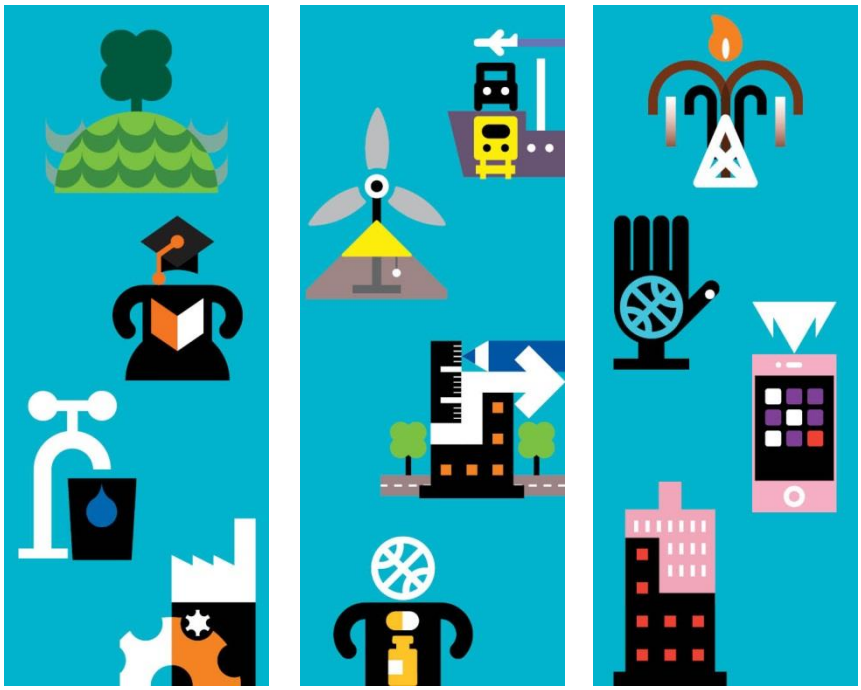

DESIGN REPORT

Design and Construction Supervision:
Bloemendal Arterial Link Road

July 2018

Nelson Mandela Bay Municipality

nelson mandela bay MUNICIPALITY

Mott MacDonald

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Design and Construction Supervision:
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Nelson Mandela Bay Municipality
Infrastructure and Engineering
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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
Rev 1	15/01/2016	M. Madatt	N Van Zyl	T Jachens	Design Report
Rev 2	15/08/2018	M. Madatt	N Van Zyl		Design Report
Rev 3	15/08/2019	N van Zyl			Design Report
Rev 4	15/05/2019	N van Zyl			Design Report

Information class: Standard

Contents

Executive Summary

Mott McDonald/Bengapoint JV was appointed by Nelson Mandela Bay Municipality as the Professional Engineering service provider for the design and construction Supervision of the Bloemendal Arterial Link road, appointment SCM/15-134/C dated 24 July 2015.

This report describes the proposed design and construction of the proposed Bloemendal Arterial Road and the North-South Link Road with appurtenant stormwater infrastructure.

Historic Background:

The original corridor for the Bloemendal Arterial Road was dictated by the township layout of the Bethelsdorp Housing Development by MDT Trust, and provided a direct link to from the Uhambiso tie in in the west to the R75 (Uitenhage Road). CEN Environmental Consultants was appointed to interrogate and verify the existing ROD and related environmental matters. The investigation indicated that the route affects three wetland areas. In order to mitigate said, various alternative alignments were investigated with appurtenant costs, inclusive of the social impact and abortive costs it may have on the Bethelsdorp Phase 1&2, construction being in progress. We refer to the Mott MacDonald "Wetlands Report" Rev 3 dated August 2017. Excluding the existing corridor, 5 alternative alignments was investigated.

Adopted alignment (2018)

- Bloemendal Arterial Road: Commencing at the Uhambiso Design termination in the west to Mission Road in the east
- North-South Link Road: commencing from Siya Street (Joe Slovo township) to tie in with the proposed Bloemendal Arterial. Siya Street is an existing surfaced road.

In the finalization of the Wetlands investigation by CEN during January/February 2019, rare species of flora, thought to be extinct was found present in Wetland 5. Taking cognisance of the various legislations and guidelines pertinent to wetlands, the recommendations forwarded by CEN was an increase of the previous 50m buffer zone to a 115m buffer.

The above resulted in requirements for the realignment of the Bloemendal Arterial Road further south of the affected wetland (refer to provided drawing). The new revised route fall outside the 115m buffer zone. In order to satisfy the geometric road design standards, the realignment commences from tie tie-in with the Uhambiso design (start of route km 0,0) to approximately the connection point at the North-South Link Road.

The above-mentioned realignment has the following impact:

- The township layout of Bethelsdorp Phases 3 & 4 will require redesign, with appurtenant services infrastructure amendments. No installed services are present in the new proposed corridor.
- DEDEAT will be required to prohibit development in the new wetland buffer zone (to township developer)
- There is a growing informal settlement in the east, around the Mission Road tie-in. NMBM will be required to relocate residents to clear the demarcated road reserve.

The North-South Link traverse through the buffer zone of Wetland 2, as per final issued buffer extents. The realignment of this section of road is not deemed as feasible due to:

- The wetland is located in a 60m electrical servitude. To the east of the route, two electrical pylons are situated.
- North of the servitude (east of route) present an existing school with existing structures present on the boundary.

As such the route cannot be aligned in an easterly direction, and westwards will encroach further into the wetland. Therefore, a relaxation is required to traverse through the buffer zone only.

Refer to the included Locality Plan and the following have reference:

The Bloemendal Arterial Road consist of a dual carriageway with a median island and is approximately 2,53km in length. The North-South Link Road consist of a single carriageway road with a length of 2,15km. The route starts from the existing Siya Street in the north and terminates with an intersection at above mentioned Arterial road. This provides a desired direct link to the R75 from inter alia Bethelsdorp and Joe Slovo areas to the R75

Both roads will be fully constructed with surfacing, kerbing and appurtenant stormwater pipe network. The designed stormwater reticulation consists of pipes that varies from 375mm to 1050mm dia size, with kerb inlets and manholes in accordance with NMBM standards.

The estimated construction cost will be approximately R80 million.

1 Project Locality & Topography

Bloemendal Arterial Link road is situated in the Northern Areas of Port Elizabeth at the border between Port Elizabeth and Uitenhage. The road serves as link between Bloemendal and the R75 between Despatch and Port Elizabeth in a low-income housing development.

A detailed engineering survey was undertaken by land surveyors, KRS Geomatics, appointed by Mott Macdonald/Bengapoint JV. That survey was used in the design of the various services involved.

CEN was appointed as the Environmental Specialist for the Specialist Studies, Environmental Impact Assessment and the Water use license application.

A geotechnical investigation has been carried out and report received. The report was assessed with results posing no implications to the design. The report also advised as to the suitability of the in-situ material for road construction.

LOCALITY PLAN
NTS

2 Existing Services

The following existing services were obtained from the NMBM GIS services:

- Sewer Pipelines
- Sewer Manholes
- Water Pipelines
- Water Valves
- Fire Hydrants
- Stormwater Pipelines.
- Stormwater manholes.

In addition to the above-mentioned GIS information the land surveyor verified the positions of all existing services infrastructure which was above ground or exposed along the proposed corridor and within the existing road where the Bloemendal Arterial link road intersects with the New Kwadwesi, Khayamnandi and Joe Slovo areas.

There other services currently being designed and installed by various consultants appointed to do the Bethelsdorp development and these services are being incorporated into the Bloemendal Arterial Design. Various services are installed under the Bethelsdorp township development that have an impact on the route alignments. Of special note here is the 355 dia water mains at approx km 1,4-1,9 on the Arterial Road. The position thereof coincided with the median island. It is proposed that the median is widened over this section, in order to prevent roadworks directly on pipeline. At road intersections, special protection measures are to be facilitated during construction.

3 Proposed New Services

3.1 Level of Service and Design Methodology

The design parameters utilised to determine the demands and requirements for civil services are in accordance with the Guidelines for Human Settlement Planning and Design compiled by the Department of Housing and Construction Technology (2000) as well as The Standard Infrastructure Details (Rev July 2007) issued by the Infrastructure and Engineering Director issued by NMBM.

3.2 Roads

The internal roads and stormwater network are designed in compliance with the NMBM requirements. The project included for two road alignments namely

- Bloemendal arterial Road: Dual carriageway with median island and 2,53km in length. The route starts in the west, joining the Uhambiso Consulting Engineers design of the Arterial Road and terminates at Mission Road intersection.
- The North-South Link Road: Single carriageway road with a length of 2,15km. The route starts at the existing Siya Street in the north and terminates with an intersection with abovementioned Arterial road. This provides the desired direct link to the R75.

Bloemendal Arterial consist of 2 x 3,4m lanes with a 3,2m outer shoulder and a median island of 2,1m. The North-South Link consist of 2 x 3,7m lanes. Provision was made for pedestrian walkways as shown. All roads will have kerbing as indicated. Typical Roads Cross Section details for the respective road reserve widths as shown on drawing no 353543·MMD-00-B01-DR-C-DET·01.

3.3 Geometry Standards

- Design speed 60 km/h
- Min horizontal curve 140m Radius
- Min vert curve (crest) K=10
- Min vert curve (sag) K=16

The proposed design attained all the above parameters and standards. The vertical alignment gradients attained on the Arterial Road varies from 0.5% to a maximum of 8.9% and on the North-South Link from 0.5% to a maximum of 10%.

3.4 Pavement Design

The following findings were made when the pavement design was commissioned:

- The existing Geotechnical report indicates that the Bloemendal roads have the subgrade material which ranges from G6 to G10 class.
- The existing subgrade material varies from good to poor with change of material types (mudstone, calcareous and weathered gravel silty sand),
- The material investigation results indicate that the existing clayey material from mudstone is inactive according to Van Der Merwe Method (on Casagrande chart)
- The DCP results also indicates that the subgrade has very good strength and will suitable for the design traffic class
- The traffic design report for Bloemendal Arterial Link road highlighted that a 2% growth rate was used to project daily traffic volumes up to 20 years. It is estimated that the road will have 10% of

heavy vehicles using the new road. The traffic report stated that the pavement class is ES0.3; however, the minimum pavement category for a Class A road is ES3. A correction was made that the design pavement category will fall between Class B and Class C. Based on the worst-case scenario according to projected traffic class; it is recommended that the pavement class for the future Bloemendal Arterial be set at ES1.

Pavement design alternatives:

Detailed structural evaluation of the pavement and recommended alternatives are dealt in this section taking into consideration all the information in the previous sections namely, existing gravel road conditions and expected traffic loading during the design period.

The following factors were considered in the pavement design:

- Structural life 20 years (recommended)
- Road category C
- Design traffic class ES 1 (0.3 - 1 MESA)
- Subgrade classification Predominantly G10

The pavement design method is based on TRH 4: 1996

Bloemendal Arterial Link Road:

These layer works are the minimum required for Category C Road and ES1 Traffic Class in moderate conditions. The pavement design alternatives that were considered are shown schematically in Figure 2 and are summarized as follows:

Pavement Alternative 1– Granular Base with Unstabilised subbase

30mm Continuously Graded Asphalt

150mm G2 base compacted to 88% ARD Mod.AASHTO

150mm G5 Subbase compacted to 95% Mod.AASHTO

150mm G7 Upper Selected Layer compacted to 93% Mod.AASHTO

150mm G9 Lower Selected Layer compacted to 93% Mod.AASHTO

Rip and Recompact in-situ material (minimum G10 quality),

Compacted to 93% Mod. AASHTO

As indicated in Figure 2 below, the estimated pavement design life (Nf) for alternative 1 is 1.05MESA for required traffic design class. There will be at least two periodic maintenance actions required to be conducted in order to meet the 1MESA traffic design (ES1 traffic design class) as shown in Table 1 below. It shall be noted that this holding action will not reduce the deterioration of lower layers. This alternative has a higher initial construction cost but a lower road user cost, due to the less extensive periodic maintenance actions.

Pavement Alternative 2 – Stabilised Base with Granular Subbase

30mm Continuously Graded Asphalt

200mm C4 Subbase compacted to 97% Mod.AASHTO

150mm G5 Subbase compacted to 95% Mod.AASHTO

150mm G7 Upper Selected Layer compacted to 93% Mod.AASHTO

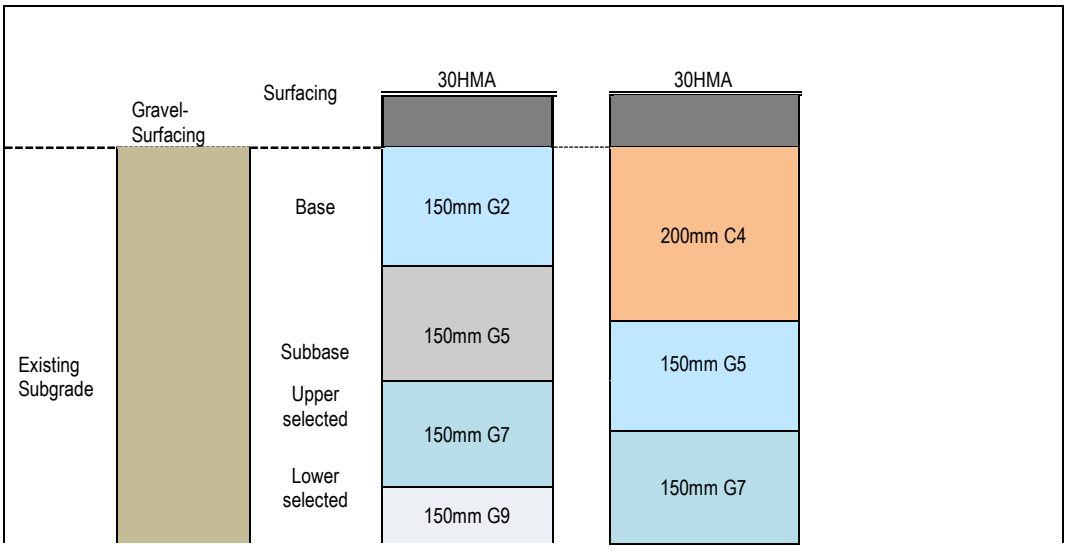
150mm G9 Lower Selected Layer compacted to 93% Mod.AASHTO

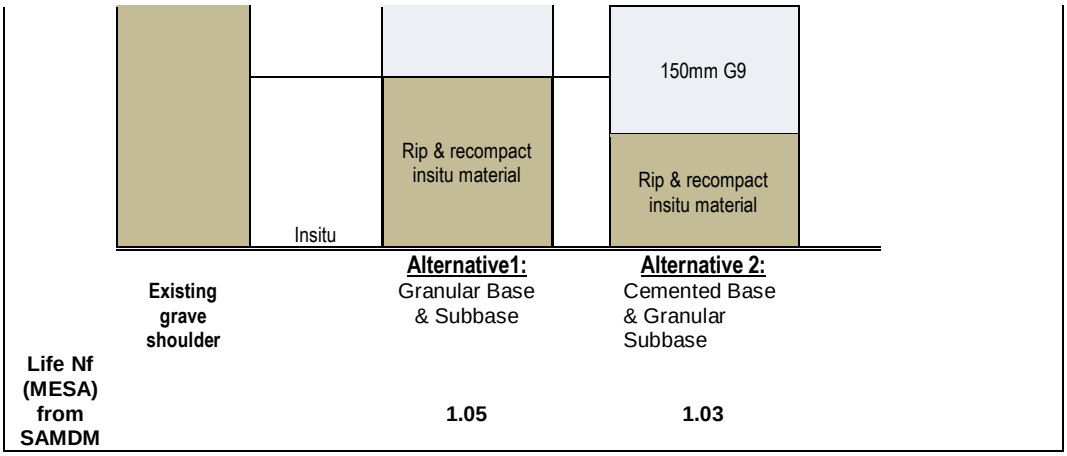
Rip and Recompact in-situ material (minimum G10 quality)

Compacted to 93% Mod. AASHTO,

The design life for this alternative under consideration indicates that the estimated design life (Nf) will be 1.03MESA which will be taking the required 20-year design traffic loading. In order to maintain the good standard of the road, it will require at least two periodic maintenance actions (patch repairs followed by a surface seal intervention) for the 1MESA traffic design class as shown in Table 1 below. This alternative has a lower initial construction cost, however it will have a higher road user costs due to the predicted higher extent of patch repairs required to deal with reflective cracking resulting from the cemented base layer.

Figure 2: Schematic illustration of upgrade alternative 1 & 2





Life cycle cost of the various pavement alternatives:

The discussions above basically highlighted two different pavement strategies with its implications that could be considered for Bloemendal Link Road at this point in time. Each of the rehabilitation strategies has some variations mainly in the type of materials being used. A Life Cycle Cost Analysis (LCCA) for two different alternatives to determined using current construction rates. Each alternative included future interventions, some of which were assumed based on previous experience as shown in Table 1.

Table 1 shows the summary of life cycle cost estimates for Alternatives 1 and 2 .The main cost items for each alternative are used in the analysis for comparison purposes.

Table 1 Life Cycle Cost of various strategies for selected pay-items

Alternative 1: Pavement Structure (Granular base & subbase)	Total Initial Cost	Maintenance	Initial Cost	Maintenance cost at various discount rate			Present worth of costs ®		
				6%	8%	10%	6%	8%	10%
		Patch Repairs (10yrs)	997500	556999	462036	384579			
		Seal (14yrs)	1225000	541819	417065	322581			
30AC	4550000								
150G2	1732500								
150G5	1312500								
150G7	1023750								
150G9	183750								
150 Rip & Recompact	168000								
	R 8,970,500.00			R 1,098,817.47	R 879,100.28	R 707,160.22	R 10,069,317.47	R 9,849,600.28	R 9,677,660.22
Alternative 2: Pavement Structure (Stabilised base & Granular subbase)	Total Initial Cost	Maintenance	Initial Cost	Maintenance cost at various discount rate			Present worth of costs ®		
				6%	8%	10%	6%	8%	10%
		Patch Repairs (8yrs)	2493750	1564609.601	1347295.531	1163352.779			
		Seal (12yrs)	1225000	608787.4704	486464.3543	390322.7517			
30AC	4550000								
200C4	302400								
150G5	2362500								
150G7	1023750								
150G9	183750								
150 Rip & Recompact	168000								
	R 8,590,400.00			R 2,173,397.07	R 1,833,759.89	R 1,553,675.53	R 10,763,797.07	R 10,424,159.89	R 10,144,075.53

It can be seen from Table 1 that alternative 1 is the most economical rehabilitation strategy taking consideration the full 20-year design period. As expected, alternative 2 has the least initial cost. However, alternative 1 is economically beneficial in the long term when periodic maintenance actions are taken into consideration.

In taking consideration of findings of this investigation, on the overall project risks, estimated construction costs and practical considerations, alternative 1 is recommended for the Bloemendal Link Road.

RECOMMENDED PAVEMENT DESIGN:

- Pavement Design for Bloemendal Arterial Road: ES1 (Max 1MESA) Traffic Design Class
- Clearing and grubbing of the required area
- Rip & recompact provided the subgrade is suitable or replace with inactive material (minimum G10),
- Construct fill layers (minimum G9) in 300mm lifts (maximum) compacted to 90% Modified AASHTO,
- Construct 150mm G7 selected subgrade layer compacted to 93% Modified AASHTO,
- Construct 150mm G5 subbase layer compacted to 95% Modified AASHTO,
- Construct 150mm G2 base layer compacted to 88% ARD,
- Construct a 30mm Continuously graded asphalt

  NB: This is the worst-case scenario and final level dictated by geometric consideration. The proposed level of road level is estimated to be 200mm above the natural ground level (NGL) in addressing the drainage.

3.5 Stormwater Design Parameters

The stormwater network is designed in compliance with the NMBM requirements and in accordance with the guidelines for human settlement planning and design (Red Book).

The minor stormwater system will be designed for the 1:5 year flood for the pipe network using the rational method and any overland flow from the major storm will be accommodated for by the road network. The Pipe size for the minor system is minimum 375mmØ.

The following Design parameters were used in the analysis:

- Return Period: 1:5 years
- Frictional Loss Formula: Manning
- Mean Annual Precipitation: 800mm
- Rainfall Region: Coastal
- Proportional Flow Depth: 80%
- Manhole Conditions: Crown to Crown
- Pipe Class: 100D
- Bedding Class: Class B
- Minimum Cover: 0.9m in verge and 1.2m at roadway crossings
- Minimum Velocity: 0.6m/s
- Maximum Velocity: 3.0m/s

Stormwater structures are provided for at maximum of 80m apart. Outfalls is provided at various positions into existing water courses by means of headwalls. The outlet velocity will be controlled by means of energy dissipaters and reno mattresses for erosion protection.

All stormwater details and structures will be as per the NMBM standard details.

3.6 Stormwater Link Details

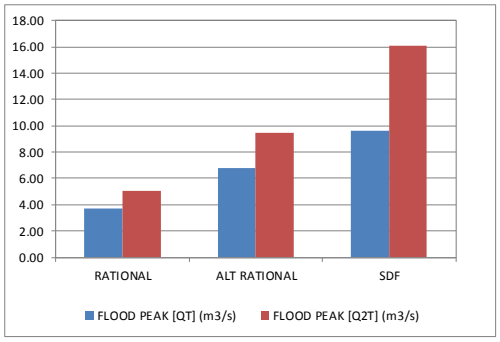
The stormwater system design resulted in pipe sizes varying from 375 dia to a maximum of 1050 dia. The velocity at some areas is in excess of 3 m³/s due to the existing topography and ground slope. The outlet velocity will be controlled by means of energy dissipaters and reno mattresses for erosion protection. The design took cognisance of the flows from the Bethelsdorp Development to the north of the Arterial road, currently under construction. Noted that a part of the stormwater reticulation is already installed from km1,50 to km 1,84 under the Phase1 and 2 Bethelsdorp township development. The position thereof was taken into consideration in the route alignment to prevent abortive costs for reconstruction and/or relaying of the lines.

The following Hydrological assessment was done for the defined water course at km 0,610 (North-South Link). The 1 in 100 Flood line was used in the calculation in the hydrological assessment and sizing of the culvert which yielded a result of 2.4m width by 2.4m height portal culvert. The calculations thereof are shown in the table below.

CLASS 4

HYDROLOGY ANALYSIS

ROAD CLASS 4 ASSESSMENT



HYDRAULIC ANALYSIS

STRUCTURE NAME			Drainage Culvert		
CHAINAGE (Km)			Crosses Bloemendal Arterial Link Road		
RIVER NAME			Unknown		
STRUCTURE NUMBER					
INTERNAL PARAMETERS		WIDTH (m)	2.40		
		HEIGHT (m)	2.40		
NUMBER of SPANS			1		
ROAD CLASS ASSESSED FOR:			4		
BRIDGE SOFFIT LEVEL (m)			NONE		
CATCHMENT AREA (km2)			2.25		
1:20 FLOOD (m3/s)			6.57	12.34	23.33
METHOD			RATIONAL	ALT RATIONAL	SDF
DESIGN FLOOD [Q_T]		DESIGN RP [T] (Years)	5	5	5.1
		FLOOD PEAK [Q_T] (m^3/s)	3.74	6.78	9.66
		FLOOD PEAK [Q_{2T}] (m^3/s)	5.03	9.43	16.07
RMF		RMF (m^3/s)	165.33		
		RMF LEVEL (m)	65.74		
STRUCTURE AVERAGE SLOPE (m/m)			0.0038	0.0038	0.0038
MAX HEADWATER DEPTH (m)			2.88		
UPSTREAM INVERT LEVEL (m)			61.00		
MAX AHL (m)			63.88		
HEADWATER DEPTH (m)			1.06	1.57	1.98
Q_T FLOOD LEVEL (m)			62.06	62.57	62.98
BACKWATER (m)		WS LEVEL INSIDE BRIDGE	61.66	62.02	62.31
		ACTUAL	0.40	0.55	0.67
		LIMIT	0.6		
VELOCITY (m/s)		OUTLET	0.47	0.25	0.32
Q_{2T} FLOOD LEVEL (m)			62.29	62.95	63.78
FREEBOARD	F_D	ITERATION 1	-0.48	-0.48	-0.48
		H/D WOULD BE	1.20	1.20	1.20
		ITERATION 2			
		F_D LIMIT / REQUIRED (m)	-0.48	-0.48	-0.48
		ACTUAL (m)	1.34	0.83	0.42
		RESULT	OK	OK	OK
	F_{SBP}	SHOULDER BREAKPOINT LEVEL (m)	64.00	64.00	64.00
		SBP LEVEL - Q2T* FLOOD LEVEL (m)	1.71	1.05	0.22
		RESULT	OK	OK	OK

4 Cost Estimate

SUMMARY OF SCHEDULES

1. **Construction Cost**

CALCULATION OF TENDERED SUM		AMOUNT
SECTION A:	PRELIMINARY & GENERAL	R 2,754,140.30
SECTION B:	ROADWORKS & EARTHWORKS	R 32,427,614.00
SECTION C:	KERBING & CHANNELING	R 4,298,163.40
SECTION D:	STORMWATER DRAINAGE	R 18,947,117.90
SECTION H:	EME SUBCONTRACTORS	R 571,877.80
SUBTOTAL A		R 58,998,913.40
ADD 10% CONTIGENCIES		R 5,899,891.34
SUBTOTAL B		R 64,898,804.74
ADD 15% VAT ON SUBTOTAL B		R 9,734,820.71
CONTRACT PRICE ADJUSTED		**R 74,633625.45**

5 Conclusion

It is concluded that the provision of engineering infrastructure, as shown in the attached drawings and this report is feasible.

It is recommended that NMBM proceed with the implementation of the project.