted as an Addendum to this report.

5.2.2 Trunk-, Complimentary- and Feeder Services

Although there is no operational plan yet, it can be assumed that the BRT System is likely to consist of three types of services, namely trunk-, feeder and complimentary services:

- **Trunk services** that are likely to use large buses which will run on segregated busways and will only stop at closed stations. Trunk service frequencies will probably range between a minimum of 10 minutes headway (6 buses per hour per service) up to 60 buses per hour (1 minute headway) on the busiest part of the route.

- **Feeder services** that are likely to use smaller buses, which will run in mixed traffic, to bring passengers to the trunk routes (a transfer would therefore be required). Feeder services will therefore not enter the segregated busways.

- **Complementary** services that are likely to use regular, non-articulated buses, with doors on both sides to allow them to operate both on normal streets (in mixed traffic, stopping kerb-side) and on the segregated busways, stopping at the median platforms.

As the operational design has not been finalised yet, it has been assumed that the frequency of buses will be such that overtaking lanes will be required at stations, which will allow the operation of both local services (stops at every station on its route) and express services (stops only at determined groups of stations defined by origin and destination concentration criteria, thereby increasing operational speeds).

Figure 5-5: Originally Proposed Station Locations

5.2.3 Feeder Routes, transfer stations, park and ride facilities and BRT Depots

The assessment of feeder routes, transfer stations, depots and park and ride facilities is not part of the scope of works as this is being addressed in the operational plan.

As the operational plan was not going to be made available within the current appointment's timeframes, GIBB recommended that further work be done on this aspect and a proposal for the extension of the current scope of work to do so has been submitted to the Project Management Office for consideration. However approval to proceed within the project timeframes was not received and it is therefore recommended that this gap be addressed as part of the operational plan development.

5.2.4 Station Types

Three types of stations, as indicated in **Figure -5-6,** have been considered:

- **Back to back stations**

  A wider (5m) median island allows the station to accommodate a bus in each direction stopping to load and off-load passengers at bus bays opposite each other. This is the preferred station, as it is the shortest and therefore most convenient for passengers. Its length can be fit in on most city blocks except sections where the road reserves are too narrow to provide the 5m island. These stations can also be provided with or without bypass lanes, depending on capacity requirements and available space.

- **Staggered stations**

  Where there is insufficient width to place the stopping bays opposite each other, the bus bays can be staggered, which result in a narrower (3,5m) median station being required, saving 1.5m in width. However the length of the station increases substantially. Staggered stations can also be provided with or without bypass lanes depending on available space.

- **Offset staggered stations**

  These stations allow bypass lanes to be provided using 3m less width than normal staggered stations, but lengthens the station by at least 49m (can be more, depending on the station setup).

Figure 5-6: Station Types

5.2.5 Single, half and double module stations

In doing the preliminary design, the same terminology of the Rea Vaya system was adopted.

A single module station is defined as a station with two stopping bays per direction, but these bus bays are not independently accessed. For a single module operation, the bus services are not limited to a particular bay, but pulls into the first available bay, and passengers would make their way to the appropriate doors as the bus approach. Specific bus services are not assigned to a specific bay.

A half module station is one with only a single bus bay per direction, as opposed to the single module's two bus bays per direction.

A double module station consists of two single modules, i.e. each module has two bus bays that are not independently accessed. The two modules are set apart by 40m so that buses can independently access each the two modules, using the bypass lanes. Due to the distance between the two modules, the services that stop at a particular module are identified on the station information, and passengers need to select the appropriate module to queue at for the particular bus they are waiting for.

As noted before, the preliminary design was done in such a way as to determine the largest station that would fit within the site constraints, and generally a double module station was designed where it could fit. The actual service design and passenger demand will determine whether a single module station or a double module station is required. It may also be desirable to design the station for two bus bays but separated by the 40m distance required to bypass and access the platform independently. This station configuration was however not used in the current design but will have a slightly shorter station footprint and can also be specified during detail design.

Before the detail design is commenced, the station sizing for the interim and ultimate service design and expected passenger demand should be finalised to ensure the stations are not built larger than necessary, particularly if service frequencies will be low.

Where single modules are adequate, a single access is likely to be sufficient. For a double module station, two access is required, to minimise walking distance as the double module stations are very long.

5.2.6 Station Dimensions

All the stations in **Figure 5-6** are half modules, i.e. only one bus bay per direction. For a full module (two bus bays per direction), the length of the design bus plus 1.5m is added to the platform length in the case of the back-to-back stops, or two times the length of the design bus plus 1.5m for the staggered stops. Note that the tapers to widen the road to accommodate the platforms are not shown in **Figure 5-6**.

The scope of this project excluded the design of the stations itself, and the concepts are therefore developed around the *station footprints* only.

The station footprints have been developed using the following dimensions:

- Station islands are 3.5m wide at staggered stops, and 5m wide at back-to-back stops.
- The design bus is 18.5m long
- The ticket area is 12m long (7m before turnstiles, 5m waiting area after turnstiles).
- The ramp area is a maximum of 4.2m long (platform height 350mm for low floor, maximum gradient for accessibility 1:12). The platforms can be extended during detail design to accommodate a more gradual gradient of 1:15.
- Where bypass lanes are provided, the width of the stopping lane is 3m and the bypass lane is 3.5m. Where no bypass lanes are provided, the BRT lane is 3.6m.
- Tapers to widen out the road to the widest part at the station has been taken as 1:15 (1:10 absolute minimum)
- For the staggered, off-set station, the distance between the two bays is 40m (to allow the buses to dock flush against the platforms)

The station footprints have been developed using the dimensions that were provided by the City. **Table 5-3** provides the standard lane widths for the City of Tshwane BRT Scheme.

Table 5-3: Design Dimensions

Lane Widths (m)	Description
BRT Lanes	
3.0	This width should only be used at localised pinch points or in the vicinity of the BRT stops.
3.6	Normal minimum width of the BRT lane, this allows 0.5m each side of a typical 2.6m width bus
4.5	This width should only be used where no segregated cycle facilities are available and the BRT lane runs adjacent to the footpath.
0.5 (0.3)	Raised Kerb between BRT Lane and Traffic Lane (absolute minimum width in inner city)
Mixed Traffic Lanes	
3.0	Minimum width of general traffic lane in urban centres
3.4	Desirable minimum lane width adjoining BRT Lane
3.7	Maximum Lane width adjoining BRT Lane.
Sidewalk / Footway	
1.5	Minimum width of footway, however adjacent to kerb it must be increased by 0.6m to allow fire hydrants, street lighting and other road furniture.
1.8	Desirable minimum width of footways
2.0	Desirable minimum width in urban centres
Cycle Lanes	
2.0 (1.5)	Minimum width of one-way exclusive cycle path or lane (absolute minimum width)
3.0 (2.0)	Minimum width of one-way cycle path shared with pedestrians (absolute minimum width)
3.0 (2.5)	Minimum width of two-way exclusive cycle path or lane (absolute minimum width)
3.5	Minimum width of two-way cycle path shared with pedestrians

5.2.7 Cycle Facilities

Part of the design requirements of this project was to include facilities for pedestrians and cyclists all along the BRT route from Soshanguwe to the Pretoria CBD.

However it was agreed during the course of the preliminary design process, that cycle facilities will be provided where possible at reasonable cost, i.e. the design should not include extremely expensive interventions (such as land acquisition or building new bridges) where it is not possible to provide the desired facilities within the existing constraints.

In these cases, where the constraint is only found over a short distance, it could either be accepted as is or if it is constrained over an extended section, alternative routes would be recommended. The reason for this approach is that it is deemed more important to develop a cycle network that leads cyclists to the nearest BRT station than necessarily provide a cycle lane in parallel to the BRT to allow cyclists to cycle to town instead of take the BRT to town, a distance beyond the normal typical commuter cycle distance.

From the Standard Lane Widths for the City of Tshwane BRT Scheme **(Table 5.3)**, the **minimum width** for a shared pedestrian and two-way cycle lane is 3.5m. It was assumed that this width allocates 2m for cyclists, and 1.5m for pedestrians, and that it would be segregated by a white line and appropriate signage. This width does not include the preferred minimum 0.6m buffer between the path and the road, which is provided where possible. There may be localised instances where the full 3.5m may have to be narrowed for a short distance to avoid having to relocate services or remove trees, but this should be the exception rather than the rule.

On sections where more space is available, 2.5m has been allowed for the cycle path and 2m for the pedestrian way, excluding the minimum preferred buffer of 0.6m. Where side drains are required, the buffer width is increased to up to 3m.

On sections where there is less than 3.5m available, sidewalks are provided but no cycle facilities, and alternative cycle routes are recommended.

Figure 5.6A provides a schematic layout of the proposed cycle facilities.

Figure 5.6A: Potential Cycle Facilities

From km 4.450 (intersection of Hebron Road and Rosslyn Road) to km 16.200 (intersection of Doreen Avenue and Rachel de Beer Street) a 4.5m wide shared but segregated pedestrian and two-way cycle lane is proposed on one side of the road.

From this point until the Pretoria CBD there is less width available for the majority of the route on either side of the road to accommodate the required minimum width of 3.5m. Cadastral boundaries, drainage facilities, trees, light poles, bridge structures and other sidewalk furniture restricts the available width.

It appears feasible to provide the minimum of 3.5m shared pedestrian and cycle facility on Rachel De Beer Road, from Doreen to Narda Street, and in some sections the facility could potentially be wider.

Sections where it is not possible to fit the minimum 3.5m facility include:

- the narrow Rachel de Beer section from Daan de Wet Nel Street to the Rainbow Junction development,
- the section through the mountain south of Lavender Road
- The two railway crossings south of station B23
- the section through the mountain between the proposed stations B24 and B25,
- other sections where cadastral boundaries limit the available width over short section.

It is proposed that alternative cycle routes such as those indicated in **Figure 5.6A** be considered. A grade separated crossing at Wonderboom Station can link the cycle way to the station and via Lavender Road, to Zambezi Road. Voortrekker / HF Verwoerd Road can also be considered as an alternative.

It may be possible to provide a 3.5m shared pedestrian and cycle way on the western side of Mansfield Road, at the section near Stations B21 and B23 but this can only be confirmed during detail design, when the cross sections and detail access configurations are considered.

Similarly it may be feasible to provide a 3.5 - 4.5m shared pedestrian and cycle facility over the majority of the section in the CBD, on the western side of Paul Kruger, but may require relocation of some services to achieve clear widths.

5.2.8 Existing Available Road Reserve Widths

The approximate available road reserve width for each homogenous section of the route (as measured from aerial photos before receipt of the survey data and verification of cadastral information) is indicated schematically in **Figure 5-7**.

Table 5-4 indicates the type of station that could potentially fit in the available road reserve as measured above and was therefore first sketched out. The highlighted sections indicate stations where the absolute minimum width needed for a particular station exceeds the estimated available space.

The two stations B18 and B19 form a **systems bottleneck**. Not only will land acquisition be required even for the absolute minimum station without bypass lanes, but mixed traffic operation will also be negatively impacted with the conversion of one of the two existing mixed traffic lanes in each direction to BRT lanes.

There are three potential solutions:

1. Expropriate one row of erven along the entire section through the Pretoria North CBD, to enable the upgrading of the route to provide a continuous link to Zambezi (via new K14 link), which may bring some relief on the M1 north-south bottleneck. This is a costly solution which will also require the extensive bridge work to allow three lanes per direction through the two bridges crossing the route east of Jan van Riebeeck Street
2. Run BRT in mixed traffic and do not provide any stops on this section
3. Expropriate a narrow strip of land at the two stations only, provide stations with no bypass lanes, adjust service design to ensure the BRT frequency is low enough so that the capacity of the station is not exceeded, and accept a significant downgrade in the mobility function of the route for mixed traffic. This will result in some through traffic diverting to other routes, which may increase pressure on bottlenecks elsewhere. If this option is selected, it would not make as much sense to construct the new K14 link through Rainbow Junction, as this section of the K14 would present a systems bottleneck for mixed traffic.

Option 1 is not likely to be affordable. Option 2 may need to be implemented in the short to medium term until such time as the preferred option, Option 3, is implemented.

At stations where there is substantial road reserve width available, the largest station with the preferred widths was sketched out. Where space was at a premium, more than one alternative was considered.

The alternatives considered are included in **Annexure A**. A brief description of each of the alternatives considered and the reasons for recommending a specific alternative are discussed in the following section.

Figure 5-7: Existing Cross Sections of Homogenous Sections

Table 5-4: Initial Station Types

Station Number	Approx. Road Reserve Width (m)	Existing Road Cross Section (mixed traffic lanes per direction)	Type of station originally considered (no of mixed traffic lanes)	Actual cross section width of proposed station (m)
B1	52	1	Back to Back, bypass (1)	35.4
B2	52	1	Back to Back, bypass (1)	35.4
B3	52	1	Back to Back, bypass (1)	35.4
B4	52	1	Back to Back, bypass (1)	35.4
B5	53	1	Back to Back, bypass (1)	35.4
B6	53	1	Back to Back, bypass (1)	35.4
B7	46	1	Back to Back, bypass (1)	35.4
B8	47	2	Back to Back, bypass (2)	42.2
B8A	25	1	Back to Back, **no bypass** (1) (2.5m sidewalks)	24.8
B9	47	2	Back to Back, bypass (2)	42.2
B10	41	1	Back to Back, bypass (1)	35.4
B11	50	1	Back to Back, bypass (1)	35.4
B12	42	2	Back to Back, bypass (2)	42.2
B13	62	2	Back to Back, bypass (2)	42.2
B12A**	27	2	Abs min staggered, **no bypass**, (2), (2m sidewalks)	27.3
B13A**	27	2	Abs min staggered**, no bypass**, (2), (2m sidewalks)	27.3
B14	42	2	Back to Back, bypass (2)	42.2
B15	62	2	Back to Back, bypass (2)	42.2
B16	62	2	Back to Back, bypass (2)	42.2
B17	62	2	Back to Back, bypass (2)	42.2
B18	18.8	2	Staggered, **no bypass**, (1), 2m sidewalks	21.3
B19	18.8	2	Staggered, **no bypass**, (1), 2m sidewalks	21.3
B20	27 - 40	2	Potential off-street intermodal interchange	TBC
B21	32	2	Staggered Offset, bypass (2), 2m sidewalks	31.7
B22	32	2	Staggered Offset, bypass (2), 2m sidewalks	31.7
B23	38	2	Back to Back, bypass (2)	37.4
B24	25	2	Staggered, **no bypass** (2), 2m sidewalks	26.5
B25	72	2	Back to Back, bypass (2)	42.2
B26*	24.8	3	Back to Back, **no bypass** (1), 3.5+1.5 sidewalks	23.8
B27*	24	2	Back to Back, **no bypass** (1), 3.5+1.5 sidewalks	23.8
B28*	24	2	Back to Back, **no bypass** (1), 3.5+1.5 sidewalks	23.8
B29*	24	2	Back to Back, **no bypass** (1), 3.5+1.5 sidewalks	23.8
B30	24	2	Off-street at Pretoria Station	TBC

* Alternative: Provide a bypass lane (staggered offset station), but sidewalk space is then sub-standard, which in the CBD is not deemed acceptable.

** Bypass not required as express services would use the main route (in mixed traffic)

5.3 Assessment of Station Design and Cross Section Options

The station types identified in **Table 5-4** was used as the starting point of the preliminary design. Potential alternatives and options considered are summarised in the following sections.

5.3.1 B1, B2, B3 and B4

Stations B1 – B4 were initially drawn as double module back to back stations.

Station B1 was placed downstream of the intersection of M17/Ruth first, when the extension on the M17 was still under consideration.

Station B2 was placed approximately 1km downstream of B1, midway between B1 and the intersection of M17 and M20 (Hebron Road), the initial location of B3.

As it has since been confirmed that the route will not include the section along M17, Stations B1 and B2 have now been omitted from the final planning drawings.

Station B3 was initially placed on the northern approach of M17/M20, but then moved to the eastern approach when the possibility was raised that the service may start at an existing bus depot approximately 2km west of the intersection of M17/M20.

Station B3 has however since been omitted due to the desire to reduce the number of stations (30 initially) to reduce BRT delay.

Station B4 has been located midway between the M17/M20 intersection and the M20/Doreen Road intersection, to maximise the catchment area of the station. It was placed east of the intersection at Km 2.8 (Streetname unknown), due to the relatively significant right turn from the western approach into this street.

Station B4 has been put on hold pending a decision on whether the BRT route will start from the west of the intersection of M17/M20 or from the east of the intersection of M20/Doreen.

It has subsequently been confirmed that the route will start at Kopanong Station and Stations B1 – B4 is therefore no longer relevant. Two new stations will be designed as part of the Kopanong Deviation, and will be submitted as an Addendum to this report.

5.3.2 B5

Station B5, a double module back to back station, was initially placed on the western approach of the intersection of M20 and Doreen, but was moved to the southern approach when the traffic impact (high right turn demand from Hebron Road into Doreen) was considered.

The station was placed midblock between the intersections of M20/Doreen and Doreen/Street Km 5.74 (streetname unknown), as it was deemed a central location to serve the adjacent community, with good pedestrian access at this particular location. A signalised mid-block pedestrian crossing is proposed. A central station access is proposed, instead of two entrances at the ends of the station.

5.3.3 B6

Station B6, a double module back to back station, has been placed north of the intersection at Km 5.74 (Streetname unknown), approximately 750m from Station B5. The station was placed north of the intersection as the right turn movement from the north appears to be less than the right turn movement from the south.

5.3.4 B7

Station B7, a double module back to back station, was placed at Kitshoff Street, due to the observed demand at the current bus and taxi laybyes at this intersection.

The station was placed on the eastern approach of the T-junction, allowing right turns from the western approach in the shadow of the station.

5.3.5 B8 or B8A

Station B8, originally a double module back-to-back station, was at first placed west of the intersection with De Waal Street, but could not fit due to the curve and the narrower road reserve. When considering the right turn movement into de Waal Street from the west, and the right turn movement into Fred Otto Street from the east, it was decided to move the station in between De Waal and Fred Otto Streets. A staggered single module station with bypass lanes can be provided here. This is also the most central location on this section of Doreen Road. Fred Otto Street also leads to Akasiaboom Station.

Closing these intersections or making it left-in, left out accesses was considered but not deemed feasible, particularly as Fred Otto is the only access into the portion of Rosslyn located on the east side of Doreen. Placing the station east of the intersection of Fred Otto Street was also considered but not deemed feasible as it is then located too close to the very busy intersection with the R566.

Due to the narrower road reserve on this section, the current design shows only minimum width medians on the approaches opposite to the Station, which means staggered pedestrian crossings, requiring a minimum of 3m wide medians, cannot be provided.

It may be possible to widen this section some more, to increase the width of the medians and possibly make a staggered pedestrian crossing feasible, and it is recommended that this be considered during the detail design stage.

Station B8A, located in Piet Rautenbach Street, is proposed as an alternative to Station B8, as discussed in **Section 5.1.1**. As this section was not surveyed, a preliminary sketch plan of a single module staggered station with no bypass lanes was done on the aerial photography. It appears to be possible to fit a station between the intersections of De Waal and Kotzenberg Street without the need for land expropriation.

5.3.6 B9

The location of Station B9, a double module back-to-back station, was selected to be approximately midway between the R566 and the Railway line, to serve the south-eastern quadrant of Rosslyn as centrally as possible. The station is placed on the south side of the intersection of Frans Du Toit and Doreen. The two staggered intersections of Van Niekerk/Doreen and Frans Du Toit/Doreen is proposed to be consolidated into a single signalised intersection.

5.3.7 B10

This station, a double module back-to-back station, was initially located immediately south of the intersection with Daan De Wet Nel, when a second station approximately 800m further south, at the intersection of Jensen and Doreen, was still planned to service the Orhards neighborhood. However with the desire to reduce the number of stations, and the Orchards being a high income, high car ownership neighborhood, it was considered that a single station would be sufficient. The block between Oaklands and Jensen/Hulton Road was selected based on its central location to the Orchards neighborhood and relatively good pedestrian access.

5.3.8 B11

Station B11, a double module back-to-back station, was initially placed north of the intersection of First Avenue and Doreen, but later moved centrally between Lynn and Felicia Streets Cul-de-sacs. The location is central to the emerging higher density neighborhood between the N4 and First Road, with good pedestrian linkage to the east. There is a large area of open land to the west of the station which provides a potential development opportunity for higher density residential developments with well-planned pedestrian access.

There is currently an access south of the proposed station. It could not be established whether this access is legal or illegal (or legal but temporary), although the layout of the proclaimed erven and accesses suggest that it is illegal and/or temporary. However for the purpose of the preliminary design it has been retained but changed to a left-in, left-out access only. It is recommended that this aspect be confirmed during the detail design stage.

If the access has to be retained, it would be preferable to change the service road to a one-way southbound, with a left in south of the corner with Lynn Street, and the left out at the current access location. This will result in a narrower lane width requirement and consequently a wider sidewalk and cycle facility can be provided.

5.3.9 B12 or B12A

Station B12, a double module back-to-back station, has been located on the northern approach of the intersection of Doreen and Rachel de Beer. It is proposed as a future station, only to be developed once the vacant land around it is developing. The surrounding land use should however be planned with good pedestrian linkage to the proposed station.

The eastern approach was also considered but discarded due to the high right turn volume from the eastern approach into Doreen Avenue, which was considered more difficult to accommodate than the high left turn volume from the north approach.

Station B12A is proposed as an alternative to Station B12, as discussed in **Section 5.1.2**. This single module staggered station with no bypass lanes, is proposed to be located in Heinrich Street, south of the intersection of First Avenue and Heinrich Avenue. As this section was not surveyed, a preliminary sketch plan of the proposed station was done on the aerial photography. It appears to be possible to fit a station without the need for land expropriation or reducing the number of mixed traffic lanes, although the sidewalks will be fairly limited at only 2m wide.

Station B12A is within easy walking distance of the higher density residential development Wonderpark Estate.

5.3.10 B13 or B13A

Station B13, a double module back-to-back station, has been placed to the west of the intersection of Heinrich and Doreen, to avoid interference with the high right turn volume from the eastern approach.

Station B13A is proposed as an alternative to Station B13, as discussed in **Section 5.1.2**. This single module staggered station with no bypass lanes, is proposed to be located in Heinrich Street, south of the intersection of Madelief Avenue and Heinrich Avenue (the shopping centre entrance). As this section was not surveyed, a preliminary sketch plan of the proposed station was done on the aerial photography. It appears to be possible to fit a station without the need for land expropriation or reducing the number of private vehicles, although the sidewalks will be fairly limited at only 2m wide.

5.3.11 B14

Station B14, a double module back-to-back station, was placed east of Main Street due to the relatively higher density of the residential areas on three quadrants. The fourth quadrant is a cemetery.

5.3.12 B15

Station B15, a double module back-to-back station, was placed west of Waterbok Street due to the lower right turn volumes from the western approach compared to the eastern approach. There is also an area of vacant land north of the station that presents the opportunity to either locate a park-and-ride site here, or in future a higher density residential development. East of Waterbok, the properties are also all single dwelling erven with poor pedestrian accessibility and therefore would probably contribute little to ridership at this station.

5.3.13 B16

Station B16, a double module back-to-back station, was placed east of Grafenheim Street to serve the shopping centre. The station was placed on the eastern approach of the T-junction to allow the right turn from the western approach to be retained. An existing left-in, left-out access to the shopping centre will be retained.

5.3.14 B17

Station B17 was originally placed east of the intersection of Rachel de Beer and Daan de Wet Nel Drive, but as the available road reserve was found to be too narrow to accommodate a station in this location, it was moved to the east of the intersection of Narda Street and Rachel de Beer. This allowed a double module back-to-back station to be fit in the available road reserve, while accommodating the right turn from the western approach.

5.3.15 B18

Station B18 is the most constricted station on the Line 1 Route and therefore determines the overall BRT system capacity bottleneck. **The narrowest station type,**

a staggered station with no bypass lanes, cannot fit within the existing road reserve without encroaching slightly on private property.

The station is sited in this location as it serves the shopping centre and several other retail nodes in the immediate vicinity, and it is the only site where it is deemed feasible to widen with only minimal land acquisition required and no structures affected.

However the location of the station here may mean the loss of some of the retail centre's off-street convenience parking, although it is believed that paid under cover parking is available in the shopping centre's parking basement. This will need to be discussed with the affected property owners.

The location of the station here also necessitates the banning of right turns from the eastern approach into Burger Street, although it is proposed to allow right turns from Emily Hobhouse Street. Similarly, right turns from the western approach will be allowed at Burger Street, but not at Emily Hobhouse Street. Again, a process of consultation with affected parties will probably be required.

5.3.16 B19

Station B19 was originally located east of the intersection of Rachel de Beer and Jan van Riebeeck. It was placed on this block to serve the school, and because it was deemed feasible to potentially encroach a few meters into the school property as there are no buildings affected.

However after rationalisation of the number of stations, it was decided to omit this station due to the severe space constraints on this section of the route.

5.3.17 B20

Station B20 consists of a single BRT module per direction, located kerb-side of the M1, to allow a modal interchange with both the Wonderboom Rail Station and the proposed Rainbow Junction bus/taxi facility.

The current layout represents one possible layout that can be partially retained when the M1 is relocated to the east as per the current Rainbow Junction designs, and ties in with the current intermodal facility layout proposed by SSI Consulting Engineers. However due to the uncertainties regarding the timing of the Rainbow Junction development, and very limited consultation to date, the option has not been developed to a high level of detail. In principle, the layout of the entire intermodal interchange as currently proposed can be redesigned to better integrate the BRT, bus and taxi modules, but this is not deemed included in the current scope of work.

Subsequent to the completion of the draft preliminary design, it was enquired whether it is possible to accommodate U-turns at Rainbow Junction intermodal facility, as this will allow a service running from Tshwane up to the Rainbow Junction only (as opposed to all the way to Rosslyn or Soshanguve) to turn around here. We have considered some sketch planning and believe it is likely to be possible, if the location of the station on the west side is adjusted.

5.3.18 B21

Station B21, a single module offset staggered station with bypass lanes, was originally placed north of the intersection of Mansfield Avenue and Van Rensburg

Street. However it has been moved midblock between the intersections of Van Rensburg Street and Louis Trichardt Street, where there is more space due to the location of a service road.

It is proposed to have a central entrance at the intersection with Green Street, which is an existing left-in, left-out access.

There is an auxiliary lane on the western side which serves as a service lane for the adjacent properties that has direct access. It is proposed to retain this lane to assist with traffic congestion as a result of vehicles slowing down to turn.

5.3.19 B22

Station B22 was originally placed north of Louis Trichard Street, later relocated midblock between Louis Trichard and Fred Nicholsen, and finally omitted due the rationalisation of stations.

5.3.20 B23

Station B23, also a single module offset staggered station with bypass lanes, are located south of the intersection of Booysen and Mansfield Road.

5.3.21 B24

Station B24, a single module offset staggered station with bypass lanes, is located midblock between the intersections of Trouw Street and Flowers Street, with a central entrance at the intersection with Van Heerden Street, which is an existing left-in, left-out access.

This location is central to the Capital Park neighborhood and the Trouw/Flowers one-way couplet on either side of the station makes it a convenient transfer or drop-off location between east-west traffic and the Line 1 Route.

There is an auxiliary lane on the eastern and western sides which serves as a service lane for the adjacent properties that has direct access. It is proposed to retain this lane where possible to assist with traffic congestion as a result of vehicles slowing down to turn.

5.3.22 B25

Station B25, a single module back-to-back station with bypass lanes, is located opposite the CJ Langenhoven School. BRT passengers would access the school via the signalised pedestrian crossing at the drop-off area, which in turn links to the school via a pedestrian underpass.

It may be possible to construct a direct underground connection from the underpass into the station, but the expected passenger demand will determine whether the additional expense is justifiable. This should be reviewed at detail design stage.

5.3.23 B26

Station B26, a single module, staggered off-set station with bypass lanes, is currently located midblock between Boom Street and Bloed Street. This location was selected as it provides a convenient transfer (drop-off) between Line 1 and east-west bus and taxi services travelling on Boom and Bloed Street one-way couplet.

Several alternative locations were considered, namely

- North of Boom Street
- South of Bloed Street
- Staggered across the intersection of Bloed Street

The final location of Station B26 will depend on the requirements for a BRT to BRT transfer station at the intersection of the Boom/Bloed east-west one-way couplet and the north-south Line 1. However as the operational plan is not yet finalised, it was not possible to get confirmation of the proposed routes interfacing with Line 1 and the transfer requirements.

If BRT passengers travelling along Boom and Bloed Streets must transfer at station B26, the current location as shown in the drawings will not work, as services from the south turning into Bloed Street to travel westbound towards Belle Ombre Station, miss the station. If however this specific route overlaps with Line 1 along Paul Kruger Street to a point south of Church Square, then the transfer can potentially take place at Church Square Station, instead of at Station B26, and need not take place at Station B26.

If the former, the station will need to be located in the block between Bloed Street and Struben Street. Care would need to be taken to ensure the northbound buses can make the left turn into Bloed Street. It may be necessary to set back the stop line of the mixed traffic lane to ease the bus turn. A third signal phase, allowing buses to turn left across the straight ahead mixed traffic, would also be required, which would reduce the capacity of the intersection substantially.

In terms of station configuration, the following options were considered:

- Option 1: single module staggered off-set station with bypass lanes, midblock entrance
- Option 2: single module station with bypass lanes, staggered across the intersection (note in the drawing the station is indicated staggered across Bloed Street with the northbound traffic stopping on the block between Bloed Street and Boom Street. This layout, developed before it became known that a transfer may be required here, should be mirrored if buses are to turn left in Bloed Street. However as this is not the preferred option, it has not been redrawn at this stage, pending confirmation of the BRT routes and services.)

It should be noted that lengthwise, the station only just fit in the available block length, and only if

a) The BRT system is low-floor and do not require longer access ramps and
b) The entrance is located midblock. In the midblock configuration, the ticket office overlaps with the 40m gap in between the two modules, which allow a bus to dock tight against the platform. If the ticket offices are located at the ends of the station, the station is too long for the block.

In terms of available width, a compromise is required to fit in the stations, bypass lanes, mixed traffic lanes and pedestrian and cycling facilities.

The conversion of the entire Paul Kruger Street into a transit mall was considered but not deemed feasible due to strategic importance of this street, which provides one of the few north-south crossings of the Magaliesberg. It was therefore accepted that at least one mixed traffic lane per direction would need to be retained. However all right turns were banned, justified by the ease of diverting around the block on the CBD grid.

The next step is to weigh up the importance of providing BRT bypass lanes. As the station is a single module station, the only purpose of the bypass lanes would be to allow express buses to bypass local buses stopping at this station. As the service design is not yet known, it is not known whether the bus frequency will be high enough to require bypass lanes. Typically, bus frequencies under 90 buses per hour do not require bypass lanes.

If bypass lanes are required (as drawn), the maximum sidewalk width that can be provided is 2.35m on each side, on the block where the station is located. The 2.35m width is not considered sufficient for shared pedestrian and cycle lanes. In between stations, the sidewalks are approximately 5.2 m wide.

From aerial photography, it appears that there may be more scope to increase the available sidewalk width on the eastern side of the block between Bloed and Struben Streets, than on the block to the north of it. While a portion of the northern block is vacant, there are some historical buildings on the south east corner of the intersection of Boom and Paul Kruger Streets which is likely to make widening at this pinch point impossible.

It is preferable to have a consistent lane width for pedestrians and cycles throughout the street to maintain constant flow of pedestrian and cycle traffic.

5.3.24 B27 and B28

Church Square is close to the geographic centre point of the central business district, with the majority of the CBD within a 800m (10 minutes' walk) radius. There are also a number of bus services stopping in the vicinity, which provides further transport connection options. It is therefore expected that the BRT station at Church Square will have a very high passenger demand. It is further expected that due to the importance of serving this destination, a number of BRT lines would be overlapping on this section of Line 1, thus also requiring a high bus capacity. It is therefore essential that more than one independently accessed module is provided, with bypass lanes.

Several options were considered, namely:

- Option 0.1: A double module back-to-back station on the block between Proes and Vermeulen Street north of Church Square, and/or the block between Pretorius and Schoeman Street, south of Church Square, with bypass lanes
- Option 0.2: A double module station staggered across Vermeulen Street, and / or a double module staggered across Pretorius Street, with bypass lanes
- Option 1: A single module back-to-back station on the block south of Vermeulen Street and a single module station north of Pretorius Street, with bypass lanes
- Option 3: a single module, staggered off-set station with central pedestrian access and bypass lanes, on the block between Proes and Vermeulen Street north of Church Square, and/or the block between Pretorius and Schoeman Street, south of Church Square
- Option 3A: a single module, staggered off-set station with pedestrian access on the block ends, and bypass lanes, on the block between Proes and Vermeulen Street north of Church Square, and/or the block between Pretorius and Schoeman Street, south of Church Square

Option 0.1 was discarded as the block length is insufficient, and the station can only fit if no mixed traffic lanes are required. This was considered but not deemed feasible due to several accesses to underground parking basements on the blocks in question.

Option 0.2 has the same problems in terms of width than Option 0.1, but provides a less convenient split station configuration, with passengers wanting to transfer between modules required to exit the station, cross the intersection and enter the station again. Due to the width constraints this option was not considered further.

Option 1 proposes that Stations B27 and B28 operate as a split station pair of single modules, with some services stopping at the northern module (B27) and some services stopping at the southern module (B28). In essence, it is similar to option 0.2 but due to the fact that there are no accesses to underground parking basements on these blocks, it is possible to ban private or mixed traffic on these blocks and therefore fit the 5m wide station, bypass lanes, and sidewalks of 3.4m on each side. The distance between these modules are approximately 160m, which while not ideal, still provides a reasonable transfer distance. No busy multilane intersections need to be crossed and the transfer is via the pleasantly landscaped Church Square environment.

Option 3 is also a single module station with central pedestrian access but is in the narrower staggered off-set configuration and is therefore likely to get more congested at high passenger volumes. If capacity requirements requires two stations (i.e. both B27 and B28 is required), this split module option has an even longer transfer distance of approximately 360m than Option 1, and requires a passenger to cross two busy 5-lane intersections.

Option 3A is a minor variation on Option 3A, with access on either end of the station, but unfortunately this does not fit in the available block length if 12m ticket offices and 4.2m ramps are required.

It is difficult to recommend a station design without any information on the likely passenger demand or service design that must be accommodated. Option 1 is therefore recommended, as it is the widest station that can be fit, and should a split module operation be required to accommodate forecasted demand, it is deemed the most convenient of these options. Should forecasted passenger demand or the BRT services routed via Church Square be lower and only one of the two modules are needed to provide sufficient capacity, it is recommended that the southern module be constructed as there are no Jacaranda trees on this block that may complicate or delay the process.

5.3.25 B29

Station B29, a single module, staggered off-set station with bypass lanes, is located midblock between Minnaar Street and Visagie Street, in front of the City Hall and Museum.

The previous phase's station location was retained as it is at a good spacing between the previous station and the last station at Pretoria Rail Station, serves a popular destination, and is located in a block where there is scope to encroach somewhat into the landscaped area in front of the City Hall to provide a wider sidewalk.

The same problem of narrow sidewalk widths (2.35m) as at station B26 is prevalent, if bypass lanes are to be provided. However in this case, it is likely to be possible to tie the sidewalk and cycle lane into the City Hall landscape in a way that will improve the environment.

As for the previous inner city stations, the station access need to be midblock if the station is to fit lengthwise.

5.3.26 B30

The preliminary design of the BRT station at Pretoria Station is excluded from the current scope of work on instruction from the Project Management Office.

The previous proposal, developed by GOBA, in consultation with PRASA and other stakeholders, are therefore shown without change. The limit of planning is indicated north of the intersection of Paul Kruger and Doreen Street.

Although excluded, the intersection operation was reviewed and it is noted that a complicated signalling solution would need to be implemented at the intersection of Paul Kruger and Scheiding Street, to avoid the conflicting straight ahead bus movement and mixed traffic right turn. A simpler solution, namely allowing the bus to merge over to the left lane, will avoid this, which obviates the need for an additional signal phase and the resultant reduction in intersection capacity, with minimal negative impact on the BRT services.

The level of detail on the current layout appears to be somewhat incomplete, lacking in pedestrian detail, and functional flow of vehicles to/from the station, road closures required by the layout etc.

The operational design will probably be the determining factor in whether there will be sufficient capacity with two modules of two bays as per GOBA layout, or whether four independent bays fit in a revised sketch plan by GIBB will better accommodate the expected demand. It is recommended that the service design and pedestrian demand forecasts be finalised as soon as possible.

6 BRT SYSTEM CAPACITY

Stations are an essential BRT component. Assessing the saturation of each station along the route is thus essential to determine whether the system will work efficiently. Estimated bus frequencies, estimated passenger numbers, and station configurations are the main factors which influence station saturation.

The station configuration is known, but since neither the bus service frequency nor the passenger demand is known at this stage, it is not possible to determine the expected BRT system capacity with any degree of accuracy but the capacity calculations was deemed necessary to point out potential capacity problems that should be considered in the operational design.

6.1 Methodology

Each station's capacity was calculated with the following input:

- Station size: a single- or double-module station.
- Number of entrances at each station.
- The frequency assumed throughout the BRT route was 60 buses per hour per direction.
- The number of lines stopping per direction assumed was 4
- The number of directions a station serves (either 1 or 2)
- The number of bays per direction at each module within the station.
- The signal interference per module (distance between signal and stopping bays).
- The interference between modules (only at double-module stations).
- A total cycle time of 60 seconds was assumed per signal, with 50% green time in most instances dedicated to BRT.

The capacity calculations used the following assumptions with regards to passenger demands:

- As no passenger demand is available, stations were classified as either small, medium or large, based on the station context. The following assumptions were made for peak hour passenger demand:
    - Small <500 passengers,
    - Medium 500 - 2 000 passengers, and
    - Large : 2 000- 4 000 passengers per hour.
- For stations B5 to B13 (these stations serving a lower income population with low car ownership), B18 and B21 to B23, a medium passenger demand was assumed, with a boarding/alighting split estimate of 80%/20% for the morning peak, and 20%/80% for the afternoon peak.
- For stations B14 to B17, a small passenger demand was assumed (these stations serving a higher income population with high car ownership), with a boarding/alighting split estimate of 80%/20% for the morning peak, and 20%/80% for the afternoon peak.
- For stations B20A and B20B, a medium passenger demand was assumed respectively, with a boarding/alighting split estimate of 50%/50% for both the

morning peak and the afternoon peak. These two stations serve as an interchange for passengers utilising the Wonderboom rail station.

- For station B25, a small passenger demand was assumed due to this station mainly serving a school, with a boarding/alighting split estimate of 20%/80% for the morning peak, and 80%/20% for the afternoon peak.
- For stations B26 to B29, located in the CBD, a medium passenger demand was assumed, with a boarding/alighting split estimate of 60%/40% for the morning peak, and 40%/60% for the afternoon peak.

Internal station passenger capacity is calculated using the following assumptions:

- Safety width of 0.5m for each direction which consists of the station infrastructure (doors and kerbs).
- Friction width of 2m
- Density of passengers waiting in stations of two passengers per square meter.
- Circulation width which is calculated by the expected circulating passengers per hour divided by 2 000 passengers per hour. Normally 2 000 passengers can pass down a meter wide sidewalk per hour at a reasonable level of service.

The dwell time refers to the time a bus is occupying a stop bay and also impacts station saturation levels. Factors that influence dwell time are passenger volumes (both boarding and alighting), frequency of buses and the entry and exit characteristics of both buses and stations.

6.2 Results

The saturation level of a station refers to the percentage of time that stop bays at stations are occupied by buses. The higher the saturation level, the lower the speed, which introduces the risk of congestion.

The saturation of each station is indicated in **Table 6.1** for both the morning peak and afternoon peak. Note that the acceptability of saturation is as follows:

- < 0.4 very good
- 0.4 - 0.5 desirable and
- 0.6 maximum

Saturation for each station for both the morning peak and afternoon peak seem to be acceptable, for the assumed bus frequency of 60 buses per hour, although the single modules are approaching the maximum saturation.

However, important to note is that all the single-module staggered offset stations with width of 3.5m appears to have insufficient capacity for the medium passenger demand assumed. It is therefore critical to confirm the passenger demand as soon as possible.

Of the wider 5m stations, only stations B27 and B28 indicates a slightly wider station requirement to accommodate the assumed 2000 passengers per module at the assumed pedestrian level of service.

Table 6.1: Station Capacity Calculation Results

												Morning Peak					Afternoon Peak						
Station Number	Station Type	Number of Modules	Number of Entrances	Bays per direction per module	Signal Interference per module		Interference between modules	Signal green time (seconds)	Sidewalk width (meters)	Platform width (meters)	Required platform width (meters)	Number of Passengers	Split boarding/ alighting		Number of Passengers Boarding	Number of Passengers Alighting	Station Saturation	Split boarding/ alighting		Number of Passengers Boarding	Number of Passengers Alighting	Station Saturation
B5	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.326	20%	80%	400	1600	0.331
B6	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.326	20%	80%	400	1600	0.331
B7	Double-module back-to-back	2	2	2	1	2	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.299	20%	80%	400	1600	0.301
B8	Single-module staggered offset	1	2	2	0	-	0	24	3.00	3.5	4.7	2000	80%	20%	1600	400	0.528	20%	80%	400	1600	0.543
B9	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.326	20%	80%	400	1600	0.331
B10	Double-module back-to-back	2	2	2	1	2	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.299	20%	80%	400	1600	0.301
B11	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.326	20%	80%	400	1600	0.331
B12	Double-module back-to-back	2	2	2	1	2	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.299	20%	80%	400	1600	0.301
B13	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	4.6	2000	80%	20%	1600	400	0.326	20%	80%	400	1600	0.331
B14	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	3.4	500	80%	20%	400	100	0.257	20%	80%	100	400	0.26
B15	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	3.4	500	80%	20%	400	100	0.257	20%	80%	100	400	0.26
B16	Double-module back-to-back	2	2	2	1	1	1	24	3.00	5.0	3.4	500	80%	20%	400	100	0.257	20%	80%	100	400	0.26
B17	Single-module staggered offset	1	2	2	0	-	0	24	3.00	3.5	3.0	500	80%	20%	400	100	0.422	20%	80%	100	400	0.426
B18	Single-module staggered offset	1	2	2	0	-	0	24	2.50	3.5	4.7	2000	80%	20%	1600	400	0.528	20%	80%	400	1600	0.543
B20A	Single-module one directional	1	1	2	0	-	0	24	5.00	5.0	4.1	2000	50%	50%	1000	1000	0.514	50%	50%	1000	1000	0.514
B20B	Single-module one directional	1	1	2	0	-	0	24	5.00	5.0	4.1	2000	50%	50%	1000	1000	0.514	50%	50%	1000	1000	0.514
B21	Single-module staggered offset	1	2	2	0	-	0	24	2.50	3.5	4.7	2000	80%	20%	1600	400	0.528	20%	80%	400	1600	0.543
B23	Single-module staggered offset	1	2	2	0	-	0	24	2.50	3.5	4.7	2000	80%	20%	1600	400	0.528	20%	80%	400	1600	0.543
B24	Single-module staggered offset	1	2	2	0	-	0	24	2.50	3.5	4.7	2000	80%	20%	1600	400	0.528	20%	80%	400	1600	0.543
B25	Single-module back-to-back	1	1	2	4	-	0	35	3.00	5.0	3.6	500	20%	80%	100	400	0.289	80%	20%	400	100	0.289
B26	Single-module staggered offset	1	2	2	0	-	0	24	2.35	3.5	4.3	2000	40%	60%	800	1200	0.528	60%	40%	1200	800	0.518
B27	Single-module back-to-back	1	1	2	0	-	0	24	3.40	5.0	5.6	2000	40%	60%	800	1200	0.528	60%	40%	1200	800	0.518
B28	Single-module back-to-back	1	1	2	0	-	0	24	3.40	5.0	5.6	2000	40%	60%	800	1200	0.528	60%	40%	1200	800	0.518
B29	Single-module staggered offset	1	2	2	0	-	0	24	2.35	3.5	4.3	2000	40%	60%	800	1200	0.528	60%	40%	1200	800	0.518

Scenarios were then tested to see at which passenger demand level the stations with insufficient width would then suffice. It was found that single-module offset stations of width 3.5m would be sufficient with a 1 100 passenger demand, and stations B27 and B28 of width 5m would be sufficient with a 1 600 passenger demand.

The need to provide a second module at the majority of the double-module back-to-back stations outside of the Pretoria CBD should be confirmed once realistic estimates of passenger demand are available. The modelled passenger numbers are merely indicative estimates but seem to indicate that the second module would not be required with the assumed relatively low bus frequency of 60 buses per hour.

Due to the limited space available at the 3.5m single-module staggered offset stations, and at stations B27 and B28, which are 5m wide but is expected to have a high passenger demand, the required widths to operate at the assumed levels of service for the assumed medium passenger demand may not be achieved. It is therefore critical to get an estimate of the potential passenger demand to ensure the stations will operate at acceptable levels of service.

Considering the physical constraints and the capacity limitations of the proposed stations, it is imperative that the IRPTN system be assessed comprehensively to allow for a parallel BRT route to Paul Kruger Street.

7 TRAFFIC IMPACT ASSESSMENT

7.1 Software Selection and Modelling Objectives

Transyt (version 13) was used for the traffic modelling. Transyt is a program that determines optimum fixed time, coordinated traffic signals timings in any network of roads for which the average traffic flows are known. It calculates a Performance Index (PI), which is a weighted sum of all vehicle delays and stops. The optimizing routine systematically alters signal offsets and green times to find the timings which minimize the PI value.

The reasons for using Transyt for the purposes of modelling the potential impact of a BRT system in preference to other modeling programs were primarily twofold:

- The main requirement of the study was to provide an understanding of the practical issues involved in implementing a BRT system in the study area, especially the impact on existing traffic at intersections. While it was important to also gain an understanding of problems along road sections between intersections, it was decided that the main bottlenecks and capacity limitations would be manifested at intersections.

- The lack of available trip pattern and volume data and the availability of a meaningful source of trip data from alternative sources, especially larger-area strategic-level models such as EMME, meant that the only source of reliable and up-to-date observed data was a series of intersection traffic counts carried out on most of the major intersections along the proposed BRT corridor. These counts were carried out for both AM and PM peak periods. The counted AM and PM peak hour was used for the modeling results described.

7.2 Data Collection

7.2.1 Intersection Layouts

The existing intersection layouts have been recorded schematically using as-built drawings, aerial photos and information recorded during site visits, for the base year model. For the scenarios with BRT implemented, it was assumed that the existing lanes will be retained or re-instated, with the exception of the sections where one of the two or three existing lanes were converted to a BRT lane.

7.2.2 Signals Settings

There are 50 existing signalised intersections that will be affected by the introduction of the BRT from Soshanguve to Pretoria CBD. The signal settings were received from City of Tshwane and used as an input into the Transyt Modelling.

In addition, a number of additional intersections, that was previously controlled using four-way stops or was give-way controlled, were assumed to be signalised when BRT is implemented.

7.2.3 Travel Time Surveys

Travel time surveys were carried out during the morning, midday and afternoon peak hours. This information was used to identify existing bottlenecks where efforts to provide public transport priority measures should be focussed. In addition, the information was also used to calibrate the base year Transyt model, which will be discussed in more detail in **Section 7.5**.

The results of the travel time surveys are indicated in **Figure 7-1 to Figure 7-3** which show cumulative travel time for a number of travel time runs. Only the peak direction of travel, i.e. Soshanguve to Pretoria CBD in the morning, and Pretoria CBD to Soshanguve in the midday and afternoon is shown.

The average off-peak travel time northbound is 40 minutes (equating to an average of 52 km/hr over the route distance of 34.6km). During the pm peak period, the average travel time increased to 72 minutes whilst the morning peak the average is 60 minutes.

In the Soshanguve to Pretoria CBD morning peak period trips,

- none of the intersections on BRT Route from Ruth First to Daan De Wet Nel East currently indicates any major delays, with the peak and off-peak travel times very similar.
- Some delays were experienced On Rachel De Beer Street from Jack Hindon Street to M1.
- In addition congestion is experienced on Mansfield Road between Lavender Road up to Paul Kruger South and again on Paul Kruger between Boom and Vermeulen Street.

In the Pretoria CBD to Soshanguve direction, afternoon peak period trips shows that,

- Some delays were experienced on Paul Kruger from Vermeulen Street to Struben Street. The main problem is experienced especially at the intersection of Vermeulen and Paul Kruger where there are major delays on traffic turning into Paul Kruger North.
- Some delays were experienced on Mansfield from Fred Nicholson to Lavender
- Generally the remainder of the route to Soshanguve from Lavender onwards does not display any significant delays at individual intersections.

Figure 7-1: Travel Time Surveys: AM Peak Period (Soshanguve to Pretoria CBD)

Figure 7-2: Travel Time Surveys: Midday Peak Period (Pretoria CBD to Soshanguve)

Figure 7-3: Travel Time Surveys: PM Peak Period (Pretoria CBD to Soshanguve)

7.2.4 Traffic Counts

Traffic counts were carried out over a two week period from the 26th of July to the 2nd of August 2011. The traffic counts were carried out as follows:

- 7 Day Classified Automatic Counts - 4 locations
- Manual 12-hour Classified Intersection Counts - 14 locations
- 12 Hour Unclassified Intersection Counts - 19 locations
- 3 Hour Peak Period Intersection Counts - 23 locations.
- 12 Hour occupancy Survey on R101 over the Magaliesberg Mountain

A summary of the AM and PM Peak hour link volumes are provided in **Annexure B**.

The traffic volumes were made available to the demand modelling team for further validation and refinement of the demand model.

7.2.5 Existing Modelled Person Trip Volumes

Network plots from the demand model, indicating rail, bus, taxi and private transport person trips in the morning peak hour, are included in **Annexure B** (base year traffic without BRT modeled).

While this information was not used directly in the Transyt modelling, it provided useful information regarding the existing traffic composition along the corridor.

7.2.6 Current Parking Demand

A parking study was carried out during August 2011 to quantify the extent and utilisation of on-street parking on Paul Kruger Street between Scheiding Street and Boom Street. The vehicle license plates were recorded in 15 minute intervals.

This stretch of Paul Kruger Street is approximately 1.8km long and there are 4 and 7 street blocks north and south of Church Square respectively. Church Square is considered to be between Bureau Lane and Vermeulen Street. The average street block length in the study area is 162m.

The section provides a summary of the key findings of the assessment. The detailed results of the study are included in **Annexure C**.

Paul Kruger Street has two lanes per direction over most of its length and on-street parking is provided on both sides of the street. There are also no stopping zones and loading bays in some blocks. **Figures 1.2 to 1.12** in **Annexure C** describes the blocks in more detail by indicating the position of vehicle access points, shops fronts, and boundary fences on aerial images.

(a) Parking Utilisation

Parking utilization represents the occupancy of a parking area i.e. the number of occupied bays (spaces) in comparison to the number of available bays (spaces) over a certain period. In each street block, there are marked, on-street parking bays, marked 'no stopping zones', and marked 'loading zones' (bays). It was noted during the survey that some vehicles park on sidewalks, in 'no-stopping zones', in loading bays, and random occurrence of double parking along side legally parked vehicles. All legally and illegally parked vehicles in the study area were counted. Therefore, the total parking demand (vehicles parked legally and illegally) can be compared with the parking supply (i.e. marked parking bays excluding other open spaces where parking is possible but is not permitted).

Excluding Church Square, the parking supply in each block is between 17 and 29 bays while the parking demand in each block is between 15 (minimum) and 45 (maximum). Generally the parking demand for the study area increases noticeably from around 07:15am to reach a peak at around 08:15am. The demand generally remains constant and near the peak demand for each block. After around 13:15 (lunchtime) there is a noticeable gradual drop in demand.

There is only one lane within Church Square for traffic and the travel direction is clock-wise. Diagonal on-street parking is provided on both sides of the lane. Palace Street is one-way north and has parallel on-street parking. Paul Kruger Street between Vermeulen Street and Church Square is one-way south. Illegal parking is common in this area even with some law enforcement to stop this practice. The parking supply at Church Square is 151 bays.

An example of the parking utilisation graphs prepared for each section is indicated in **Figure 7.4.1**.

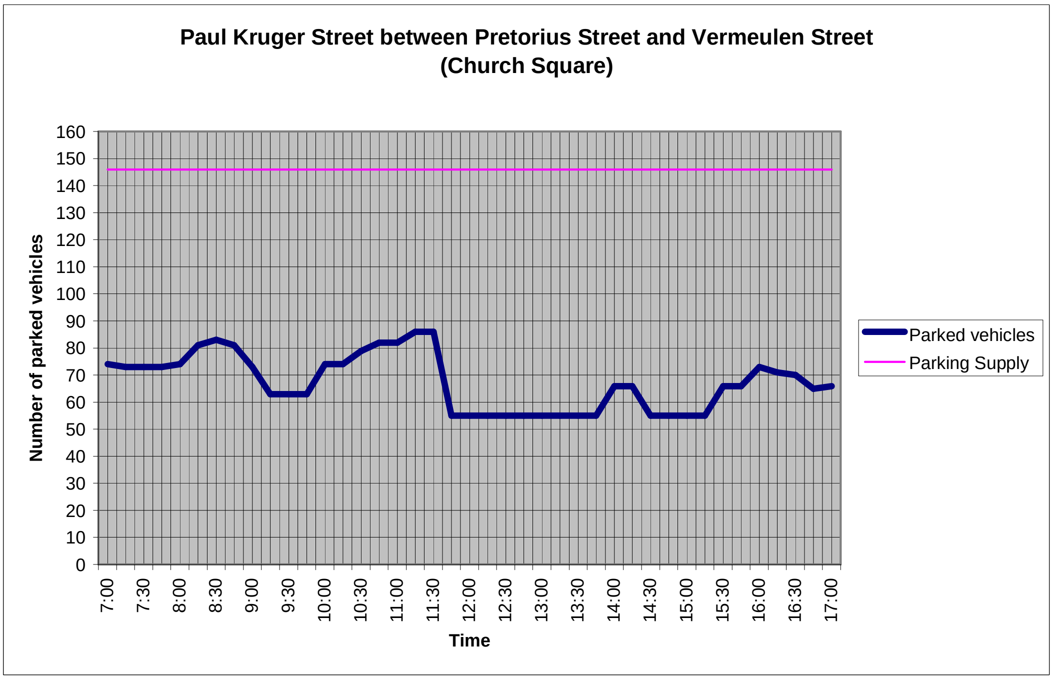


Figure 7.4.1: Example of cumulative parking demand and supply plot

The total number of on-street parking bays between Scheiding Street and Boom Street is 326 bays. The minimum and maximum parking demand between 07:00am and 17:00 on a weekday is 172 and 288 vehicles respectively. Therefore, when parking over the total corridor is considered, an oversupply of parking bays of 11% was observed during the survey period.

However the parking demand in the central area south of Church Square, from Minnaar Street to Pretorius Street, exceeds the parking supply. This area is generally mainly characterised by small shops situated on the ground floor of the multi storey buildings that align Paul Kruger Street.

The blocks between Scheiding and Minnaar, and Pretorius and Bloed Street, including Church Square, were generally not fully occupied with spare parking capacity throughout the day.

The overall parking utilisation is indicated in **Figure 7.4.2**, with individual sections detailed in **Annexure C**.

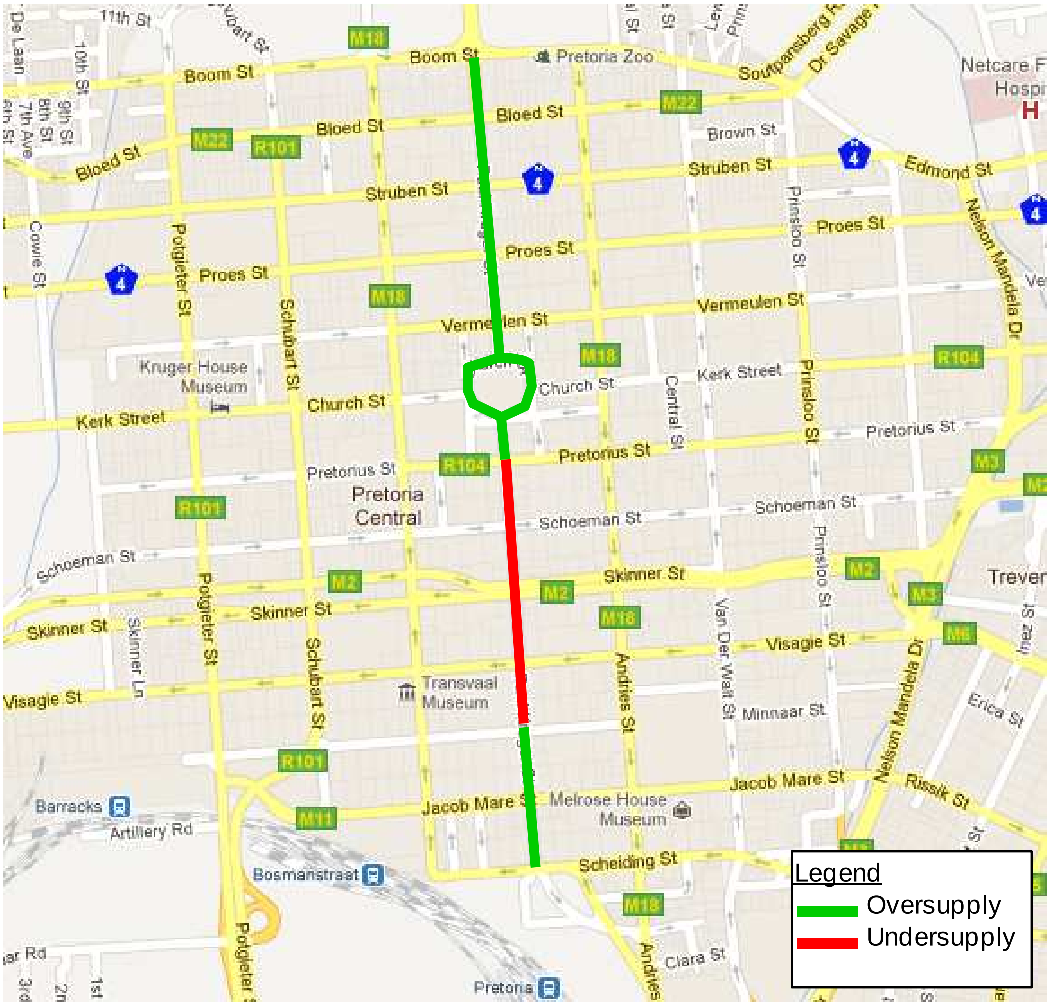


Figure 7.4.2: Parking Supply Summary

(b) Duration of Parking

The duration of occupancy was also determined from the survey data collected. This indicates the time that is spent by vehicles being parked in the study area. Histograms were prepared that indicate the distribution of parking duration (example indicated in **Figure 7.4.3**). Relatively short parking duration may be an indication of visitors (shoppers), pick-up and drop-offs, or deliveries. Longer parking durations may indicate visitors attending meetings, people who work in the vicinity such as shop owners who would park in front of their shops.

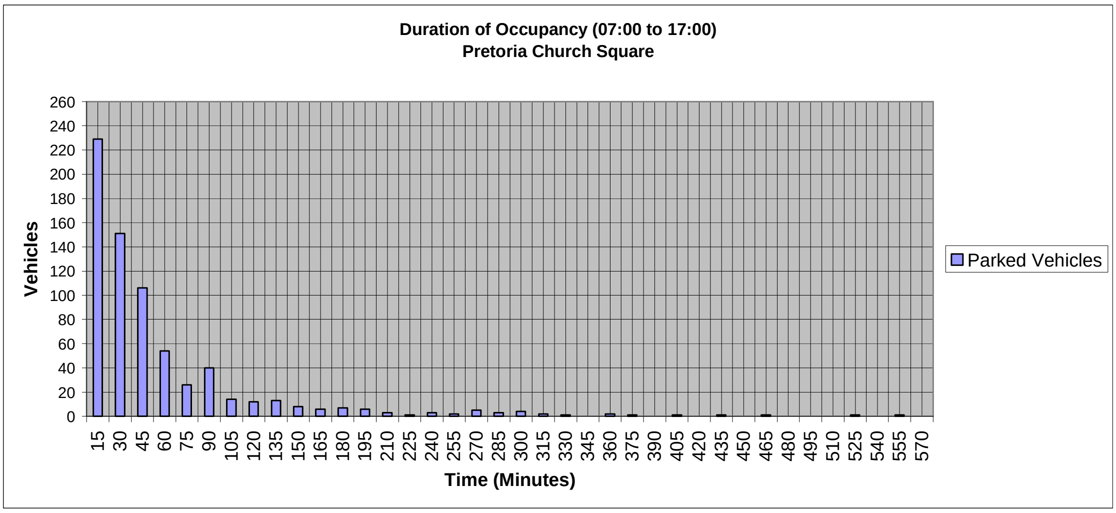


Figure 7.4.3: Example of cumulative parking demand and supply

90% of vehicles surveyed parked between one and two hours. Between 40% and 60% of vehicles surveyed parked for 15 minutes or less, indicating a high turnover of short term parking

Individual sections' parking duration is detailed in **Annexure C**.

Key conclusions are that the majority of on-street parking appears to be short-term, high turn-over, serving the businesses along the corridor. There is some spare capacity of Church Square, which means that the impact of the reduction in parking bays proposed here (approximately 20 bays) should not be significant.

However, alternative off-street parking should be sought to mitigate the proposed elimination of on-street parking bays, and clearly signed. The scope of the study did not include finding alternative off-street parking and checking the available capacity of this supply. It is proposed that this be addressed during the next stage of the project. It is estimated that approximately 180 on-street parking bays would be removed.

Provision is made for a recessed loading zone and dedicated bus and or taxi stopping area on each block. Note that the sidewalks are widened in between these bays to provide more pedestrian space, particularly at corners.

7.2.7 Future Public Transport Trips

Future public transport demand by BRT will depend on the operational design, which was not yet finalised at the time of completion of this report.

The critical unresolved issue that impacts on the traffic impact assessment is whether there will be a reduction in other bus and minibus taxi trips when BRT is implemented and if so by how much.

As no information could be provided by the operational planning team and demand estimation team regarding the rationalisation of competing public transport services, it was necessary to make assumptions in this regard, discussed in more detail in the Transyt modelling section.

7.2.8 Private Trips

The current private demand was estimated from the traffic counts. The private vehicle trips would also change once the BRT services are modelled, as there should be some diversion from private car to BRT. In addition, the changes in road capacity would also result in some traffic deviating away from the route onto parallel routes, and some peak spreading, to better balance traffic flows on congested sections. Ideally, this information should be an output from the demand modelling. In the absence of the demand modelling results, certain assumptions had to be made. These assumptions are discussed in more detail in **section 7.3** below.

7.3 Transyt Modelling Methodology

7.3.1 Network Coding

The study area was divided into four Transyt sections, mainly because of the variable nature of the corridors being modelled, and also to allow flexibility in the choice of fixed cycle times. In particular it was clear that sections north of the CBD, especially the Rachel de Beer and Doreen sections, were characterized by relatively few signalized intersections; priority intersections predominate on these sections, including four-way stops (which Transyt is not designed to model).

The sections of the Transyt model are:

- Section 1: CBD – Paul Kruger between Scheiding and Boom Street
- Section 2: Paul Kruger/Mansfield from Boom Street to M1/Lavender Street
- Section 3: Rachel de Beer from Koos de la Rey Street to Doreen Avenue
- Section 4: Doreen Avenue from Rachel de Beer to Soshanguve (M20)

The Transyt network was coded to reflect the existing 2011 typical weekday peak situations, in accordance with the periods surveyed for the traffic counts. Each intersection along the proposed BRT corridor was coded in accordance with typical accepted practices for Transyt models. This means that the base year intersection (called a node in Transyt parlance) was coded with the existing signal plans, including cycle time, number of stages, and green splits and inter-green times. These values were taken directly from signals plans as supplied by the City of Tshwane Metropolitan Municipality.

Transyt links were coded to reflect each unique turning arrangement on approach to the intersection. This means that Transyt links are not necessarily identical to the actual lane configuration on the ground, since a link can consist of more than one physical lane, if the turning/queuing characteristics of individual lanes are identical.

An example is shown in **Figure 7.4**, which shows the base year coding of Paul Kruger and Skinner (Transyt node 14). Note that in reality links 1426 and 1462 comprise 4 physical lanes but since they all only allow straight through movements and therefore cater for the same movement, they can be considered as a single modelled Transyt link, albeit with the appropriate capacity that reflects four actual lanes.

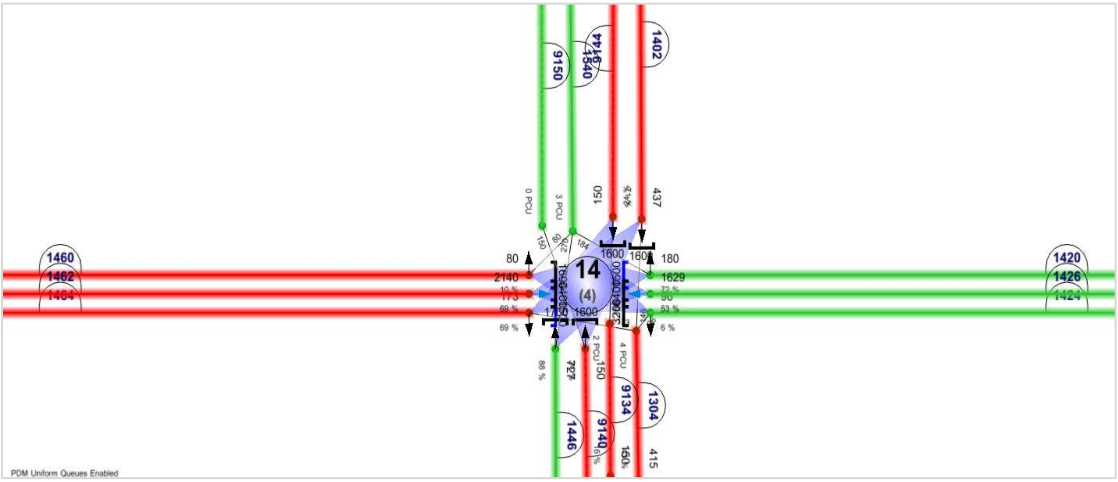


Figure 7.4: Example of Transyt Intersection coding

The following general assumptions were made for the base year model:

- Based on limited queue data and spot-check saturation calculations at some intersections, average peak hour saturation values for lanes at signalized intersections were set at
  - o 1600 PCUs/hour for through movements, including lanes with mixed through and turning movements;
  - o 1500 PCUs/hour for exclusive right-turn lanes
  - o 1600 PCUs/hour for exclusive left-turn lanes
- As part of the validation process, specific link saturation levels were adjusted upwards in order to improve the model accuracy and to reflect varying characteristics of specific link approaches at different junctions.
- Average free-flow link speed for non-freeway sections was assumed to be 50kph. Average free-flow speeds for some roads such as M1 between Paul Kruger/Mansfield and Lavender, were assumed to be 70 kph.

- Start and end displacements on signalized links was assumed to be 2 and 3 seconds respectively. Some links, mostly right turn links, were modelled with 2 to 3 extra seconds end displacement in order to enable right turners to clear the intersection and prevent excessive queuing to occur on these links, which the surveyed counts clearly indicate was not happening.

7.3.2 Traffic Flows

For the purposes of the Transyt modelling, peak hour counts were converted to equivalent Passenger Car Unit (PCU) values and input directly into the Transyt model. PCU values used were:

- 1.0 for light vehicles and minibus-taxis
- 2.0 for heavy vehicles
- 2.5 for buses (including BRT buses).

Where classified counts were unavailable estimates of vehicle mix were made and an overall factor applied to the unclassified count. For intersections that were uncounted (this applied mostly to minor non-signalised intersections on the Rachel de Beer and Doreen to Soshanguve sections) estimates of main corridor counts were made from upstream and downstream counted intersections and realistic estimates of turning volumes from the minor arms were made.

Allocation of counted upstream volumes to downstream links were made using simplifying assumptions about the degree of lane switching that would have been likely to occur. On CBD links, given their relatively short length, the general assumption was that lane switching would be minimal and that no vehicles would turn from an upstream intersection with a view to turning back in the direction it came from at the downstream intersection.

7.3.3 Signal Settings

Signal settings for all signalised intersections along the modelled corridor were obtained from the relevant authorities.

As an illustration, **Figure 7.5** shows the signal stages for node 14.

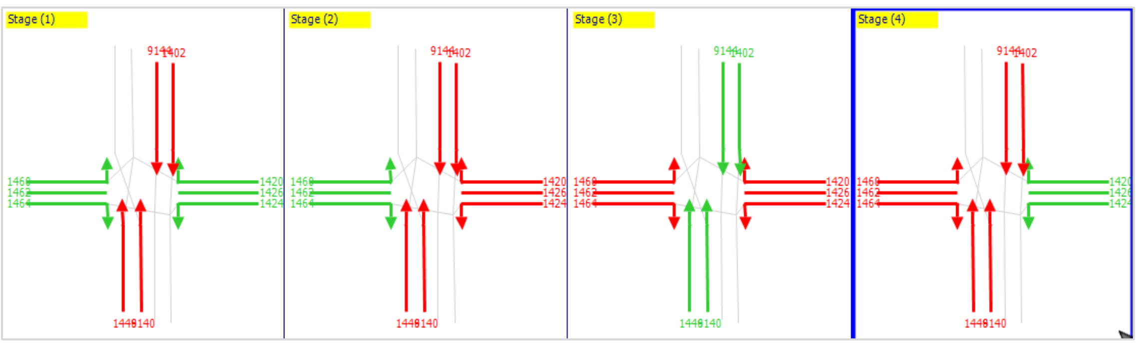


Figure 7.5: Example of Signal Phasing at Node 14

7.3.4 Base Year Model Validation

Since Transyt is exclusively an urban-area model designed to model coordinated fixed signal systems which assumes either 100% signals at all intersections or limited numbers of non-signalised intersections, and the validation of the model can only be realistically achieved in such areas, the validation exercise was carried out on the section that best characterized this, namely the CBD section from Scheiding in the south to Boom in the north, and the adjacent section north of Boom out to D F Malan/M1. These sections were originally kept separate in the base year because they had different fixed cycle times of 75 and 90 seconds respectively.

The diverse nature of the entire modelled corridor meant that it was not practical to validate all intersections with directly observed calculations. In fact, Transyt model validation is rarely attempted across an entire network, since this would prohibitively time-consuming and of limited worth. Standard practise with Transyt models is that only a representative selection of typical intersection types in the study area be selected for validation purposes and critical parameters, particularly saturation levels, then be applied to similar intersections in the area, with individual adjustments applied as part of the validation process.

The road network outside of the CBD area, especially from Rachel de Beer through Doreen to Soshanguve, is characterised by relatively few signalised intersections, most of which are isolated with non-signalised priority intersections upstream and downstream of them. While Transyt can model priority intersections, these are not typically considered to be critical intersections in the model since they do not involve factors such as platooning and linked intersection parameters such as offsets or common cycle times. Also, Transyt cannot properly model four-way stop intersections and these have to be modelled as more conventional priority intersections with, in the case of this study, the BRT corridor links being regarded as the major arms and the non-BRT links as the minor.

For these reasons, validation of the network was carried out for selected intersections in the CBD section only. The saturation levels were then applied to other intersections. The base year model was then adjusted on a node-by-node basis in order to adequately reflect observed conditions.

Validated critical model parameters – most importantly lane saturation values – were obtained for the CBD sections and these were applied to the other sections directly.

The AM peak hour model was run and went through a series of fine-tuning adjustments to individual intersections to improve the model results compared to observed counts. In addition, modelled average travel times along the corridor were compared with surveyed travel times and further adjustments made, particularly to the modelled average link speeds, to ensure modelled times were in line with surveyed times. After the completion and fine tuning of the AM peak hour model the PM peak hour model was also run.

7.3.5 Description of Future Year Scenarios Modelled

The base year Transyt model was modified to reflect the situation with a BRT service added to the existing network. Since Transyt models intersections only, no direct modeling of mid-link was undertaken. However, cognizance of potential mid-link capacity issues was taken. Also, where the introduction of a mid-link BRT station was planned, this was modelled in Transyt as a new ‘bottleneck’ node with a two-stage signal setting and a minimum pedestrian green time of 12 seconds.

BRT free-flow speeds were set to a standard 40kph and BRT lane saturation levels were set to 1600 PCUs/hour. An hourly service frequency of 60 buses (150 PCUs) was assumed throughout the corridor.

In the absence of data on existing bus and minibus-taxi routes and frequencies, no competing public transport route removal along the BRT corridor was carried out. While the classified counts give an indication of average bus and minibus-taxi volumes at intersections along the route, what is needed in order to make a realistic analysis of which current services are likely to be in direct competition with BRT is knowledge of each service’s actual route along the corridor. In the absence of such data all existing routes were left in the model, even though this means that there is a likely overestimation of total demand.

Similarly, potential mode shift from private car to BRT was not assumed, again resulting in a probable overestimation of overall demand in the model.

For the road network, the general approach was to assume existing intersection capacities would be unchanged, i.e. no additional lanes would be added, and saturation values would remain as per the base year. (Note again that this applies only to the intersections; it is assumed that capacity along the roads themselves are adequate to cater for the modelled demand. Since there may be additional lanes at intersections that do not occur on the roads in between, this may not necessarily be correct.)

The exception to this was in several CBD intersections which currently permit on-street parking. While in the base situation the left-hand lane was either omitted entirely to traffic due to the presence of parked vehicles (although the validation process would adjust the capacities of left hand lanes to allow some vehicles to queue to the left) this lane was assumed to be available when the BRT was in place.

The existing middle lane on the approach with the BRT was dedicated to BRT traffic only, where this was considered feasible. This had the biggest impact on right-turning maneuvers, although other movements were affected. The following alterations were modelled, depending on location and the available capacity:

- Because of the grid-like nature of the network - meaning that alternative convenient routing options were generally available - all CBD right-turning movements along Paul Kruger in both directions between Boom and Scheiding were eliminated. These trips were manually reallocated to other intersections, usually by converting them from right turners at the upstream intersection to left turners at this same intersection and then through movements at the next available downstream intersection. In the absence of a strategic-level model to assist in the determination of actual re-routings, this assumption was considered to be acceptable. However, note that all right turning volumes were reallocated to the Transyt network, whereas in reality it is likely that some or all of these trips would reallocate to less localised routings, many disappearing from the BRT corridor completely.
- Outside of the CBD, the model configuration was determined based on practical limitations. Eliminating all right turns was not feasible in these areas because unlike in the CBD, the availability of practical alternatives was often not available. Therefore, the treatment of right turns was modeled as discussed in more detail in **Section 7.4**.

Also, where BRT stations were likely to be built away from intersections along a link, the Transyt network was modified to show this. Since passenger volumes were not known, it was assumed that mid-link stations would be signalized in order for pedestrians to access the platform and pavements from the station. The Transyt network was changed to include a nominal 12 second red period for buses and other vehicles at this point, even though explicit pedestrian movements were not modelled.
Peak hour BRT volumes were assumed to be one per minute frequency, giving a modelled Transyt volume of 150 PCUs per hour.

7.3.6 Future Year Mixed Traffic Flow Adjustments

Critically for the study, Transyt is a fixed-demand model, which means it cannot reassign/reroute demand based on prevailing conditions across the network in the manner that a standard transportation model such as EMME or SATURN can do. In order to account for this deficiency, certain assumptions were made regarding the likelihood of traffic rerouting or reducing along the BRT corridor.

Where the existing capacity of an intersection is reduced as a result of BRT-related interventions, it is likely that the flow of mixed traffic will change from what is currently observed (from the traffic counts). Changes may be due to

a) Reduced numbers of buses or taxis if the BRT will replace certain licensed routes
b) Reduced numbers of private cars if there is a modal shift to BRT
c) Reduced numbers of vehicles travelling via the BRT route due to traffic deviating to alternative routes and
d) Reduced numbers of vehicles travelling via the BRT route during the peak hour due to peak spreading

As the demand modelling and BRT service design, and its impact on existing public transport services, is not known at this stage, it is not possible to estimate the impact of a) and b). Traffic deviation (re-assignment of traffic to alternative routes as a result of the capacity on a particular route being reduced) can only be modelled in a larger scale strategic *network* model, which was not available during this study.

7.4 Treatment of Right Turns and Conflicting Bus Turns

Where it is not feasible to eliminate mixed traffic right turns, right turns can be accommodated in one of the following three ways, indicated in **Figures 7.6A – 7.6C**:

- **Option 1:** An additional right-turn only stage is added to the signal plans. This reduces the capacity of the intersection and also impacts on the BRT since both BRT and through trips are on a red phase during this additional right-turn stage
- **Option 2**: Sharing of middle lanes by BRT and other traffic either by installing upstream pre-signals that would give priority to BRT vehicles, thus allowing them to get through the downstream intersection before right-turning traffic, or merging right turning and BRT vehicles at the intersection.
- **Option 3**: Mid-link weaving to allow right turners to arrive at the intersection in a dedicated right turn lane, with BRT vehicles in the outside lane

The same solutions can also apply for other conflicting movements such as the bus needing to turn left from the median lane.

Options 1 and 2 reduces capacity for BRT and mixed traffic, but is preferred by some traffic engineers as it is perceived to favour BRT since BRT do not need to merge and mix with general traffic as in Option 3. In instances of high conflicting traffic volumes, the weaving solution may however result in some BRT delay.

In November 2009, the City of Johannesburg requested an expert opinion from internationally recognised BRT traffic engineer Mr Pedro Szazs regarding which of the above options are optimal for Rea Vaya. Mr Szasz was responsible for compiling the majority of the traffic engineering chapters of the “Bus Rapid Transit Planning Guide” (June 2007), published by the Institute for Transportation and Development Policy (ITDP).

Mr Szasz’ professional opinion is summarised in the Sections following (full report available on request).

Figure 7.6A: Option 1: Signalised right turn phase

Figure 7.6B: Option 2: Right turns allowed through Pre-signal

Figure 7.6C: Option 3: Right turns allowed through merge and cross-over

7.4.1 Mixed Traffic turning right

Two options are possible namely:

- With a traffic signal, with BRT stopped while mixed traffic turns and
- weaving mixed traffic and BRT buses at a convenient point before the intersection (by interrupting the BRT lane) and starting the BRT lane again after the conflicting movements have separated into the correct lanes. The BRT lane is preferred to start again before the signal, but sometimes is only started again after the intersection.

The first solution is the more usual and has been applied in most BRT systems (including Rea Vaya). Two examples in Sau Paulo are noted namely:

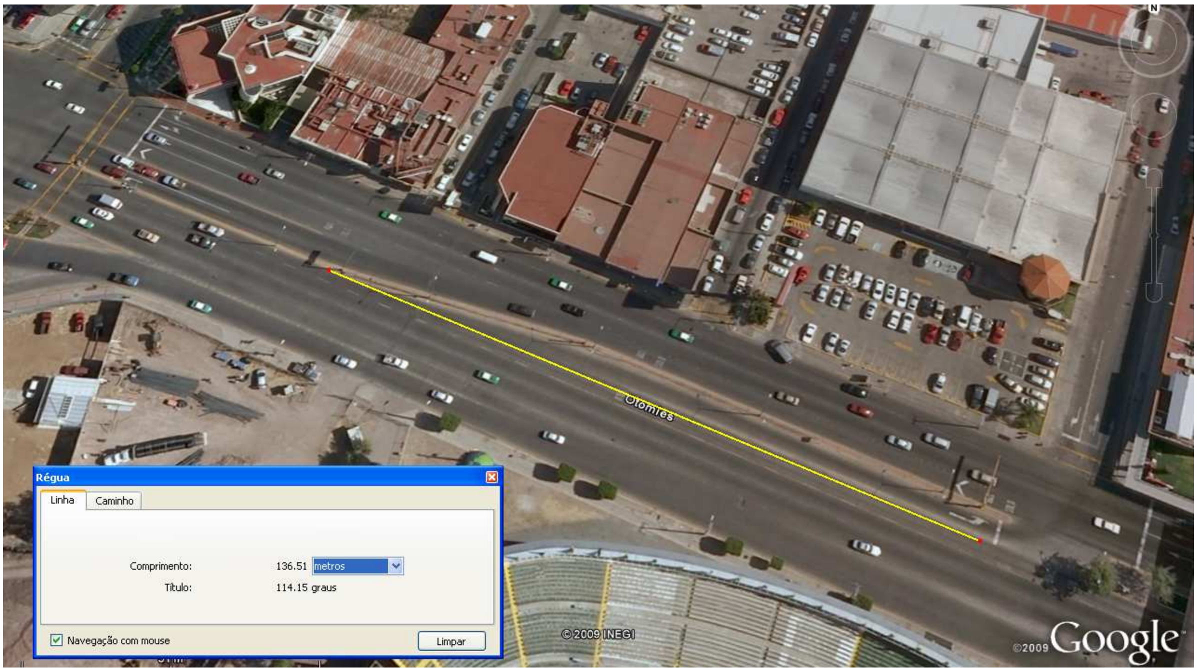
- **Santo Amaro Avenue**: two phases: 250 buses x 800 turning pcu
- **Sao Paulo- Consolaçao Avenue**: 130 buses x 800 turning cars, two phase

Mr Szasz strongly recommends that an island is built to separate the two flows if this solution is adopted.

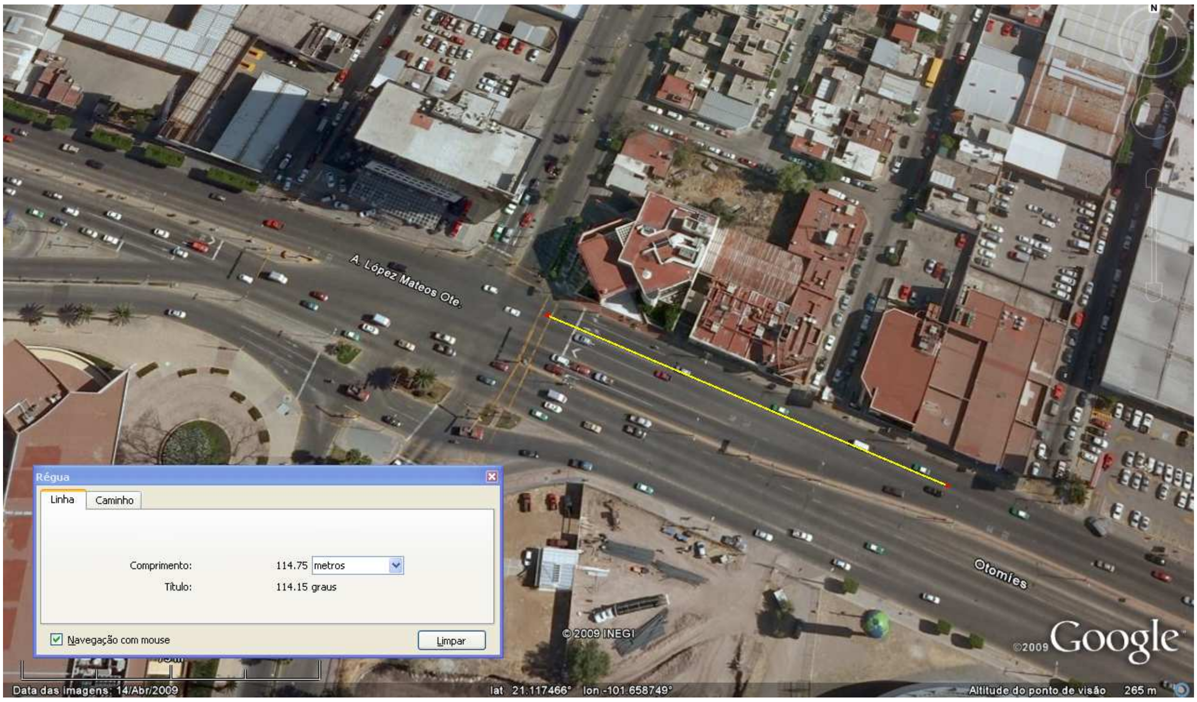
Examples of application of the second option are noted, namely

Sao Paulo: Consolacao Avenue, Bus=130, cars=1800- two phases. In this case, there are two successive near left turns with around 900 cars/hour each. There are also buses that turn, so the traffic is mixed on the weaving section and the bus ways starts again after the second left turn signal.

Leon –Mexico 60 buses x 200 cars two phases



Leon – Mexico 60 buses x 1200 cars- Two phases



On this corridor on Leon almost all conflicting movements (significant traffic volumes) are accommodated through the weaving process. Some of them have very high volumes and eventually get congested, and the bus may experience some delay.

Mr Szasz proposed this solution in 2001, when the corridor was implemented, and another consultant, when revising the project in 2007, was of the opinion that the solution was dangerous, and recommended that it be changed to a signalised scenario. The solution is therefore polemical without a standard established.

The two solutions compares as follows:

(a) Delay and Capacity

Both solutions can deal with considerable high volumes. Weaving usually would have greater capacity, but this advantage are not usually realised because, after weaving, turning cars need to stop on a signal for a long time before crossing, so this time can be used anyway for buses to cross.

The defenders of not weaving therefore argues that if cars need to stop anyway, why allow weaving, if all cars will stop on the signal and buses could pass without any problem?

There is a difference on delay for buses, because after weaving, buses have one conflict less at the signal, or more green time, and therefore less delay.

This difference is expressed by:

Extra Delay= TC*(px^2+2*px*py)/(2*(1-Vb/Sb)

Where
TC= cycle time
.px= fraction of cycle used on turning movement (including intergreen times)
.px= fraction of cycle used on other bus conflicting movement (including intergreen times)
Vb= bus flow
Sb= bus saturation flow

Note: this formula is valid only where the right turn has a special phase that is not shared with other bus conflicting movements (like an opposite right turn).

For a cycle of 100 seconds this extra delay would be as indicated in **Table 7.4.1.1**.

Table 7.4.1.1 Extra delay (sec) avoided for weaving buses and left turn before intersection

car turning volume/lane	Other conflicting movements cycle fraction (include intergreen)*					
	0%	10%	20%	30%	40%	50%
100	1	3	5	6	8	10
200	3	5	8	11	13	16
300	5	8	12	15	19	22
400	7	12	16	21	25	30
500	11	16	22	27	32	38
600	15	21	27	34	40	46

* movements that conflicts with cars right turn and BRT bus lane.

Therefore the extra delay is more significant when -

- the conflicting movement has a high volume and
- there are other movements that requires additional red time for buses.

Based on the delay, the weaving should be preferable in cases that imply generally high saturation.

The disadvantage of weaving is that there is an amount of extra time on the weaving operation itself, estimated in **Table 7.4.1.2.**

Table 7.4.1.2: Extra delay (sec) for buses, due to the weaving with turning movement before intersection

car turning volume/lane	bus lane volume									
	20	40	60	80	100	120	140	160	180	200
100	0	0	0	0	1	1	1	1	1	2
200	0	0	1	1	1	1	2	2	2	3
300	0	1	1	1	2	2	2	3	3	3
400	0	1	1	2	2	3	3	3	4	4
500	0	1	1	2	3	3	4	4	5	5
600	1	1	2	2	3	4	4	5	6	6
700	1	1	2	3	3	4	5	6	6	7
800	1	2	2	3	4	5	6	6	7	8
900	1	2	3	4	4	5	6	7	8	9
1000	1	2	3	4	5	6	7	8	9	10
1200	1	2	3	5	6	7	8	9	11	12

Comparing the two tables it can be concluded that the additional delays due to weaving are usually much less than subsequent bus delays incurred in the signalized solution.

The other possible disadvantage with weaving would be congestion on the right turn movement, so mixed traffic would be queueing up before the intersection and this congestion will affect buses also. This may also happen on signalised crossings, blocking intersections but on weaving, the common area shared is longer so this effect might be greater.

(b) Safety

On weaving the conflicts are proportional to the product of bus x car volumes. More common accidents are damage only accidents with fatalities rare.

On signals, accidents occur usually during the phase transitions or at random when volumes are lower. Accidents may have more gravity and there is no direct correlation with volumes.

If it is assumed that

Caw= Accidents cost with weaving = K*Vb*Vc

Where
K= constant
Vb= bus volumes
Vc= car volumes

and

Cas= Accidents cost with signal= constant.Ks

Then, a signal would be recommended when Cas < Caw

Therefore, use a signal when Vb*Vc>Ks/K= KL

The values of the presumed constants Ks and K are unknown, and if the delays and also some dependencies of Ks and K on the volumes are included, a much more complicated formula will be obtained, with more unknown constants that would not help.

At the end of the day, in the absence of data, Mr Szasz prefered to assume the previous formula and assume a value of KL that seems reasonable namely KL= 50 000, resulting in the values in **Table 7.4.1.3** and graph in **Figure 7.5A**.

Therefore: for

Vb*Vc > 50 000 signal
Vb*Vc < 50 000 weaving

Table 7.4.1.3: Signal vs Weaving Choice, Volume Limits

Signal x weaving choice,: volume limits					
cars	buses	cars	buses	cars	buses
200	250	1000	50	2200	23
250	200	1100	45	2400	21
300	167	1200	42	2600	19
350	143	1300	38	2800	18
400	125	1400	36	3000	17
450	111	1500	33	3200	16
500	100	1600	31	3400	15
600	83	1700	29	3600	14
700	71	1800	28	3800	13
800	63	1900	26	4000	13
900	56	2000	25		

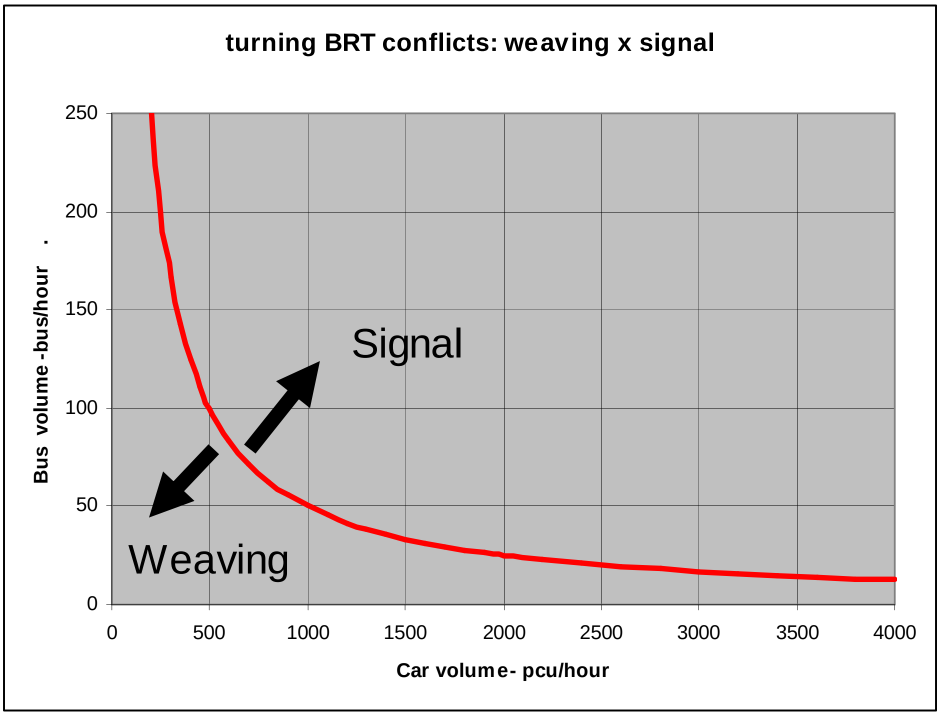


Figure 7.5A: Turning conflicts: Weaving Vs Signal

The above criteria has some theoretical support, on the shape of the curve, but not on the actual value of 50 000, adopted by Mr Szasz based on engineering judgment.

It would be more correct to say that Csw=Vb*Vc/50 000 = signal to weaving preference index, giving an idea of the choice. Locations with high Csw would be more likely to solve Bus and mixed traffic conflict using a signal and those with low values should use weaving. Mr Szasz's recommendation for Rea Vaya was to use a signal when Csw>1 and weaving when less.

For the Tshwane operational BRT frequency of 60 buses per hour assumed, using the above criteria, weaving would be recommended for conflicting mixed traffic right turn volumes in excess of 800 pcu/hour. This high right turn volume is only observed at one intersection namely the right turn from the south into Lavender Street, in the afternoon peak.

7.4.2 BRT Buses turning left

The conflicts are quite similar to that discussed in **Section 7.4.1**. There are some peculiar differences on speed, volumes, lanes to be crossed, dangers, and space available, but at the end of the day it does not seem to change the previous criteria and Mr Szasz therefore also recommend the same criteria namely:

Vb*Vc > 50 000 signal
Vb*Vc < 50 000 weaving

Again this is only a general indication. There are cases of greater volumes where signals is recommended but there are no space at the intersection for additional lanes for the extra exclusive lanes for turning, that should be solved by weaving. Other cases with small volumes may have no distance available for weaving so the signal have to be used.

7.4.3 Pre-signals

Pre-signals may have the following advantages over weaving:

1- Less horizontal distance: weaving may require up to 250 meters, and pre signals usually not more than 100 meters before the signal
2- Control of congestion: in cases of heavy congestion ahead, weaving may represent a considerable delay for buses, and a pre signal may control mixed traffic to transfer this congestion to behind the pre-signal stopline

However, pre-signals has some important disadvantages:

1- The pre-signal has the same disadvantages as the normal signal ahead, with considerable additional delay for buses.
2- The signal is different from the usual and is not particularly safe for pedestrians, that may walk when cars are stopped (bus buses are going)
3- The signal may be disregarded by motorists, because it is not a normal one, and there may be no apparent reason for it from the motorist's perspective. If it is ignored, it may pose a danger and be useless without enforcement

As enforcement and obedience seems not to be a strong point in South Africa, Mr Szasz considered the disadvantages mentioned enough to not implement them now, instead recommending weaving, that is simpler.

It is noted that Mr Szasz's position is not against pre-signals, as it is deemed a possible effective tool against heavy congestion. However it would be possible to change weaving implemented now to a pre-signal in future, if and when warranted.

7.4.4 TRANSYT modelling Scenarios of Right Turns

On Section 1, all right turns were eliminated. On Section 2, right turns were accommodated by way of an additional right turn stage (option 1).

On sections 3 and 4, two scenarios were modelled, namely:

- **Scenario 1**, where most intersections with right turning traffic are modelled as 3-stage signals, including an additional right-turn only stage (option 1)
- **Scenario 2**, where most intersections with right turning traffic are modeled as 2-stage signals, with right turning traffic merging midblock across the BRT lane (option 3)

In both the above scenarios, intersections with stations located immediately up- or downstream, were modelled as pre-signals. Furthermore, not all intersections were modelled as 2-stage signals in the second scenario (option 3), there were instances where a protected turning stage is still required to accommodate high right turns, however the right turning traffic are allowed to cross over the BRT lane by means of allowing a midblock weave.

The intersection configuration modelled are summarised in **Tables 7.4.2A** and **7.4.2B**. The stage diagrams for each section of the BRT route is provided electronically but due to the bulky nature of the information it was not printed.

Table 7.4.2A: Intersection Scenarios – Section 3

Node No.	Intersection Name	Scenario 1 - 3 Phase Signals	Scenario 2 - Merge
44	Koos De Le Rey	LILO	LILO
45	Jan van Riebeeck	3 Stages - no exclusive right turn phase	Merge - 2 Phases
46	General Beyers	LILO	LILO
47	Danie Theron	LILO	LILO
48	Ben Viljoen	Proxy presignal	Merge - 2 Phases
49	Emily Hobhouse	Proxy presignal	Merge - 2 Phases - Double Cylce
50	Burger Street	Proxy presignal	Merge - 2 Phases - Double Cylce
51	Eufees St	LILO	LILO
52	Jack Hindon St	LILO	LILO
53	West St	LILO	LILO
54	Daan De Wet	Proxy presignal	Merge - 2 Phases
55	Narda St	Proxy presignal	Merge - 2 Phases
56	Francois St	Proxy presignal	Merge - 2 Phases
57	Makkie St	LILO	LILO
58	Grafenheim	3 Stages with right turn phase	Merge - 2 Phases
59	Waterbook	Proxy presignal	Proxy presignal
60	Willem Cruywagen	3 Stages with right turn phase	3 Stages with right turn phase
61	Main St	LILO	LILO
62	Sylvia St	3 Stages with right turn phase	Merge - 2 Phases
63	R80 East Terminal	3 Stages with right turn phase	3 Stages with right turn phase

64	R80 West Terminal	3 Stages with right turn phase	3 Stages with right turn phase
65	Heinrich Avenue	Proxy presignal	Proxy presignal

Table 7.4.2B: Intersection Scenarios – Section 4

Node No.	Intersection Name	Scenario 1 - 3 Phase Signals	Scenario 2 - Merge
67	Brits Road	Pre-Signal + 3 Stage signal	Pre-Signal + 3 Stage signal
69	1st Avenue	Pre-Signal + 3 Stage signal	Merge + 3 Stage Signal
71	Hulton Street / Jensen Street	Pre-Signal + 3 Stage signal	Pre-Signal + 3 Stage signal
72	Oaklands Street	Non Signalised	Non signalised
73	Pine Street	Non Signalised	Non signalised
74	Daan De Wet Nel Road / Garden Road	3 stage	Merge + 2 Stage
76	Van Niekerk Street	Pre-Signal + 3 Stage signal	Pre-Signal + 3 Stage signal
77	R 566	3 Stage Signal	4 Stage Signal
78	Fred Otto Street	3 Stage Signal	Merge + 2 Stage
79	De Waal Street	3 Stage Signal	Merge + 2 Stage
80	Piet Pretorius	3 Stage Signal	Merge + 2 Stage
81	Kitshoff Street	3 Stage Signal	Merge + 2 Stage
82	Tungsten Drive	3 Stage Signal	Merge + 3 Stage Signal
83	Road 9	3 Stage Signal	Merge + 2 Stage
84	Road 8 (km 5.74)	Pre-Signal + 3 Stage signal	Merge + 2 Stage
85	Road 7	3 Stage Signal	Merge + 2 Stage
86	Hebron Road	3 Stage Signal	3 Stage Signal

7.5 Definition of Performance

The following definitions from the Highway Capacity Manual (TRB, 2001) are used in this Section:

Capacity The maximum hourly rate at which vehicles can reasonably be expected to traverse a lane or roadway during a given period under prevailing traffic and control conditions.

Volume The hourly rate of vehicle arrivals at an intersection.

Degree of Saturation (DOS) The ratio of volume to capacity (VOC) also referred to as the saturation flow rate.

Level of service Level of service is defined in terms of delay. Delay is a measure of driver discomfort, frustration, fuel consumption and lost travel time. The levels of service for signalised and non-signalised intersections as defined in the Highway Capacity Manual (HCM) are tabulated in **Table 7.4.1.**

Table 7.4.1 HCM Level of Service Definitions for Vehicles

Level of Service	Rating	Control delay per vehicle in seconds, d (including geometric delay)	
		Signals and Roundabouts	Stop Signs and Give-Way (Yield) Signs
A	Excellent	d < 10	d < 10
B	Very Good	10< d < 20	10< d < 15
C	Good	20 <d<35	15 <d<25
D	Acceptable	35<d<55	25<d<35
E	Poor	55<d<80	35<d<50
F	Very Poor	d >80	d >50
Note: An intersection is deemed to be operating acceptably at levels of service A to D Source: TRB, 2001			

7.6 Transyt Modelling Results

7.6.1 AM Peak Period

(a) Traffic Flow Adjustments and Scenarios modelled

In the absence of estimates from larger-scale strategic models, or other suitable sources of potential trip diversion and reassignment, manual adjustments were made to the counted 2011 traffic volumes along the corridor concerned.

Traffic flow adjustments made to each of the four sections for the AM peak hour are briefly described below.

(i) Sections 1 to 2: CBD – Paul Kruger, Mansfield and M1

Several incremental adjustments were made to counted southbound (morning peak direction) volumes on Mansfield and Paul Kruger between the M1 DF Malan and Boom Street. In the absence of any guidance as to where these trips might return to the affected corridor, it was assumed that they would re-enter the corridor between the section south of Boom and Scheiding and not at any specific downstream intersection. For practical purposes, these trips were not reintroduced at any specific point, meaning there is an artificial 'jump' in demand on Paul Kruger southbound at Boom.

The incremental adjustments were made with a view to obtaining a network that was less oversaturated than with the full counted volumes. The adjustments were:

- Reduction of southbound through volumes by 200 PCUs. These 200 vehicles were added to the right-turn demand onto DF Malan at the DF

Malan/Mansfield intersection, and were therefore removed from the Transyt analysis.

- Reduction of southbound volumes by 200 PCUs plus a further reduction in steps of 10%. This was done for reductions of 10, 20 and 30%.

(ii) Section 3: Rachel de Beer from M1 to Doreen Avenue

For section 3 of the BRT link (R513/Rachel De Beer) a 30% reduction on trips was applied to the counted volumes on the section between Narda Street and Koos De Le Rey Street. The main reason for the reduction was due to the reduction of capacity on this section as a result of the introduction of an exclusive BRT lane. Currently, two lanes per direction are provided along this section. One of these will be converted to BRT, leaving only one lane for mixed traffic.

The 30% reduction in counted volumes was applied on both the west-east (AM peak direction) and the east-west direction. The counted traffic volumes on this section are relatively high for both directions in the AM Peak.

- West - East Diversions - A 30% reduction between Narda Street and Koos De Le Rey Street resulted in 300 PCUs being diverted from the west-east direction. In order to apply this reduction it was assumed that 30% of all southbound trips between the R80 East ramp terminal and Francois Street will not use Rachel De Beer. Instead these trips will divert on to the R80 or alternatively use President Steyn Street directly onto M1. As such the traffic was not reintroduced on the downstream intersections. However the full counted volumes at M1 north and south of Lavender are kept since the traffic would use this route into Pretoria CBD.

- East West Diversions - From the east–west direction the same principle was applied were 30% of the westbound trips were removed from the Transyt network. This implied that 261 PCUs were also diverted at Koos De Le Ray from the westbound straight movements. The trips are also not reintroduced on downstream intersections. The reduction was also applied between Koos De Le Rey and Narda Street.

(iii) Section 4: Doreen Avenue from Rachel de Beer to Soshanguve (M20)

The traffic volumes on the sections north of the intersection of Doreen and Rachel De Beer was not reduced although some reduction can be expected, if not due to diversion, then due to an expected modal shift towards BRT resulting in a reduced number of other public transport vehicles on the road. The actual traffic impact is therefore likely to be slightly over stated in the Transyt results and may be slightly less than modelled.

(b) Modelled Performance by Section

This section provides a summary of the analysis results for the intersections which performed poorly together with the mitigation measures which have been proposed to improve the operation of the intersection in the AM peak. Summary Transyt results tables are provided in **Annexure D** with full Transyt output files provided electronically.

(i) Sections 1 to 2: CBD – Paul Kruger, Mansfield and M1

At 70% of full demand some sections of the corridor were still over-capacity. However, it was decided that any further incremental reductions would not be meaningful in the absence of more concrete reasons beyond just artificially creating a scenario that achieved an under-saturated network. Sections still modelled as over-capacity at this level of demand are (all southbound AM peak direction and leaving out some minor road turning capacity issues):

- M1 north and south of Lavender (since no reduction of demand was made until the intersection of M1 and Mansfield, the full counted volume was kept on this section). The through north and south through movements are marginally over capacity (100% and 102% respectively)
- Mansfield and van Rensburg; (right turns on the east and south approach)
- Mansfield between Booysens and Franzina (running at capacity);
- Bloed Street (already at capacity in existing scenario, also evident in the travel time survey graphs) and reduced demand was not applied to intersections south of and including Boom.
- Franzina (right turn on west approach, may divert to other intersections, such as the right turn at Paul Kruger and Mansfield)

The AM Peak average intersection level of service and delay are provided in **Figures 7.6.1 to 7.6.4 (am) at the end of Section 7.5.1**. The BRT delay (seconds) in the peak direction, is also shown in the second Figure.

It is recommended that the feasibility of increasing capacity on the eastern approach of Bloed Street / Paul Kruger intersection be assessed during detail design, e.g. by widening to provide an additional lane at the intersection.

(ii) Section 3: Rachel De Beer from M1 to Doreen

On this section, several intersections were modelled as left-in, left-out (LILO), while at other intersections, the right turns were banned, as indicated schematically in **Figure 7.6**.

In all the scenarios modelled, the main problem intersections from a performance point of view are:

- Emily Hobhouse/Rachel De Beer Street

Even though a 30% reduction of counted volumes has been applied, right turn movements from the west are banned and a double cycle (45 seconds as opposed to the general corridor cycle length of 90 seconds) is modelled, the intersection still performs at a Level of Service F, due to the western approach being at capacity (saturation 109%).

In practice, it is likely that more traffic may deviate away from the route, to avoid this congested point. Alternatively, this intersection should be changed to operate as a left in left out, i.e. the right turns from the eastern approach should be banned (which may not be acceptable to affected stakeholders).

The BRT however does not experience significant delay at this intersection (16 seconds). The mean maximum queue on the eastern approach right turn lane is 8 PCU's (or approximately 40m), which indicates that at the modelled right turn volume, the right turning traffic, which merge across the BRT lane, would be unlikely to block the BRT lane (shared lane 60m).

Figure 7.6 Modelling of Right Turns on Rachel de Beer

- Burger Street/ Rachel De Beer Street

  A 30% reduction of counted volumes is applied, right turn movements from the east are banned (due to the station location) and a double cycle is applied at this intersection. The overall level of service achieved is D, due to the right turn on the eastern approach operating at LOS E (degree of saturation 98%). However there is no excessive delay to BRT.

  The mean maximum queue on the western approach right turn lane is 3 PCU's (or approximately 15m), which indicates that at the modelled right turn volume, the right turning traffic, which merge across the BRT lane, would be unlikely to block the BRT lane (shared lane 60m).

  Several iterations of three-stage signal plans were also tested but in all the intersection performed poorly. The 2-stage merge scenario is deemed the only feasible solution.

- Narda Street/Rachel De Beer Street

  Even though a 30% reduction of the counted volumes is applied, the intersection still performed at a Level of Service F, as a result of the LOS F on the Western approach, due to the downstream reduction from two lanes to one lane. This approach is however only marginally over capacity (106%) and may operate at an acceptable LOS if a somewhat higher diversion than 30% materialise in practice. The right turn at this intersection cannot be banned as it provides an important access to areas south of Rachel de Beer from the west, since right turns on Rachel de Beer is banned at most intersections.

- Intersections with pre-signals

  The intersections of Rachel de Beer with Narda, Waterbok and Heinrich Roads have been modelled as pre-signals. While the level of service (LOS) for mixed traffic is fairly good at these intersections, BRT delays in **Figures 7.6.6** and **7.6.8 (am) at the end of Section 7.5.1**clearly indicate that it is at the cost of BRT delay (37, 62 and 34 seconds respectively). This is because the pre-signal configuration gives only a limited green time to the BRT movement.

  In comparison, at intersections with 2-phase signals, and right turning vehicles and buses share or merge across, the BRT delay is less, even at the congested intersections of Emily Hobhouse and Burger Streets.

  It should be noted that Transyt only models fixed time signals and can therefore not model active bus priority. With active bus priority, the modelled BRT delay at these pre-signals could be reduced somewhat.

  In practice, it may not be possible to provide priority (e.g. green extension or early red truncation) to every bus, particularly at high bus frequencies, as this often results in undue delay to all other traffic. Passive priority (i.e. maximising capacity by minimising the number of phases, maximising bus green time, and ensuring good progression), benefits all traffic, including buses, and should not be disregarded.

The AM Peak average intersection level of service and delay are provided in **Figures 7.6.5** to **7.6.8 (am) at the end of Section 7.5.1.**

(iii) Section 4: Rachel De Beer / Doreen up to M20 (Hebron Road)

All intersections on this section operates at an overall level of service better than LOS D, except for the intersection of Doreen and Km 5.74.

- Intersection of Doreen and Km 5.74

This intersection operates at a LOS E, due to western approach operating at a LOS F, at a degree of saturation of 130%.

The intersection is currently operating as a four way stop, and the eastern approach therefore only has one approach lane. In the signalised configuration, two lanes, namely a left and straight shared lane, and an exclusive right turn lane were modelled. However in light of the high right turn movement, it is likely that **an additional short double right turn lane** may be required to accommodate this movement at an acceptable LOS (this was not modelled).

- Doreen and First Avenue

At Doreen and First Avenue, a single approach lane was initially modelled on the east and west approaches, which resulted in some delays on these approaches. **Adding a short exclusive right turn lane** is sufficient to bring this intersection to an overall LOS C.

- Doreen and R566

The intersection of Doreen and R566 is a very busy intersection. It is currently operating as a 4-stage signal.

Initial modelling results indicated a very poor level of service with the existing four stage signal and lane configuration, as there are very high right turn volumes on all four approaches.

An additional exclusive right turn lane was added on the eastern and western approaches (R566) by widening into the median. With this capacity upgrade and signal settings optimised, the intersection improved to a LOS D for mixed traffic and LOS C for BRT.

A scenario was also tested where the four stages were reduced to three, i.e. the protected right turn phase on the northern and southern approaches, were removed. This requires the right turning traffic to weave midblock across the BRT lane. The reduction in signal stages reduced capacity by such an extent that with this configuration, the intersection LOS for mixed traffic is C, while that of BRT has also improved to a LOS B.

The AM Peak average intersection level of service and delay are provided in **Figures 7.6.9** to **7.6.12 (am) at the end of Section 7.5.1.**

It is therefore recommended that the existing right turn lanes on the R566 be upgraded to double right turn lanes and the number of stages be reduced from four to three.

(c) Overall Network Performance

The overall network performance statistics are indicated in **Table 7.4.3**.

Table 7.4.3: Summary of Overall Network Performance

Network Performance Statistic Parameter	Section	Scenario 1	Scenario 2	Scenario 2 as a % of Scenario 1
Total Network Delay (PCU-hr/hr)	3 Rachel de Beer	940.5	519.3	55%
	4A Rosslyn	262.6	224.1	85%
	4B Soshanguve	108.3	48.5	45%
Percentage Of Oversaturated Links (%)	3 Rachel de Beer	5	3	60%
	4A Rosslyn	9	9	100%
	4B Soshanguve	11	1	9%
Journey Time Per PCU (s)	3 Rachel de Beer	116.1	74.1	64%
	4A Rosslyn			
	4B Soshanguve			
BRT Delay in Peak Direction of Travel (min)	3 Rachel de Beer	7.9	3.8	48%
	4A Rosslyn	3.1	4.1	131%
	4B Soshanguve	-	1.0	
Mixed Traffic Delay in Peak Direction of Travel (min)	3 Rachel de Beer	48.2	8.7	18%
	4A Rosslyn	3.6	3.0	83%
	4B Soshanguve	-	1.7	

From **Table 7.4.3** it is clear that Scenario 2, which has far fewer three-phase signals, results in significantly less delay and oversaturated links.

On Rachel de Beer, the merge scenario's BRT delay in the peak direction of travel is less than half that of the delay in the 3-phase scenario. On this section, in the merge scenario, the higher capacity of the intersections also greatly benefit the mixed traffic, which shows a very high delay of 48 minutes (unrealistically so in practice, as this level of congestion would result in a major diversion of traffic away from this link, which is not modelled by Transit) on the 3-phase scenario.

On the Rosslyn section, the BRT delay is approximately a minute more on the merge scenario than on the 3-phase scenario, but the mixed traffic delay is slightly less.

(On the Soshanguve section, only the merge scenario was modelled as the three-phase scenario is not deemed appropriate on this section, given lower traffic volumes).

Figures 7.6.1 – 7.6.12: Modelling Results (AM)

7.6.2 PM Peak Period

(a) Traffic Flow Adjustments and Scenarios modelled

(i) Sections 1 to 2: CBD – Paul Kruger, Mansfield and M1

The PM peak hour was modelled in the same way as the AM. Two demand scenarios were modelled, namely the full PM peak hour demand as defined by the traffic counts, and a scenario with demand reduced as per the AM peak hour except in the northbound direction. It should be noted, however, that the non-peak southbound direction was characterised by higher overall volumes along DF Malan and Mansfield than in the AM peak hour, with CBD directional volumes generally similar in both peaks.

(ii) Section 3: Rachel De Beer from M1 to Doreen

The counted PM peak link volumes are relatively much higher than the AM peak volumes for both the east west and west east movements on Rachel De Beer between Koos De Le Rey and Heinrich Avenue.

From the AM Peak Model Results, the 3 Phase Signal Scenario was deemed inappropriate due to the poor overall network performance compared to the 2 Phase Merge Scenario. As such the 3 Phase Signal Scenario was not modelled for the PM Peak period.

A maximum reduction of 30% was applied for the counted volumes between Narda Street and Koos De Le Rey Street. A similar procedure for the reductions that was applied to AM Peak counted volumes was also followed and it was also assumed that these traffic volumes will not join back to Rachel De Beer due to the proposed capacity reduction on this section.

Three scenarios were modelled in Transyt for the PM Peak as follows:

- **Scenario 1 -** 2 Phase Merge Scenario with 100% of counted traffic volumes with a 90 second single cycle for all intersections
- **Scenario 2 -** 2 Phase Merge Scenario with 30% traffic reduction with a 90 second single cycle for all intersections
- **Scenario 3 -** 2 Phase Merge Scenario with 30% traffic reduction with a 90 second single cycle for all intersections with the exception of the intersection of Burger Street & Rachel de Beer and Emily Hobhouse Street & Rachel De Beer. In addition an additional northbound lane is added on the R80 West Terminal due to the high volume turning left onto Rachel De Beer.

(iii) Section 4: Rachel De Beer / Doreen up to M20 (Hebron Road)

From the AM Peak Model Results the 3 Phase Signal Scenario was deemed inappropriate due to the poor overall network performance compared to the 2

Phase Merge Scenario. As such the 3 Phase Signal Scenario was not modelled for the PM Peak period and only the 2 Phase Merge Scenario with 100% of counted traffic volumes and a 90 second cycle for all intersections was modelled in Transyt for the PM peak period.

(b) Modelled Performance by Section

(i) Sections 1 to 2: CBD – Paul Kruger, Mansfield and M1

Transyt results for the full PM peak hour demand indicate capacity problems at the following intersections. The optimal cycle time for PM peak hour was calculated by Transyt as 75-80 seconds (compared to 60 seconds in the AM peak). 80 seconds was used for all runs.

- Bloed Street – as with the AM peak situation, counted demand at this intersection indicates capacity problems under existing conditions, with again very high volumes on Bloed (2,461). The situation is worse than in the AM since while demand on Paul Kruger in the peak direction is similar (about 1,100 vehicles) the non-peak demand is 421 in the PM versus 257in the AM.

- Boom Street western slip road to north – this is modelled in the Transyt network as a single lane slip road giving way to demand on Paul Kruger northbound. However the actual layout has the slip road joining Paul Kruger in its own exclusive lane. While this is likely to result in capacity problems along the link itself, given the high demand in both lanes (1,724 on the slip-road and 1,005 on Paul Kruger) and the likelihood of weaving it is likely the high level of congestion indicated by Transyt will be significantly less at the actual intersection.

- Paul Kruger and Flowers northbound – two lanes catering for a PM peak hour demand of 2,467 vehicles and with a high east to west demand of 905.

- Intersection accessing railway land between Myburgh and Mansfield – this has a single lane northbound through and therefore cannot cope with the counted demand of 2,998 PCUs. For modelling purposes, therefore, an extra lane was added to the Transyt network in order to avoid significant downstream flow reduction. Even with the additional capacity this intersection functions near to capacity.

- Between Mansfield and Myburgh there are capacity problems at the following intersections. The main reason why these intersection show problems and others in the same section do not is primarily due to differences in demand on the non BRT arms. Where these are low, the main corridor demand tends to get sufficient green time to get through; where these are high then this results in a reduced green time for the main corridor and subsequently leads to over-capacity.

    - Mansfield and Franzina – northbound right-turning volume fairly high (258 PCUs) and northbound through movement;
    - Mansfield and Booysens – westbound left turn from south;
    - Mansfield and Louis Trichardt – northbound right-turn.

- M1/Lavender - this is the southbound arm of the M1/Lavender intersection and the right turn movement from the south into Lavender. The counted right turn demand is 1,256 vehicles with 1,332 southbound vehicles on M1. Even with a reduced downstream modelled demand of 1,021 PCUs both this arm and the southbound arm are running at capacity.

At 70% of full demand sections of the corridor were still over-capacity but it was considered that any further incremental reductions would not be meaningful in the absence of more concrete reasons beyond just artificially creating a scenario that achieved an under-saturated network. Sections still modelled as over-capacity at this level of demand are:

- Since no change was made to demand south of Boom, these sections exhibit similar problems as with the full PM peak demand scenario, i.e. Bloed Street remains congested on most approaches.

- The section of Paul Kruger between Myburgh and Mansfield reduces to a single lane for through traffic. As with the full demand scenario this causes significant congestion and downstream reduction in demand. For purposes of assessment, the network was modified to assume extra capacity at this point in order to analyse full demand between Mansfield and Lavender.

- No reduction of demand was assumed north of M1/Mansfield so problems persist at the Lavender intersection, particularly as the eastbound peak demand from the south is actually greater in this scenario since there is a less severe upstream bottleneck. The counted right turn volume is 1,256 vehicles, nearly all of which is now getting through from upstream thanks to the reduced through volumes.

The PM Peak average intersection level of service and delay are provided in **Figures 7.6.1 to 7.6.4 (pm) at the end of Section 7.5.2**. The BRT delay (seconds) in the peak direction, is also shown in the second Figure.

(ii) Section 3: Rachel De Beer from M1 to Doreen

In all the scenarios modelled the main problem intersections are still:

- Emily Hobhouse & Rachel De Beer
- Burger Street & Rachel De Beer

These intersections are experiencing the same problems that were encountered for the AM Peak model in terms of level of service but with significantly higher delays. The modelled delays are unlikely to materialise in practice, as a higher degree of diversion and peak spreading is likely to occur than the 30% reduction assumed. It is however clear that these intersections should ideally be changed to operate as left in left out instead of allowing right turn access but this is likely to require a process of consultation with affected parties.

The intersection of Rachel de Beer and Narda Street is also marginally over capacity with the 30% reduction modelled.

The PM Peak average intersection level of service and delay are provided in **Figures 7.6.5** to **7.6.8 (pm) at the end of Section 7.5.2.**

(iii) Section 4: Rachel De Beer / Doreen up to M20 (Hebron Road)

All intersection on this section operates at an overall level of service of LOS D or better except for the intersection of Doreen and First Avenue.

The eastern and western approaches of the Doreen Avenue / First Avenue intersection experience heavy delays during the PM peak period.

Adding a second exclusive right turn lane on the eastern approach and an additional through lane on the western approach brings this intersection to an overall LOS E during the PM peak period.

The AM Peak average intersection level of service and delay are provided in **Figures 7.6.9 to 7.6.12 (pm) at the end of Section 7.5.2**.

Figures 7.6.1 – 7.6.12: Modelling Results (PM)

8 STRUCTURES ASSESSMENT

There are 12 bridges and major culverts located along the route. They are road over river, road over road and rail over road structures.

In September 2011 the five bridges and the major culvert which are affected by the planning on Section km 0 to 18 of the route were inspected by our SANRAL accredited bridge inspectors. Here the proposed BRT route follows the alignment of Gauteng Province Department of Roads and Transport routes K217, K216, K63 and K14.

The inspection was carried out to identify any major problems related to the proposed widening of the existing bridges and the major culvert. The As-Built information provided for these structures is incomplete and provides no information on the requirement of piled foundations or any foundation stabilisation.

The description of and a proposed method of construction for each of these structures is given in **Section 8.1**. A preliminary assessment of the structural capacity of the bridges and major culverts to accommodate the BRT loading is added under **Section 8.2**. **Section 8.3** contains recommendations for further work to be done as part of the detail design stage.

The location of the six structures is indicated in **Figure 8.1**.

8.1 Description and Assessment of Structures to be widened

Structure No 6: Bridges No 4003 A & B at km 17.85 are road over road bridges built in 1981. The bridges cross over the dual carriageway of the R80. Each bridge consists of a 2 span continuous box deck supported on abutments and a central pier. The width of the open median between the two bridges is approximately 10 m. It is proposed to widen the existing bridges on the inside, closing the median in the process.

Traffic accommodation for the under-passing R80 would be extremely difficult and costly if the bridge deck is to be constructed in the conventional way on scaffolding. The vertical clearance for the road underneath is limited and an alternative method of construction will therefore have to be adopted. This could, among other possible methods, consist of building the deck widening at a higher level and afterwards dropping it to the existing bridge levels, suspending the deck formwork during construction between steel girders supported and placed at a level above the required minimum vertical clearance for the under-passing road, or constructing the bridge deck by incrementally launching it from one side to the other.

Structure No 5: Bridge No 2183 at km 14.41 is a road over road bridge built in 2002. The bridge crosses over the dual carriageway of the N4 Freeway. The bridge consists of a 4 span continuous box deck supported on abutments and piers. The deck is monolithically connected to the centre pier. There is an existing 600 diameter water main located along the eastern side of the bridge. It is proposed to construct a new bridge on the eastern side of the existing one in order to accommodate the proposed south bound carriageway of the BRT route.

Figure 8.1: Location of Affected Structures

Traffic accommodation for the under-passing N4 would be extremely difficult and costly if the bridge deck is to be constructed in stages in the conventional way on scaffolding. The vertical clearance for the road underneath is limited and an alternative method of construction will therefore have to be adopted. This could be done in a similar way as described above for Bridge No 6.

Structure No 4: Bridge No 2934 at km 12.67 is a road over rail bridge built in 1970. The bridge crosses over two rail lines. The bridge consists of a 2 span simply supported deck structure supported on closed abutments and a centre pier. There is an existing 600 diameter water main located along the eastern side of the bridge. It is proposed to construct a new bridge on the eastern side of the existing one in order to accommodate the proposed south bound carriageway of the BRT route.

The new bridge can be constructed without the additional requirement of a temporary traffic accommodation. The bridge deck will have to be constructed with precast beams, which have to be placed under rail occupation over the tracks.

Structure No 3: Bridge No (B) at km 9.69 is an un-numbered major culvert where the road crosses over a river, date of construction unknown. The culvert consists of a battery of 5/3.0 x 2.1m precast portal culverts, crossing the road at an approximate 30 degree angle of skew. There are no guardrails or parapets along the sides of the existing road. It is proposed to widen the structure on the left hand side, i.e. the north eastern side, to accommodate the additional traffic lanes required.

The widened culvert section can be constructed without the additional requirement of a temporary traffic accommodation. However, the river would have to be channelized to allow for the segmental construction of the base slab for the portal culverts.

Structure No 2: Bridge No 4218 at km 7.75 is a road over rail bridge built in 1979. The bridge crosses over single De Wildt - Bapsfontein rail line. The bridge consists of a 3 span simply supported deck structure on one open and one closed abutment and two piers. It is proposed to construct a new bridge on the eastern side of the existing one in order to accommodate the proposed south-bound carriageway of the BRT route.

The new bridge can be constructed without the additional requirement of a temporary traffic accommodation. The bridge deck will have to be constructed with precast beams, which have to be placed under rail occupation over the track.

Structure No 1: Bridge No 5513 at km 3.4 is a road over river bridge, date of construction unknown. The bridge consists of 8 - 3.0 x 3.0m in-situ cast cells with continuous deck slabs, each stretching over 4 spans. It is proposed to widen the structure on the left hand side, i.e. the north eastern side, to accommodate the additional traffic lanes required.

The widened bridge section can be constructed without the additional requirement of a temporary traffic accommodation. However, the river would have to be channelized to allow for the segmental construction of the cell structures of the bridge.

8.2 Assessment of Structural Capacity

It appears that the bridges and major culvert on this section of the BRT route were constructed between 1970 and 2002. During this time the existing road structures would have been designed to carry the traffic loading specified by the TPA Code of Procedures, Structures, or since 1981 as specified by TMH 7, Code of Practice for the Design of Highway Bridges and Culverts in South Africa. In both cases the 10.2 ton axle load of the BRT bus falls within the envelope of the specified design traffic loads. It can therefore be concluded that no structural strengthening would be required for the existing bridges and the major culvert.

Some repair and rehabilitation work may however be required locally, especially at the 5-cell portal culvert, Structure No 3, where guardrails/parapets have to be erected to safeguard the structure and to reduce accidents.

The structures on the remainder of the BRT Trunk Route, from km 18.0 to 34.5, are two road over river bridges, three rail over road overpass bridges and one road over road overpass bridge. The river bridges on Paul Kruger Road would also have been designed according to the TPA Code of Procedure, Structures, or the TMH7, and should thus be able to carry the BRT bus loading.

The loading on the rail and road bridges passing over the BRT is not affected by the BRT busses.

8.3 Recommendation

It is recommended that the widening of the existing structures and/or the construction of new bridges along this section of the BRT Trunk Route should be implemented as proposed.

It is however essential, that before any detailed planning can proceed, all available As-Built and existing services information would have to be collected.

A detailed survey and geotechnical investigation at every structure would have to be carried out, especially to determine the requirement of piled foundations for the bridges, as this would have a major influence on the construction cost.

9 UTILITIES (SERVICES) ASSESSMENT

The known service information has been collated onto CAD drawings which was superimposed onto the preliminary design layout drawings, to identify what services would be affected and the potential cost implications of this, or alternatively what design changes can be done to minimise service relocation costs.

To increase the clarity on the preliminary design layout drawings, the services were not included on the layout drawings but are provided in a separate set of services drawings.

No fatal flaws in terms of the known services affected have been identified.

9.1 Electrical Services

The electrical scope of work will include but not be limited to removal of existing luminaires and replacing with new luminaires, retaining all median luminaires and repairing faulty cable work. All electrical services on the intersections along the BRT route will be lowered or encased in sleeves. The services on the proposed BRT station areas shall be relocated.

9.1.1 Streetlight Poles and luminaires

Street lighting will be upgraded by means of new A6 streetlight poles with the luminaires. The proposed main luminaires that will be installed along the route is a rear entry 250W-Metal Halide Bekastrada. All the existing S- poles will be upgraded to A6 streetlight poles. Luminaires will be installed on the 15° spigot and will be installed on the side of the road. All existing median poles will be retained in the existing positions and replace the luminaires only. The station areas will be lit up by means of 250W Bekastrada as the main luminaire and a 150W pedestrian luminaire mounted on a 0.5m outreach. The pedestrian luminaire shall be mounted at the height of m from ground level. These streetlights will be installed on both side of the road.

9.1.2 Control Panel

All newly installed streetlight poles shall be connected to new streetlight control panels. The new control panel shall be connected to the electrical source supplied by the authority. The control panel shall be a pole mounted control panel, which will be manufactured according to City Of Tshwane specifications.

9.1.3 Streetlight Network Type

All streetlights in the CBD and along the route up to corner of Rachel De Beer and Doreen avenue shall be wired with the 4 core copper cable which will be installed underground.

The remaining streetlights up to the limit of construction in Soshanguve shall be wired with the two core bundle conductor, which will be mounted on poles (overhead network). The existing underground streetlight circuits that are currently installed in the Soshanguve area have been vandalised, hence recommending the use of overhead network. This network will be a single phase network and not a three phase network. The reason for using a single phase network is that the five-core bundle conductor is heavy for poles and the poles starts to bend due to stress. The appointed electrical contractor shall repair all the damaged existing streetlight cables and non-operational streetlights inclusive of installing all the required materials.

9.1.4 Relocation/Lowering of existing electrical services

All the existing electrical services that are on the BRT route will be identified with the help of City Of Tshwane Electrical department (C.O.T). The services shall be exposed and encased in sleeves where possible or they will be lowered. C.O.T. will be contacted on as and when required to assist with the lowering of the elec. services. Any electrical service installed underground and in the way of the BRT Bus station shall be relocated to the area that is outside the station area. C.O.T. shall be engaged prior to the commencement of the project to plan the new cable routes that will be employed.

The relocation of the existing services will only take place when the main contractor is in the affected area with the project or when required to do so. The electrical contractor will assist with the repair all the damaged cables due to construction of the BRT layer works and make joints where applicable. Due to road widening, all the affected services along the route shall be relocated to the area decided by the municipality. These services are relocated due to the thickness of the layer works that will prohibit the maintenance of the services if/ when required.

10 ENVIRONMENTAL SCAN

The key findings of the environmental scan is summarised below. The comprehensive report is included in **Annexure G**.

10.1 Benefits and Negative Impacts of BRT

The implementation of a Bus Rapid Transit system brings major changes to people's life in the way they commute. It also has impacts on the natural and urban built environment, which require consideration before construction commences. The true impact of BRT is not simply the positive impact of the system on traffic levels, but rather the improvements that it creates in people's lives in the spheres of economic development, social interactions and urban habitat form. The positive impacts on environmental quality are also considerable.

An effective public transport system is central to development as it leverages the empowerment of communities by providing access to employment, education and public services. The direct (jobs, technology transfer) and secondary economic development impacts (reduction in the cost of production and consumption) of BRT should not be underestimated.

The separation of BRT buses from the rest of the traffic stream, improvements to traffic lights and pedestrian crossings can produce significant safety benefits. Reduction of private vehicle use by switching to public transport systems and the concomitant reduction in vehicle emissions has the potential for major health benefits, especially if BRT busses are propelled by cleaner fuel.

There is solid scientific evidence that BRT typically brings environmental benefits through the reduction of private vehicle use and subsequent associated emissions. Further positive impacts are the reduction of overall noise levels and decreases in liquid and solid waste generation. The Johannesburg's Rea Vaya BRT has rightly been dubbed as the single largest climate change initiative ever undertaken by the city. Following suit, the introduction of a Bus Rapid Transit system represents a major turning point in how Tshwane deals with pollution and greenhouse gases as a result of transportation.

The chief negative impacts of BRT arise during the construction phase. They relate to dust and noise generation, stormwater management issues, traffic jams from the temporary closure of roads and the application of bitumen products. The impacts can usually be effectively mitigated through a dedicated environmental management programme.

Arguably the most conflict potential arises from the profound change of the preferred mode of transportation by commuters adopting BRT. Minibus taxi operators are frequently opposed to BRT replacing the taxi service. Historically in most BRT systems negotiations with existing minibus taxi operators have been tense. In the best cases major social upheaval has been avoided by negotiations which ensured that minibus drivers were retrained as BRT bus drivers and ancillary support staff. This achieved an acceptable solution so that the public interest was not held hostage to the demands of these private interests.

10.2 Environmental compliance

10.2.1 EIA Regulations

The introduction of the Tshwane BRT is subject to the provisions of the Environmental Impact Assessment Regulations promulgated in terms of the National Environmental Management Act, No. 107 of 1998, as amended, which specify those activities that may not commence without prior environmental authorisation from the competent authority. Regulations identify two separate administrative processes for EIAs, depending on the nature of the activity. A Basic Assessment (BA) process is required for those activities that are likely to have a low detrimental impact on the environment; an EIA is required where more significant environmental impacts are likely.

10.2.2 Environmental implications of route design changes

The original design of Line 1 of the Tshwane BRT connected the Soshanguve side of the Mabopane railway station precinct with the Pretoria railway station precinct. In October 2009 environmental authorisation was granted for the above route by the Department of Environmental Affairs under the previous EIA Regulations of 2006 through a Basic Assessment.

As an outcome of the preliminary design process, changes have been proposed to the BRT line 1 that deviates from the design concept for which environmental authorisation has been obtained. The revised design of Line 1 of the Tshwane BRT is connecting Soshanguve South with the Pretoria railway station precinct. Overlap with the previous route is largely restricted to the Pretoria CBD area.

Although subsequent changes to the BRT route would definitely require an review of the impacts assessed, they do not trigger any activities listed in Government Notice R545 in terms of the EIA Regulations, which would require authorisation through Scoping and full EIA.

New EIA Regulations were introduced in July 2010 that has substantially relaxed the requirements for authorisation for road projects inside the urban fence. Specifically, road and stormwater structure upgrades within the road reserve no longer requires Basic Assessment.

Along the revised route, two bridges over watercourses were identified that may conceivably trigger activity 39 in Government Notice R544, which deals with *"The expansion of ...(iii) bridges within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, where such expansion will result in an increased development footprint."* and requires a Basic Assessment:

1. At km 1.14 from the start of Line 1 at the junction of the M20 with the M17, the route crosses a watercourse. The existing bridge is approximately 26 m wide and the preliminary design requires the road over the river culvert to be lengthened. If this lengthening would encroach closer than 32 m to the edge of the watercourse, activity R544:39 would be triggered.
2. At km 7.49 from the start of Line 1 at Soshanguve, the route crosses a watercourse near Peter Pretorius St in Rosslyn. The existing bridge is approximately 18 m wide and has a staggered box culvert design. The box

culverts presently extend either side beyond the actual road surface, which may be used to achieve a slight widening. Should this prove impossible and bridge widening would have to occur with traditional engineer's means, activity R544:39 would be triggered.

It is recommended that a meeting be scheduled with the DEA to discuss the planned deviations from the approved alignment before any designs are finalised. Should the two contentious river crossings have to be modified, DEA should be approached to allow that the Basic Assessment be restarted under the 2010 EIA Regulations with the focus on the only remaining listed activities, namely the river crossings. Much of the general information written for the previous Basic Assessment Report could be recycled and this will greatly aid the swift completion of a new set of documents for submission to DEA.

10.3 Heritage compliance

10.3.1 Heritage Regulations

Under the umbrella of the Basic Assessment process a Heritage Impact Assessment (HIA) was conducted for purposes of development compliance with the requirements set out in the National Heritage Resources Act (No 25 of 1999) and submitted to the South African Heritage Resources Agency (SAHRA) for approval.

10.3.2 Heritage compliance implications of route design changes

Since heritage approval was granted by SAHRA under the previous route design concept, this has now been superseded. The changes to the BRT route would definitely require a review of the impacts assessed, and if found substantive, result in an application to SAHRA to amend the permit.

Since heritage resources are mostly located on the unchanged BRT route section at Paul Kruger Street and Church Square, the focus of any newly commissioned Heritage Impact Assessment would still be in that general area. It is therefore recommended that SAHRA be approached how to proceed in the matter. Conceivably the original heritage consultant Cultmatrix could modify their previous assessment in a way that satisfies SAHRA's requirements. Attention is drawn to SAHRA's request that all final designs be approved by them prior to commencement of any construction activities.

10.4 Water use licensing compliance

Registration of water use is required in terms of section 26 (1)(c) and 34(2) of the National Water Act (Act 36 of 1998). In those areas where the BRT intersects watercourses, a Water Use License will be required if any of the following water uses of section 21 of the Water Act is triggered:

21.(c): impeding or diverting the flow of water in a watercourse;
21.(d): engaging in a stream flow reduction activity contemplated in section 36;

21.(f): discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit; or
21.(i): altering the bed, banks, course or characteristics of a watercourse.

A Water Use License is applied for by completing the official forms obtainable from the Department. These are submitted together with the Basic Assessment Report as the supporting document.

Since no general water use licenses seem to have been applied for under the previous design layout, the matter should be held over until the engineering design has matured sufficiently to determine where road stormwater structures will have to be modified and newly constructed.

11 GEOMETRIC DESIGN

This section of the report describes the existing road and road surface condition, the design considerations for the proposed Tshwane BRT Line 1, and a description of the proposed road works.

The section under consideration begins at the M17 / Ruth First Street intersection in Soshanguve, northwest of Pretoria, and ends at the Paul Kruger Street / Scheiding Street intersection in Pretoria Central.

The route follows the M17, M20 (Hebron Road / Doreen Avenue), R513 (Brits Road / Rachel de Beer), and the R101 (Mansfield Road / Paul Kruger Street).

Information regarding the existing road pavement structure or subsequent maintenance that may have been undertaken is not included as in-situ tests and a materials investigation have not been undertaken.

11.1 Existing Pavement Investigation – Visual Road Condition Survey

The visual road condition survey was carried out during July 2011. The completed forms containing the visual road condition survey is attached as **Annexure E – Visual Road Condition Survey**.

The visual assessment includes the type of road usage, road and verge layout with approximate dimensions, street furniture and services as well as road surfacing type and road condition such as surface defects and failure types if any. The complete visual condition survey is split into convenient sections ranging in length from 2km to 5km. More specific notes and photos are provided in the appendix describing features applicable to each section.

For ease of reference the route has been divided into 5 sections based on common road cross section and features:

- Section 1: M17 / Ruth First Street, Soshanguwe, to M20 (Doreen Avenue) / Piet Pretorius Street, Rosslyn
- Section 2: M20 (Doreen Avenue) / Piet Pretorius Street, Rosslyn, to M20 (Doreen Avenue) / van Niekerk Street, Rosslyn East
- Section 3: M20 (Doreen Avenue) / van Niekerk Street, Rosslyn East, to R513 (Brits Road), Doreg AH
- Section 4: R513 (Brits Road), Doreg AH, to M22 (Boom Street), Pretoria Central
- M22 (Boom Street), Pretoria Central, to R101 (Paul Kruger Street / Scheiding Street, Pretoria Central

Proposed improvements such as widening, provision of sidewalks, kerbed medians and bus stops are described briefly in each of the sections below. For more detail, refer to the layout drawings included in **Volume 3 – Book of Drawings**.

11.1.1 Section 1: M17 / Ruth First Street, Soshanguwe (km0.000), to M20 (Doreen Avenue) / Piet Pretorius Street, Rosslyn (km10.400)

The section is approximately 10,4km long. Starting at km0.000 at the M17 / Ruth First Street intersection, the section covers portions of the M17 and M20 which are both single carriageways partially offset from the centreline. The longitudinal grade is fairly flat and ranges from about 0,5-1,5%. The road has a single crossfall sloping at about 1-2% from right to left between Ruth First and the M20 (Hebron Road) km2.250, and thereafter from left to right to km10.400, approximately 500m beyond Piet Pretorius Street in Rosslyn.

The road width varies between 9m and 15m in this section.

(a) Ruth First (B1) km0.000 to M20 Hebron Road (B3) km2.250

Cross section:

Road lanes are generally 3m wide.

Starting at Ruth First and heading south-westerly towards the M20 (Hebron Road), the roadway consists of 2 lanes in each direction at the intersection followed by 1 lane left hand side (LHS) and 2 lanes on the right hand side (RHS) up to the first intersecting street (name unknown) km0.620. Speed humps are installed on either side of this intersection. The road has 3m surfaced shoulders on both sides of the road.

From this intersection to the next intersection at Sikhukhuni Road, the road has 3 lanes LHS and 1 lane RHS with 0,5m surfaced shoulders.

From Sikhukhuni Road to the M20 (Hebron Street) km2.250, the roadway has 1 lane LHS and 3 lanes RHS with 0,5m wide surfaced shoulders. A kerbed median island varying in width from 2m-3m commences at about km2.050 (i.e. before the M20 (Hebron Road) intersection) separating the 2 lanes in each direction. The roadway is paved with 80mm pavers (block paving) for about 50m leading up to and through the intersection with 0,5m wide shoulders.

Road condition:

The condition of the asphalt section is fair with 60% edge breaks on both sides, slight block cracking and longitudinal cracking over about 30% of the area. Isolated minor potholes are evident over the section.

General:

The gravel road verge has a drop-off of up to 300mm in places. The verge width is 10m left and right with trees on the left side only. Telkom / Eskom poles are located 10m from the left side of the road for the first 950m.

Streetlights are located at 40m centres about 3m from the right side of the road.

An open drain, partly gravel and partly concrete lined, is situated on the left side of the road for much of its length. A 2400 x 400 box culvert crosses the road just north of Sikhukhuni Road.

In places, houses have encroached into the road reserve on the left side.

At this stage, improvements to the section from Ruth First km0.000 to M30 Hebron Road km2.250 are not under consideration.

(b) M20 Hebron Road (B3) km2.250 to Rosslyn Road (B5) km4.450

Cross section:
The road width in this 2,250km section varies from 6m to 15m with 0,3m wide paved shoulders flanked by 3m wide gravel shoulders.

From the M20 (Hebron Road) / M17 intersection km2.250, heading east, the road has 2 lanes in each direction separated by a kerbed 1,5m wide median island. The lanes are paved with 80mm concrete block pavers for about 50m leading out of the intersection. From the island up to the next intersecting road at km2.800 (name unknown), the roadway has 2 lanes LHS and 1 lane RHS. At the intersection there are 2 lanes LHS and 3 lanes RHS with 0,5m paved shoulders.

East of this intersection the road narrows to one 3,5m wide lane in each direction. After approximately 300m (km3.100) it widens again to 3 lanes LHS and 1 lane RHS (all 3m wide) as it approaches the next intersecting road (position B4, road name unknown) at about km3.340.

Immediately east of the M17 / M20 intersection the road has a 1 lane LHS and 3 lane RHS configuration where after it narrows to 1 (3,5m wide) lane in each direction for a further 300m.

Leading up to and through the next intersection at km3.900, the road widens to two 3m wide lanes in each direction.

Beyond the intersection the road again narrows to 1 lane in each direction.

Approaching the Rosslyn Road intersection (B5), the road widens to a 3 lane LHS and 1 lane RHS configuration with a taxi lay bye on the right side.

Road condition:

The condition of the asphalt section is fair to good with 30% edge breaks on both sides. Patching has taken place over about 10% of the surfaced area. Isolated minor potholes are evident over this section.

General:

The gravel road verge has a drop-off of 100-300mm in places.

The verge width is 10m left and right with isolated vegetation and trees on both sides.

An open channel is situated beyond the 3m wide gravel shoulders on the left side. Various culverts cross the M20 at approximately 300m, 450m, 500m and 600m east of the M17 / M20 intersection.

Telkom / Eskom poles are located about 10m from the left side of the road. Streetlights positioned at 40m centres are located about 3m from the right side of the road.

The road has a bridge / culverts over the watercourse approximately 1100m east of the M17 / M20 intersection.

At this stage improvements to this section (km 2.250 to km 4.450) are not under consideration.

(c) M20 Rosslyn Road (B5) km4.450 to M20 Doreen Avenue (near Piet Pretorius Street) km10.400, Rosslyn

Cross section:

The road width in this approximately 6,000km section varies from 7m to 12m. The roadway consists of 1 lane (lane width varies between 3,0m-3,5m) in each direction between intersections. The entire section has 0,3m wide paved shoulders, flanked by 3m wide gravel shoulders on both sides.

Exiting the Rosslyn Road (B5) intersection at km4.450 and heading south, the road has 1 lane LHS and 2 lanes RHS then widens to 3 lanes LHS and 3 lanes RHS on the approach to the next intersection at km5.150 (road name unknown).
On approaching and through this intersection, the roadway widens to 2 lanes in each direction before again returning to the 1 lane (3,5m wide) in each direction.

A road over Rail Bridge is located at about km7.750. The bridge crossing caters for 1 lane in each direction with 1,5m surfaced shoulders with guardrails on each side. A 1m wide surfaced walkway is situated between the bridge headwall / balustrade on each side.

On approach to and through the Tungsten Road intersection at km8.180, the road widens to 2 lanes LHS and 1 lane RHS; before returning to 1 lane (3,5m wide) in each direction. On approach to and through Kitshof Street intersection (B7) at km8.900, the road widens to 2 lanes LHS and 1 lane RHS.

At approximately km10.400 the single carriageway becomes a dual carriageway.

Road condition:

The condition of this asphalt section is fair with 60-70% edge breaks on both sides. Patching has taken place over about 20% of the surfaced area. Crocodile cracks, pumping and rutting are evident over about 20% of the road.

General:

The gravel shoulder / verge has a drop-off of 100-300mm in places. The verge width is 10m on the left and 5m to 8m on the right with isolated vegetation and trees on both sides.

A 500m long concrete lined channel starting at Rosslyn Road (B5) km4.450 and heading south is situated on the left side of the road.

Telkom / Eskom poles are located about 10m from the right side of the road from km5.000 up to the road over rail bridge. Streetlights positioned at 40m centres are located on the right side of the road between Rossyln Road (B5) and the first intersection and on the left side from this point onwards for a further 600m.

Taxi lay byes are provided along the route on either side of some intersections. Improvements to this section include widening (varying between 1 lane and 3 lanes) on the left side of the road between km4.450 and km10.800. Minor widening is planned on the right side between km10.400 and km10.800. The roadway will be separated by a kerbed median. A pedestrian / cycle path will be provided on the left side of the road up to Kitshof Street, km8.900; thereafter the path will be on the right side.

11.1.2 Section 2: M20 (Doreen Avenue) / Piet Pretorius Street km10.400, Rosslyn, to M20 (Doreen Avenue) / (near) van Niekerk Street km12.400, Rosslyn East

Cross section:

This section commences at about km10.400 and continues to approximately 500m before the Daan de Wet Nel Street (B10) intersection at km13.000. This section of the M20 has a median separated dual carriageway and is approximately 2.6km long.

The median island is kerbed and the 3m wide shoulders are surfaced for 0,3m only.

The longitudinal grade is fairly flat and ranges from about 0,5-1,0%. The road slopes from left to right at about 1%. The road is superelevated through the right hand curve at about km10.400.

The dual carriageway consists of two 3,5m wide lanes in each direction. Slipways are provided to the R80 which is at km11.300.

Road condition:

The condition of the asphalt is fair to good with 10% edge breaks on either side. Patching has taken place over about 20% of the surfaced area. Longitudinal and transverse cracks are evident over about 20% of the road.

General:

The verge width is 10m on both sides with isolated vegetation and trees.

Streetlights are positioned at 40m centres in the median.

A gas pipe crossing is located at about km9.800. GTMM crossings are found near km11.7500 and km12.400. An Eskom line crosses the road at about km12.020.

Culvert crossings are located at km9.100, km9.680 (5 No. 3000 x 2400 culverts), km12.180 and km12.420 respectively.

Improvements include lane widening in the median and minor widening (about 1m) on both left and right sides. A pedestrian / cycle path will be provided on the right side of the road up to Frans du Toit Street, km12.100; thereafter the path will be on the left side.

11.1.3 Section 3: M20 (Doreen Avenue) / (near) van Niekerk Street km12.400, Rosslyn East, to R513 (Brits Road) km16.200, Doreg AH

Cross section:

This single carriageway section varies in width between 8m and 12m and consists of 3,8km of the M20 (Doreen Avenue). The entire section has 0,3m wide paved shoulders, flanked by 3m wide gravel shoulders on both sides.

The section commences at km12.400, i.e. at the start of the single carriageway, and heads south towards Brits Road passing through a residential area. At the R513 (Brits Road) junction (km16.200) the route follows the R513 heading east. The section terminates at the start of the dual carriageway section which is at about km16.500.

The road has a longitudinal grade of about 0,5% and a single crossfall of about 0,5% from left to right.

The road crosses over the railway line at km12.660.

The M20 cross section consists of 1 lane (3,5m wide) in each direction between intersections. The roadway widens to 3 lanes LHS and 2 lanes RHS on approach to and through the Daan de Wet Nel Street intersection (km13.000). A median island about 100m long extends south from the Daan de Wet Nel intersection.

Through the Pine Street (km13.300) and Oaklands Street (km13.600) intersections, the M20 widens to a 2 lane LHS and 2 lane RHS configuration. Through the Hulton Road (km13.900) and First Avenue (km15.200) intersections, the M20 widens to a 3 lane LHS and 3 lane RHS configuration.

The M20 passes over the N4 Bakwena Highway at km14.400. Lanes approaching and through the intersections are 3m wide.

Road condition:

The condition of the asphalt surfacing is fair to good with 20% edge breaks on both sides. Longitudinal, transverse and crocodile cracks and pumping are evident over about 20% of the road.

General:

The verge width is about 20m on the left side and 10m on the right side. Trees and light vegetation are evident on both sides of the road.

Telkom services are located on the right side of the road. Streetlights are positioned at 40m centres on the left side of the road. Between First Avenue and the R513 intersection, a gas pipeline crosses the road twice. Sasol fuel line markers are visible between First Avenue and the R513. Eskom poles are located on the left side of the road from a point immediately south of Hulton Road up to the R513.

Vehicle entrances on the left side of the road are evident over the last 800m of the section.

Some intersections have kerbed bellmouths.

A taxi lay by is situated 100m south of the Hulton Road intersection on the left side of the road.

Improvements to this section are to include lane widening ranging from 2 to 3 lanes wide on the left side up to R513 Brits Road, km16.200. Isolated portions of this section will require widening on the right side. Kerbed median separation is provided up to km14.900 and at bus stops. A pedestrian / cycle path will be provided on the left side of the road up to R513 Brits Road, km16.200.

11.1.4 Section 4: R513 (Brits Road) km16.200, Doreg AH, to M22 (Boom Street) km31.760, Pretoria Central

This section commences at the start of the dual carriageway portion of the R513 (Brits Road) and ends at the M22, Boom Street, Pretoria Central.

(a) R513 (Brits Road) from the M20 Doreen Avenue (B12) km16.200 to Daan de Wet Nel Drive (B17) km22.850

Cross section:

This subsection is about 6,65km long with a flat longitudinal grade. From the M20 / R513 intersection heading east the road consists of a single carriageway with 1 lane (3,5m wide) LHS and 2 lanes (3,0m wide) RHS. The cross-fall is about 0,5% left to right. From about km16.800, the road widens to a median separated dual carriageway. Between intersections, the dual carriageway consists of two 3m wide lanes in each direction with 0.5m wide surfaced shoulders and 3m wide gravel shoulders all the way to Daan de Wet Nel Drive (km22.850).

At the approaches to intersections, the number of lanes increases to 3 lanes at most intersections in order to provide right turn access. The westbound approach to the Heinrich Avenue intersection (km17.050) has 5 lanes, allowing for both left and right turns. The approaches to the Sylvia Street intersection (km18.700) are 4 lanes and 2 lanes in the eastbound and westbound directions respectively. The approaches to the Willem Cruywagen Street intersection (km19.620) are 4 lanes in each direction.

The median is approximately 8m wide up to about km17.360 where it widens to about 15m up until Grafenheim Street (km21.180). Beyond Grafenheim Street the median varies between 8m and 10m up to Narda Street (km19.120). Between Narda Street and Daan de Wet Nel Drive the median varies from 5m to 8m in width. The median is grassed with trees and has streetlights spaced at 40m intervals.

Road condition:

The road surface is seal and slurry and is in fair to good condition with 20% edge breaks on both sides. Longitudinal and transverse cracking over about 20% of the area is evident. Bleeding is evident over 20% of the section.

General:

The verge width is 10m to 20m on the left side and between 6m and 10m on the right side of the road.

Telkom / Eskom poles are located 10m from the left side of the road for the first 950m. Streetlights positioned at 40m centres on the left side up to the start of the median separation. Through the median-separated section the streetlights are situated in the centre of the median. An irrigation system and trees are evident in the median separated section.

Bus stops are located on both sides of the road.

The bridge over the R80 is situated at approximately km17.840 which is midway between Heinrich Avenue and Sylvia Streets.

Improvements to this section include widening on both the left and right sides between km16.200 and km16.700. Thereafter widening will take place within the median up to Daan de Wet Nel Street, km22.850. Widening on both sides will be required at bus stops. Pedestrian / paths will be provided on the left side of the road.

(b) R513 (Brits Road) from Daan de Wet Nel Street (B17) km22.850 to Lavender Road (R513) km25.900

Cross section:

This section is about 3,00km long with a flat to rolling longitudinal grade. From Daan De Wet Nel Street heading east, the road consists of a dual carriageway with 2 lanes (varies from 3m-4m wide) LHS and 2 lanes (3m wide) RHS up to km24.900. The crossfall is about 0,5% right to left for most of the section, however at the sharp curve under the M1 road bridge the carriageways are superelevated from left to right. The number of lanes increases to 3 lanes at the approach to most intersections providing for right turn lanes.

The remaining 1km section up to Lavender Road (km25.900) consists of a dual carriageway with 3 lanes (3.0m wide) LHS and 2 lanes (3.0m wide) RHS. The crossfall is about 0,5% right to left for most of the section. At approaches to intersections the number of lanes increases to accommodate the right turns.

Sections of the roadway have gravel shoulders and others paved sidewalks.

Approximately 2km of this section is a dual carriageway, which is separated in sections by concrete barriers, guard rails, and fencing. The last 1km has a 5m wide grass median with trees.

Road condition:

The condition of this seal and slurry section is fair to good with 60% longitudinal and transverse cracking, 50% block cracking, and 20% crocodile cracks. Patching and rutting is evident over about 20% of the surfaced area.

General:

The verge is 2,5m wide with isolated vegetation and trees on both sides. Eskom lines extend from Daan De Wet Nel Street (km22.850) to Generaal Beyers Street (km24.050) with a power box some 350m east of Daan De Wet Nel Street on the LHS. There are three bridges east of Howard Street (km24.480), one rail bridge at km24.580, one road bridge (M1, R566 Main Road Bridge) at km24.640, and a pedestrian bridge at km24.950. Between the rail and road bridges there is an on-ramp to the M1 on the LHS and just after the road bridge an off-ramp. On the RHS between the road and pedestrian bridge there is an off-ramp , and just after the pedestrian bridge an on-ramp.

Streetlights are positioned at 40m centres on the LHS from Daan De Wet Nel Street until the rail bridge. Thereafter streetlights are located on both sides up until the start of the grass median from where the streetlights are positioned in the centre of the median.

There is an entrance / exit on the LHS just after the M1 off-ramp to and from the bus and taxi stopping area. Paved sidewalks are mostly 2,5m wide.

Improvements will include widening on both left and right sides at bus stops between km22.850 and km25.140. Pedestrian / cycle paths will be provided on both sides of the road.

(c) R101 (Mansfield Road) from Lavender Road (R513) km25.900 to Paul Kruger Street km26.900, Mountain View (located near B21)

Cross section:

This section is about 1,00km long with a flat longitudinal grade. The road width varies from 6,6m to 17m. From Lavender Road heading south for 800m, the road consists of a dual carriageway with 3 lanes (3m wide) on both LHS and RHS separated by a concrete barrier. Thereafter the roadway splits for approximately 300m before merging back into a conventional dual carriageway. The crossfall is about 1% which varies from left to right and right to left.

At the (M1) D. F. Malan Drive intersection, the number of lanes decreases to two lanes in each direction due to the split in the road (D.F. Malan Drive and Mansfield Road respectively). The two carriageways merge near Paul Kruger Street km27.000, Mountain View. Right turns are provided with frequent merging and diverging of lanes in the vicinity.

Paved shoulders 1,5m wide are provided on both sides of the road. Along the median, the shoulders are 0,3m wide.

Road condition:

The asphalt surfacing is in a fair condition. Longitudinal and transverse cracks are evident along the entire length on both carriageways.

The bridge joints (2 bridges) over the Apies River are exposed and in poor condition.

General:

The verge width is 3m left and right with isolated vegetation and trees on both sides.

Streetlights are positioned at 40m centres on the median concrete barrier or in the median.

Along the RHS there is a retaining wall for the railway line. Approximately halfway through the section are two bridge crossings over the Apies River. Paved sidewalks are located on the left side and for the most part are 2,5m wide.

Improvements will include widening on both left and right sides at bus stops. Pedestrian / cycle paths will be provided on the left side of the road.

(d) R101 (Mansfield Road) from Paul Kruger Street, Mountain View (located near B21) km26.900, which becomes R101 (Paul Kruger Street) to Boom Street (B26) km31.760

Cross section:

This section is about 4,90km long with a flat to rolling longitudinal gradient. Approximately 3.7km of this section is a dual carriageway separated by a 4m wide grass median with trees. The next 300m it is separated by a concrete barrier only, while the remainder of the section is a single carriageway.

Heading south for 3km from Paul Kruger Street near Mountain View up to about km29.900, the road consists of a dual carriageway with two 3m wide lanes in both directions. The crossfall is about 1% which varies from left to right and right to left. At approaches to intersections there are 3 lanes to accommodate right turns. The road width varies from 8m to 14m.

The rest of the section consists of 3 lanes (3m wide) LHS and 2 lanes (3m wide) RHS. The crossfall is about 0.5% left to right for most of the section. At approaches to intersections lanes increase to accommodate right turns.

Paved shoulders 3m wide are located on both sides of the road.

Road condition:

The condition of the asphalt and seal is fair to good with 50% longitudinal and transverse cracking and 20% crocodile cracking. Bleeding is evident over 20% of this section. Asphalt shoving is evident over 10% of the road.

General:

The verge width is 5m-15m on the left and 4m-7m on the right with isolated vegetation and trees on both sides.

There are two rail bridges at about km29.240 and km29.720 respectively. A pedestrian tunnel passes under the road in the vicinity of the school entrance at km31.120.

A water channel passes under the road about 100m south of the tunnel.

Streetlights positioned at 40m centres in the median for the first 4km where after streetlights are positioned on both sides of the road.

Along the RHS road edge immediately before the National Geological Gardens is a 300m long concrete barrier or balustrade.

Sidewalks 2,5m wide are paved with concrete paving blocks.

Improvements will include widening on both left and right sides at bus stops. Pedestrian / paths will be provided on both sides of the road.

11.1.5 Section 5: M22 (Boom Street) km31.760, Pretoria Central to R101 (Paul Kruger Street) / Scheiding Street km33.790

Cross section:

This section is about 2,50km long including the loop around Church Square. The longitudinal grade is flat to rolling from Boom Street to Church Square. From Church Street to Scheiding Street the longitudinal grade is flat.

The cross section consists of a single carriageway tapering from 3 lanes (3m wide) in each direction at Boom Street to 2 lanes in each direction at Bloed Street. From Bloed Street to approximately midway between Bloed and Proes Street, the cross section consists of 1 lane LHS and 2 lanes RHS. The left lane is wider allowing for roadside parking. From here to Church Square, the road has one lane in each direction with roadside parking and loading zones on both sides of the road. The road width varies from 14m to 19m.

Entry into Church Square (km32.500) is by means of a single lane (single direction - clockwise) about 5m wide. Parking is provided on both sides of the road. The cross section has a 0,5% camber and is about 10m wide.

From Church Square to Pretorius Street, the road consists of one lane (6,5m wide) in each direction with parking provision on both sides. The kerb-to-kerb width is 16m. From Pretorius Street to Scheiding Street the roadway consists of two 3m wide lanes in each direction with parking (2m – 2,5m wide) on both sides.

Road condition:

Between Boom Street and Church Square, the condition of the asphalt is fair to good although the road is experiencing the following defects:

- patching and potholes over approximately 10% of the area,
- asphalt shoving over about 20% of the area,
- longitudinal and transverse cracks over about 40% of the area,
- crocodile cracks over about 20% of the area.

The Church Square loop is in good condition although there is some longitudinal and transverse cracking over about 20% of the surface area.

The section of asphalt road from Church Square to Scheiding Street is in good condition with shoving of blocks and rutting over about 10% of the area and longitudinal and transverse “v” cracks over about 20% of the area.

General:

The section from Boom Street up to and through Church Square is kerbed and has verges of 5m on both sides of the road. Sidewalks are paved on both sides of the road. Vehicle entrances are provided along the route.

From Boom Street to Church Square large trees are located on both sides of the road.

Streetlights are located on the right side of the road. An Eskom box is located approximately 250m south of Boom Street on the RHS and a fire hydrant on the LHS about 200m south of Boom Street. Cast iron manholes (service unknown) are located in the left lane. Eskom and Telkom services are evident.

Bus shelters / stops are located at various points on both sides of the road.

Through Church Square the shoulders are paved and about 3m wide. Various raised pedestrian crossings cross the road. Stormwater inlets are provided on both sides of the road. Streetlights are provided on the RHS of the road.

From Church Square to Scheiding Street, the paved verge varies between 3m to 5m on both sides of the road. Vehicle entrances and statues are located on both sides of the road.

Streetlighting at 30m centres is provided on both sides of the road. Manholes are located in the left lane.

The Minnaar Street intersection (km33.480) is block paved. Building overhangs extending into the road are noted on both sides of the road. A 50m long, 2m wide concrete median is situated near Jacob Mare Street (km33.640).

Improvements will include widening on both left and right sides at bus stops. Pedestrian / cycle paths will be provided on both sides of the road.

11.2 Drainage

The scope of this preliminary design does not investigate the existing storm water drainage reticulation in detail; however, provision has been made in the cost estimate for expected additional drainage structures and extensions to the existing storm water system.

The route passes through urban development over its entire length. The section from Soshanguve to the intersection of Rachel de Beer and Daan de Wet Nel (about km22.9) is drained mainly by open side drains and culvert structures crossing the road. From this section into and including the CBD, the existing storm water drainage provision is mainly underground.

Any additional storm water reticulation necessary for the BRT will supplement or replace the existing underground reticulation and connect into it. In the case of the northern section the surface water drainage will be conveyed in open side drains or kerb and channel constructed in the buffer zone between the road shoulder and the proposed shared cycle and pedestrian way.

Also refer to City of Tshwane and Gauteng Department of Transport and Public Works typical details and design standards.

11.3 Materials investigation

A centreline materials investigation is excluded from the scope of the Preliminary Design Phase. The road pavement structure is therefore not known at this stage.

The road surface generally appears to be in reasonable condition but it must be noted that these roads have probably never been exposed to the expected heavy loading and volume of the proposed BRT.

The pavement analysis is discussed in **Sections 11.5 and 11.6.**

11.4 Design dimensions and cross sections

Various cross section designs have been considered based on traffic and pedestrian requirements and the space available, as indicated in **Annexure F – Design Cross Section Alternatives on K-Routes**.

On the majority of the northern section (from Soshanguve up to the R513 Brits Road), which is located on various provincial K-routes, the existing cross section consists of a single lane per direction (except at intersections), offset from the centreline of the road reserve but not built on the K-route design alignment. To add two BRT lanes, three options were considered, namely:

- Building a second carriageway, off-set from the existing two lanes, on the correct K-route alignment (Option 1)
- Widen by two lanes to the one side of the existing (Option 2)
- Widen by one lane on each side of the existing (Option 3)

For Options 1 and 2, three lanes will need to be constructed (two new lanes and reconstruction of one bus lane on the existing) while for Option 3, four new lanes will need to be constructed (2 new mixed traffic lanes and reconstruction of the existing to bus lanes). Option 3 is therefore discarded as significantly more expensive.

Option 1 has the added advantage over Option 2 of easier traffic accommodation and the fact that it will be constructed to K-standards, creating an opportunity to also upgrade the second carriageway in future to K standards.

The recommendation to proceed with Option 1 was approved and the preliminary design was therefore done to this cross section.

11.5 Traffic loading

11.5.1 Axle loading of buses

The heavy axle loading of the buses is a common issue dealt with on all BRT roads and the resulting number of E80's calculated per bus is therefore substantial.

Table 11-1: Axle Loading of Articulated Buses

Axle	NDOT Bus (kN)	Possible Tshwane Bus	
		High Floor (kN)	Low Floor (kN)
Front	77.0	76.6	74.9
Centre	125.0	102.0	99.7
Rear	125.0	89.6.	94.8
Total per bus	**327.0**	**268.2**	**269.4**

It is understood the type of bus has not yet been finalised and for this report the conservative approach has been used by assuming the use of the heavier NDOT bus proposal.

The articulated buses' axle loads (sourced from the DOT proposal) are however understood to be calculated based on full (crush) loads of 160 people but for this report a maximum of 120 passengers per bus has been assumed. It is then assumed that the busses will operate on average at 80% full.

Coupled with the heavy loading, some sections on the route may operate under high bus frequencies. However the bus frequencies have also not yet been resolved and for this report a peak hour frequency of 90 busses per hour on the busiest section has been assumed.

Table 11-2 indicates the estimated number of articulated bus trips over 10 years and 20 years assuming no future growth as well as the number of equivalent standard 80 kN axles (E80's) over that period.

Table 11-2: Number of buses and E80s on the busiest section (90 buses per hour) – no growth

Summary Results	10 Years		20 Years	
	Buses	E80s	Buses	E80s
Articulated Buses	2 600 000	8 981 000	5 200 000	18 000 000

TABLE 11-3 shows the increased number of trips and E80's due to a potential growth rate of 5% for the first 2 years followed by 2% growth thereafter.

Table 11-3: Number of buses and E80s on the busiest section (90 buses per hour – 5% growth in years 2 and 3 and 2% p.a. thereafter

Summary Results	10 Years		20 Years	
	Buses	E80s	Buses	E80s
Articulated Buses	2 884 000	9 970 000	6 205 000	21 500 000

The heavy loadings impose large stresses in the underlying road pavement layers and substantially deep and strong pavements are called for to avoid early failure of the subgrade layers.

There are numerous accounts of BRT Systems that had been operational for some time with significant pavement failures early in the life of the facility, pointing to inadequate pavement design as one of the areas where new systems can learn from the mistakes made on earlier systems.

The SA Mechanistic Design Method is used for the determination of the proposed pavement structure. As the bus lanes are dedicated for buses only the expected bus axle loading is used directly in the analysis. The pavement is then checked against the catalogue designs TRH4.

11.5.2 Normal (mixed) traffic loading

Based on the visual assessment it appears that for the most part the existing pavement structure will remain sufficient for the normal traffic (the light loads) it is expected to carry.

A materials investigation is proposed to be carried out at the detail design phase to confirm the above.

11.6 Pavement Design

The roads under consideration have their own particular problems when considering the upgrading to accommodate dedicated bus lanes, and a generic design solution can therefore not be applied here. Even different sections within a route will have different solutions as a result of the different infrastructure to be provided, with and without private and or parking traffic lanes and widely differing bus volumes (frequencies).

Between bus stops it may be possible to upgrade the BRT lanes only but this will be dependant largely on the current road cross-section.

Approaches to the bus stops and at the bus stops themselves however will probably require the complete upgrade of the road profile.

11.6.1 Rehabilitation of existing lanes for general traffic

These lanes will generally fall into the ES3 pavement class based on the design traffic loading.

A typical existing pavement structure may be expected to be as follows:

- Asphalt surfacing of varying thickness
- 150mm G2 crushed stone or waterbound macadam base
- 150mm to 300mm G5 or C4 subbase
- 150mm G7 gravel selected layer
- In-situ G7 to G9 roadbed material

It is envisaged that in many sections only a 40mm asphalt overlay will be applied to existing pavement. There are sections of existing pavement however that will require reconstruction due to the extent of the cracking and deformation while some sections will require extensive edge break repair and reworking the gravel shoulders.

The surfacing may require additional rehabilitation measures before an overlay is constructed, such as:

- Cleaning and sealing of longitudinal and transverse cracks
- Patching where extensive cracking is evident
- Patching where settlement or rutting has occurred

11.6.2 Road widening

Widening of the road cross section is required in places. The new road sections would also likely fall into the ES3 pavement class as described above.

A typical pavement structure for new mixed traffic lanes and road widening would be as follows:

- 40mm asphalt surfacing, continuously graded, course grade
- 150mm G2 crushed stone base
- 150mm to 300mm subbase C3 (probably recovered from existing pavement)
- 150mm SSG using in-situ or G6-G7 mechanically modified soils

11.6.3 New BRT traffic lanes

The new BRT lanes fall within the ES30 pavement class and will therefore require new construction.

A typical pavement structure for BRT lanes will be as follows:

- 40mm aphalt surfacing, continuously graded, course grade
- 150mm asphalt base, continuously graded (2 x 75mm layers)
- 150mm upper subbase C3 (Recovered from existing pavement)
- 150mm lower subbase C3 (Recovered from existing pavement)
- 150mm selected subgrade C4 using stabilised mechanically modified in-situ subgrade material

** At bus stops, 40mm surfacing with cementiously grouted open graded asphalt (salphalt or similar) is proposed as this surfacing type will not be damaged by fuel spillage. Alternatively a concrete pavement may be considered.

Various asphalt surfacing mix designs will be considered at detail design stage.

A concrete road pavement structure is more expensive and difficult to construct in an urban environment with many service crossings.

11.7 Lane Demarcation

The demarcation of lanes needs to be considered in terms of a *physical* barrier separating the BRT from normal traffic lanes as well as the *visual distinction* between the lanes types.

11.7.1 Physical barrier lane separation

A barrier is recommended to physically separate the BRT lanes from the normal traffic lanes. The purpose of the barrier is to prevent or at least discourage non-BRT traffic from entering into the BRT lanes.

Various barrier options are available:

(a) Kerb separation

Kerbs can be used to separate the BRT traffic from normal traffic lanes. This can be done by either installing barrier kerbs or installing mountable kerbs combined with a raised surface for the BRT lane.

The barrier kerbs would not allow any traffic movement from BRT to normal lanes or vice versa. The negative impact of using barrier kerbs is that should a bus break down, subsequent buses will not be able to pass the broken down bus, bringing the system to a halt. Dealing with the stormwater runoff is also a problem and additional underground drainage would be required to prevent the concentration of runoff.

The combination of mountable kerbs with raised BRT lanes would also aid in separating the traffic types, but could be dangerous should a bus leave the demarcated BRT lane in higher speed sections as the steering wheel may "pull". Raised BRT lanes also need to be feathered back to the normal road section at intersections.

This alternative is not recommended.

Photo 11.7.1: Barrier Kerb Seperator in Guyaquil, Equador
(Photo – L de Beer, GIBB, 2007)

(b) Concrete barrier / wire rope / Klemmfix delineator separation

A concrete barrier would work in much the same manner as the barrier kerb separation option. As with the barrier kerbs option, broken down busses will pose problems possibly bringing the system to a halt.

A wire rope barrier would effectively prevent vehicles from crossing into the wrong lanes but they require substantial maintenance and will also be problematic in the case of bus breakdowns.

Photo 11.7.2: Wire rope barrier
(Photo – http://www.armcorsp.co.za)

Klemmfix delineators are flexible (collapsible) delineators that could be used to separate lanes. These may require maintenance when damaged, and is expensive relative to concrete or polymer rumble blocks and are therefore not recommended for continuous application over long distances.

Photo 11.7.3: Klemmfix Delineators in Florida, USA
(Photo – M Hagler, 2011)

(c) Rumble blocks

The BRT in Johannesburg's inner city made use of concrete and later plastic-polymer rumble strips to separate the BRT traffic from normal traffic. The rumble blocks are roughly the same dimensions as a conventional kerb but with the top surface made up 75mm high ripples. These ripples though not impossible to cross with a light vehicle, are uncomfortable to cross thereby discouraging vehicles from crossing into the BRT lanes. In the case of a broken down bus in the BRT lane, following buses could cross over the barrier and pass around the broken down bus.

The drawback of using the concrete rumble blocks is that many have been chipped and damaged by vehicles crossing over them. This is particularly evident at intersections where vehicles have clipped the edges of the rumble blocks.

Yellow road marking paint on the concrete rumble blocks also do not seem to last long, requiring high maintenance to keep the rumble blocks highly visible.

Photo 11.7.4: Concrete Rumble Block, Rea Vaya (newly painted and faded/warn contrast)
(Photo – H Hoffman, GIBB, 2011)

The polymer rumble blocks, do not seem to lose its bright yellow colour and do not chip as easily as the concrete blocks, but have been found to come loose quite easily.

Photo 11.7.5: Vitalcor 114 Molded Rumble Block, Rea Vaya
(Photos – D Plummer, Vitalcor, 2011)

(d) Raised asphalt lane

The BRT lane can be raised relative to the normal traffic lanes. The raised surface separation may be formed by tapering the raised asphalt layer of the BRT lane down to the mixed traffic lane over the same width as a mountable kerb with minimal cost implication. Although the lanes will be clearly distinguished, this option could prove dangerous.

The combination of kerb and raised surface has been described above.

(e) Roughened or raised asphalt rumble strip

A rumble strip can be a series of simple troughs (typically 1 cm deep and 10 cm wide) that is ground out of the asphalt. Other alternatives use raised strips, painted or glued to the surface (such as thermoplastic products) to warn of hazards or not to stray into a specific lane. They create a strong vibration when driven over that will alert a driver both by sound and the physical vibration of the vehicle.

Although the noise and discomfort experienced in crossing the strips could discourage most road users from straying into the wrong lanes, these strips do not provide any protection to vehicles should they stray in to the wrong lanes and is deemed unlikely to effectively deter transgressors.

Photo 11.7.6: Raised Thermoplastic Line
(Photo – http://en.wikipedia.org/wiki/File:Linia-groszkowa-na-A4.JPG)

11.7.2 Visual bus lane demarcation

Visual lane demarcation aids in clearly distinguishing between BRT and normal traffic lanes. Visual separation does not offer any protection or safety to vehicles and so should be considered in conjunction with physical barrier separation as described above.

(a) Coloured asphalt or coloured surface applications

Various coloured asphalt or coloured surface applications are available. These options are all very expensive and based on trial sections in Johannesburg, dirt, fuel and oil build up detract from the coloured effect fairly quickly.

In the case of red oxides applied to asphalt, the colour is not a very bright red, and fairly quickly fades to the colour of the aggregate. In previous investigations for the City of Johannesburg, no bright red aggregate could be sourced locally in Gauteng, although aggregate with a light pink tinge is available, but in time would hardly be distinguished by the general public from the normal grey aggregates.

The Cape Town BRT uses a product called "Tyregrip" with reddish Jasper stone chips but this product is deemed prohibitively expensive.

Photo 11.7.7: MyCiti Trial Section of Tyregrip coloured surface application
(Photo – SATC 2011 Presentation, "BRT Infrastructure in Cape Town", HHO)

This product was also put down in a Rea Vaya trial section in 2008, starting out as a bright red but faded in time to a burgundy-colour.

Photo 11.7.8: Tyregrip surface application, Rea Vaya Trial (photographed 3 years after application in 2008)
(Photos – L de Beer, GIBB, 2011)

(b) Concrete surface

Although visually distinguishing, a concrete pavement is unforgiving in both construction and maintenance especially where many services are encountered such as in a developed area and notably so in an old city.

It is also more expensive initially but could prove less expensive over the life cycle of the project due to potential lower maintenance cost.

(c) Broad painted in-lane lines

This option involves painting a broad coloured line down the centre of the BRT lanes. The strip painted is wide enough to clearly demarcate the BRT lane, yet narrow enough to fit between the wheel tracks of the busses, i.e. the buses' wheels drive on either side of the painted line, minimising wear and tear.

Photo 11.7.9: Bus Lane in Haifa, Israel
(Photo – www.streetbond.com)

Photo 11.7.10: Solvent based road marking paint trial for Rea Vaya
(Photo – H Hoffman, GIBB, 2011)

Trials for Rea Vaya have shown that solvent-based paints are more durable in this application than the more expensive thermoplastic paints, with trial strips of older than three years, applied in front of one of the busiest Metrobus Depots and thus carrying high bus traffic, still being bright red.

Photo 11.7.11: Solvent based road marking paint trial for Rea Vaya, photographed in 2011, three years after application in 2008
(Photo – L de Beer, GIBB, 2011)

This option is also relatively inexpensive compared to the other options discussed and is planned to be applied to Johannesburg's BRT lanes in 2012.

(d) Road marking symbols

The conventional approach of applying road marking symbols to the BRT lanes is also necessary. The symbols can be either the standard "buses only" signage or a new symbol unique to the BRT.

11.8 Standards and Typical Details

The City of Tshwane Roads and Stormwater Division's "Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure" issued September 2008, are specified in general for the metropolitan roads and are not referenced individually on each drawing.

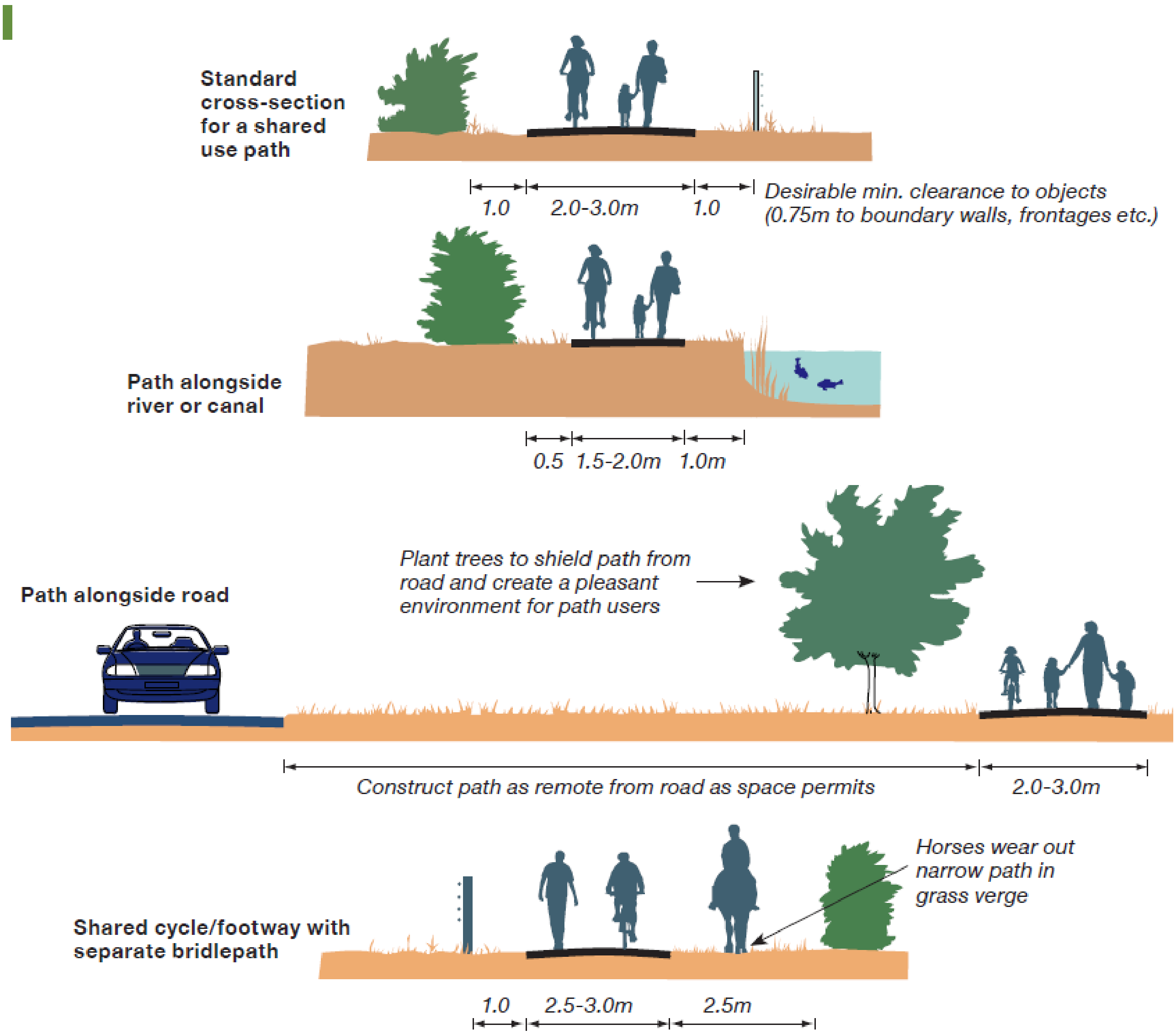
For the provincial roads, the Department of Transport and Public Works "Typical plans for road design" are specified, and are not referenced individually on each drawing.

Particular details queried during the course of the design development are referenced in **Table 11-4:**

Table 11-4: Typical Details References

Detail	Reference	Drawing Number	Comment
Pedestrian Ramps	Tactile Ground Surface Indicators and Pedestrian Crossings	TGSI_000 - 018	GIBB document
Walkways and Cycle Tracks	Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure See **Section 5.2.7**.	STD008	There are numerous international design guidelines detailing international best practice, which should be used in addition to the minimum requirements set out in the Tshwane typical detail and the NDOT Guideline "Pedestrian and Bicycle Facility Guidelines", August 2003. Segregated pedestrian and cycle lanes, as recommended in NDOT Guidelines, are proposed where a minimum 3.5m width is available See examples **Figure 11.9.1** and **11.9.2**
Cycle Crossings	Tactile Ground Surface Indicators and Pedestrian Crossings	TGSI_018	
Handrails, Ballustrades and Bollards	Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure	STD011	- Increase minimum height of balustrade on bridge with cycle way to 1.4m - Gauteng standards require guardrails where minimum buffer of 0.6m is used or where a kerbed cross section is not used.
Bus and Taxi Laybyes	Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure Gauteng Department of Public Transport Roads and Works (GDPTRW) Typical Details	STD015 GTP 6/1	Metropolitan Roads Provincial Roads
Detail of 1.2m wide separation between BRT Lanes	Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure	STD007	Semi-vertical (Figure 7) kerbs
Treatment of right turns	See **Section 7.4**	-	Detailed typical drawing (including road markings and signage) to be developed during detail design stage.
Landscaping of medians		-	Generally grassed with trees retained where possible
Road Markings and Signage, Signal Design	South African Road Traffic Signs Manual (SARTSM)	-	

Figure 11.9.1: Examples of segregated shared cycle and pedestrian way



Most traffic-free paths aim for at least 2.0m width in rural areas and 3.0m and more in urban ones, more or less to accommodate the likely usage. The examples here are the ones commonly specified

Figure 11.9.2: Examples of Pedestrian and Cycle Way Design Widths
(Source: Connect2 and Greenway Design Guide)

11.9 Summary of Proposed Upgrading

The extent of the upgrading proposed is summarised by section in **Table 11-5,** and specific issues or aspects on which comments or queries on the draft drawings were received, are discussed in more detail in **Section 11.10.**

Stations are of the following types:

- Double module stations with bypass lanes: B5, B6, B7, B9, B10, B11, B12, B13, B14, B15, B16
- Single module back-to-back station with bypass lanes: B25, B27, B28
- Single module one-directional station with bypass lanes: B20
- Single module, staggered off-set stations with bypass lanes: B8, B17, B21, B23, B24, B26, and B29
- Single module with **no bypass lanes**: B18 on Rachel De Beer in Pretoria North CBD.

While some stations are single modules, all except Station B18 have bypass lanes. B18 has been identified as the Line 1 systems bottleneck, and will determine the overall BRT system capacity, should bus frequencies on this section be increased above the capacity of a station without bypass lanes.

The preliminary design layout plans and the services drawings are included in **Volume 3**. It should be noted that the layout drawings in **Volume 3** show engineering detail e.g. where bus lane layer works and widening or new construction are needed, and hatching therefore reflects the function or use of lanes (e.g. shared or used exclusively by BRT) rather than the appearance of the final product in terms of lane markings.

It is important to note that not all comments were necessarily incorporated in the drawings and preliminary design drawings should therefore be read in conjunction with the report and in particular notes in Section 11.10, when commencing with the detail design.

A second set of “presentation” drawings that do not show the underlying layer works or widening, and which therefore have less detail and clearer lane and intersection configurations, was developed for wider consultation and presentation to non-technical stakeholders. These drawings are included in **Volume 4**.

Table 11-1 Summary of Proposed BRT Upgrades

Section	Road	From	To	Length (km)	Current Cross Section	Extent of BRT Upgrades
1	M17	Ruth First	M20 (Hebron Road)	2.3	Single carriageway with 1 lane per direction, with local widening for turning lanes at intersections	(Excluded)
2	M20	M17 (Hebron Road)	Doreen	2.2	Single carriageway with 1 lane per direction, with local widening for turning lanes at intersections	Widen road to two lanes per direction, with one lane reserved exclusively for BRT buses and one lane for mixed traffic. Road over river culvert to be lengthened. (Excluded due to route change to Kopanong Station)
3	Doreen	M17	Kitshoff	4.5	Single carriageway with 1 lane per direction, with local widening for turning lanes at intersections	Widen road to two lanes per direction with one lane reserved exclusively for BRT buses and one lane for mixed traffic. New road over rail bridge.
4	Doreen	Kitshoff	Daan de Wet Nel	4.1	Single carriageway with 1 lane per direction with local widening for turning lanes at intersections, except for a section from De Waal Street to Van Niekerk Street which has been widened already to a dual carriageway (two lanes per direction).	Widen road to add an additional lane per direction, reserved exclusively for BRT buses. The number of lanes for mixed traffic therefore remains as it currently is. Road over river culvert to be lengthened New road over rail bridge.
5	Doreen	Daan de Wet Nel	Rachel de Beer	3.2	Single carriageway with 1 lane per direction with local widening for turning lanes at intersections	Widen road to two lanes per direction, with one lane reserved exclusively for BRT buses and one lane for mixed traffic. New road over road bridge (N4).

Section	Road	From	To	Length (km)	Current Cross Section	Extent of BRT Upgrades
6	Rachel de Beer	Doreen	Daan de Wet Nel	6.7	Dual carriageway with 2 lanes per direction and a wide landscaped median with mature trees	Widen road into the median to add an additional lane per direction, reserved exclusively for BRT buses. Two mixed traffic lanes will remain. New road over road bridge (R80) to close the gap between the two carriageways. Trees in median may be affected at the stations and the start of the section.
7	Rachel de Beer	Daan de Wet Nel	Lavender	3.0	Two lanes per direction. The section west of the bridge is undivided while the section from the bridge to Lavender has a median.	This section cannot be widened without substantial land acquisition and there is a rail over road and a road over road bridge which would be very costly to widen due to the physical constraints. One of the existing two lanes is thus proposed to be reserved for BRT, with one lane remaining for mixed traffic. South of the M1 bridge, the road widens to two mixed traffic lanes per direction, in addition to the BRT lanes. As the widening will take place into the median, some trees will be affected here. A number of intersections in Pretoria North CBD will be changed to left-in, left-out access, i.e. some right turns will be banned, resulting in minor deviations required to some routes. [The reduction in capacity to private traffic will also mean that it would be pointless to construct the K14 link through Rainbow Junction, linking Rachel de Beer and Zambezi Drive, unless the section of Rachel de Beer between Daan de Wet Nel and the two bridges is also widened (major land expropriation needed over a section

Section	Road	From	To	Length (km)	Current Cross Section	Extent of BRT Upgrades
						of approximately 2km). The transport study for Rainbow Junction indicates that the substantial trip generation forecast at the proposed new development will rely on the additional capacity created by the new link. The developer could potentially oppose the proposed reduction in capacity for mixed traffic]
8	R101	Lavender	Paul Kruger	1.1km	Three lanes per direction through the "Poort" and adjacent to the Apies River	Due to the strategic importance of this link through the Magaliesburg Ridge on the regional traffic flows of Tshwane (with limited alternatives which are also at capacity), it is not proposed to reduce the mixed traffic lanes from three per direction to two per direction, as initially considered. A contraflow bus lane is considered, as discussed in more detail in **Section 11.11.**
9	Mansfield	Paul Kruger	Boom	4.9	Dual carriageway with two lanes per direction up to Myburgh Street, thereafter widening to three lanes per direction, with local widening for turning lanes at intersections.	In Mansfield Road, it will be very costly to widen the road to add a new lane, and there are two rail over road bridges which would also need to be widened if an additional lane is to be added. It is thus proposed that one of the existing lanes be reserved for BRT, with one lane remaining for mixed traffic. On the section between Myburgh Street and Boom Street, there would be one BRT lane per direction and two mixed traffic lanes per direction. Trees in the median would be affected. A cost estimate is however also provided to widen the road and the two bridges.

Section	Road	From	To	Length (km)	Current Cross Section	Extent of BRT Upgrades
10	Paul Kruger	Boom	Vermeulen	0.6	Generally between one and two lanes per direction, with limited on-street parking. There are mature Jacaranda Trees on both sides of the street.	One of the existing lanes will be reserved for BRT, with one lane remaining for mixed traffic, per direction. On-street parking will be removed although provision is made for lay byes on one side of the street, to accommodate loading of goods and mini-buses stopping to drop off or pick up passengers. Some trees may be affected but this is mostly on the blocks where there are stations. In between stations, road widening is generally not required.
11	Church Square	Vermeulen	Pretorius	0.3	One lane per direction around the square and diagonal parking bays Jacaranda Trees on both sides of the street on the section north of the Square	The section of Paul Kruger between Vermeulen and Pretorius will be reserved for BRT only. Parking on the parcel north of the Square will be converted to pedestrian space. Access to the remaining pockets of parking will be via Parliament and Mutual Streets. A BRT station is proposed north and south of the Square. The station on the north will probably affect trees and there are some bus shelters which could be historical but it is likely that these can be relocated. There are no trees or other features impacted on the southern side. The project will enhance the pedestrian space and urban environment around the Square, with the conversion of large sections of asphalt to more aesthetically pleasing alternatives.
12	Paul Kruger	Pretorius	Scheiding	1.0	Generally between one and two lanes per direction, with limited on-street parking.	One of the existing lanes will be reserved for BRT, with one lane remaining for mixed traffic. On-street parking will be removed although provision is made for lay byes on one side of the street, to accommodate loading of goods and

Section	Road	From	To	Length (km)	Current Cross Section	Extent of BRT Upgrades
						mini-buses stopping to drop off or pick up passengers.
13	Pretoria Station				The GOBA proposal have not been reviewed / re-worked yet – still under development	Impacts identified should be similar to the previous project: station buildings and precinct = historical. Some loss of parking and change of access arrangements can be expected. Enhancement of pedestrian space and urban environment.

A 4.5m shared cycle and pedestrian way is proposed along the route (on one side of the road) from the intersection of Hebron Road and Rosslyn Road (km 4.450) up to the intersection of Doreen Avenue and Rachel de Beer Street (km 16.200). From here to the CBD, a 3.5m (minimum width) shared cycle and pedestrian way is proposed along one side of the road on the sections where possible, as discussed in **Section 5.2.7**. On sections where it is not possible to provide a 3.5m minimum clear width, alternative cycle routes are recommended.

11.10 Comments Received on Draft Preliminary Design Drawings

Preliminary design drawings were submitted to and discussed with the City of Tshwane Programme Managers for comment during the development of the design. A meeting was held with City of Tshwane officials on 2 December 2011 at which the salient points of the design was presented and discussed.

Comments obtained from the Programme Managers and as discussed at the meeting with City of Tshwane officials, and the subsequent amendments incorporated in the final drawings (where relevant), and / or references to the appropriate report section, are summarised in **Table 11.1**.

The third column in **Table 11.1** refers to the Drawing Sheet Number (Volume 3) where the comment refers to or in the case of a general comment relevant to several sheets, the sheet where the comment was first noted.

Table 11.1: Comments on Draft Preliminary Design Drawings

No.	Comment	Sheet No.
1	**Sidewalks and Cycle Lane Widths** Cross sections, on the northern section showed an incorrect shared cycle and pedestrian way. The corrected layout now shows a 2m sidewalk on the outer side (furthest from vehicular traffic) with a 2.5m two-way cycle way on the inside (closest to the road) See **Section 5.2.7** and **Section 11.8**	3
2	**Drainage** Refer to **Section 11.2**	3
3	**Single / double modules and distance between bus bays and modules** See **Section 5.2.5** (new section)	3
4	**Extent of new sidewalks** As a rule, pedestrian sidewalks are provided on both sides of the BRT route, with the exception of some undeveloped sections along Doreen Road, where a shared cycle and pedestrian way is provided on one side only. The layout plan indicates short sections of pedestrian links, either shown as sidewalks, or alternatively as possible future walkways (blue dashed line). Possible future walkways are generally shown schematically and link lower order side streets via the shortest possible route to the BRT route and stations. Some of these links are not currently possible due to property boundaries preventing direct access, and it is recommended that pedestrian servitudes be registered during the detail design stage,	3

No.	Comment	Sheet No.
	to improve pedestrian access.	
5	**Right Turns** See **Section 7.4** and **Section 11.8**	3
6	**Guardrails or Pedestrian Handrails at Embankments / Cut / Fill** Where specific embankments were identified, a note was added indicating the need for guardrails to protect pedestrians / cyclists. The exact extent of these will however only be finalised during the detail design stage, when the cross sections are generated, according to the typical standards for Tshwane metropolitan roads and Gauteng provincial roads. For example, Gauteng design standards require a guardrail to separate pedestrians and vehicular traffic on Class 2 roads, when a kerbed cross section is not provided or when the minimum 0.6m buffer is provided. See **Section 11.8**	3
7	**Landscaping** Medians are to be grassed and landscaped where desirable. It is recommended that the detail design include the development of typical landscaping details and planting specifications.	4
8	**Access to Properties** Where specific existing accesses were identified from site visits, aerial photos and comments received, drawings indicates whether it should be retained or removed. As a general rule, all informal individual erf accesses on K-routes are illegal. However, to minimise resistance by stakeholder, these were retained as left-in, left-out accesses where safe to do so. Gautrans would reserve the right to enforce the abandonment of these in future. However it should be noted that the survey did not pick up all individual accesses, particularly on the metropolitan roads where mountable kerbs provide virtually un-interrupted access to each property directly. On these sections, it is likely that all accesses will need to be retained unless a detail road access management plan (RAMP) is developed in consultation with the affected property owners. The detail design will need to consider each property's access individually but will require a more comprehensive topographical survey to do so.	4
9	**Sidewalk width on new structures** Previously, the typical (minimum) sidewalk as per the Gauteng Department of Transport and Public Works typical details for bridges was provided. However as the cost increment on wider than minimum sidewalks on a new structure is not substantial, the drawings and cost estimate was amended to reflect a sidewalk of the same width as the	5

No.	Comment	Sheet No.
	shared walkway and cycle way (but with no buffer).	
10	**Pedestrian and / or cycle crossings** Pedestrian crossings were staggered where possible, i.e. when the median width is at least 3m (to accommodate the pedestrian handrails). At T-junctions, where the right turn lane on the main road resulted in a median width less than 3m (typically 1.2m), the pedestrian crossing on this approach was removed where the pedestrian crossing on the other approach could be staggered. There is however still a number of intersections where staggered pedestrian crossings cannot be provided without substantial and costly widening and or re-alignment. At these intersections, adequate green time and pedestrian clearance time should be allowed in the signal design, complying to SARTSM requirements. It should be noted that the location of the accessibility ramps and tactile indicators were not drawn to scale and the actual locations of these ramps, as governed by the typical details (see **Section 11.8**) may change the precise location of the crossings relative to the bellmouths. This level of detail is usually addressed in the detail design. In any event, due to the poor quality of the survey data, some of the bellmouths were also drawn schematically to correspond with the aerial photos.	6
11	**Double Entry to Stations** **See** Section 5.2.5	6
12	**Relocation of Street Furniture where road is widened** Street furniture such as lighting and advertising boards needs to be relocated if road widening results in it being located too close to the travelled way, generally a minimum of 1m (with guardrail) on provincial roads.	8
13	**Lane Drop to reduce number of lanes to cross at pedestrian crossing** It is possible to drop the mixed traffic lane sooner to reduce the crossing width, but the drawing was not amended as the double module and thus the second entrance may not be required – to be confirmed before commencement of the detail design.	8
14	**Service Road at Station B11** At station B11, there is a two-way service road with parking in front of a business, providing access to Lynn Road. It could not be established if this is a legal access that needs to be retained, or a temporary or illegal access and to be safe it was assumed that it needs to be retained. The current layout results in a narrow 2.5m sidewalk. Ideally, the status of the access should be confirmed and if it is possible to convert it to a left-in, left-out one-way service road, the sidewalk	10

No.	Comment	Sheet No.
	/cycleway can potentially be widened to the desirable 4.5m width.	
15	**Trees** Special measures to avoid the removal of mature trees where new road construction is required, was not taken, in accordance with the requirements indicated in the environmental assessment. The survey was in any event not detailed enough to delineate each individual tree with confidence. According to our environmental expert, even the proposed removal of approximately 16 Jacaranda trees north of Church Square (Station 27) can be mitigated and does not represent a fatal flaw. The sidewalk / cycle way design considered the location of trees in aggregate i.e. where a linear row of trees were detected and it was possible to avoid it, the path was placed accordingly. However it is proposed that the detail design should further refine the sidewalk design where feasible to avoid unnecessary removal of individual mature trees.	11
16	**Lane Layout at Intersection of Doreen / Brits Road** Conflicting lane movements were changed to the conventional layout. Conflicting movements (buses turning left and mixed traffic proceeding straight or turning right) are now separated by the upstream pre-signal.	12
17	**Median width on Rachel De Beer** Rachel de Beer has a 7.6m wide median, narrowed from the current width due to the construction of the BRT lanes on the inside of the existing 2 lanes in each direction. This was done to minimise construction cost but results in the remaining road reserve on the outside being smaller than desired. Nevertheless it is likely to be sufficient for a 3.5m shared sidewalk / cycle path at least up to Punctata Street, where the road reserve narrows.	12
17A	**Capacity of shared right turn lanes at R80 on-ramps** Refer to **Section 7.6, Figures 7.6.7(am), 7.6.8(am), 7.6.7(pm) and 7.6.8(pm)**. Both intersections operate at LOS A in both the AM and PM. Average mixed traffic intersection delays are less than 30 seconds and average BRT delays are less than 6 seconds. The shared right turn movements are therefore deemed to operate well, with no adverse impact on BRT delay. However as noted in **Section 7.6.2.a (ii)** it was necessary to model an additional left turn lane on the south approach of the western terminal to accommodate the high left turn volume.	13

No.	Comment	Sheet No.
17B	**Can Makkie Street be changed to a LILO?** A traffic count was not done for this intersection, but from assessment of the network, it is likely to carry relatively low volumes. On the south side it only gives access to the Golf course, while on the north side it provides access to the suburb of Tileba. Changing it to a LILO will result in detours for three of the four affected movements of between 500m and 2km. While the suburb of Tileba is easily accessible from other streets (Waterbok, Barbara and Francois Street) and the impact is not deemed substantial, the Golf Course do not have alternative access. Traffic from the west will need to turn left in Makkie, right in Brits Road and make their way back to the Golf Course from the east. More severely impacted on is the exit from the Golf Course to the east. Traffic will need to turn left in Brits Road, and make a U-turn at Waterbok Street, a detour of 2km. It is therefore recommended that Makkie remains a full access.	15
18	**Geometric alignment at Brits / Grafenheim** – adjusted to straighten	15
19	**1.2m Median typical detail** – See Table 11-4.	15
20	**Pedestrian Crossings on Rachel De Beer Street from Daan de Wet Nel Street to Koos de La Rey Street** Initially, pedestrian crossings were not shown where intersections are proposed to be converted to LILO access. However the distance between signalised intersections are deemed too long, which means pedestrians are likely to cross illegally and cause a hazard. The drawings were therefore amended to indicate unsignalised pedestrian crossings. The rumble blocks should be interrupted to avoid a trip hazard for pedestrians. The use of Klemmfix delineators (or similar) separating the two bus lanes, across the LILO intersections, should be considered to prevent illegal movements to/from the side streets, across the BRT lanes. The provision of a crossing on one side only of the LILO access was considered but not deemed advantageous as pedestrians are likely to cross illegally on the other side if not provided.	16
21	**2.5m Pedestrian Sidewalks on Rachel De Beer Street from Daan de Wet Nel Street to Koos de La Rey Street** The restricted width is too narrow for cycle facilities either in the road or shared on the sidewalk. Alternative cycle routes are therefore recommended and the cross sections amended accordingly. See **Section 5.2.7.**	16
22	**Station B18** The TRANSYT results indicate potential capacity problems, particularly in the afternoon peak, if the right turns (shared with BRT lanes) are provided as shown. However given the number of businesses located on this section, it is unlikely that the conversion of these intersections to LILO would be acceptable to stakeholders. Further consultation is	16

No.	Comment	Sheet No.
	recommended. Refer to **Sections 5.2.18, 5.3.15, 7.6.1** and **7.6.2** (TRANSYT Results) for more detail.	
22A	**General concern with the reduction in capacity on Rachel De Beer with the conversion of one of the existing lanes to BRT** The reduction of mixed traffic lanes from two lanes per direction to one lane per direction will no doubt have an impact on the capacity of mixed traffic and increase congestion. The development of Rainbow Junction will exacerbate the problem. The TRANSYT results indicate the expected impact given the existing traffic, with an assumed 30% reduction in peak hour traffic as a result of diversion to other routes, peak spreading and mode a change from private car, bus and minibus taxis towards BRT (see **Sections 7.6.1** and **7.6.2**. City of Tshwane roads and stormwater officials requested completion of simulation modelling prior to commencement of the detail design. The BRT Division noted that this is planned, but that the decision to proceed with implementation is however likely to be a policy decision (to prioritise public transport over private transport) regardless of the outcome of the simulation modelling.	16
23	**Cross over of BRT from median lanes to kerbside lanes, U-turn at Rainbow Junction and access to properties** The signalised cross-over originally located west of the bridge was relocated to the location immediately north of the proposed off-street facility. The signal will also allow a U-turn, should BRT services be terminated at the proposed Rainbow Junction intermodal facility in the interim. The geometric feasibility of providing a U-turn was checked on a sketch plan but the drawing was not altered. It is recommended that this be developed further with the conceptual design of the Rainbow Junction intermodal facility (not included in the current scope of work). The draft layout plan previously indicated the closure of two median openings south of the proposed Rainbow Junction intermodal facility, as the median would be converted to BRT lanes on this section. It was the intention that the access to the properties that currently gain access via these median openings be converted to LILO access only. However it was pointed out that Rainbow Junction will also have a full access at this point. The revised drawing shows the planned Rainbow Junction access. Since this access requires the demolition of existing buildings, it is assumed that it will only be constructed when the property is developed (timeframes unknown). The drawing is thus revised to show a temporary consolidated signalised access and service road. The signal can be coordinated with the upstream signal at the exit from the Rainbow Junction intermodal facility, which will also eliminate the unsignalised merge and cross over from the intermodal facility (kerb	17

No.	Comment	Sheet No.
	side) to the median lane (southbound direction) previously provided.	
24	**Proposed Contraflow Public Transport Lane from Lavender to DF Malan Road** A peak period (temporary) contraflow lane was proposed, but more details were requested. In particular, it was noted that the on-going operational cost may justify spending additional capital cost to rather widen this section to add a permanent reversible lane. Refer to **Section 11.11** (new section) for more details.	18A and 18B
25	**Service Road / Lane on Mansfield Road from Van Rensburg Street to Myburgh Street** On this section, segregated service roads are provided on one side of the street on most blocks, to provide access to individual properties. On the other side of the street however, properties are still served through direct access. In the current layout, a sub-standard width auxiliary lane is provided to assist with access on these blocks. In the revised layout (with BRT) this lane is retained as far as possible. Its demarcation has been corrected now (previously it was noted as a bus/taxi laybye). On the blocks between Flowers Street and Trouw Street, all on-street parking is to be removed.	19 & 20
25A	**Station 23B: Can the right turn at the intersection of Booysen Street be banned?** The existing right turn volumes are relatively low (91 PM peak hour) and these right turns can be accommodated at Fred Nicholson although it will result in this intersection being more congested, and would result in a detour of around 500m which is deemed acceptable. The right turn lane at Fred Nicholson may need to be lengthened. The design drawing was not changed and should be updated during detail design stage.	19
26	**Paul Kruger / Mansfield Intersection** Drawing amended to show lane drop schematically	20
27	**Drainage of Sidewalks under bridges** Drawing amended to reflect note indicating the need to upgrade or change (cover) the drainage channel to maximise the sidewalk width.	20
28	**Alignment at Mansfield / Flowers Intersection** - straightened	20
29	**Station 25B at School** Pedestrian handrails added to protect pedestrians walking from the signalised crossing to the station entrance. A direct underground link between the underpass and the station is likely to be technically feasible but the additional cost should be considered against the potential pedestrian demand (unknown).	20

No.	Comment	Sheet No.
30	**Dividing barrier from Station B25 to Boom Street** The existing cross section is considered too narrow to provide a barrier, and cannot be widened cost effectively due to the rock cuttings and bridge constraints on this section of the route. A dividing barrier is therefore not recommended.	20
31	**Station B26** This station is currently shown between Boom and Bloed Street but due to changes in the operational design it has subsequently been decided to move it to the north of Boom Street.	21
32	**Station B27** See **Section 5.3.24** for a discussion of options considered and the reasons for recommending the two modules immediately north and south of Church Square to operate as a double module integrated station. Capacity considerations seem to indicate that both modules are likely to be required. **Refer to Table 6.1** Station Capacity Calculations. According to our calculations, the 5m wide single module station is marginally under capacity with the assumed 4 lines stopping, 60 buses per hour (combined) using the station, and 1200/800 passengers per hour boarding / alighting. Note however that the calculated internal platform width required to accommodate the 2000 hourly passengers assumed to be boarding and alighting is 5.6m, marginally wider than the 5m provided. A 5m station will therefore have a slightly lower than desirable passenger LOS during peak periods. If the expected demand is higher than the assumed boardings and alightings, two modules will be required. **It is recommended that the passenger demand be finalised as a matter of urgency**. Previous passenger estimates from the demand model indicated significantly higher passenger numbers than the 2000 assumed, but some unrealistic distribution of demand was observed, possibly as a result of course model zones and inaccurate walk link and / centroid connector coding.	22
33	**Removal of mixed traffic lanes on Paul Kruger Street** Refer to **Section 5.3.23**, which discusses the trade-offs / options for Paul Kruger Street. Dropping a lane was considered early in the study and was extensively discussed with the programme management team but was not deemed a feasible solution.	22

11.11 Contraflow Public Transport Lane from Lavender to DF Malan Road

11.11.1 Manually Reversed Moveable Contra-flow lane

Due to the strategic importance of the Mansfield link through the Magaliesburg Ridge on the regional traffic flows of Tshwane (with limited alternatives which are also at capacity), it is not proposed to reduce the mixed traffic lanes from three per direction to two per direction, as initially considered.

It was instead proposed to operate a manually, operated reversible contra-flow BRT lane. The traffic lanes will be operated through special traffic signal controlling entry and exit to the lane and manual setting up of a delineator system before commencement of the peak. **Figure 11.11.1** indicates a potential moveable barrier system that can be considered.

Figure 11.11.1: Example of a movable delineator system to shift contraflow lanes
(Source: Photo – Manfred Hagler, Blue Key Road Safety Technologies cc)

In the morning peak period, one of the northbound lanes will be reserved for BRT buses travelling southbound (the peak direction). On the return journey, the northbound buses (off-peak direction) will run in mixed traffic.

In the afternoon, one of the southbound lanes will be reserved for BRT buses travelling northbound (the peak direction). On the return journey, the southbound buses (off-peak direction) will run in mixed traffic.

These scenarios are indicated in **Sheets 18A and 18B** in **Volume 3**.

Law enforcement, traffic safety and public awareness will need to be considered. Depending on the BRT service design, it may be necessary to allow other public transport services to also use the contra-flow lane, if the BRT service frequency will be low.

The advantage of this system is a relatively low capital cost, but it will have a high on-going operational cost.

GIBB was therefore requested to consider other options, where a permanent reversible BRT lane is created, to reduce the ongoing manual operational cost. Two options are discussed in the following sections.

11.11.2 Permanent reversible Peak BRT Lane with narrow sidewalk on the eastern side only

A second option, working with the available 30.4m width (from the railing along the bridge on the left hand side to the retaining wall along the railway line on the right hand side), would be to provide an additional exclusive 3.6m BRT lane in place of the existing barrier, as indicated schematically in **Figure 11.11.2**.

This would require the reduction in width of mixed traffic lanes to 3.5m each (reduction in speed limit essential) a complete removal of the sidewalk on the western side (widening), and a reduction in width of the sidewalk on the eastern side to **only 1.6m wide**. Note that the provision of permanent delineators (0.3m wide) along both sides of the BRT lane and a barrier (0.4m wide) along the sidewalk is included. Provision has also been made for the clearance of 0.5m on either side of the delineators to both BRT and mixed traffic, and 0.6m along the barrier on the left hand side and 0.6m along the retaining wall on the right hand side for mixed traffic.

The cost of the permanent delineators (Klemmfix or similar), concrete New Jersey Barriers, and road layerworks for the widening on the western side is estimated at around **R8.8 million**. This however excludes the cost of new lighting, as the current lighting is located on the median and will need to be reconstructed on the side.

11.11.3 Permanent reversible Peak BRT Lane with 4.5m shared pedestrian and cycle way

A third option would be to widen the existing bridge structure on the eastern side by 3.0m to accommodate a shared cycle and pedestrian lane of 4.5m, additional to the configuration given in option 2 above, as indicated schematically in **Figure 11.11.2**.

This would still mean a complete removal of the sidewalk on the western side. The cost of the bridge widening would be approximately R30,000/m^2, resulting in a cost of in the order of **R72,000,000** for the required length in addition to the **R8.8 million**.

Note this excludes the cost of the channelizing the river which runs along the road to the east and assumes the environmental requirements can be met, as well as the cost of reconstructing the lighting.

Figure 11.11.2: Additional Cross Sections Considered for Reversible BRT Lane

12 COST ESTIMATES

The schedule of quantities is based on the Standard Specifications for Road and Bridge Works for State Road Authorities prepared by COLTO (Committee of Land Transport Officials). The schedule has been drawn up for the purpose of estimating the value of civil engineering construction work based on measured or estimated quantities for items of work expected for this type of contract and shown on the preliminary planning drawings. Unit rates from similar type contracts have been applied to this schedule with the exception of the following:

- A provisional allowance is made for the relocation of services as the extent and detail of the services requiring relocation or protection are not fully known at the preliminary design stage. The location of known existing services has been collated and is shown on the services drawings. The information is strictly as provided by the various service authorities.
- The bridge component is priced on the basis of an all-inclusive rate per square metre of bridge deck area for each bridge.
- The cost for street lighting is based on an inclusive rate per kilometer of street lighting installed and commissioned for both street lighting provided within the median island of dual carriageway sections and for street lighting outside the shoulder or on the sidewalk sides of the roadway.

A contingency allowance of 10% is provided and a contract price adjustment (CPA) provision of 20% is allowed. VAT is then added.

It is noted that the cost of building works such as the bus stations are not included in the costing provided as this is not part of the scope of the preliminary planning.

The provisional estimated cost of works is approximately **R929 Million** excluding VAT and contingencies, as indicated in **Table 12.1**. Adding 10% contingencies, 20% CPA and 14% VAT brings this total to **R1.4 billion**. The detailed schedule of quantities is included in **Annexure H**.

Table 12.2 provides an indication of the potential additional cost for widening the two sections from km 22.8 to km 24.8 (Rachel De Beer from Daan de Wet Nel Street to K14 link) and km 29.0 to km 30.0 (Paul Kruger from Mansfield Street to Myburgh Street) by an additional mixed traffic lane per direction. The cost estimate also includes widening of the three rail over road bridges and one road over road bridge. However it does not include the cost of land acquisition on Rachel De Beer Street.

The above Tables also do not include the cost of widening the road and bridge through the “Poort” to provide an additional reversible lane to serve as permanent peak direction BRT lane and a shared pedestrian and cycle way to the required minimum width. As indicated in **Section 11.11**, this will add a further **R8.8 or R80.4 million** to the total, excluding the cost of channelization of the river (if approved by the environmental authorities) and the cost of providing new lighting.

Table 12:1 Cost Estimate excluding Widening at Bottlenecks

SECTION	DESCRIPTION	AMOUNT (RAND)
1200	GENERAL REQUIREMENTS AND PROVISIONS	22 624 600
1300	CONTRACTOR'S ESTABLISHMENT ON SITE AND GENERAL OBLIGATIONS	142 457 800
1400	HOUSING, OFFICES AND LABORA- TORIES FOR THE ENGINEER'S SITE PERSONNEL	5 622 330
1500	ACCOMODATION OF TRAFFIC	50 244 400
1700	CLEARING AND GRUBBING	4 938 750
2100	DRAINS	1 885 550
2200	PREFABRICATED CULVERTS	40 079 550
2300	CONCRETE KERBING, CONCRETE CHANNELLING, CHUTES AND DOWNPIPES, AND CONCRETE LININGS FOR OPEN DRAINS	39 824 341
3300	MASS EARTHWORKS	34 023 500
3400	PAVEMENT LAYERS OF GRAVEL MATERIAL	110 343 000
3600	CRUSHED STONE BASE	9 600 000
3900	PATCHING AND REPAIRING EDGE BREAKS	2 203 200
4100	PRIME COAT	7 236 000
4200	ASPHALT BASE AND SURFACING	233 742 000
4800	TREATMENT OF AN EXISTING SURFACE EXHIBITING CERTAIN DEFECTS	560 000
5400	GUARDRAILS	8 296 000
5500	FENCING	116 250
5600	ROAD SIGNS	9 692 500
5700	ROAD MARKINGS	33 753 000
5800	LANDSCAPING AND PLANTING PLANTS	10 150 000
5800	FINISHING THE ROAD AND ROAD RESERVE AND TREATING OLD ROADS	550 000
7300	CONCRETE BLOCK PAVING FOR ROADS / PEDESTRIAN AND CYCLE PATHS	51 050 000
8100	TESTING MATERIALS AND WORKMANSHIP	4 400 000
6000	BRIDGE WIDENING AND NEW BRIDGE CONSTRUCTION	87 305 000
E000	ELECTRICAL WORKS	18 750 000
TOTAL CARRIED FORWARD		**929 447 772**

Table 12.2 Cost Estimate for Widening at Bottlenecks

SECTION 1 - KM 22.8-KM 24.8	**AMOUNT (RAND**
ROADWORKS	14 000 000
BRIDGEWORKS	
(A) BRIDGE NO. 7 (KM 24.6 - 2 SPAN SIMPLY SUPPORTED DECK)	11 000 000
(B) BRIDGE NO. 8 (KM 24.66 - 4 SPAN CONTINUOUS BOX DECK)	4 400 000
STREETLIGHTING	1 400 000
SUBTOTAL (EXCL. VAT)	**30 800 000**
NOTE: LAND ACQUISITION COST IS NOT INCLUDED	
SECTION 2 - KM 29.0-KM 30.0	**AMOUNT**
ROADWORKS	7 000 000
BRIDGEWORKS	
(A) BRIDGE NO. 10 (KM 29.26 - DOUBLE PORTAL)	6 000 000
(B) BRIDGE NO. 11 (KM 29.72 - DOUBLE PORTAL)	11 000 000
STREETLIGHTING	700 000
SUBTOTAL (EXCL. VAT)	**24 700 000**
TOTAL (EXCL. VAT)	**55 500 000**

13 CONCLUSIONS AND RECOMMENDATIONS

ARCUS GIBB was appointed by A-M Consulting Engineers (AMCE) for the preliminary design of the **Bus Rapid Transit (BRT) Line 1 Soshanguve to Pretoria CBD**, in order for the City of Tshwane to proceed with implementation of this line during the 2012/13 financial year. AMCE is appointed by the City of Tshwane as Programme Managers for the BRT project.

Due to the urgency of implementation, the preliminary design was completed in the absence of an approved operational plan as the City is still in the process of re-developing an operational plan, including appropriate demand modelling, in parallel to the preliminary infrastructure design process. The preliminary infrastructure design proposed in this report will need to be reviewed once the operational plan is complete, prior to commencing the detail design.

Due to the short project time frames, the traffic impact assessment was also done largely in parallel to the preliminary design process. Some of the proposed changes identified through the Transyt modelling that were not incorporated into the draft drawings, have now been incorporated into the final drawings. The remaining changes should be done during the detail design process, once there is more finality regarding the operational design parameters, as some changes may not be necessary if a smaller BRT system is proposed than what is currently designed for.

The service design and thus BRT system frequency is not yet confirmed and the approach of sizing the infrastructure for maximum capacity, as a worst case scenario, was therefore adopted.

This includes provision of bypass lanes and stations with two independent docking areas with two bus bays each, where feasible. The design identified sections or locations where the above high capacity is not achievable. **It is critical to note that the preliminary design currently reflects the highest capacity facilities that can fit within the current constraints without major land acquisition. It does not represent the optimal design to cater for the forecasted passenger demand and service design, as this information is not yet available.** The ultimate system capacity requirements may well be significantly less than the current design on some sections of the route. Reduced system capacity could result in some cost savings.

The provisional estimated construction cost is approximately **R929.5 Million** excluding VAT and contingencies. Adding 10% contingencies, 20% CPA and 14% VAT brings this total to **R1.4 billion**. The cost of station buildings is not included.

The additional cost for widening Rachel De Beer from Daan de Wet Nel Street to K14 link and Paul Kruger from Mansfield Street to Myburgh Street by an additional mixed traffic lane per direction, including widening of bridges, but excluding the cost of land acquisition on Rachel De Beer Street, is estimated at **R55.5 million**.

Adding a permanent reversible BRT lane through the Poort would add an additional minimal cost of **R8.8 or R80.4 million** to the total, excluding the cost of channelization of the river (if approved by the environmental authorities) and the cost of providing new lighting.

The following recommendations are made:

- The operational plan and demand forecasting should be completed as soon as possible, to confirm various assumptions made throughout the course of the preliminary design. Aspects that cannot be finalised without this includes:
  - Route start point
  - Final route and station locations
  - Feeder and distribution stations
  - BRT system sizing (particularly station capacity confirmation)
  - Pavement design
  - Cost estimates
- Further consultation on Rainbow Junction is proposed, as this may impact on the proposed route.
- The bridge widening at river crossings will trigger a Basic Environmental Assessment and it is recommended that this process be started as soon as possible, as it can take up to 5 months. The previous heritage assessment will need to be updated due to the route changes, and it is recommended that the previous Consultants be asked to do this, to minimise the time and cost. An application for a water use license will also need to be applied for at the river crossings where bridges are widened.
- Due to the short time frames allowed for the preliminary design, the detail design phase should allow sufficient time to further develop some aspects not fully addressed during the preliminary design stage.
- The traffic impact study will need to be updated once the demand modelling is available, as the current study made a number of assumptions in terms of future traffic flow.

14 REFERENCES

1. City of Tshwane. 2005. *City of Tshwane Strategic Public Transport Network*.
2. *Tshwane Integrated Transport Plan (2006-2011)*
3. Wright, L. Viva Cities. May 2007. *Tshwane Rapid Transit: Implementation Framework*.
4. Advanced Logistics Group. 2008. *Tshwane BRT Operational Plan*.
5. GOBA, MPA, SSI. *Proposed Tshwane BRT System Line 1: Section A – D*.
6. City of Tshwane. *City of Tshwane Metropolitan Spatial Development Framework*
7. City of Tshwane. 2007. *North Western Regional Development Framework*.
8. City of Tshwane. 2006. *Inner City Development Strategy*.
9. City of Tshwane. 2005. *Re Kgabisa Tshwane*.
10. GSTN Joint Venture. 2010. *Gauteng Strategic Road Network (GSRN) 2010 Review*. Gauteng Department of Roads and Transport
11. SSI. 2010. *Pretoria North Station Modal Interchange Preliminary Design Report*. City of Tshwane
12. Techso. 2010. Rainbow Junction Traffic Impact Assessment Report.
13. PRASA. 2007/2008. *Gauteng Rail Passenger Census*
14. VKE. 1998. *Inner City Distribution System*.
15. www.gautrain.co.za
16. GIBB. 2005 -2012. Rea Vaya Preliminary and Detail Designs
17. Department of Transport. 2003. *Pedestrian and Bicycle Facility Guidelines*.
18. http://www.sustrans.org.uk/what-we-do/connect2/connect2-resources#greenways. *Connect2 and Greenway Design Guide*
19. GIBB, 2006. *Strategic Public Transport Network: Assessment of a Pilot Cycle Facility*
20. PWV Consortium. 2005. *Walking and Cycling on Roads and Streets in Gauteng*. Gauteng Department of Roads and Transport
21. Moeur, Richard C. 2004. *Bicycle Facility Design.*
22. Litman, T et all. *Pedestrian and Bicycle Planning, a Guide to Best Practices*. Victoria Transport Policy Institute.

23. City of Portland Bureau of Transport. 2010. *Bikeway facility design: Survey of best practices, portland bicycle plan for 2030.*

24. ITDP. 2007. *BRT Planning Guide*.

25. Transportation research board. 2003. *TCRP Report 90: Bus Rapid Transit, Volume 2: Implementation Guidelines*.

26. Department of Transport. 1999. *South African Road Traffic Signs Manual (SARTSM)*.

27. Department of Transport. 1985. *Parking Standards (Second Edition)*.

28. Szasz, Pedro Álvaro. 2009. *Traffic signal evaluation, Johannesburg Rea Vaya Detail Design*.

29. TRB. 2001. Highway Capacity Manual.

30. TMH 7. *Code of Practice for the Design of Highway Bridges and Culverts in South Africa*.

31. Seedat, E. National Department of Transport. 2008. *Minimum National Requirements Bus Rapid Transit Systems In South Africa*.

32. HHO. SATC 2011 Presentation. *BRT Infrastructure in Cape Town*.

33. City of Tshwane Roads and Stormwater. 2008. *Standard construction details and design standards for Roads and Stormwater Drainage Infrastructure*.

34. Gauteng Department of Transport and Public Works. *Typical plans for road design*.

35. GIBB. 2011. Tactile Ground Surface Indicators and Pedestrian Crossings.

36. 2012. Manfred Hagler, Blue Key Road Safety Technologies cc.

37. Standard Specifications for Road and Bridge Works for State Road Authorities prepared by COLTO (Committee of Land Transport Officials)

38. TRL Department of International Development. . *Overseas Road Note 21: Enhancing the mobility of disabled people: Guidelines for Practitioners*.

39. NDOT. 2005. *National Guidelines for Road Access Management in South Africa (RAM)*

40. TCRP. *Transit Capacity and Quality of Service Manual, Part 4 Terminal Capacity*.

DOCUMENT CONTROL SHEET
(FORM IP180/B)

CLIENT : AMCE

PROJECT NAME : Tshwane BRT Line 1 Preliminary Design **PROJECT No. :** J31059

TITLE OF DOCUMENT : Final Preliminary Design Report

ELECTRONIC LOCATION :

	Approved By	Reviewed By	Prepared By
ORIGINAL	NAME **K Pillay**	NAME **P Hurry**	NAME **L de Beer**
DATE **26 August 2011**	SIGNATURE	SIGNATURE	SIGNATURE

	Prepared by	Prepared By	Prepared By
REV1	NAME **K Pillay**	NAME **P Hurry**	NAME **L de Beer**
DATE **31 August 2011**	SIGNATURE	SIGNATURE	SIGNATURE

	Approved By	Reviewed By	Prepared By
REV2	NAME **K Pillay**	NAME **P Hurry**	NAME **L de Beer**
DATE **1 Nov 2011**	SIGNATURE	SIGNATURE	SIGNATURE

	Approved By	Reviewed By	Prepared By
REVISION **FINAL**	NAME **K Pillay**	NAME **P Hurry**	NAME **L de Beer**
DATE **20 Feb 2012**	SIGNATURE	SIGNATURE	SIGNATURE

Arcus GIBB (Pty) Ltd
Postal Address :
Contact Person : Lize de Beer
Telephone No. : 011 519 4600

Website : www.gibb.co.za
Physical Address : 14 Eglin Road, Sunninghill
Email Address : ldbeer@gibb.co.za
Fax No. : 011 807 5670

VOLUME 2
ANNEXURES

Annexure A	–	Alternative Station Design and Cross Section Options
Annexure B	–	Indicative Base Year Peak Hour Passenger Demand (Person Trips) and Traffic Counts
Annexure C	–	Parking Assessment on Paul Kruger Street
Annexure D	–	TRANSYT Modelling Results
Annexure E	–	Visual Road Condition Survey
Annexure F	–	Cross Section Alternatives on K-Routes
Annexure G	–	Environmental Report
Annexure H	–	Cost Estimates

Annexure A

Alternative Station Design and Cross Section Options

Annexure B

Indicative Base Year Peak Hour Passenger Demand (Person Trips)

&

Traffic Counts

Annexure C

Parking Assessment on Paul Kruger Street

Annexure D

TRANSYT Modeling Results

Annexure D

TRANSYT Modeling Results

AM

Annexure D

TRANSYT Modeling Results

PM

Annexure E

Visual Road Condition Survey

Annexure F

Cross Section Alternatives on K-Routes

Annexure G

Environmental Report

Annexure H

Cost Estimates

VOLUME 3

Preliminary Design Layout Plans

VOLUME 4

Presentation Layout Plans