PROVINCE OF KWAZULU - NATAL - ISIFUNDAZWE SAKWAZULU - NATALI

DEPARTMENT OF TRANSPORT

UMNYANGO WEZOKUTHUTHA

CONSULTING ENGINEERING SERVICES FOR THE UPGRAGE OF P449 KM 0 TO 11.3

STRUCTURES REPORT

June 2017

Prepared for:

KwaZulu-Natal Department of Transport
Private Bag X9043
PIETERMARITZBURG
3200

Prepared by:

Royal HaskoningDHV
Enhancing Society Together

P O Box 1066
PIETERMARITZBURG
3200

TABLE OF CONTENTS

APPENDICES

1. Introduction

1.1 Background

Royal HaskoningDHV was appointed by the Province of KwaZulu-Natal: Department of Transport (hereafter referred to as KZN: DOT) to conduct engineering services for the Detailed Design and the Construction Monitoring for the rehabilitation of Main Road 449 km 0 to km 11.3.

After further investigation it was decided that the road required more extensive repair due to poor drainage and alignment conditions therefore an upgrade is to be undertaken.

The upgrade of Main Road 449 comprises the bulk earthworks, layerworks, surfacing, drainage, ancillary works and major structures required for the upgrading of Main Road 449. The required roadworks starts at km 0,0 (the intersection of Main Road 522-1) and ends at Km 11,3 (the intersection of Main Road 444).

1.2 Locality

Main Road P449 is situated within the uMkhanyakude district of the Jozini Local Municipality. It starts from its intersection with P522-1 in Jozini and ends at its junction with Main Road P444. The total length of the road is approximately 11.3 Km of which only the first 6.0 km will form part of this report. The road is classified as a class 3 road and forms part of the access route from Jozini to the community of Mbazwane. The project Locality Plan is provided in Appendix A of this report.

There are six major culvert river crossings and two river bridges on this project as listed in the table below:

Table 1.1 Mayor Culverts KM 0 to KM 11.3

Structure No.	Chainage (km)	Existing Structure	Proposed Structure	Description of Works
STC 3962	1.990	1 / 750mm diameter Concrete Pipe	3 / 1,2m x 1,8m Box Culvert	Replace existing undersized culvert.
STC 3958	3.877	2 / 900mm diameter Concrete Pipe	6 / 1,8m x 1,8m Box Culvert	Replace existing undersized culvert.
STC 3959	4.445	1 / 750mm diameter Concrete Pipe	6 / 1,8m x 1,8m Box Culvert	Replace existing undersized culvert.
N / A	6.75	River Bridge		These structures have not been sized as this portion of the works is still being designed.
	6.956	Mayor Culvert		
	7.169	Mayor Culvert		
	7.500	Mayor Culvert		
	8.666	River Bridge		

1.3 Scope of this Report

The scope of this report is to review the mayor culverts between km 0 and 6 and to recommend for widening, lengthening, improvements, replacement of these existing mayor culverts.

2. Site and Miscellaneous Dictates

2.1 Existing Culverts

The existing mayor culvert river crossings that form part of this report along P449 between km 0 and km 6.0 are summarized in table 2.1 below:

Table 2.1 Existing Culverts KM 0 to KM 11.3

Chainage (km)	Existing Culvert Size	Photo
1.990	3 Number 750mm diameter concrete pipes.	
3.877	2 Number 900mm diameter concrete pipes.	
4.445	1 Number 750mm diameter concrete pipes.	No picture available.

These existing culvert crossing were inspected by RHDHV staff and although they were structurally still in a reasonable condition, there were signs of overtopping, debris and erosion found on site.

Figure 2.1: Existing Culvert at km 1.990 – Debris due to overtopping.

2.2 Hydrology

Hydrology analyses for the existing culvert crossings were carried out using SANRAL's Drainage Manual 6th Edition. The headwater to depth ratios for inlet control and outlet control, including the free board requirements where analysed to check the hydraulic capacities of the structures.

The flood estimates were calculated using the following methods:

- Rational,
- Alternative Rational,
- Standard Design Flood (SDF),
- Unit Graph and
- Empirical.

The estimated flood peaks were based on the Rational Method as the catchment areas for the culverts were all less than 15 km^2. The Standard Design Flood (SDF) method and other relevant methods were also used in the evaluation for comparison.

The principal catchment parameters for the culverts are shown in **Table 2.2** below.

Table 2.2 – Culvert Catchment Parameters

CULVERT NUMBER	CATCHMENT AREA (km^2)	LONGEST COLLECTOR (km)	10/85 HEIGHT DIFFERENCE (m)	SDF BASIN No.	TIME OF CONC. (hrs.)
STC 3962 at km 1.975	0.69	0.91	30	27	0.21
STC 3958 at km 3.862	9.55	9.13	250	27	1.30
STC 6959 at km 4.430	9.69	6.55	90	27	1.32

The following are the peak flows for the return period calculated using Utility Programs for drainage.

Table 2.3 – Summary of Peak Floods

CULVERT NUMBER	CALCULATION METHOD	RETURN PERIOD: 10YRS (Q10)	RETURN PERIOD: 20YRS (Q20)	RETURN PERIOD: 50YRS (Q50)	RETURN PERIOD: 100YRS (Q100)	RETURN PERIOD: 200YRS (Q200)
STC 3962 at km 1.975	Rational	9	11	16	20	
	Alt. Rational	12	16	21	26	29
	SDF	17	24	35	43	52
	Unit Graph	11	15	23	32	
	Empirical	13	14	20	25	
STC 3958 at km 3.862	Rational	49	63	86	111	
	Alt. Rational	50	65	86	104	118
	SDF	78	110	156	194	234
	Unit Graph	52	72	107	148	
	Empirical	40	46	64	81	

CULVERT NUMBER	CALCULATION METHOD	RETURN PERIOD: 10YRS (Q10)	RETURN PERIOD: 20YRS (Q20)	RETURN PERIOD: 50YRS (Q50)	RETURN PERIOD: 100YRS (Q100)	RETURN PERIOD: 200YRS (Q200)
STC 6959 at km 4.430	Rational	49	64	87	112	
STC 6959 at km 4.430	Alt. Rational	50	66	87	105	119
	SDF	79	111	157	196	236
	Unit Graph	61	84	126	172	
	Empirical	43	50	69	87	

The P449 is classified as a Class 3 road for drainage purposes. Figure 8.2 of the SANRAL Drainage Manual was used to determine the design flood frequency based on a $\mathbf{Q_{20}}$ peak flow rate. The rational method is considered more appropriate for these sites due to the fact that the catchment areas are considerably less than 15km^2. The Rational method flood peak estimates are summarized in **Table 2.4** below.

Table 2.4 Class 3 Flood Peak Estimates (Rational Method)

CULVERT NAME	Q_{20} (m^3/s)	DESIGN FLOOD QT		DESIGN FLOOD Q2T	
		RETURN PERIOD (Years)	PEAK FLOW (m^3/s)	RETURN PERIOD (Years)	PEAK FLOW (m^3/s)
STC 3962 at km 1.975	11	10	9	20	11
STC 3958 at km 3.862	63	13	49	26	63
STC 6959 at km 4.430	64	13	49	26	64

The Rational method estimated flood peak values from **Table 2.4** above (Class 3, Rational Method) were used in the hydraulic assessment for the existing culverts. The Rational Method is deemed accurate and appropriate for catchment areas up to 15 km².

2.3 Hydraulics

The hydraulic capacity of the existing structures was checked against the Class 3 road requirement in accordance with SANRAL's Drainage Manual.

The existing culverts were so grossly undersized that the results of the hydraulic analysis are not worth recording. It is thus recommended that all three of the culverts be replaced with sizes complying with the relevant hydraulic requirements.

The new replacement culverts were sized on the basis of the dimensionless inlet control performance curves given in the Design Manual for Standard Box Culverts Figure 5.13. All the proposed structures will conform with the freeboard (freeboard FD for Q_T and Shoulder breaking point freeboard F_{SBP} for Q_{2T}) requirements in terms of Chapter 8.3 of the SANRAL Drainage Manual. The requirements are:

- The submergence limit, H/D = 1.2, of the design flood, Q_T,
  - FD> or = 0.3 m if debris is present where FD =(D-Hw)
- The maximum allowable submergence level for the design flood Q_{2T} = smallest of 2D or Shoulder Break Point height
  - F_{SPB}< or = 0 m where F_{SPB} =(D +H_{Fill} – Hw)

The hydraulic assessments of the culverts are shown in **Table 2.5** below.

Table 2.5: Proposed Replacement Culverts

CULVERT NUMBER	PROPOSED REPLACEMENT CULVERT	Hw/D FOR Q_T <= 1,2	Hw/D FOR Q_{2T} <= 2,0	FD Calc. (> or = 0.3) (m)	H_{fill} (m)	F_{SBP} Calc. (> or =0) (m)
STC 3962 at km 1.975	3 / 1,2m x 1,8m Box Culvert	0.83 OK	1.01 OK	0.200	0.593	0.793 OK
STC 3958 at km 3.862	6\3 / 1,8m x 1,8m Box Culvert	1.15 OK	1.42 OK	-0.262	0.944	0.181 OK
STC 6959 at km 4.430	6\3 / 1,8m x 1,8m Box Culvert	1.15 OK	1.43 OK	-0.272	1.075	0.294 OK

2.4 Foundation Investigations

The foundation investigations consisted of trail pits at the inlet and outlet sides of each culvert crossing which was inspected and interpreted by our Geotechnical Engineer (Robby Dunbar).

The founding material and foundation improvement recommendations for the three culverts were similar. The founding material is a clayey, sandy gravel for about 2.0 meters. The foundation recommendation is to excavate 1.0 meters of the clayey, sandy gravel and replace it with an engineered rock fill.

2.5 Topographical Survey

A culvert site survey has not been done at the sites. The culverts have been positioned using the road strip survey.

2.6 Environmental Authorization

The Environmental Impact assessment for the entire project is still to be undertaken and can only be initiated once the detailed design is approved by KZN DOT.

The Contractor will be responsible for the overall implementation of the Environmental Management Plan in accordance with the requirements of Department of Environmental Affairs and Tourism (DEAT) or relevant legislation. He will also be responsible for all third party work on the project.

The particular negative environmental impacts which construction works are likely to cause, together with their mitigating reduction factors, are summarised below:

- **Normal River Flow**: Protection during normal river flows will be done by means of temporary earth berms to keep the normal flow out of the trench excavations. Seepage into trench excavation will be addressed by dewatering using pumps. It is recommended that construction of the river structures be undertaken during dry seasons. The berms will be removed after construction.
-
- **Storm Events**: Appropriate storm water soil erosion control is important during construction. Storm events do provide a major hazard to the construction work in river beds. All labour equipment and materials will be removed from river. To facilitate drainage during storm events, excavation of trenches will proceed in an upstream direction to allow for the trenches to drain after a storm to protect construction works against storm flow.

- **Water pollution**: The contractor must employ adequate mitigation to insure there will be no deleterious substances entering the canals during construction which could affect the quality of water.

- **Material Handling**: The stockpiles will be placed outside the 1:50 year flood lines in such a way that it will not impact on the river courses. Concrete kept on site will be limited because the contractor will make use of local supplier for ready mix concrete.

– **Traffic accommodation**: Although every effort will be made to minimise traffic disruptions it can be expected that during the construction of the structures there will be significant disruptions for extended periods -therefore the contractor must employ traffic plan that will calm the traffic.

3. Codes and Standards

The new culvert's designs and construction where applicable will comply with:

- The formal agreement between KZN DOT and RHDHV for this project.
- SANRAL's Code of Procedures for the Planning and Design of Highway and Road Structures in South Africa (February 2002).
- KZN DOT current Standard Details.
- SANRAL Drainage Manual 6th Edition.
- Relevant directives issued by KZN DOT's Bridge Engineer.
- TMH7 Parts 1, 2 and 3 (as amended 1988). Traffic Loading : NA and NB36.
- Design Manual for Standard Box Culverts

4. Cost Estimate

4.1 Basis of Cost Estimate

Quantities extracted from the drawings for the main structural elements form the basis for the cost estimates. The rates used in arriving at the estimates are based on rates for other recent contracts and prices obtained from manufacturers and suppliers.

4.2 Estimate

The cost estimates summarised in the tables below, but exclusive of:

- Preliminary & General Cost (P & G)
- Accommodation of Traffic Cost
- Contingencies Cost
- Contract Price Adjustment (CPA)

Table 4.1: Estimated Costs for Culverts Improvements.

CULVERT	ESTIMATED COST
STC 3962 at km 1.975	R 700 000
STC 3958 at km 3.862	R 1 400 000
STC 6959 at km 4.430	R 1 700 000
Total (excl VAT)	R 3 800 000

5. Summary and Recommendation

5.1 KZN DOT plan to upgrade the P449 from km 0 to 6.0 and have appointed RHDHV to design and document the proposed culvert replacements.

5.2 It is recommended that:

- The existing 750mm diameter pipe culvert at km 1.975 be replaced with a 3 x 1.2m x 1.8m box culvert.
- The existing 2 x 900mm diameter pipe culvert at km 3.862 be replaced with a 6 x 1.8m x 1.8m box culvert.
- The existing 750mm diameter pipe culvert at km 4.430 be replaced with a 6 x 1.8m x 1.8m box culvert.

5.3 It is recommended that KZN DOT accept these proposals in principle, subject to which the design will be developed to final design approval prior to construction.

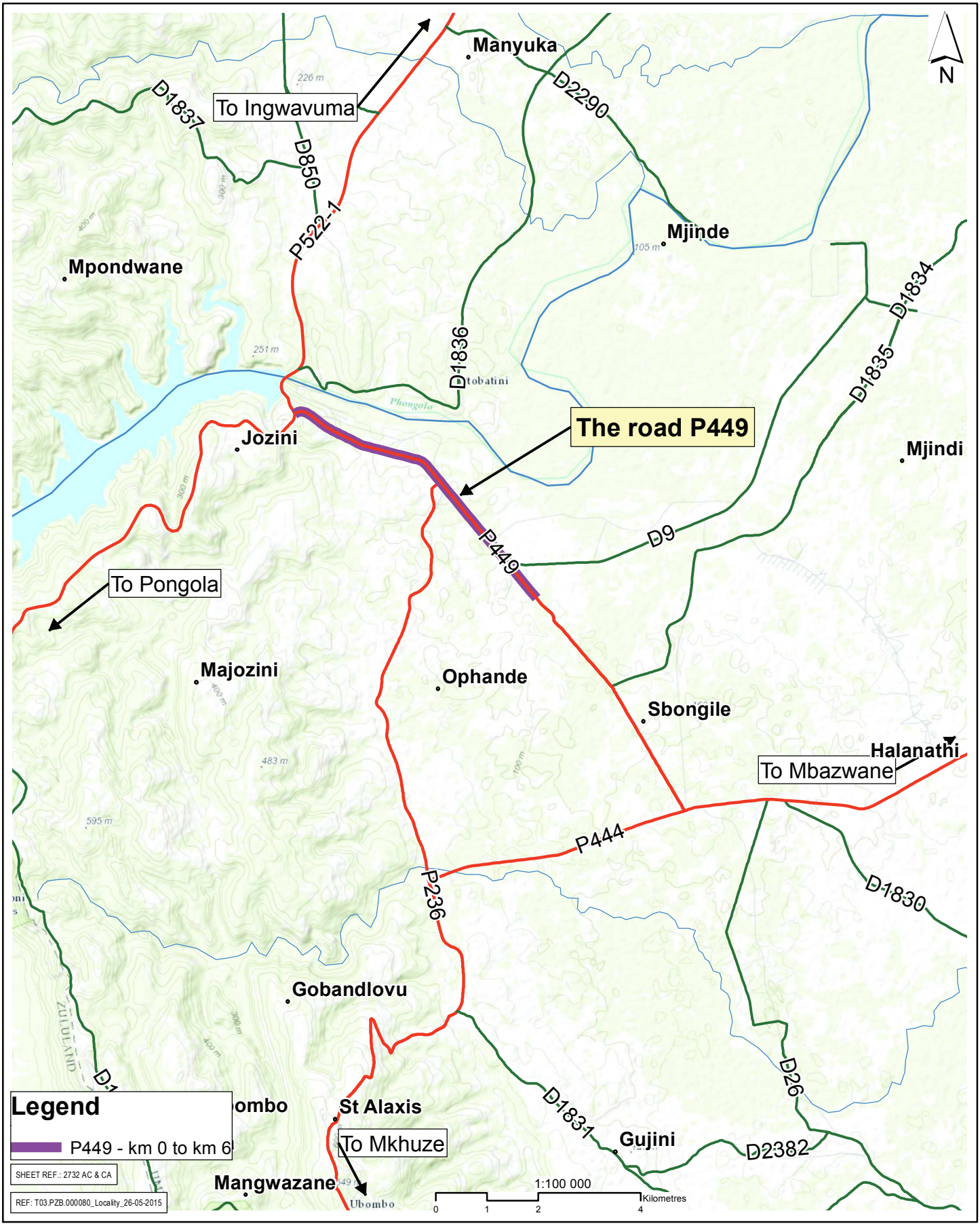
19/06/2017

Report prepared by: **Date**

Mr GA Visser Pr Eng
Principal for Royal HaskoningDHV

Appendix A: Locality Plan

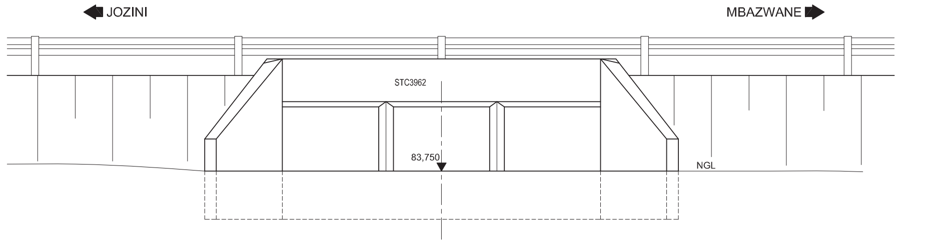
Locality Plan



Royal HaskoningDHV
Enhancing Society Together

Main Road 449
Locality Plan

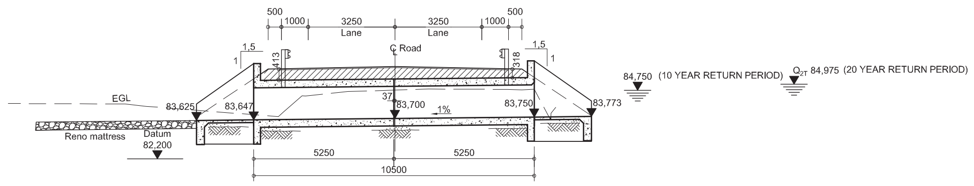
Appendix B: Proposed General Arrangements



UPSTREAM ELEVATION

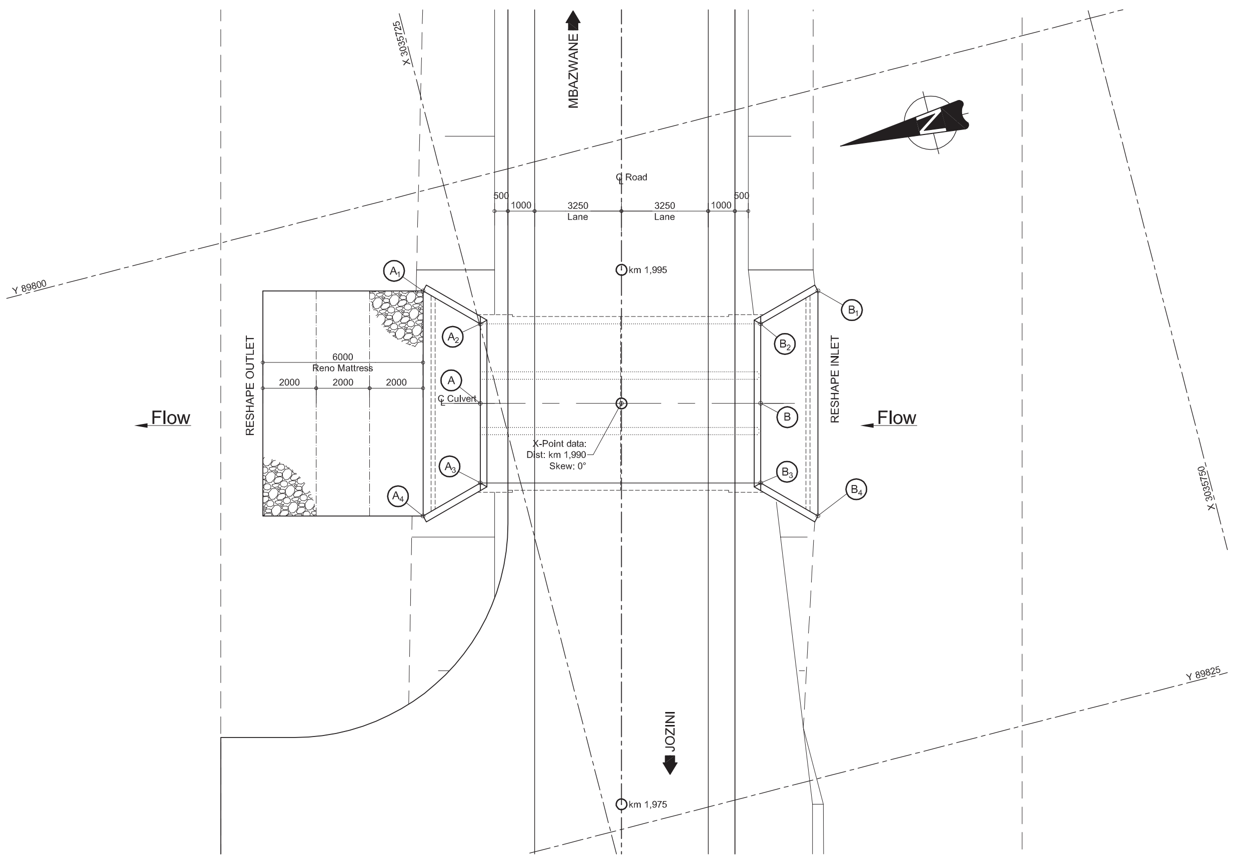
Apron slab not shown for clarity

1 : 50



SECTION ALONG CULVERT CENTRELINE

1 : 100



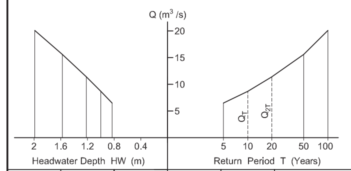
PLAN

Guardrails not shown

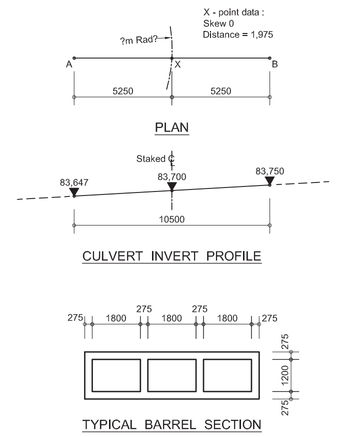
1 : 100

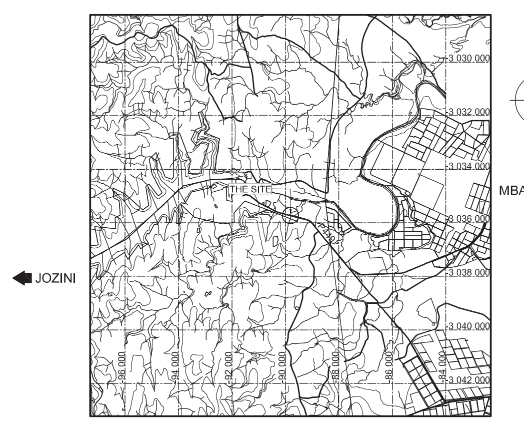
SUMMARY OF HYDROLOGIC, HYDRAULIC & GEOMETRIC DATA

Flood calculation method : Rational Method
Catchment area A : 0,69 km^2
Longest collector : 0,91 km
10-85 Height difference : 300 m
T_c : 0,2 h
MAP : 890 mm
Road Class 3
Slope at structure : 1%
Design flood return period T : 10 years



T (years)	Q (Rational) (m^3 /s)	HW (m)	Flood Elevation (m)	Maximum Velocity (m/s)	Exit Conditions
5	6,5	0,83	84,58	3,53	Erodible material Provide Reno mattress downstream of apron slab provided.
10	**8,7**	**1,0**	**84,75**	**3,87**	
20	11,4	1,215	84,975	4,21	
50	15,6	1,575	85,325	4,63	
100	20,1	1,99	85,710	4,99	
RMF = 83,1 m^3 /s ($100A^{0,50}$)			K = 5,0		





LOCALITY PLAN

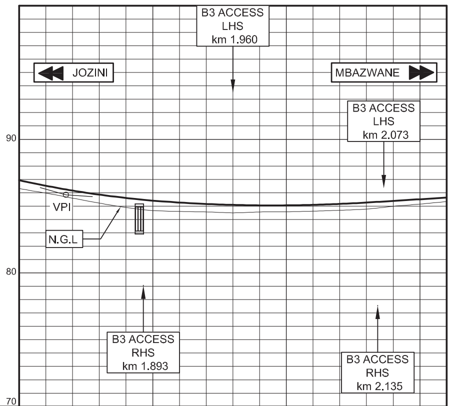
1 : 50 000

SCHEDULE OF DRAWINGS

Drawing No.	Description
STC3962 / 1	General Arrangement
STC3962 / 2	Barrel Details
STC3962 / 3	Earwing Details
STC3962 / 4	Bending Schedule Details

WG Lo 33° CO-ORDINATES

Point	Y	X
A	+ 89 808,244	+ 3 035 724,286
A_1	+ 89 803,629	+ 3 035 723,265
A_2	+ 89 805,364	+ 3 035 725,030
A_3	+ 89 811,124	+ 3 035 723,541
A_4	+ 89 811,785	+ 3 035 721,156
X	+ 89 809,567	+ 3 035 729,404
B	+ 89 810,872	+ 3 035 734,541
B_1	+ 89 807,330	+ 3 035 737,581
B_2	+ 89 807,992	+ 3 035 735,196
B_3	+ 89 813,752	+ 3 035 733,707
B_4	+ 89 815,488	+ 3 035 735,472



LEFT HAND SIDE	GUARDRAIL SIDE DRAINS CENTRE LINE ROAD MARKING SIDE DRAINS																
RIGHT HAND SIDE	GUARDRAIL																
EARTHWORK QUANTITIES	CUT (M^3) ADJ.CUT (M^3) FILL (M^3)																
FINISHED RD. LEVELS	4.25M LEFT OF CENTRE LINE	86.845	86.429	86.068	85.762	85.512	85.317	85.174	85.070	85.000	84.965	84.966	85.002	85.073	85.179	85.303	85.427
CHIP & SPRAY: TOP OF BASE COURSE	CENTRE LINE	86.930	86.514	86.153	85.847	85.597	85.402	85.259	85.155	85.085	85.050	85.051	85.087	85.158	85.264	85.388	85.512
ASPHALT: TOP OF SURFACING	4.25M RIGHT OF CENTRE LINE	86.845	86.429	86.068	85.762	85.512	85.317	85.174	85.070	85.000	84.965	84.966	85.002	85.073	85.179	85.303	85.427
STAKED LINE GROUND LEVELS		86.277	85.993	85.589	85.230	84.857	84.660	84.581	84.599	84.447	84.591	84.567	84.618	84.696	84.744	85.004	85.137
GRADES %		1935.000 85.850 -0.700 % 2000.000 84.800 -0.700 % 2085.000 84.800															
VERTICAL CURVES		150.00m VC K = 72.491; 2010.00 2010.00 EVC; 150.00m VC K = 113.705; 2160.00 EVC															
LEFT HAND EDGE SUPERELEVATION RIGHT HAND EDGE																	
HORIZONTAL CARDINAL POINTS HORIZONTAL ALIGNMENT DEFLECTION DEGREE OF CURVATURE																	
STAKED KILOMETRE DISTANCE		1900	1920	1940	1960	1980	2000	2020	2040	2060	2080	2100	2120	2140	2160	2180	2200

LONGITUDINAL SECTION

1 : 2000 Horizontally
1 : 200 Vertically

NOTES

1. **Design**
   Designed in accordance with the KZN Department of Transport's Design Manual for Standard Box Culverts.

2. **Loading**
   The loading is in accordance with TMH 7 : Parts 1 & 2 : 1981 (Revised December 1988). The following loading and design variables have been used:
   2.1 Live Load :NA ; NB24 Traffic Loading
   2.2 Dead Load : Reinforced Concrete - 24kN/m^3
   2.3 Earth Pressure behind Earwing & Barrel Walls based on 'Coulomb' theory
   Density of soil 1885kg/m^3
   Angle of internal friction 30°
   2.4 Saturation of fill not envisaged.
   2.5 Design fill height: 0.41m
   2.6 Assumed settlement condition $r_{sd}p$ = 0.1
   2.7 Barrel checked for Geostatic Loads.

3. **Design Parameters**
   3.1 Young's Modulus of Elasticity
   Concrete (short term)
   In accordance with table 3 of BS 5400 : 1984
   Reinforcing Steel - 210GPa

4. **Characteristic Strength of Materials**
   4.1 Concrete (f_{cu})
   Blinding 15 / 19
   Barrel & Earwalls 30 / 19
   4.2 Steel Bar Reinforcement (f_y)
   (in accordance with S.A.B.S. 920)
   Hot rolled high-yield-stress deformed bars (Y - bars) 450MPa
   Hot rolled mild steel bars of round cross section (R - bars) 250MPa

5. **General Notes**
   5.1 **Surface Finishes**
   5.1.1 Formed Surfaces
   Concealed surfaces Class F1
   Exposed surfaces Class F2
   5.1.2 Unformed Surfaces
   Top of barrel Class U1
   Top of walls, invert of barrel & apron slab Class U2
   5.2 All sharp corners shall be chamfered to 20mm x 20mm.
   5.3 Concrete cover to reinforcement shall be 40mm.
   5.4 Foundation Conditions
   5.4.1 Type of founding material Engineered fill
   5.4.2 Permissible bearing pressure
   Assumed : 200 kPa
   5.4.3 Design bearing pressure : 150 kPa
   5.4.4 Anticipated settlement : Nil

6. **Method of Analysis**
   The culvert has been analysed elastically using slope-deflection equations for non-prismatic sections.

7. **Culvert No.**
   The STC number is to be recessed 10mm deep in 100mm letters and numerals with the year of construction, centrally orietated below in 75mm numerals, centrally positioned in the parapet wall on the downstream face of the outlet headwall. All numbers and lettering are to be carefully painted with two coats of balck alkali resistant paint.

8. **Construction Safety**
   8.1 The Contractor shall observe all safety requirements of the construction regulations of the OHS Act No. 85 of 1993
   8.2 Special attention shall be paid to :
   - Lateral support of excavations exceeding 1,5m in depth
   - Protection around open excavations
   - Fall protection from all components during erection and concreting

Rev	Date	Description / Beskrywing	Checked	Signed
A	2017/05/17	Issued for construction	G.A.V.	

AMENDMENTS

AS BUILT

Supervising Engineer Date

Supervising Authority

Designed by :-	G Visser
Checked by :-	W Harrison
Drawn by :-	Z Pylman
Checked by :-	G Visser
File Reference :-	MRP449 / 6 / 1

Designed by :
Royal HaskoningDHV
Enhancing Society Together
Signed Date 18/05/2017

PROVINCE OF KWAZULU-NATAL
DEPARTMENT OF TRANSPORT

Bridge Engineer

Head : Transport

MAIN ROAD P449 JOZINI TO INTERSECTION WITH P444

3 / 1,2 x 1,8 BOX CULVERT

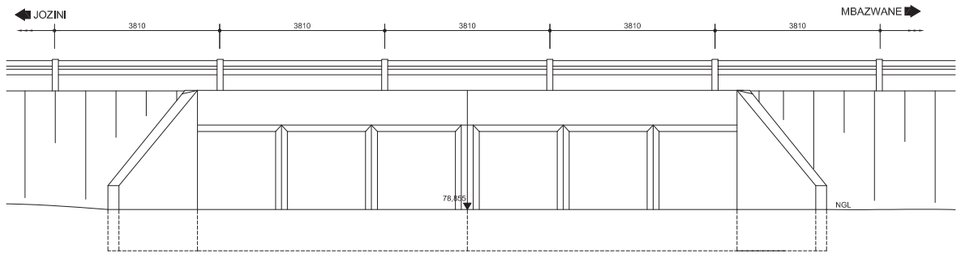
GENERAL ARRANGEMENT

Staked km distance 1,990
S27 25 52.05
E32 05 30.1

Scale: As shown

Sheet :- 1 of :- 4

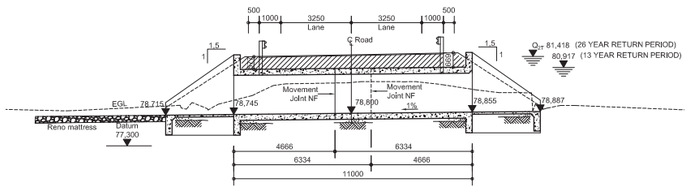
Plan No. :- STC3962/1 Rev A



UPSTREAM ELEVATION

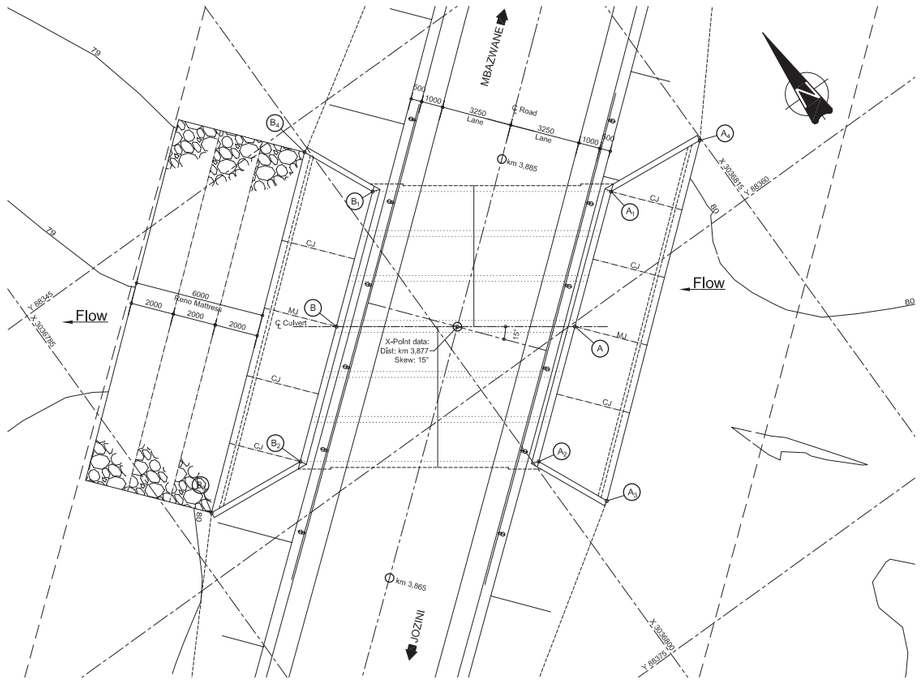
Apron slab not shown for clarity

1 :50



SECTION ALONG CULVERT CENTRELINE

1 : 100

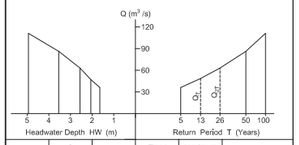


PLAN

1 : 100

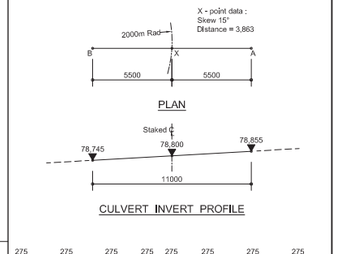
SUMMARY OF HYDROLOGIC, HYDRAULIC & GEOMETRIC DATA

Flood calculation method : Rational Method
Catchment area A : 9,55 km²
Longest collector : 9,13 km
10-85 Height difference : 250 m
T_c : 1,3 h
MAP : 890 mm
Road Class 3
Slope at structure : 1%
Design flood return period T : 13 years



T (years)	Q (Rational) (m^3/s)	HW (m)	Flood Elevation (m)	Maximum Velocity (m/s)	Exit Conditions
5	36,2	1,643	80,498	4,84	Erodible material?? Provide Reno mattress downstream of apron slab provided.
13	**48,5**	**2,062**	**80,917**	**5,26**	
26	63,1	2,563	81,418	5,65	
50	86,2	3,544	82,399	6,12	
100	111	4,935	83,790	7,09	

RMF = 309 m^3/s $(100A^{0.66})$ K = 5,0



LOCALITY PLAN

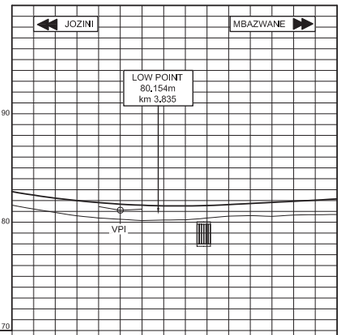
1 : 50 000

SCHEDULE OF DRAWINGS

Drawing No.	Description
STC3958 / 1	General Arrangement
STC3958 / 2	Barrel Details
STC3958 / 3	Earwing Details
STC3958 / 4	Bending Schedule Details

WG Lo 33° CO-ORDINATES

Point	Y	X
A	+ 88 360,162	+ 3 036 805,226
A_1	+ 88 356,086	+ 3 036 810,218
A_2	+ 88 364,240	+ 3 036 800,235
A_3	+ 88 367,550	+ 3 036 801,726
A_4	+ 88 356,560	+ 3 036 814,923
X	+ 88 357,002	+ 3 036 800,826
B	+ 88 353,736	+ 3 036 796,300
B_1	+ 88 349,659	+ 3 036 801,290
B_2	+ 88 357,813	+ 3 036 791,308
B_3	+ 88 357,339	+ 3 036 786,602
B_4	+ 88 346,350	+ 3 036 799,800



LEFT HAND SIDE	GUARDRAIL	
	SIDE DRAINS	
	CENTRE LINE ROAD MARKING	
	SIDE DRAINS	
RIGHT HAND SIDE	GUARDRAIL	
EARTHWORK QUANTITIES	CUT (M^3)	
	ADJ.CUT (M^3)	
	FILL (M^3)	
FINISHED RD. LEVELS	4,25M LEFT OF CENTRE LINE	82,900 82,579 82,303 82,072 81,885 81,686 81,492 81,423 81,415 81,452 81,534 81,637 81,741 81,845 81,948 82,052
CHIP & SPRAY: TOP OF BASE COURSE	CENTRE LINE	82,815 82,494 82,218 81,987 81,800 81,658 81,561 81,508 81,500 81,537 81,619 81,722 81,826 81,930 82,033 82,137
ASPHALT: TOP OF SURFACING	4,25M RIGHT OF CENTRE LINE	82,730 82,409 82,133 81,902 81,715 81,580 81,483 81,433 81,423 81,583 81,665 81,702 81,772 81,845 81,948 82,052
STAKED LINE GROUND LEVELS		81,566 81,219 80,898 80,588 80,391 80,269 80,148 80,202 80,219 80,377 80,549 80,597 80,541 80,660 80,892 80,702
GRADES %		0,519 % 3800,000 81,100 83,200 4000,000
VERTICAL CURVES		200,000m VC K = 89,549
LEFT HAND EDGE SUPERELEVATION RIGHT HAND EDGE		2,000 -2,000 2,000 -2,000
HORIZONTAL CARDINAL POINTS HORIZONTAL ALIGNMENT DEFLECTION DEGREE OF CURVATURE		Curve 6 Right Radius=4500,000 l= 1,52,29 ECC 3796,801 3807,358 BCC Curve 7 Left Radius=2000,000 l= 1,56,25 ECC 3837,660 Direction 320,20,03
STAKED KILOMETRE DISTANCE	3700	3720 3740 3760 3780 3800 3820 3840 3860 3880 3900 3920 3940 3960 3980 4000

LONGITUDINAL SECTION

1 : 2000 Horizontally
1 : 200 Vertically

NOTES

1. **Design**
   Designed in accordance with the KZN Department of Transport's Design Manual for Standard Box Culverts.

2. **Loading**
   The loading is in accordance with TMH 7 : Parts 1 & 2 : 1981 (Revised December 1988). The following loading and design variables have been used:
   2.1 Live Load :NA ; NB24 Traffic Loading
   2.2 Dead Load : Reinforced Concrete - 24kN/m^3
   2.3 Earth Pressure behind Earwing & Barrel Walls based on 'Coulomb' theory
   Density of soil 1885kg/m^3
   Angle of Internal friction 30°
   2.4 Saturation of fill not envisaged.
   2.5 Design fill height 0,67m
   2.6 Assumed settlement condition r_{soil} = 0,1
   2.7 Barrel checked for Geostatic Loads.

3. **Design Parameters**
   3.1 Young's Modulus of Elasticity
   Concrete (short term)
   In accordance with table 3 of BS 5400 : 1984
   Reinforcing Steel - 210GPa

4. **Characteristic Strength of Materials**
   4.1 Concrete (f_{cu})
   Blinding 15 / 19
   Barrel & Earwalls 30 / 19
   4.2 Steel Bar Reinforcement (f_y)
   (in accordance with S.A.B.S. 920)
   Hot rolled high-yield-stress deformed bars (Y - bars) 450MPa
   Hot rolled mild steel bars of round cross section (R - bars) 250MPa

5. **General Notes**
   5.1 **Surface Finishes**
   5.1.1 Formed Surfaces
   Concealed surfaces Class F1
   Exposed surfaces Class F2
   5.1.2 Unformed Surfaces
   Top of barrel Class U1
   Top of walls, Invert of barrel & apron slab Class U2
   5.2 All sharp corners shall be chamfered to 20mm x 20mm.
   5.3 Concrete cover to reinforcement shall be 40mm.
   5.4 Foundation Conditions
   5.4.1 Type of founding material Engineered fill
   5.4.2 Permissible bearing pressure
   Assumed : 200 kPa
   5.4.3 Design bearing pressure : 150 kPa
   5.4.4 Anticipated settlement : Nil

6. **Method of Analysis**
   The culvert has been analysed elastically using slope-deflection equations for non-prismatic sections.

7. **Culvert No.**
   The STC number is to be recessed 10mm deep in 100mm letters and numerals with the year of construction, centrally orientated below in 75mm numerals, centrally positioned in the parapet wall on the downstream face of the outlet headwall. All numbers and lettering are to be carefully painted with two coats of balck alkali resistant paint.

8. **Construction Safety**
   8.1 The Contractor shall observe all safety requirements of the construction regulations of the OHS Act No. 85 of 1993
   8.2 Special attention shall be paid to :
   - Lateral support of excavations exceeding 1,5m in depth
   - Protection around open excavations
   - Fall protection from all components during erection and concreting

Rev	Date	Description / Beskrywing	Checked	Signed
A	2017/05/17	Issued for construction	G.A.V.	

AMENDMENTS

AS BUILT

Supervising Engineer ..... Date .....

Supervising Authority .....

Designed by :- G Visser
Checked by :- B P Durow
Drawn by :- Z Pylman
Checked by :- G Visser
File Reference :- MRP449 / 6 / 1

Designed by : Royal HaskoningDHV Enhancing Society Together
Signed ..... Date 18/05/2017

PROVINCE OF KWAZULU-NATAL
DEPARTMENT OF TRANSPORT

Bridge Engineer .....
Head : Transport .....

MAIN ROAD P449 JOZINI TO INTERSECTION WITH P444

6 / 1,8 x 1,8 BOX CULVERT

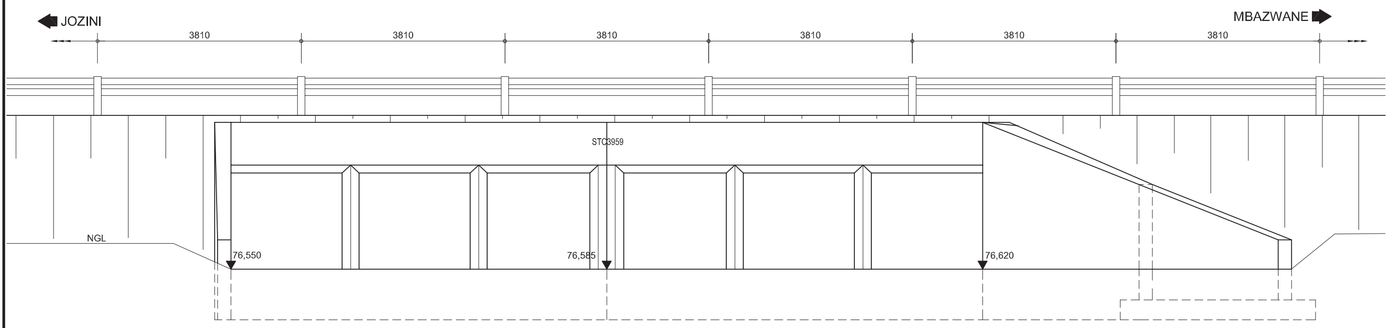
GENERAL ARRANGEMENT

Staked km distance 3,877
S27 26 27,1
E32 06 22,7

Scale As shown

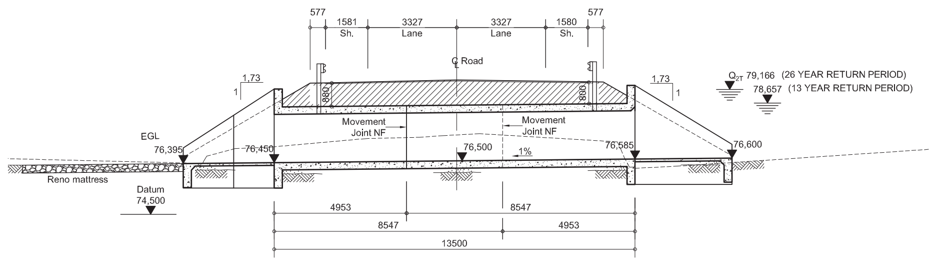
Sheet :- 1 of :- 4

Plan No. :- STC3958/1 Rev A



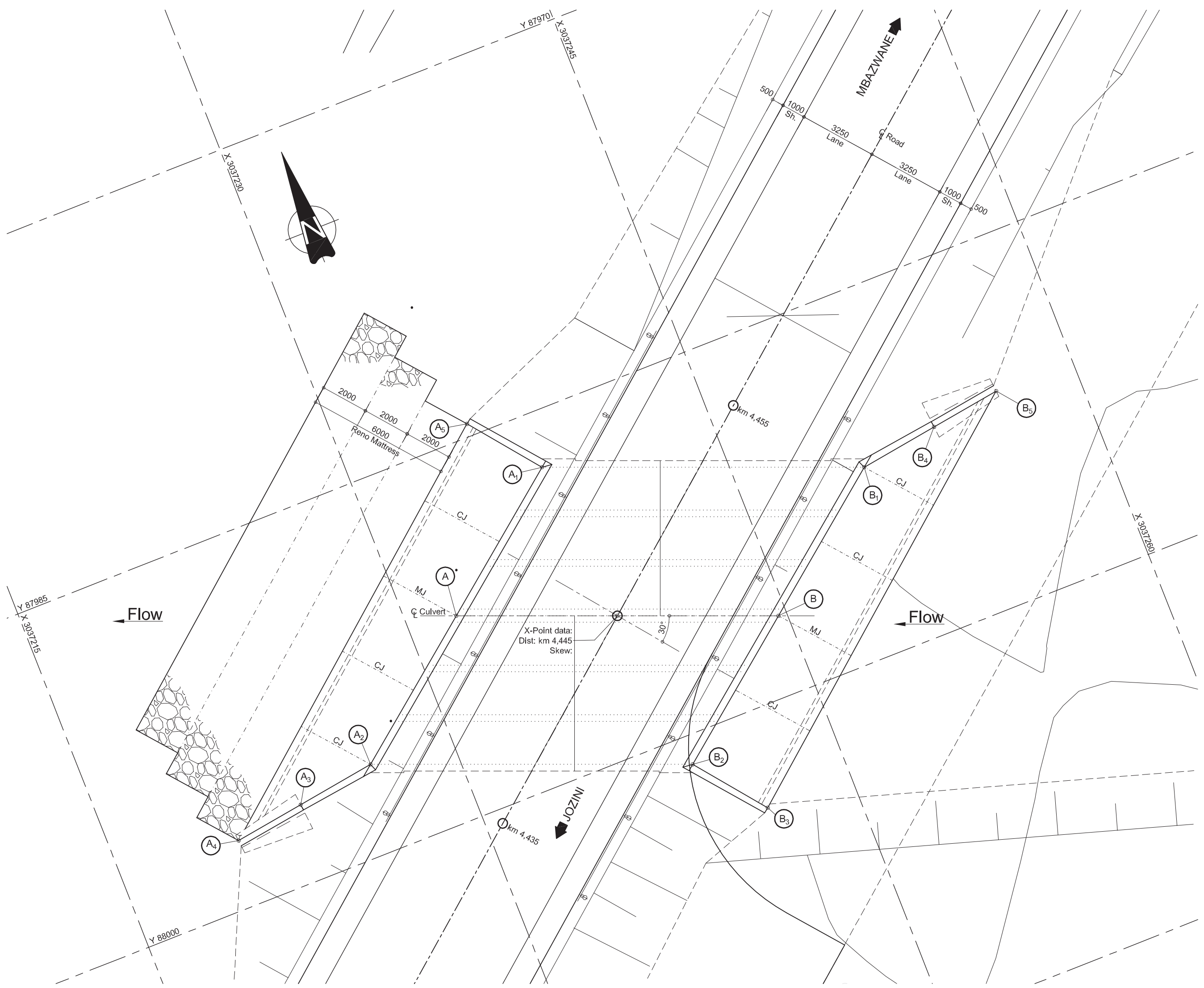
UPSTREAM ELEVATION

Apron slab not shown for clarity
1 :50



SECTION ALONG CULVERT CENTRELINE

1 : 100

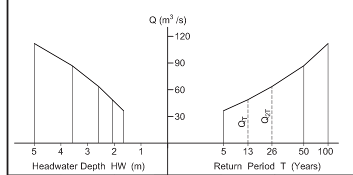


PLAN

1 : 100

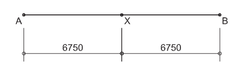
SUMMARY OF HYDROLOGIC, HYDRAULIC & GEOMETRIC DATA

Flood calculation method : Rational Method
Catchment area A : 9,69 km^2
Longest collector : 6,55 km
10-85 Height difference : 90 m
T_c : 1,32 h
MAP : 890 mm
Road Class 3
Slope at structure : 1%
Design flood return period T : 13 years

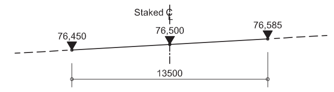


T (years)	Q (Rational) (m^3 /s)	HW (m)	Flood Elevation (m)	Maximum Velocity (m/s)	Exit Conditions
5	36,4	1,650	78,235	4,85	Provide Reno mattress downstream of apron slab.
13	**48,8**	**2,072**	**78,657**	**5,25**	
26	63,6	2,581	79,166	5,66	
50	86,8	3,574	80,159	6,13	
100	111,8	4,980	81,571	7,13	
RMF = 309 m^3 /s (100A^{0,50})			K = 5,0		

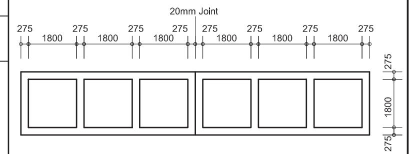
X - point data :
Skew 30°
Distance = 4,430



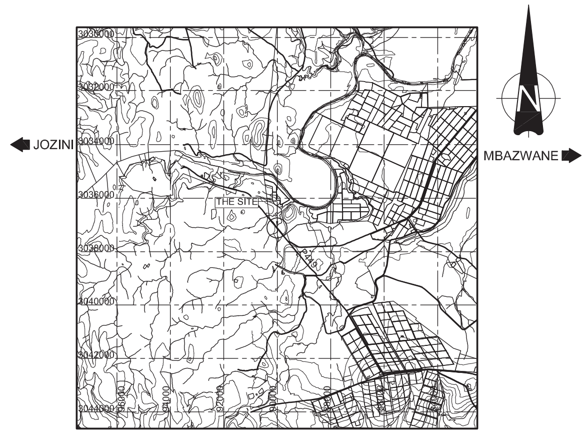
PLAN



CULVERT INVERT PROFILE

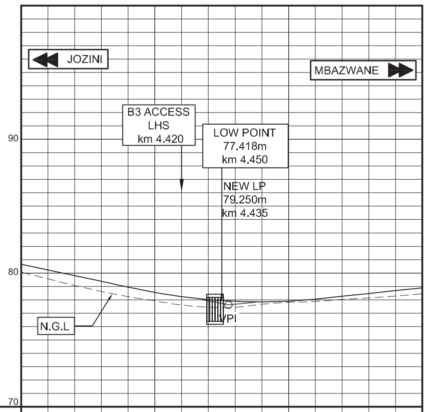


TYPICAL BARREL SECTION



LOCALITY PLAN

1 : 50 000



LEFT HAND SIDE	GUARDRAIL	
	SIDE DRAINS	
	CENTRE LINE ROAD MARKING	
	SIDE DRAINS	
RIGHT HAND SIDE	GUARDRAIL	
EARTHWORK QUANTITIES	CUT (M³)	
	ADJ.CUT (M³)	
	FILL (M³)	

Row		4300	4320	4340	4360	4380	4400	4420	4440	4460	4480	4500	4520	4540	4560	4580	4600
FINISHED RD. LEVELS	4.25M LEFT OF CENTRE LINE	-4,250 80.610	-4,250 80.213	-4,250 79.817	-4,250 79.420	-4,250 79.023	-4,250 78.650	-4,250 78.359	-4,250 78.152	-4,250 78.030	-4,250 77.993	-4,250 78.040	-4,250 78.172	-4,250 78.364	-4,250 78.559	-4,250 78.754	-4,250 78.949
CHIP & SPRAY: TOP OF BASE COURSE	CENTRE LINE	80.695	80.298	79.902	79.505	79.108	78.735	78.444	78.237	78.115	78.078	78.125	78.257	78.449	78.644	78.839	79.034
ASPHALT: TOP OF SURFACING	4.25M RIGHT OF CENTRE LINE	4,250 80.610	4,250 80.213	4,250 79.817	4,250 79.420	4,250 79.023	4,250 78.650	4,250 78.359	4,250 78.152	4,250 78.030	4,250 77.993	4,250 78.040	4,250 78.172	4,250 78.364	4,250 78.559	4,250 78.754	4,250 78.949
STAKED LINE GROUND LEVELS		80.068	79.563	79.069	78.626	78.232	77.919	77.608	77.443	77.444	77.669	77.812	77.870	78.025	78.141	78.280	78.448
GRADES %		-1.984 % ; 4455.000 77.620															
VERTICAL CURVES		140.000m VC K = 47.306															
LEFT HAND EDGE ——— SUPERELEVATION RIGHT HAND EDGE - - - -																	
HORIZONTAL CARDINAL POINTS HORIZONTAL ALIGNMENT DEFLECTION DEGREE OF CURVATURE																	
STAKED KILOMETRE DISTANCE		4300	4320	4340	4360	4380	4400	4420	4440	4460	4480	4500	4520	4540	4560	4580	4600

LONGITUDINAL SECTION

1 : 2000 Horizontally
1 : 200 Vertically

SCHEDULE OF DRAWINGS

Drawing No.	Description
STC3959 / 1	General Arrangement
STC3959 / 2	Barrel Details
STC3959 / 3	Earwall Details
STC3959 / 4	Wingwall Details
STC3959 / 5	Bending Schedule Details

WG Lo 33° CO-ORDINATES

Point	Y	X
A	+ 87 991,788	+ 3 037 232,070
A_1	+ 87 987,308	+ 3 037 237,692
A_2	+ 87 996,267	+ 3 037 226,450
A_3	+ 87 996,820	+ 3 037 223,106
A_4	+ 87 997,215	+ 3 037 220,140
A_5	+ 87 984,470	+ 3 037 235,427
X	+ 87 994,256	+ 3 037 238,350
B	+ 87 996,725	+ 3 037 244,635
B_1	+ 87 992,245	+ 3 037 250,255
B_2	+ 88 001,204	+ 3 037 239,015
B_3	+ 88 004,043	+ 3 037 241,275
B_4	+ 87 991,743	+ 3 037 253,600
B_5	+ 87 991,297	+ 3 037 256,565

NOTES

1. **Design**
Designed in accordance with the KZN Department of Transport's Design Manual for Standard Box Culverts.

2. **Loading**
The loading is in accordance with TMH 7 : Parts 1 & 2 : 1981 (Revised December 1988). The following loading and design variables have been used:
2.1 Live Load :NA ; NB24 Traffic Loading
2.2 Dead Load : Reinforced Concrete - 24kN/m^3
2.3 Earth Pressure behind Earwing & Barrel Walls based on 'Coulomb' theory
Density of soil 1885kg/m^3
Angle of internal friction 30°
2.4 Saturation of fill not envisaged.
2.5 Design fill height: 0.88m
2.6 Assumed settlement condition $r_{sd}p$ = 0.1
2.7 Barrel checked for Geostatic Loads.

3. **Design Parameters**
3.1 Young's Modulus of Elasticity
Concrete (short term)
In accordance with table 3 of BS 5400 : 1984
Reinforcing Steel - 210GPa

4. **Characteristic Strength of Materials**
4.1 Concrete (f_{cu})
Blinding 15 / 19
Barrel & Earwalls 30 / 19
4.2 Steel Bar Reinforcement (f_y)
(in accordance with S.A.B.S. 920)
Hot rolled high-yield-stress deformed bars (Y - bars) 450MPa
Hot rolled mild steel bars of round cross section (R - bars) 250MPa

5. **General Notes**
5.1 **Surface Finishes**
5.1.1 Formed Surfaces
Concealed surfaces Class F1
Exposed surfaces Class F2
5.1.2 Unformed Surfaces
Top of barrel Class U1
Top of walls, invert of barrel & apron slab Class U2
5.2 All sharp corners shall be chamfered to 20mm x 20mm.
5.3 Concrete cover to reinforcement shall be 40mm.
5.4 Foundation Conditions
5.4.1 Type of founding material Engineered fill
5.4.2 Permissible bearing pressure
Assumed : 200 kPa
5.4.3 Design bearing pressure : 150 kPa
5.4.4 Anticipated settlement : Nil

6. **Method of Analysis**
The culvert has been analysed elastically using slope-deflection equations for non-prismatic sections.

7. **Culvert No.**
The STC number is to be recessed 10mm deep in 100mm letters and numerals with the year of construction, centrally orietated below in 75mm numerals, centrally positioned in the parapet wall on the downstream face of the outlet headwall. All numbers and lettering are to be carefully painted with two coats of balck alkali resistant paint.

8. **Construction Safety**
8.1 The Contractor shall observe all safety requirements of the construction regulations of the OHS Act No. 85 of 1993
8.2 Special attention shall be paid to :
- Lateral support of excavations exceeding 1,5m in depth
- Protection around open excavations
- Fall protection from all components during erection and concreting

Rev	Date	Description / Beskrywing	Checked	Signed
A	2017/05/17	Issued for construction	G.A.V.	

AMENDMENTS

AS BUILT

Supervising Engineer .... Date ....
Supervising Authority ....

Designed by :-	G Visser
Checked by :-	W Harrison
Drawn by :-	Z Pylman
Checked by :-	G Visser
File Reference :-	MRP449 / 6 / 1

Designed by : Royal HaskoningDHV Enhancing Society Together
Signed .... Date 18/05/2017

PROVINCE OF KWAZULU-NATAL
DEPARTMENT OF TRANSPORT

Bridge Engineer ....
Head : Transport ....

MAIN ROAD P449 JOZINI TO INTERSECTION WITH P444

6 / 1,8 x 1,8 BOX CULVERT

GENERAL ARRANGEMENT

Staked km distance 4,445 S27 26 41.6 E32 06 35.9
Sheet :- 1 of :- 5
Scale: As shown
Plan No. :- STC3959/1 Rev A