DELINEATION OF THE 1:50 & 1:100 YEAR FLOODLINES AT THE KEBRA ROODEPOORT COLLIERY MINING DEVELOPMENT – FARM ROODEPOORT 151 IS

CONTENTS

LIST OF ABBREVIATIONS

APP	Approved professional person
DWA	Department of Water Affairs
EPP	Emergency preparedness plan
FSL	Full supply level
HRU	Hydrological Research Unit
K	Regional coefficient
MAP	Mean annual precipitation
MAR	Mean annual run-off
MSL	Mean sea level
NOC	Non-overspill crest
NWA	National Water Act, Act 36 of 1998
OMM	Operation and maintenance manual
PMF	Probable maximum flood
PMP	Probable maximum precipitation
RDD	Recommended design discharge
RDF	Recommended design flood
RI	Recurrence interval
RL	Reduced level
RMF	Regional maximum flood
SANCOLD	South African Committee on Large Dams
SCS	Soil Conservation Service
SED	Safety evaluation discharge
SEF	Safety evaluation flood

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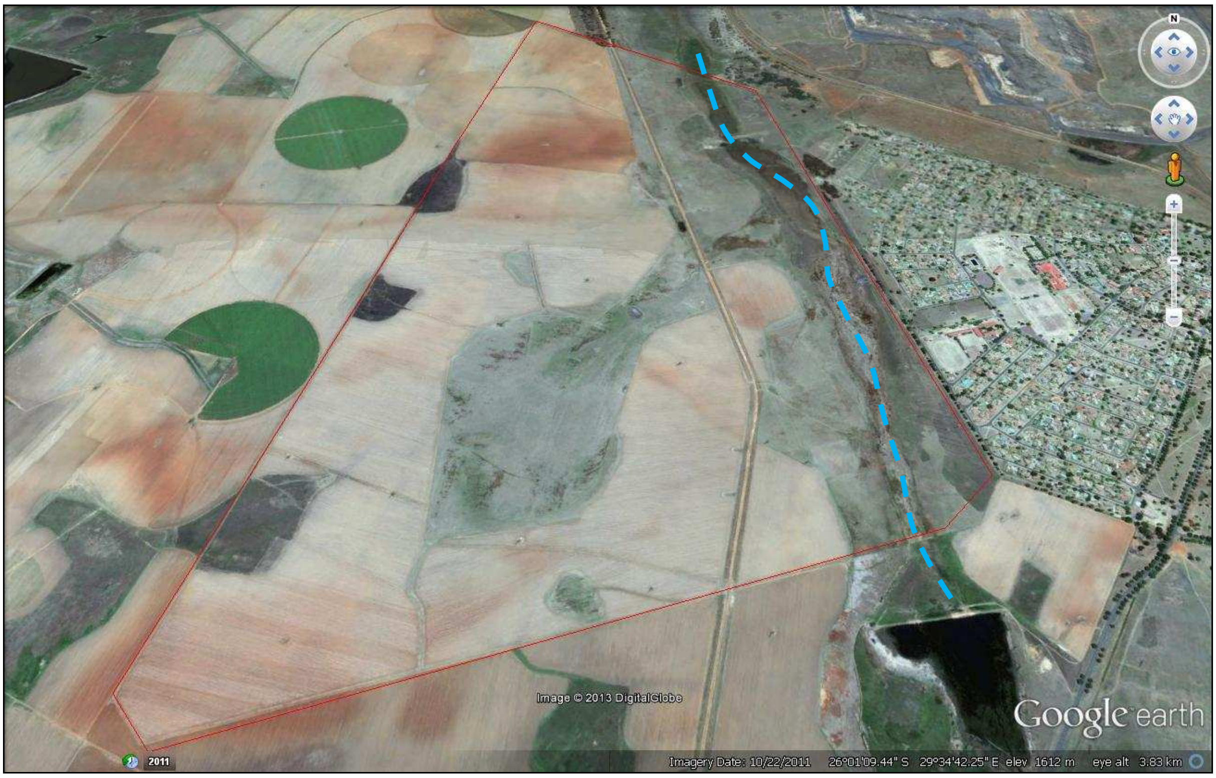
SECTION 1: INTRODUCTION

A floodline analysis was required to determine the position of the 1 in 50 and 1 in 100 year floodlines on an unnamed watercourse at the proposed KEBRA Roodepoort Colliery Mining Development near the town of Pullen's Hope (Hendrina Power Station) – situated on the farm Roodepoort 151 IS, district of Nkangala in the Mpumalanga Province. Refer to Google image below.

The coordinates of the proposed mining development site are approximate Latitude **26° 00' 59" S** and Longitude **29° 35' 09" E** (WGS84 Lo29).



According to the regulations on use of water for mining and related activities aimed at the protection of water resources (GN 704 in Government Gazette 20119 of 4 June 1999);

"No person in control of mine or activity may:

a) *Locate or place any residue deposit, dam reservoir, together with any associated structure or any other facility* ***within the 1:100 year floodline or within a horizontal distance of 100 meters from watercourse*** *or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor* *the pollution of groundwater, or on waterlogged ground, or on ground likely to become water-logged, undermined, unstable or cracked;*

b) Except in relation to a matter contemplated in regulation 10, carry on any underground or opencast mining, prospecting or any other operation or activity under or within 1:50 year floodline or within a horizontal distance of 100 meters from any watercourse or estuary, whichever is the greatest;

c) Place of dispose of any residue or substance which causes or is likely to cause pollution of a water resource, in the workings of any underground or opencast mine excavation, prospecting diggings, pit or any other excavation; or

d) Use any area or locate any sanitary convenience, fuel depots for any substance which causes or is likely to cause pollution of a water resource within the 1:50 year floodline of any watercourse or estuary."

The specific development area which was analyzed during this investigation will be affected by the flow of flood water in an unnamed tributary of the Woes-Alleenspruit passing through the property's eastern side. Refer to Google image attached.

For the floodlines delineation, an electronic 0,5m-interval contour layout DTM base map (as provided by Avon Engineers), was used to generate cross-sections as described later in the report.

The determination / analysis of the 1:50 and 1:100 year floodlines were carried out by PG Consulting Engineers in association with Avon Engineers and Project Managers.

SECTION 2: HYDROLOGY AND SUMMARY OF FLOW DIMENSIONS

a) Methods used for Calculations

Methods that were used to calculate the different run-off peaks with variance in return periods are summarised below (a deterministic method with four (4) different implementations were applied). Due to the relative small catchment size as well as the present development already within the catchment, it was decided to focus more on applying the rational method as it allows for more detailed input regarding the site specific catchment conditions. The empirical TR137 method was also applied for reference purpose as well to establish the RMF and PMF peaks for the total catchment.

a) Rational method – Implementation 1: DWA approach (REGFLOOD)

b) Rational method – Implementation 2: Based on an alternative approach by Prof. WJR Alexander ("Alexander" - 1990) REGFLOOD

c) Rational method - Implementation 3: Based on the regional DDF-equations representing the HRU 1/78 DDF-relationships ("Op ten Noort & Stephenson" - 1982)

d) Rational method - Implementation 4: Based on the DDF-tables of TR102 for an n-day storm depths in Southern Africa ("Adamson" -1981)

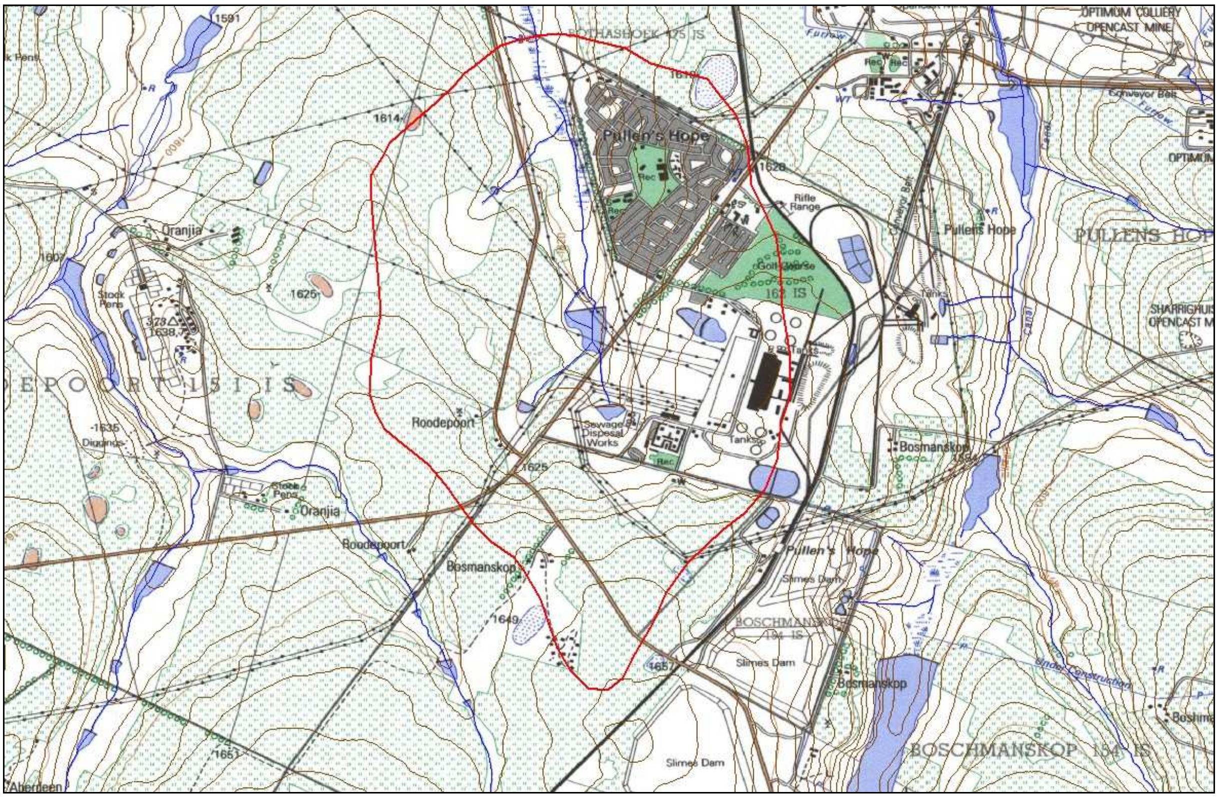
e) Empirical Method (TR137) – Regional maximum floods based on "Francou-Rodier" K-values ("Kovacs" - 1988) - Commonly used by DWA for catchments >10km²

b) Catchment Parameters

One global catchment was identified in the study area for the hydrology calculations in order to determine the expected 1:50 and 1:100 year flood peaks. Refer to topographical and ortho images included below). It was decided to use the tributary's exit point as reference for catchment delineation as well as hydrology all calculations which renders a rather conservative approach.

Homogeneous catchment characteristics were applied for calculation purposes as obtained from appropriate 1:50 000 topographical maps as well as the 1:10 000 ortho photos. The catchment characteristics are summarized below.

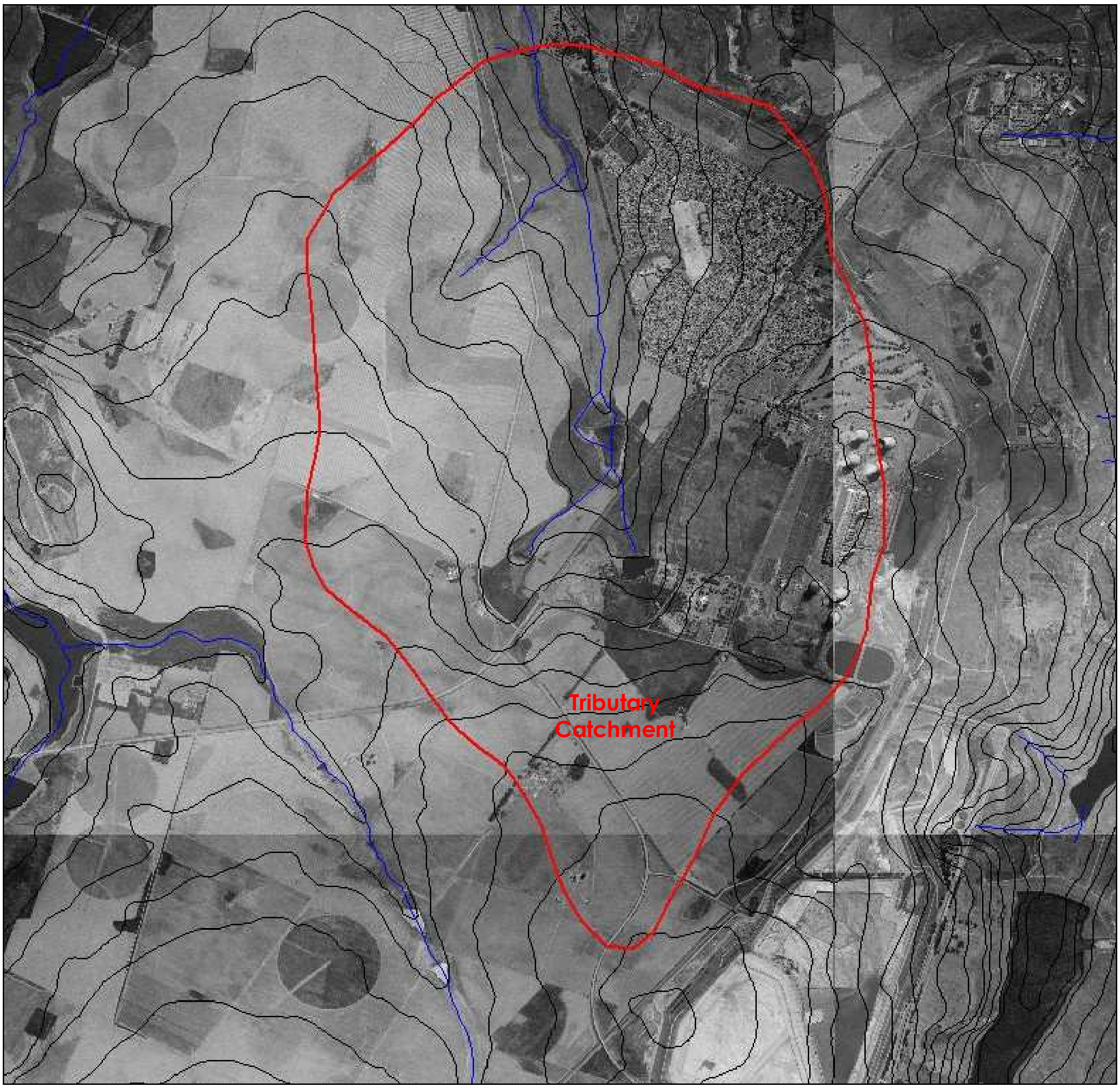
Specific sub-catchment is part of quaternary catchment **B12B** (Klein-Olifants River). Mean annual rainfall of site specific catchment based on GISap polygon grid data and nearest reliable rainfall station is given as **662mm**.



<u>**Catchment Characteristics**</u>

Catchment area (km²)	**13,915km²**
10/85 vertical difference of catchment (m)	**37,5m**

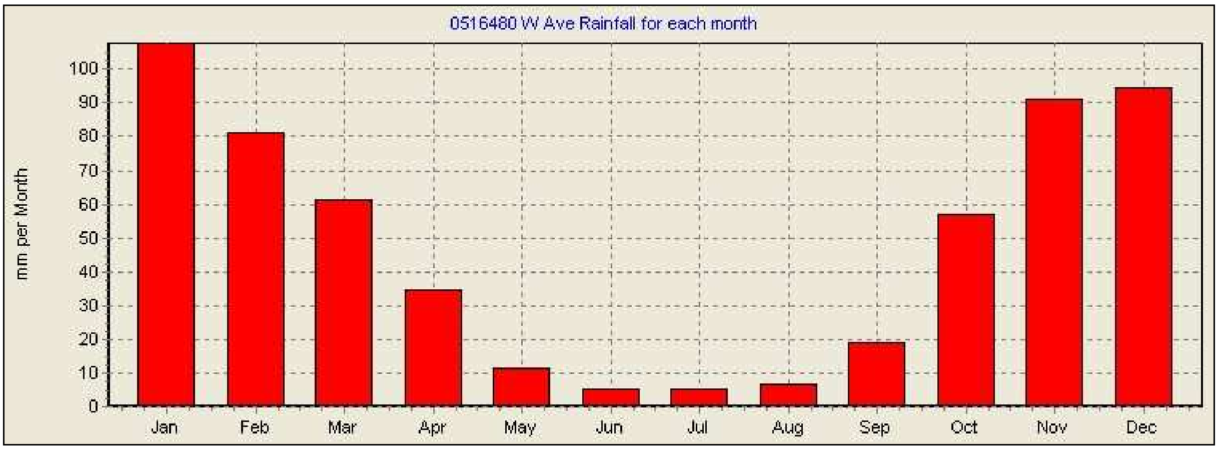
Flow length of longest watercourse (km)	**4 480m**
Average slope of catchment (10/85)	**0,84%**
Catchment urbanization percentage applied	**40%**
Catchment run-off coefficient (Q_{100})	**0,475**
Catchment run-off coefficient (Q_{50})	**0,558**
Time of concentration (Tc)	**1,33 hrs** **80 min**



Data from the following rainfall station was incorporated during the calculations.

Station name:	**SCHOONOORD**	Station number:	**516 480**
Latitude:	**26° 00'**	Longitude:	**29° 46"**
Mean annual rainfall:	**662mm**	Records:	**62 years**
Approximate distance from site:	**18km**		

Duration	Recurrence Interval (years)					
	5	10	20	50	100	200
	Rainfall P (mm)					
1 day	*74*	*88*	*104*	*126*	*144*	*164*
2 days	*96*	*117*	*140*	*172*	*200*	*230*
3 days	*109*	*132*	*157*	*194*	*224*	*258*
7 days	*136*	*163*	*192*	*232*	*265*	*301*



Data obtained from Hydrological Report TR 102 – Department of Water Affairs.

c) Summary of Hydrology

While applying the four (4) implementations of the Rational (deterministic) method, the hydrology calculations were furthermore based on present catchment development conditions (i.e. 40% urbanization was applied).

Some minor disparities were found between the four rational implementations applied (Refer to the table below). The main reason for this is that although all the implementations allow for detailed catchment parameters input, different depth-duration-frequency (DDF) approaches were applied at each.

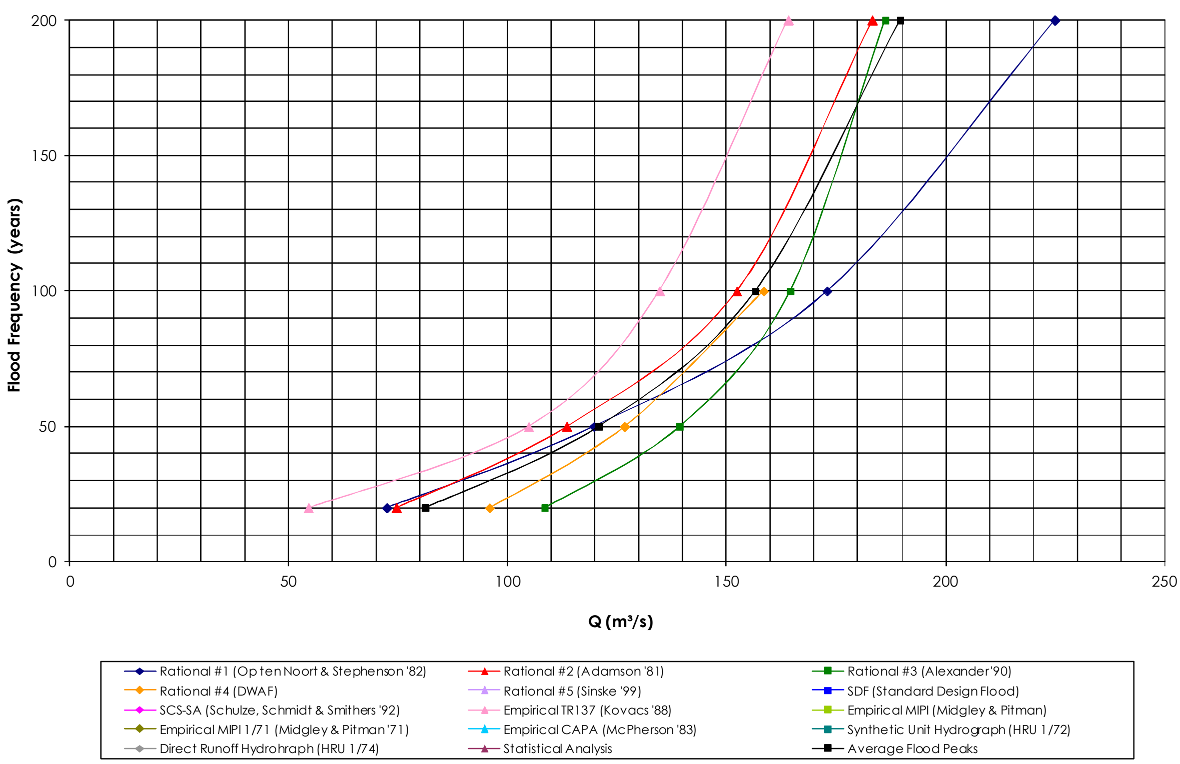
For the final calculations in order to obtain realistic 1:50 and 1:100 year flood peak values, it was decided to apply the averages of all calculated method and implementation results. This also allows for a rather conservative (safe) approach.

(Refer to graphs included with specific reference to the black lines).

Flood peaks derived			
Values in m³/s	Q_{50}	Q_{100}	Q_{200}
Rational – Implementation #1	126.6	158.4	-
Rational – Implementation #2	139.2	164.5	186.2
Rational – Implementation #3	119.6	172.9	224.9
Rational – Implementation #4	113.4	152.2	183.2
Empirical TR137 (K-region 4,6)	*104.7*	*134.6*	*164.0*
Average of all above	**120.7**	**156.5**	**189.6**

Regional maximum flood (RMF) – calculated for K_e - region 4,6: 272m³/s
Probable maximum flood (PMF) 1:10 000 years – $K_{e\ max}$ – region 5,6: 599m³/s

DERIVED FLOOD PEAKS WITH DIFFERENT INTERVALS



d) Recommended Flood Peaks for the Floodline Computations

<u>Stream flow section (RS100 – RS91)</u>
Q_{50} used for floodlines determination: **121m³/s**
Q_{100} used for floodlines determination: **157m³/s**

(See hydrology calculations, attached as Appendix A)

e) Floodlines Computations

For the computation of the different floodlines, the HEC-RAS (Version 3.1.3) computer analysis software was used.

Ten (10) major cross-sections were generated from the 0,5m-contour data provided. For the purpose of the floodlines determination, additional cross-sections were generated by interpolation. The sections after interpolation were approximately 50 meters apart.

f) Assumptions during Analysis

All the calculations were based on Manning's formula using the following average "n"-values for the different flow sections.

- Main channel flow (MC)- 0,040
- Left bank flow (LB)- omitted
- Right bank flow (RB)- omitted

The overbank flows were omitted in the analysis model as no significant differences were found between the flow conditions within the watercourse channel and the adjacent banks.

An "s" - value of 0,00581m/m as determined from the contours, was adopted for the specific tributary section analysed.

All the computations were based on "steady flow stage" conditions with a "mixed flow regime".

(See hydraulic calculations attached as Appendix A, and profile sections attached as Appendix B)

g) Results

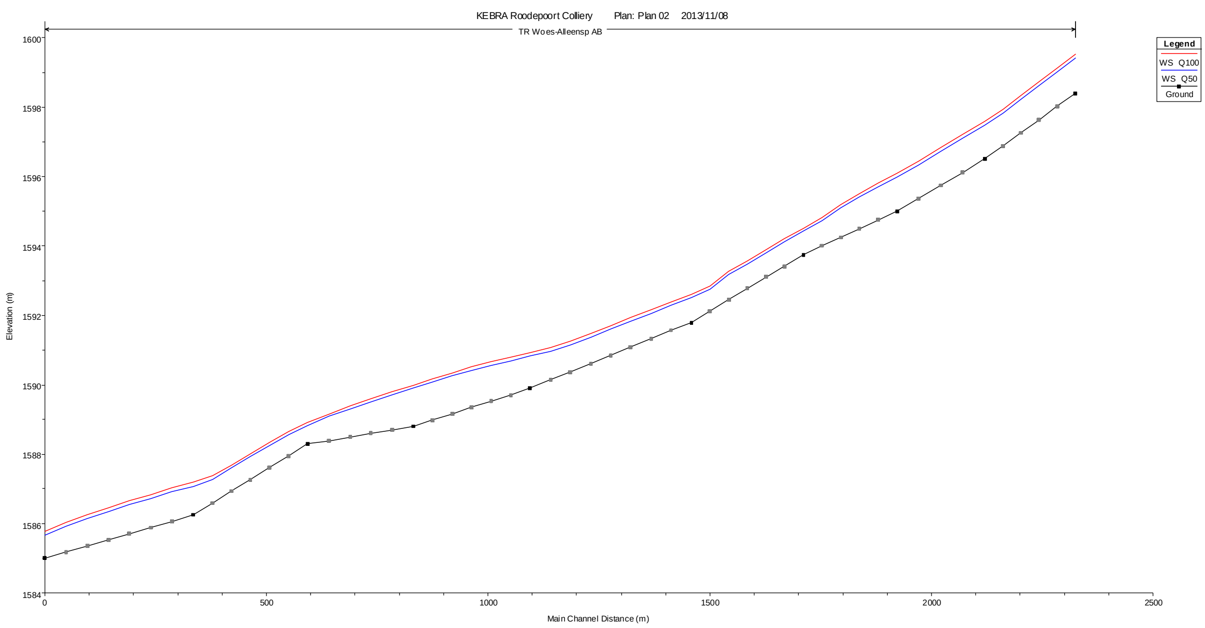
The following tables give a summary of the flow data of the expected flood peaks which were calculated for the specific stream flow section.

1:50 year flood – Tributary Section				
Cross-sections (see drawing)	Q_{50}-value (m^3/s)	Max. flow velocity (m/s)	Max. flow depth (m)	Section top width (m)
RS100	121	1.75	1.01 (1599.41)	116
RS99	121	1.57	0.98 (1597.48)	126
RS98	121	1.45	0.98 (1595.98)	140
RS97	121	1.28	0.67 (1594.42)	198
RS96	121	1.08	0.71 (1592.51)	226
RS95	121	0.87	0.92 (1590.82)	236
RS94	121	1.08	1.10 (1589.90)	197
RS93	121	1.01	0.54 (1588.84)	288
RS92	121	1.04	0.83 (1587.08)	196
RS91	121	1.29	0.68 (1585.68)	168

1:100 year flood – Tributary Section				
Cross-sections (see drawing)	Q_{100}-value (m^3/s)	Max. flow velocity (m/s)	Max. flow depth (m)	Section top width (m)
RS100	157	1.90	1.12 (1599.52)	122
RS99	157	1.71	1.10 (1597.60)	133
RS98	157	1.58	1.09 (1596.09)	147
RS97	157	1.39	0.76 (1594.51)	206
RS96	157	1.18	0.80 (1592.60)	230
RS95	157	0.94	1.04 (1590.94)	249
RS94	157	1.19	1.20 (1590.00)	204
RS93	157	1.11	0.61 (1588.91)	293
RS92	157	1.13	0.94 (1587.19)	205
RS91	157	1.42	0.78 (1585.78)	172

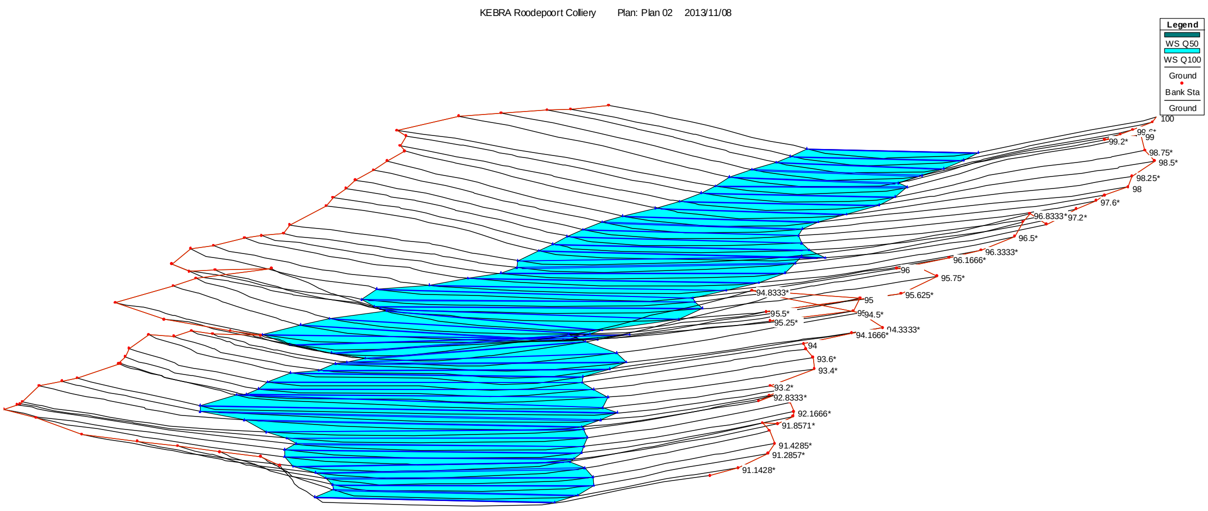
Note: Corresponding high flow actual contour levels indicated in brackets, in the above tables. Section top widths rounded-up to nearest meter. Refer to attached A3 layout drawing for positions of major cross-sections.

The following graph illustrates the expected water levels to be generated by the two different flood peaks on the stream flow sections analysed.



Graph below illustrates the expected variances in the flow velocities of the stream flow section during the 1:50 and 1:100 year recurrence intervals.

Following is 3D schematic illustration of the high water levels, during the expected 1:100 year flood peak (from RS100 up to RS91).



(See hydraulic calculations attached as Appendix A, and cross-sections attached as Appendix B)

h) XY Co-ordinates of the 1:100 Year Floodlines for reference (WGS84) Lo29°

The following tables give the exact XY co-ordinates of the 1:100 year floodlines as determined, for both the left and right banks of the applicable tributary section analyzed, at each of the major cross-sections (refer to attached drawings). These co-ordinates can be utilized by a professional surveyor to set out the different floodlines. The 1:50 year floodline co-ordinates can be provided on request.

1:100 Year Floodline – Tributary Section					
Left bank			Right bank		
Cross-section	X	Y	Cross-section	X	Y
RS100	2 879 606	-58 636	RS100	2 879 589	-58 757
RS99	2 879 404	-58 616	RS99	2 879 384	-58 750
RS98	2 879 191	-58 599	RS98	2 879 199	-58 749
RS97	2 878 973	-58 526	RS97	2 878 988	-58 734
RS96	2 878 754	-58 531	RS96	2 878 736	-58 763
RS95	2 878 490	-58 473	RS95	2 878 380	-58 698
RS94	2 878 225	-58 422	RS94	2 878 196	-58 624
RS93	2 878 013	-58 319	RS93	2 877 948	-58 606
RS92	2 877 772	-58 256	RS92	2 877 717	-58 456
RS91	2 877 440	-58 150	RS91	2 877 418	-58 327

SECTION 3: CONCLUSIONS

- For the analysis of the 1:50 and 1:100 year floodlines, cross-sections were generated from an electronic 0,5m-interval contour DTM layout provided by Avon Engineers (Pty) Ltd. All other relevant information was obtained by utilizing the appropriate topographical maps and ortho photos applicable, as well as hydrological data acquired from GISap.

- With reference to GN 704, applicable to mining activities, it was also deemed necessary to include the delineation of the required 100m buffer zone as specified, specifically on the western side. The analysis had revealed that the above buffer zone was found to be of more or less similar extent than the 1:100 year flood zone.

- The 50 and 100 year floodlines derived from the analysis, as well as the standard 100m zone boundaries are indicated on attached (A3) drawings PB-13-292-FL01 and PB-13-292-FL02, Appendix C. An electronic dwg file with the floodline layer will be e-mailed.

- With reference to Appendix B (cross sections) it clearly indicates that there are very little difference between the top widths of the expected 1:50 and 1:100 years floodlines. As a result of this the position of the floodlines indicated on the attached drawings are very similar.

- It is important to note that any foreign / manmade obstacles (i.e. access walkways etc) in the watercourse may also result in the alteration of the specified floodline.
- It is hereby **certified** that the floodlines indicated on the attached contour layout drawings, represent the maximum flood levels likely to be reached on an average every 50 and 100 years respectively, by floodwater in the specific watercourse analyzed (Certificate attached as Appendix D).

SECTION 4: LIST OF APPENDICES

Appendix A:	Hydrology / hydraulic calculations spreadsheets
Appendix B:	Cross-sections with 1:50 & 1:100 years flow depths indicated with blue and red lines, as well as computation printouts
Appendix C:	Layout drawing indicating floodlines (x2)
Appendix D:	Floodline certificate

SECTION 5: REFERENCES

a) Adamson PT (1981)
Southern African storm rainfall, Report TR102, Department of Environmental Affairs

b) Alexander WJR (1990)
Flood hydrology for Southern Africa, SANCOLD

c) HRU (1972)
Design flood determination in South Africa, HRU Report 1/72, Wits University

d) Kovacs Z (1988)
Regional maximum flood peaks in Southern Africa, Z Kovacs, Technical Report TR137, Department of Water Affairs and Forestry

e) Midgley DC & Pitman WV (1978)
A depth-duration-frequency diagram for point rainfall in Southern Africa, HRU Report 1/78, Wits University

f) Op ten Noort & Stephenson (1982)
Regional DDF-equations representing the HRU 1/78 DDF-relationships

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