MANAGING UNPAVED ROADS IN URBAN AREAS

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Soon after the 1994 elections the city of Durban's boundaries were extended to include areas such as Inanda and Ntuzuma in the north and Umlazi in the south. The inclusion of these areas presented certain challenges for the city:

The road network in the northern areas of Inanda, Ntuzuma and Kwa-Mashu, comprising both paved and unpaved roads, had never been formally captured. Maintenance of these roads became the responsibility of the Roads Department (RD): Durban.

This paper presents the approach adopted by the Roads Department: Roads Maintenance (North) Branch to face the challenges in maintaining and upgrading the unpaved roads of this network. The paper describes the methods employed in capturing, managing and enhancing the unpaved road network's data.

The paper also introduces Road Maintenance North's TURMS (T Unpaved Roads Management System) programme which is a direct product of these efforts.

1 INTRODUCTION

The pass laws and influx control set up by the previous apartheid government initially delayed development in the erstwhile townships on the outskirts of the city of Durban. From the early 1980's the influx control was gradually relaxed and then removed completely and it was in this period that development proceeded at a great pace in the peri-urban areas adjacent to the tribal areas around Durban. At the time this development was not encouraged by either the city and government authorities and development tended to be neglected and generally under managed.

Initially these areas were managed by the provincial government organ then known as the Department of Local Government and Housing. This authority had endeavoured to provide these townships with an accessible road network and indeed more than 50% of the network in these areas was paved, albeit in a reasonably poor state. The remainder of the roads could loosely be termed as "unpaved".

The initial demarcation boundaries set up after the 1994 elections placed a substantial proportion of these northern townships (Inanda, Ntuzuma and KwaMashu) under the control of the Durban Metropolitan Authority. By this time the uncontrolled development of the last two decades had started slowing down.

Initially the RD: Durban carried on with the maintenance procedures employed by the Department of Local Government and Housing. Maintenance of unpaved roads consisted of routine maintenance being carried out by departmental and hired plant under the direct supervision of departmental officials and the letting of a number of gravelling contracts every year which carried out the periodic maintenance such as betterment and re-gravelling of the unpaved road network. Although some records were kept on these maintenance contracts, their format and detail did not allow for accurate monitoring and evaluation.

In June 1999 Tifflin Purchase and Associates were appointed to oversee several of these planned re-gravelling contracts. It soon became evident that the identification and prioritisation of those roads requiring re-gravelling was impossible without the acquisition of more detailed information on the road network:-

> No reliable maps of the area were available. The actual extent of the paved and unpaved road network was not known. Although a desktop study carried out by Durban's GIS Section had provided some data, this needed to be verified on site as the work had been done using quite old aerial photographs.
>
> None of the roads had names or other forms of identification.
>
> It was generally accepted that a proportion of the informal network would and could not be maintained by the department due to the fact that they served as individual accesses to private dwellings and in some cases resembled pedestrian footpaths These roads, termed "informal", could only be classified by inspection and consultation.

2 COMMUNITY PARTICIPATION

Since maintenance could not be put on hold while the extent of the network was ascertained it was necessary to identify and prioritise those roads requiring urgent attention with the help of the recently elected councillors. A series of road shows were held in an attempt to provide a measure of transparency and also to introduce the various service units to the communities. The success of these workshops cannot really be quantified but it did serve to open the channels of communication between the service units and the communities.

Inspections with each councillor were also carried out and these one on one meetings produced a list of roads on which to base the initial planning. However it was not enough...

Councillors, without adequate information, tended to fall back on roads they were most familiar with or listen to residents who shouted the loudest. The more the investigation teams inspected the network the more they discovered previously unknown, but reasonably well trafficked roads. It was evident that a planned roads audit had to proceed as soon as possible.

3 ROAD MAINTENANCE NEEDS

Available literature and previous experience which had focused mainly on rural roads showed that there was benefit in applying, a standardised visual assessment procedure to determine the needs of the townships' unpaved roads on a network level. An assessment form was developed to suit the terrain and the clients requirements. (See Figures 1a to 1c).

A map accurate GPS provided an indication of the location and alignment of each road and track. This ensured that no gaps in the assessment were possible as the spatial positioning was verified using the corporate GIS with aerial photographs as a backdrop. The unpaved roads were classified in terms of their present <u>status</u> and their perceived <u>function</u>:

Status:	Track,	Function:	Formal
	Ungravelled road		Informal
	Gravelled road		

The condition of each road was assessed in terms of it's structural and functional condition and also it's gravel properties. Particular attention was paid to each roads' surface drainage.

The summaries of the results of the visual condition survey or audit were presented both graphically (Figures 2 to 5) and spatially on GIS.

The results of this network survey certainly reinforced the generally held view that the present cycle of construction and reconstruction of gravelled roads in the northern townships was a futile exercise:-

> Previous record keeping made it impossible to apply a managed approach to maintaining the network. Certain roads, due to their drainage and alignment, were receiving more attention than most. A "black hole" situation had developed where the majority of resources were being channelled towards a select few roads which regularly lost their gravel after each heavy downpour.
>
> Routine maintenance usually gave way to heavier periodic maintenance due to the fact that the terrain was generally too steep for gravel roads and the material used lacked sufficient plasticity to be an effective gravel wearing course.

Another strategy had to be developed which would optimise the maintenance funding available:

4 DEVELOPMENT OF A STRATEGY

In December 2000 the futility of proceeding with a mere gravelling programme was certainly rammed home when Durban experienced the worst floods in a decade. Although numerous paved roads were also damaged, it was noted that a large proportion of the gravelling which had taken place in the last few years was completely obliterated.

Another factor to consider was that the source of gravel used for all gravelling and betterment was almost exhausted and other sources were required. This posed certain challenges as areas with suitable natural gravel on undeveloped land in the township were becoming quite scarce.

The existing gravel, with a PI of <6 was unsuitable as a gravel wearing course but it was determined that, with modification, the gravel could be used as a base-course on a paved road.

4.1 Planned Maintenance

The Road Maintenance Branch had limited plant and personnel and a large proportion of the budget was being spent on the hiring of plant for maintenance activities. What was required was the introduction of the elements of productivity and quality into routine maintenance activities.

A Planned Maintenance Procedure, which comprised the following, was prepared:

> A Planned Maintenance Contract was let on an annual basis which presented all maintenance activities in the document for pricing. Four planned establishments by the contractor over the year were also included.
>
> Formal visual assessments of a list of candidate roads were undertaken before each establishment. The list of candidate roads was formulated by routine reports carried out by the departmental officials and by feedback from councillors. The visual assessment form used was designed for project rather than network level planning.
>
> The project level assessments were then analysed to determine the maintenance needs of each candidate road and it’s priority ranking. Roads which were assessed as “problem” roads were put forward for upgrading to surfaced seal. This procedure is fully described in para 4.2 below.
>
> A further visit was then made to the highest priority roads to determine the quantities required for carrying out the maintenance activity determined by the analysis. This quantity sheet had to be signed by both the official and the contractor before work commenced.
>
> Once the contractor had completed each road it would be inspected and the final agreed quantities would be added to the same form and signed off. No maintenance or defects liability period was included.

The assessment sheets and a summary of the work carried out was then captured on the GIS for reporting to management.

This Planned Maintenance Procedure ensured that adequate checks and controls on maintenance spending were in place. It also provided vital information for middle management to determine their maintenance operations. Lastly it allowed top management access to data which was previously unattainable. An element of transparency was achieved.

4.2 Upgrading

It was decided to allocate a large proportion of the maintenance budget to upgrade those roads which seemed to require more attention than others. The aim being to methodically transform these roads into low volume, low maintenance paved roads which would, in the medium term, free up vital maintenance funds for routine maintenance of unpaved roads.

By systematically reporting on all maintenance activities on unpaved roads, it is possible to isolate those roads which require more attention than what could be considered cost effective. These roads would then become candidates for upgrading.

4.3 The Five Year Plan

A plan was developed to reduce the present unpaved road length to manageable proportions within five years (see Figure 6). The ultimate aim being the provision of appropriate access to the majority of inhabitants keeping in mind the following:

Gravel is not a renewable resource.

Environmentally friendly construction materials must be utilised as much as possible. The damaging effects of dust and widespread erosion in the townships must be minimised.

5 DESIGN STANDARDS

5.1 Pavement Structure Standards

Previous experience had shown that the construction of a light pavement structure was a feasible option if careful attention was paid to material selection and construction standards. The existing gravel material was available but could not achieve the standards of a base material without modification. Previous experience in the northern townships with the use of lime and cement had not been encouraging and cost benefit analyses indicated that bitumen stabilisation was a feasible option. (See Figure 7). The question still remained, could a bitumen stabilised base be constructed to the required standards in such restricted areas?

The RD: Durban were confident that standards could be maintained in the townships and testing was initiated. Tests showed that the final product of 1.5% bitumen mixed with the residual granite of the borrow pit provided CBRs ranging from 60 to 80 @ 100% Mod. AASHTO density.

The existing pavement strength was determined using the Dynamic Cone Penetrometer (DCP) and it's layer strength determination programme. Each road was investigated at regular intervals along it's length and it's existing layer strength determined. From this the additional thickness of pavement was calculated to carry the required traffic.

Attention was focussed on ensuring that the DCP results were representative of the road by doing DCPs at random positions across the width of the road.

In most cases it was found that only 100mm of additional cover was required, as an extra factor of safety it was decided that in the initial stages of the programme a minimum of 150mm of new material would be imported as a base. This was done to also ensure that a degree of uniformity was achieved during construction.

Although routine process control was carried out it was also decided to carry out more DCP testing on the final road to get an indication of the effects of heavy compaction on the underlying pavement layers. These tests showed that additional compaction was being achieved to depths of 300 to 400mm.

5.2 Surfacing Standards

High deflections were anticipated from this light pavement and it was expected that this flexibility would produce early life cracking in a too rigid surfacing. The use of a seal rather than a slurry was favoured. However the limited amount of bitumen allowed with a single and even a double seal was a concern. It was felt that early ageing of the surfacing would become a maintenance problem.

A graded crushed stone seal was therefore chosen as the most appropriate surfacing because it not only had a relatively high binder content but it also made use of graded stone which was much more abundant and cheaper than the single size stone required for other seals.

5.3 Geometric Standards

Both the uncompromising terrain and the restrictions caused by unconstrained development meant that geometric standards had to be scrutinised to ensure that the roads were passable to the expected traffic. The other constraint was that the roads also had to be navigated by cumbersome plant during the construction stage. The use of labour intensive methods were also proposed and later adopted.

5.4 Drainage Standards

The drainage requirements for unpaved roads are different to paved roads: Cambers usually give way to cross falls, formal kerb and channel drainage are preferred to the gravel roads' meadow and mitre drains. The management of subsurface water becomes more critical for surfaced roads.

One of the major problems encountered was the integration of the drainage systems constructed for the upgraded roads with the present drainage. Firstly the present drainage was usually totally inadequate and secondly no drainage master plan was available to ensure that any drainage conformed to a set standard.

6 IMPLEMENTATION PHASE

6.1 Trial Section

It must be said that the initial trial contract for the upgrading rather than re-gravelling of unpaved roads could not have had a more rigorous initiation:

Since traffic accommodation was a high priority, the work was planned in such a manner that the newly constructed bitumen emulsion treated bases would be open to traffic for a very limited time to ensure that the surface was not damaged. However, due to unforeseen problems encountered by the contractor, the newly constructed base surface was exposed to traffic for over a month.

The method of enriching the top layer of the base with bitumen proved to be most successful and hardly any traffic wear was experienced in the month that the base was left open to traffic.

However, more trials and tribulations were to follow, the rather steep grades encountered on some of the sections also proved to be a problem for the surfacing contractor who had no experience in constructing a graded crushed stone seal.

Initial stone application rates were actually too well controlled and the chip spreader tended to pick up the newly sprayed bitumen when starting a new pull up a steep hill. This problem was eventually solved by allowing an over-application of stone on the steeper sections and thus providing additional cover for the chip spreader. It was found that the graded crushed seal could be comfortably constructed on inclines of as much as 30%.

6.2 Construction

Production rates were initially low as the contractor experimented with various forms of plant and techniques to find the most appropriate methods of construction in such confined and steep conditions. Production rates improved but experience has now shown that normal production rates are unattainable.

Survey control was not generally used as adequate lines and levels were achieved when ripping and re-compacting the existing road surface. These lines and levels could then be maintained through the construction of the new 150mm base. Layer thicknesses were monitored by inspection holes and alignments generally done by eye. Nevertheless a pleasing and acceptable alignment has always been achieved in the most testing of circumstances. Kerb laying, carried out by local subcontractors was generally of a very high standard.

7 INTEGRATION WITH THE REGIONAL DEVELOPMENT PLAN

Once the unpaved roads audit was complete it was found that the only reliable source of data on the road network resided with the Road Maintenance Branch. The construction site staff tended to play a pivotal role in determining the network requirements with regards to development planning. Even drainage planning outside of the realm of road maintenance made use of the data.

The impact of formalising the road network and the paving of roads tended to overload the existing stormwater management network. The Drainage and Coastal Engineering Department was in most instances unable to provide the capacity improvements owing to a limited budget. The Roads Maintenance Branch therefore provided funding for the design and construction of drainage improvements on their upgraded roads.

8 AUTOMATING THE PROCESS

The Planned Maintenance Procedure with it's formal visual inspections and data gathering was ideally suited for some form of automation. The procedure focussed on the regular visual inspections of candidate maintenance projects and the results of these were captured on a database. Software was acquired to provide the following:

Serve as a repository for all data relating to unpaved roads. Static information, assessment data, drainage data, borrow pit information, as built data and maintenance history.

Serve as a conduit of information which would be accessible to all planners and developers in the Durban Metropolitan Authority.

Analyse data and produce reports relevant for all levels of supervision and management.

Provide detailed information and reports for the planning and execution of projects in the Annual Planned Maintenance Contract.

Provide a strategic indicator to highlight those roads which were requiring periodic maintenance on a too frequent basis so that they could be flagged for upgrading. (Gravel roads which require routine re-gravelling were considered to be a drain on the limited resources in the township and should become the major candidates for upgrading).

The routine visual assessment forms initially developed for the roads audit were modified to ensure that sufficient information was gained from them to allow project based planning.

A standard estimate form was added to the visual assessment form used in the Planned Maintenance Contract. The proper completion of these forms by the officials, together with the contractor, formed the basis of the contract.

9 CONCLUSION AND RECOMMENDATION

The solutions presented in this paper may seem unique in as much as they were developed to meet challenges specific to the area. The decision to upgrade to blacktop rather than re-gravel was certainly influenced by the available materials:-

> The decision to follow an upgrade strategy rather than to carry on with re-gravelling was largely influenced by the fact that the natural gravel was more suited to being modified as a base course rather than being used as a gravel wearing course.
>
> The cost of acquiring the gravel was limited to excavation and transport as the borrow pit was directly under the Road Maintenance Branch’s control. No royalties were paid for the material.
>
> The source of the modified bitumen and the crushed stone used for the graded crushed stone seal were situated reasonably close to the site and transport costs were therefore relatively low.

Nevertheless it is pertinent to note that the solutions developed were less aggressive to the environment in the long term. This, coupled with the programme meeting the long term goals of Durban, proved to be another completely different approach to road upgrading than the methods used previously.

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NORTH CENTRAL LOCAL COUNCIL CITY ENGINEER'S UNIT ROAD MAINTENANCE

UNPAVED ROADS VISUAL ASSESSMENT AND MAINTENANCE REQUIREMENT FORM

				Formal		Informal
Date	____________		Road Type	Gravelled	Ungravelled	Track
Ward	____________		Traffic	Light	Medium	Heavy
Rover file name	____________		Terrain	Flat	Rolling	Mount
Section	From ____________		To	____________		

Width	< 3m	3 to 5m	5 to 7m	> 7m	Moisture	Wet	Moist	Dry

STRUCTURAL ASSESSMENT

STRUCTURE			DEGREE					EXTENT				
			Slight			Severe		Slight			Severe	
			1	2	3	4	5	1	2	3	4	5
Potholes:		0										
Corrugations:		0										
Rutting:		0										
Loose material:		0										
Dust:		0										
Stoniness:	Fixed	0										
	Loose	0										

	General Condition:	Very Good	Good	Fair	Poor	Very Poor
GRAVEL PROPERTIES	Material Type:	US Base	Mixture	Granite	Mixture	Dolerite
	Maximum Size (mm):	>50	25 to 50	13 to 25	< 13	
	Classification:		Coarse	Medium	Fine	
	Approximate PI:		< 6	6 to 15	> 15	
	Gravel Thickness (mm):		< 75	75 to 150	> 150	

FUNCTIONAL ASSESSMENT

Riding Quality:		Very Good	Good	Fair	Poor	Very Poor
Skid Resistance:			Good	Fair	Poor	
Road Surface Erosion:	Longitudinal		None	Minor	Severe	
	Transverse		None	Minor	Severe	
Drainage	On the road surface		Good	Fair	Poor	
	On the side of the road		Good	Fair	Poor	
	Drainage structure problems	Culverts	Side drains	Mitre Drains	Too low	
Road Formation above ground		Well above	Just above	Level	Just below	Well below

NOTABLE ISOLATED PROBLEMS

Isolated Potholes	Yes	No	Rough Areas	Yes	No
Subgrade Exposed	Yes	No	Slippery Areas	Yes	No
Rough Areas	Yes	No	Saturated Areas	Yes	No
Saturated Areas	Yes	No	Assessment of when last maintenance was done		
Slippery Areas	Yes	No	within 2 months	within last year	Never

MAINTENANCE REQUIREMENTS

MAINTENANCE		IMPROVEMENT			
Normal blading		Light betterment		Construction of minor culvert headwalls	
Watering and blading		Heavy betterment		Gravel processing	
Patch gravelling		Minor culvert Installation		Gravel dumping and processing	

DRAINAGE REPAIRS AND MAINTENANCE		EMERGENCY REPAIRS	
Cutting mitre drains		Repairs to damaged cuts and fills	
Subsoil drain installation		Removal of debris and spoil from washaways and subsidences	
Repairing concrete drains		Other (specify)	
Construction concrete drains		Other (specify)	

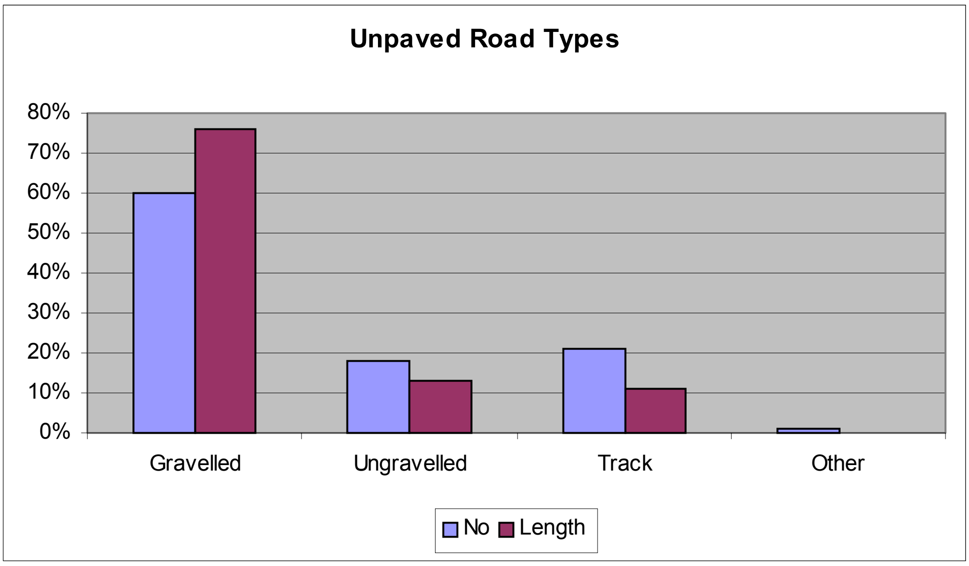
Figure 1a

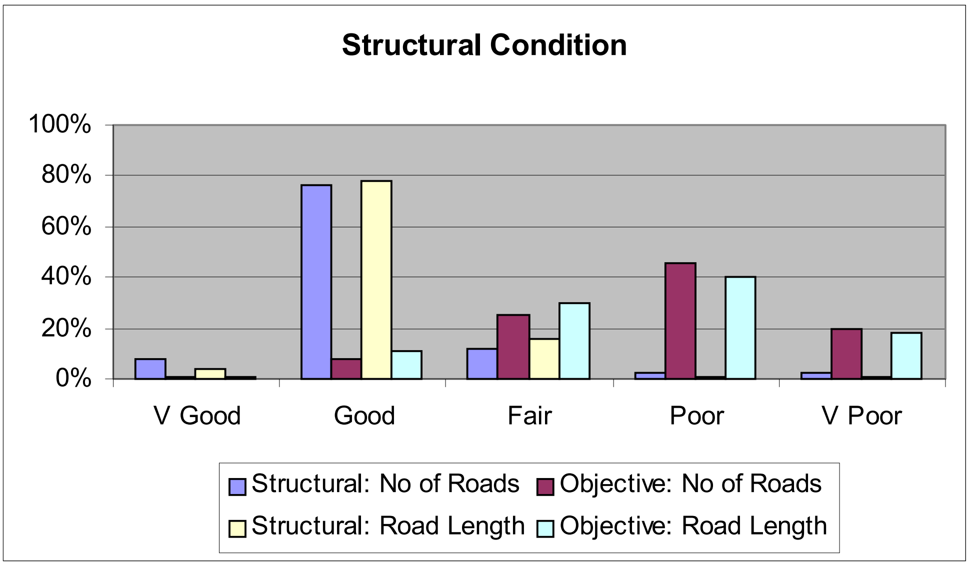
Item	Description	Unit	ESTIMATED Quantity	ESTIMATED Rate	ESTIMATED Amount	FINAL Quantity	FINAL Rate	FINAL Amount
	DAYWORKS							
22	a) Foreman	hr		60			60	
23	b) Skilled	hr		40			40	
24	c) Semi-skilled	hr		30			30	
25	d) Unskilled	hr		10			10	
26	a) Backactors (1) TLB	hr		150			150	
27	(i) Pedestrian vibrating roller (Bomag 60)	hr		30			30	
28	(ii) Vibrating roller (80 kw 9 ton)	hr		130			130	
29	(i) 6 m3 tip truck	hr		140			140	
30	(ii) 7000 l water tanker	hr		140			140	
31	(i) D 4 or similar	hr		250			250	
32	Material	PS						
	DAYWORKS							
	SECTON 2 : SITE CLEARANCE							
33	Cleaning out of manholes and catchpits	m3		30			30	
34	Cleaning open channels, lined or unlined	m3		20			20	
35	Cleaning out of existing pipe culverts	hr		160			160	
36	Clearing and grubbing of road prism	m2		0.5			0.5	
	SITE CLEARANCE							
	SECTION 3: CONCRETE WORK							
37	Trapezoidal drain	m3						
38	V drain	m3						
39	Weldmesh	t						
40	Formwork to sides of slabs	m2						
41	Formwork to ends of slabs	m2						
	CONCRETE WORK							
	SECTION 4 : EARTHWORKS BULK							
42	Imported fill from Ngoqokazi	m3		60			60	
43	Compaction of fill	m3		10			10	
44	Cut to spoil	m3						
45	Overhaul	m3.km		1.5			1.5	
	EARTHWORKS BULK							
	SECTION 5 : EARTHWORKS PIPE TRENCHES							
	Excavate and backfill for 600 mm conc pipe							
46	Depth 0,0-1,5m	m3		40			40	
47	Depth 1,5-2,0m	m3		65			65	
48	eo for hard material	m3		110			110	
49	eo for rock	m3		170			170	
50	Selected backfill for excavations	m3		40			40	
51	Prove services: 0,0m - 1,5m	m3		0			0	
52	Prove services: 1,5m - 2,0m	m3		0			0	
	EARTHWORKS FOR PIPE TRENCHES							
	SECTION 6: KERBS AND HAUNCHES							
53	Type A Barrier kerb and channel	m						
54	Type D Barrier kerb and channel	m						
55	Type D Mountable kerb and channel	m						
56	Scoop kerb and channel	m						
	KERBS AND HAUNCHES							
	SECTION 5: PROTECTION WORKS							
57	Excavation for gabions: 0,0m to 1.0m	m3		40			40	
58	Gabion mattresses 6m x 2m x 0.3m	m3		400			400	
59	Gabion boxes 2m x 1m x 1m	m3		420			420	
	PROTECTION WORKS							
	SECTION 6 : NON-PRESSURE PIPELINES							
60	Supply, Lay 600 mm dia. pipe	m		360			360	
	NON PRESSURE PIPELINES							
	SECTION 7: GRAVELLING & BETTERMENT							
61	Scarify Unpaved Road Surface	m2		1.25			1.25	
62	Compaction of material from Ngoqokazi	m3		0			0	
63	Compacting Scarified Surface	m2		1.5			1.5	
64	Overhaul	m3.km		1.3			1.3	
65	Forming Parallel Road Drainage	m		3			3	
66	Headwalls	No		3200			3200	
67	Repair of existing brick headwalls	m2		0			0	
68	Inlet type S1: Depth 1,5 up to 2,0m	No		3200			3200	
69	extra over compacting in narrow widths	m3		10			10	
70	extra over compacting in small areas	m3		15			15	
71	Shaping the road surface	m2		1.5			1.5	
	GRAVELLING AND BETTERMENT							
			Date:	____ / ____ / ____		Date:	____ / ____ / ____	
Comments			Signed for RMN:			Signed for RMN:		
			Signed for Contractor			Signed for Contractor		

Figure 1 b

ACTIVITY Nos		ACTIVITY Description	PAY ITEM No	PAY ITEM Description
1	**Gravel Maintenance**			
	1	Normal blading	71	Shaping the road surface
	2	Patch gravelling	61	Scarify Gravel Road Surface
			62	Compaction of material from Ngoqokazi
			63	Compacting Scarified Surface
			64	Overhaul
			42	Imported fill from Ngoqokazi
			65	Forming Parallel Road Drainage
			69	extra over compacting in narrow widths
			70	extra over compacting in small areas
			71	Shaping the road surface
2	**Gravel Improvements**			
	1	Betterment	42	Imported fill from Ngoqokazi
			43	Compaction of fill
			45	Overhaul
			62	Compaction of material from Ngoqokazi
			69	extra over compacting in narrow widths
			70	extra over compacting in small areas
			71	Shaping the road surface
	2	Minor culvert Installation	46	Excavate 600mm pipe depth 0,0-1,5m
			47	Excavate 600mm pipe depth 1,5-2,0m
			48	eo for hard material
			49	eo for rock
			50	Selected backfill for excavations
			57	Excavation for gabions: 0,0m to 1.0m
			58	Gabion mattresses 6m x 2m x 0.3m
			59	Gabion boxes 2m x 1m x 1m
			60	Supply, Lay 600 mm dia. pipe
				Headwalls
				Repair of existing brick headwalls
				Inlet type S1: Depth 1,5 up to 2,0m
	3	Construction of minor culvert headwalls		Headwalls
				Repair of existing brick headwalls
				Inlet type S1: Depth 1,5 up to 2,0m
	4	Gravel processing	61	Scarify Gravel Road Surface
			63	Compacting Scarified Surface
			65	Forming Parallel Road Drainage
	5	Gravel dumping and processing	42	Imported gravel from Ngoqokazi
			62	Compaction of material from Ngoqokazi
			64	Overhaul
			65	Forming Parallel Road Drainage
3	**Drainage Maintenance and Repairs**			
	1	Cutting mitre drains	65	Forming Parallel Road Drainage
	2	Repairing concrete drains	33	Cleaning out of manholes and catchpits
			34	Cleaning open channels, lined or unlined
			35	Cleaning out of existing pipe culverts
	4	Construction concrete drains	53	Construct kerb & channel
			38	Construct concrete side drain
4	**Emergency Repairs**			
	1	Repairs to damaged cuts and fills	42	Imported fill from Ngoqokazi
			43	Compaction of fill
			45	Overhaul
	2	Removal of debris and spoil from washaways and subsidences	44	Cut to spoil
			45	Overhaul

Figure 1c


Unpaved Road Types
80%
70%
60%
50%
40%
30%
20%
10%
0%
Gravelled
Ungravelled
Track
Other
No
Length


Structural Condition
100%
80%
60%
40%
20%
0%
V Good
Good
Fair
Poor
V Poor
Structural: No of Roads
Objective: No of Roads
Structural: Road Length
Objective: Road Length

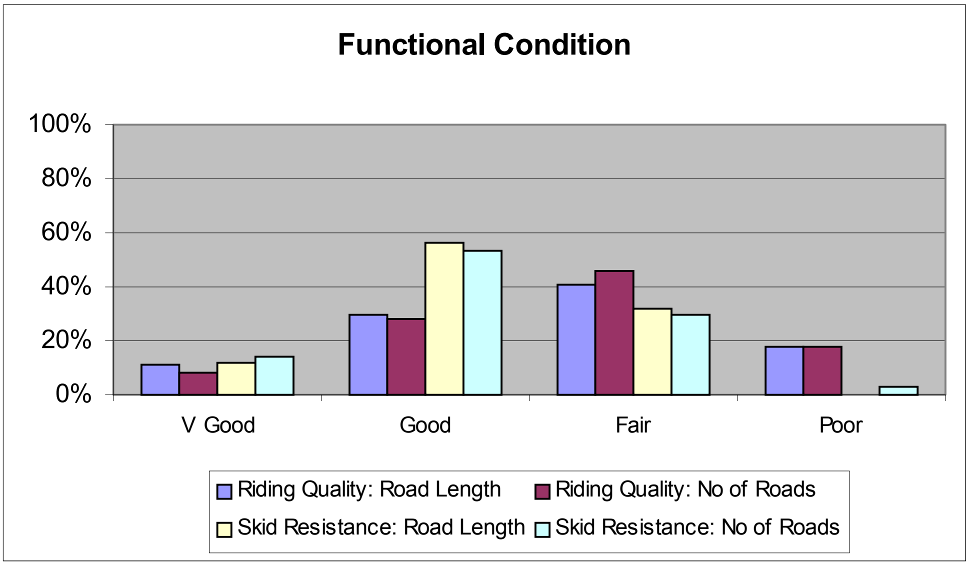

Functional Condition
100%
80%
60%
40%
20%
0%
V Good
Good
Fair
Poor
Riding Quality: Road Length
Riding Quality: No of Roads
Skid Resistance: Road Length
Skid Resistance: No of Roads

Figure 2

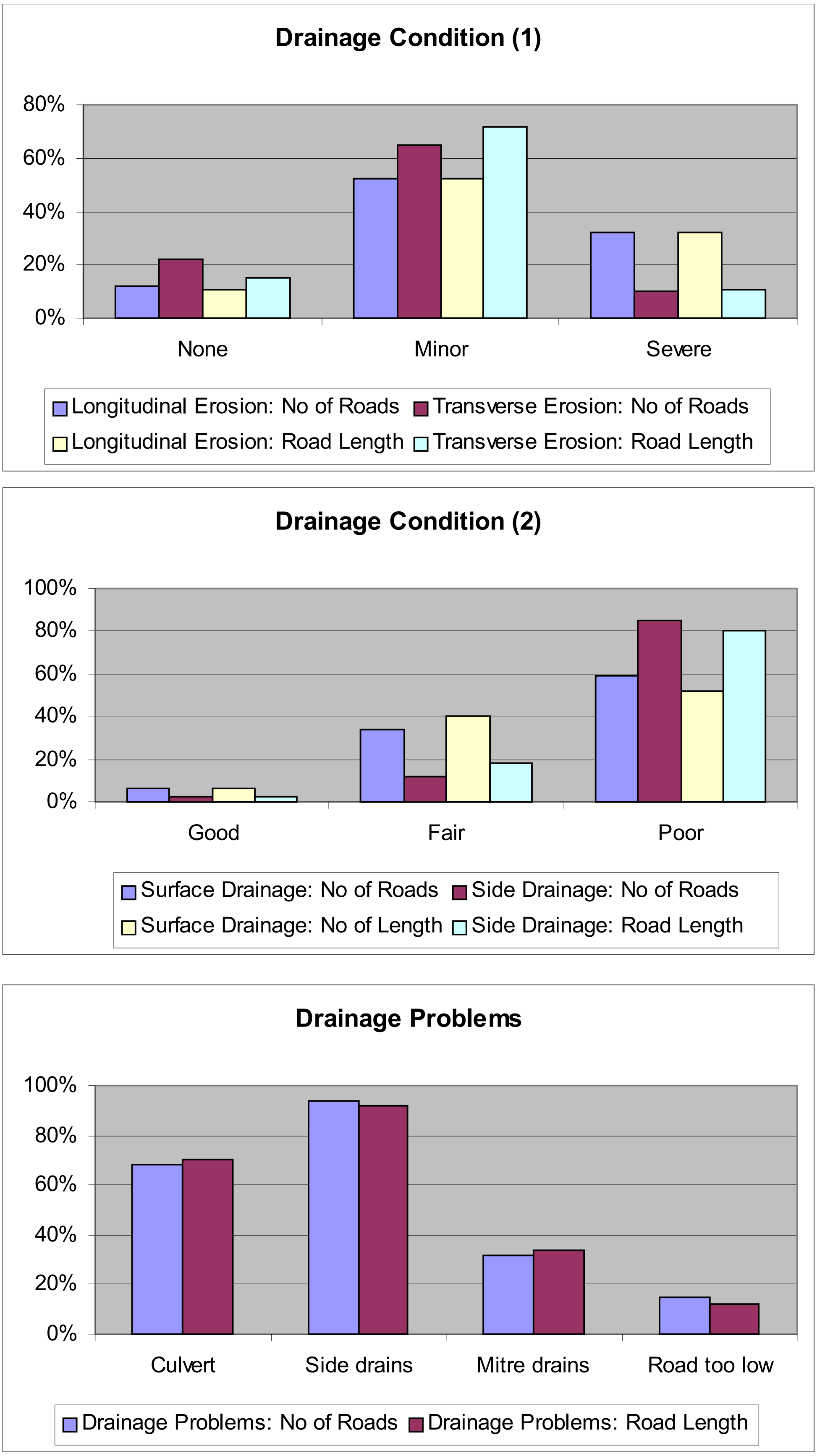

Drainage Condition (1)
80%
60%
40%
20%
0%
None
Minor
Severe
Longitudinal Erosion: No of Roads
Transverse Erosion: No of Roads
Longitudinal Erosion: Road Length
Transverse Erosion: Road Length
Drainage Condition (2)
100%
80%
60%
40%
20%
0%
Good
Fair
Poor
Surface Drainage: No of Roads
Side Drainage: No of Roads
Surface Drainage: No of Length
Side Drainage: Road Length
Drainage Problems
100%
80%
60%
40%
20%
0%
Culvert
Side drains
Mitre drains
Road too low
Drainage Problems: No of Roads
Drainage Problems: Road Length

Figure 3

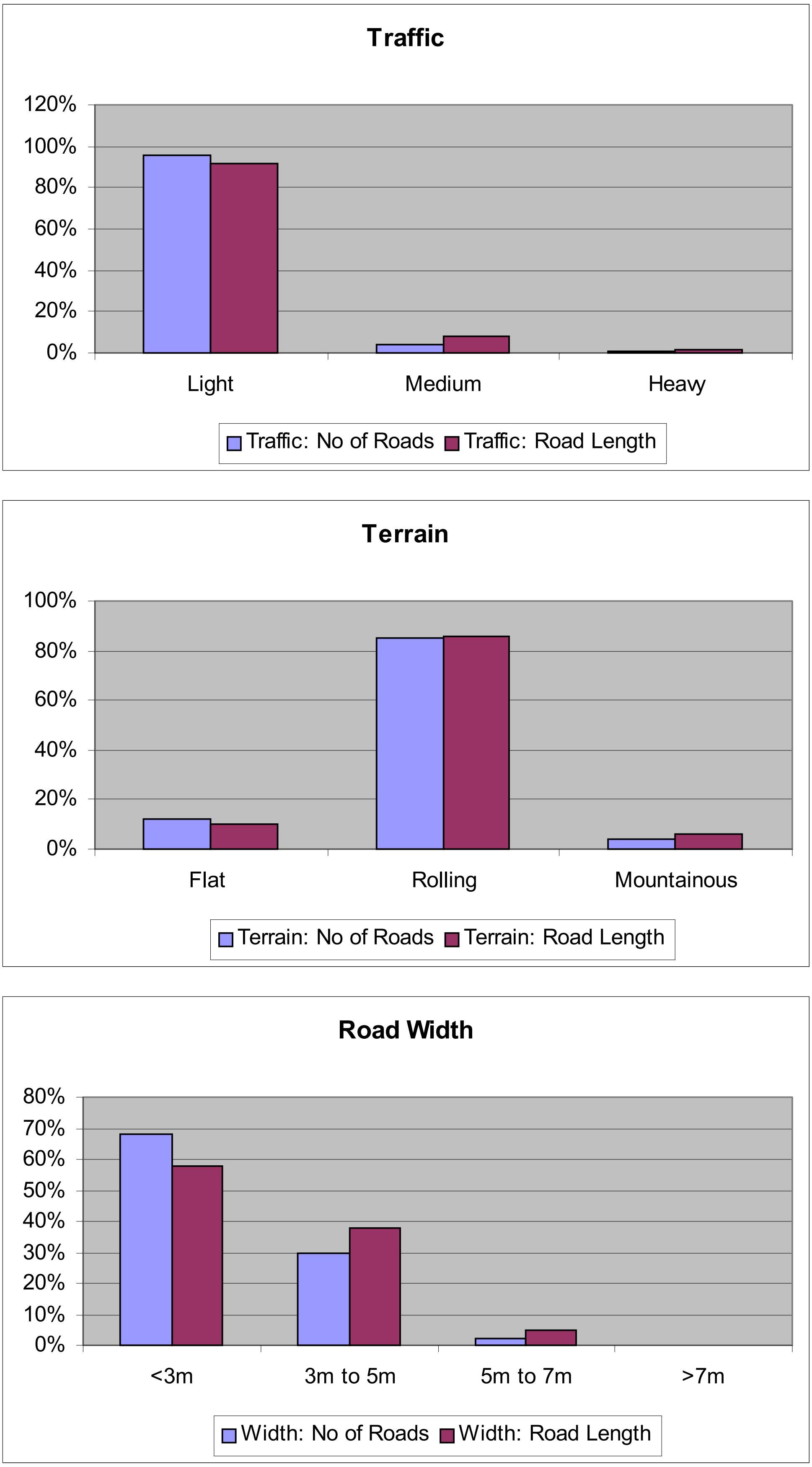
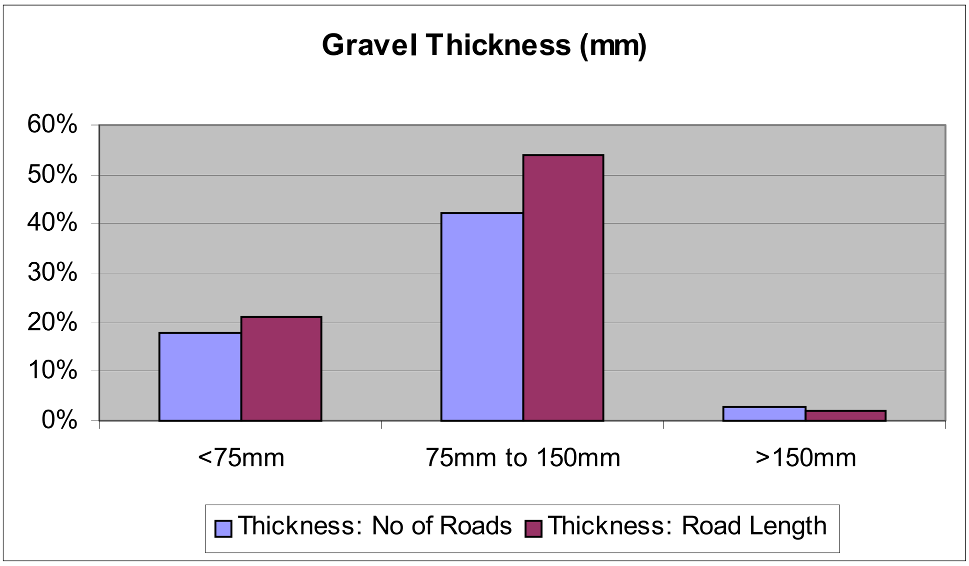
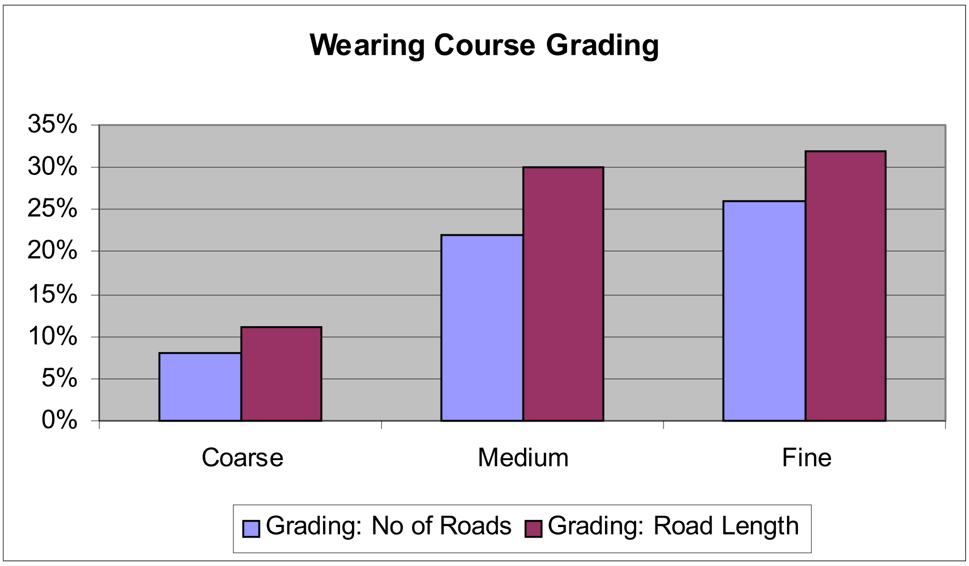

Traffic
120%
100%
80%
60%
40%
20%
0%
Light
Medium
Heavy
Traffic: No of Roads
Traffic: Road Length
Terrain
100%
80%
60%
40%
20%
0%
Flat
Rolling
Mountainous
Terrain: No of Roads
Terrain: Road Length
Road Width
80%
70%
60%
50%
40%
30%
20%
10%
0%
<3m
3m to 5m
5m to 7m
>7m
Width: No of Roads
Width: Road Length

Figure 4


Gravel Thickness (mm)
60%
50%
40%
30%
20%
10%
0%
<75mm
75mm to 150mm
>150mm
Thickness: No of Roads
Thickness: Road Length


Wearing Course Grading
35%
30%
25%
20%
15%
10%
5%
0%
Coarse
Medium
Fine
Grading: No of Roads
Grading: Road Length

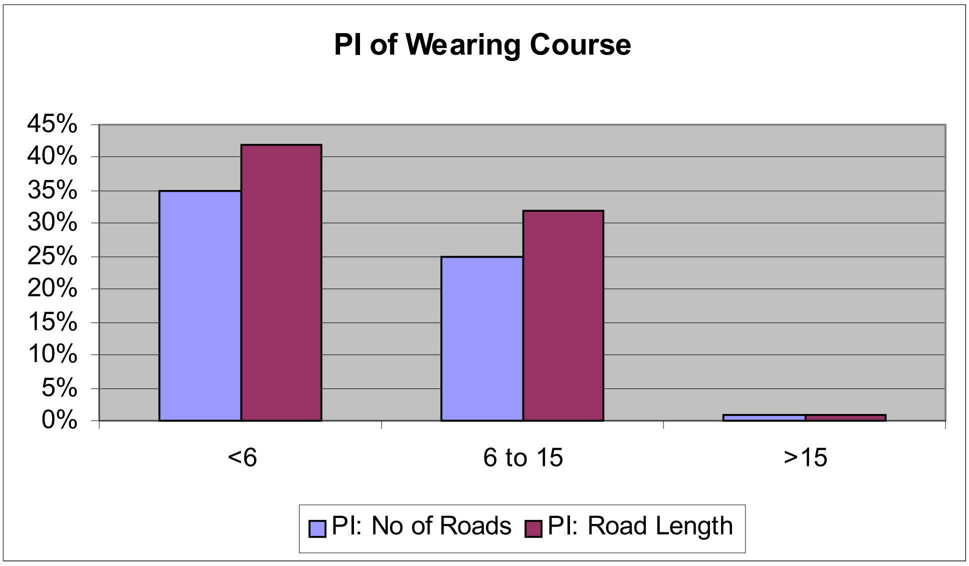

PI of Wearing Course
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
<6
6 to 15
>15
PI: No of Roads
PI: Road Length

Figure 5

GRAPHICAL REPRESENTATION OF BUDGETARY PROJECTIONS BASED ON A FULL ROAD NEEDS STUDY

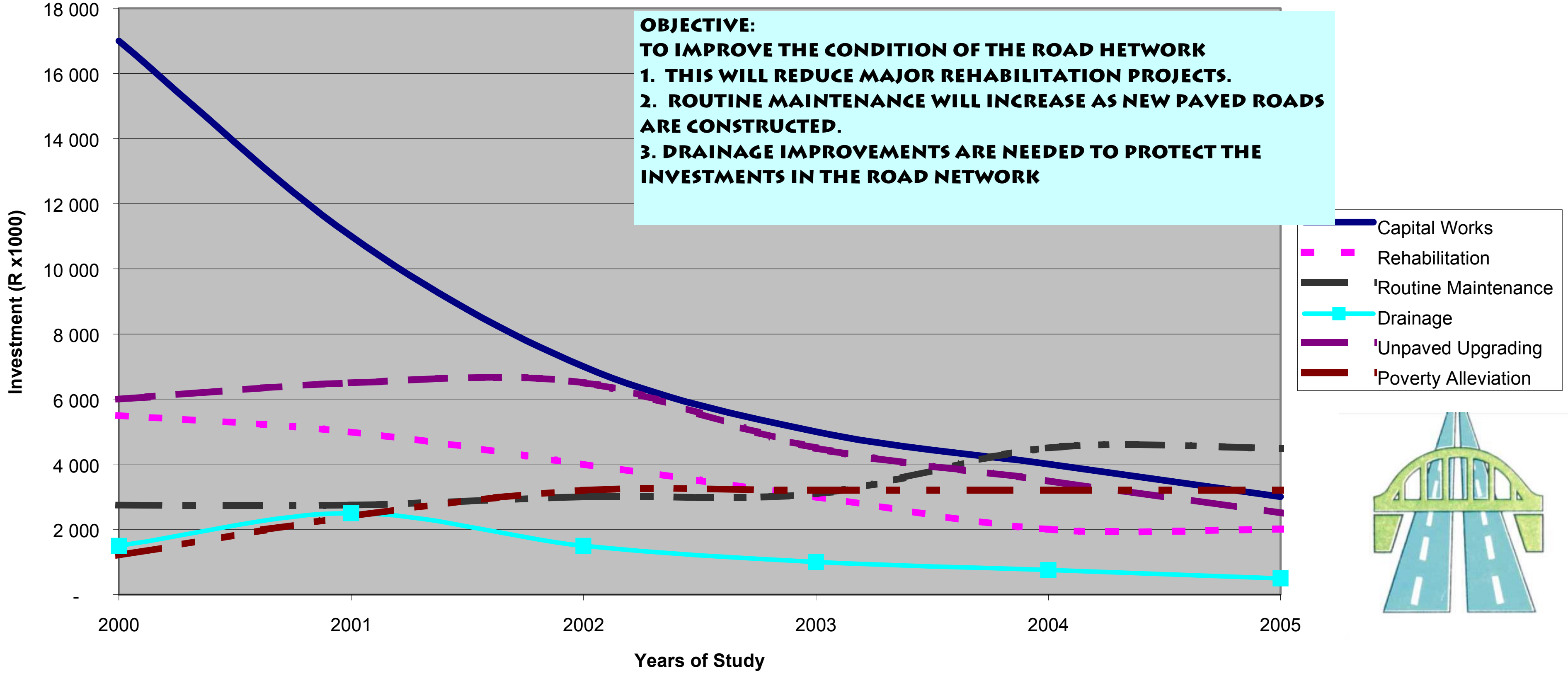
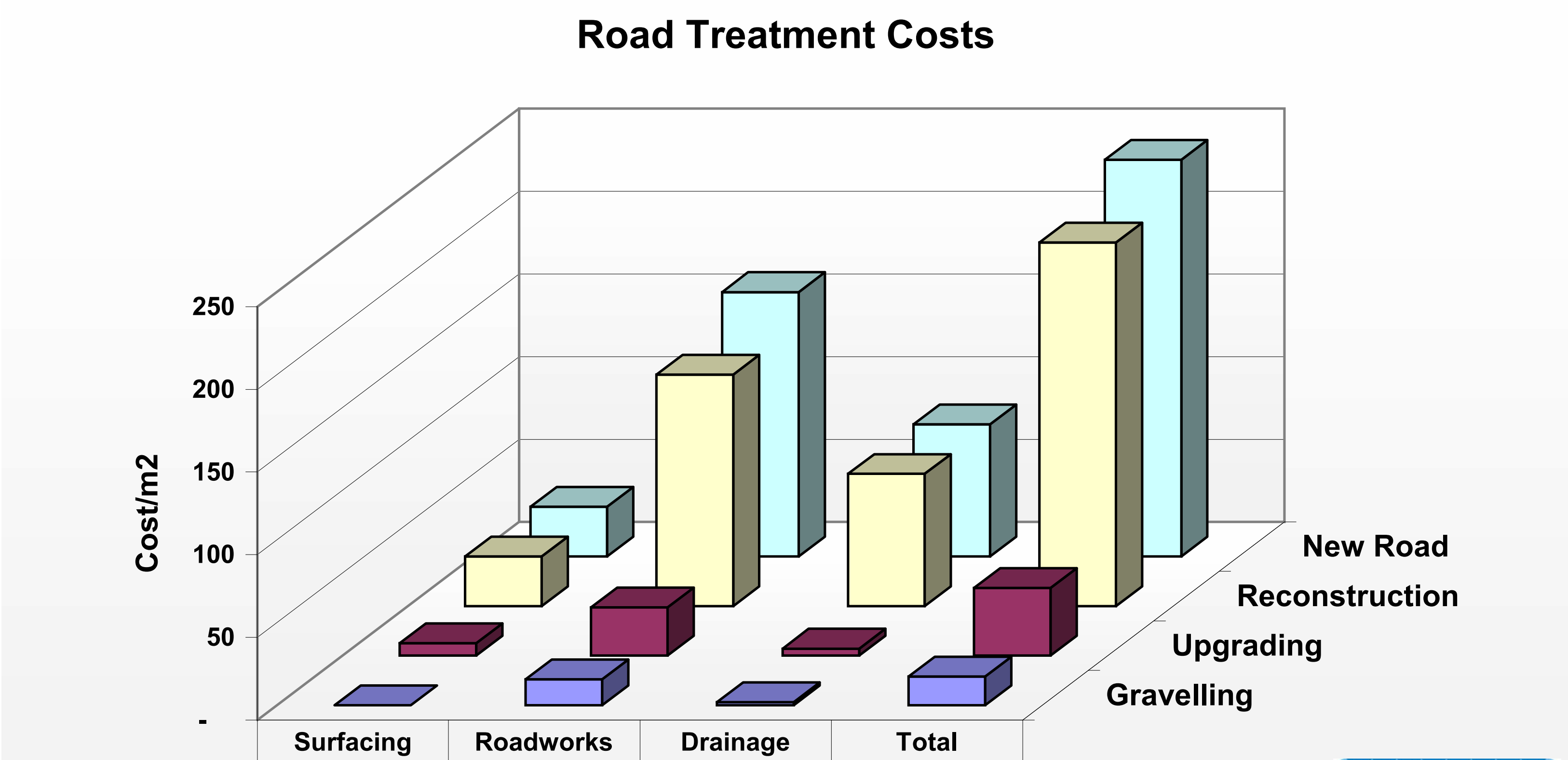


Figure 6



	Surfacing	Roadworks	Drainage	Total
Gravelling	-	15.59	1.78	17.4
Upgrading	7.6	29.11	4.23	40.9
Reconstruction	30	140	80	220.0
New Road	30	160	80	240.0

Figure 7

MANAGING UNPAVED ROADS IN URBAN AREAS

Mr KRISHNA NAIDOO
B Tech Eng (Civ),
North Central Local Council - Durban
Old Fort Road, Durban, 4001

Mr ROGER B PURCHASE
Pr Eng. BSc(Eng) GDE, MSAICE
Tifflin Purchase & Associates
P O Box 1575, Westville, 3630

Curriculum Vitae of Roger B Purchase

Roger was born in Johannesburg, educated at Parktown Boys High School and obtained his BSC and GDE degrees from Witwatersrand University. As a civil engineer he has spent the majority of his 18 years in fields relating to roads. (New road construction, road upgrading, road rehabilitation and pavement management systems).

As a member of Tifflin Purchase & Associates he has concentrated almost exclusively on delivering services to underdeveloped areas in KwaZulu-Natal. These include urban areas such as Inanda and Ntuzuma and rural areas such as Bergville and Ladysmith.

Roger is married to Lynne and has four children.