SIYANQOBA TOWNSHIP: FLOODLINE REPORT

PROPOSED DEVELOPMENT OF SIYANQOBA TOWNSHIP: FLOODLINE ANALYSIS REPORT IN WITBANK

JANUARY 2014

Rev. 00

SUBMITTED TO	SUBMITTED BY
The Technical Director Vipcon (PTY) LTD P O Box 74162 Lynnwood Ridge 0040 Tel: +27 12 807 5153 Fax: +27 86 212 5535 Contact Person: Mr. S Pohl Email: strat@vipcon.co.za	The Engineer Monde Consulting Engineers 27 Hendrik Potgieter Street Nelspruit PO Box 6838 Nelspruit 1200 Tel: +27 31 752 4616 Fax: +27 31 752 6166 Contact Person: Mr MP Kangudi kangudi@mondeconsulting.co.za

TABLE OF CONTENTS

1. INTRODUCTION

This floodline delineation has been prepared in response to a request from Mr S Roets of Terraplan Gauteng cc to determine the 1:50 and 1:100 year floodlines for **Blosbokspruit** tributary located in B11K quaternary catchment for the Siyanqoba layout development within Leeuwpoort cadastral map (Figure 1). Flood frequency analysis is frequently adopted in design flow estimation for catchments where recorded streamflow data of reasonable length are available and a variety of statistical methods are available. It is important to note that the contours provided did not cover the whole project layout and the area marked '**portion requiring additional survey'** in Figure 1 was not included in the assessment.

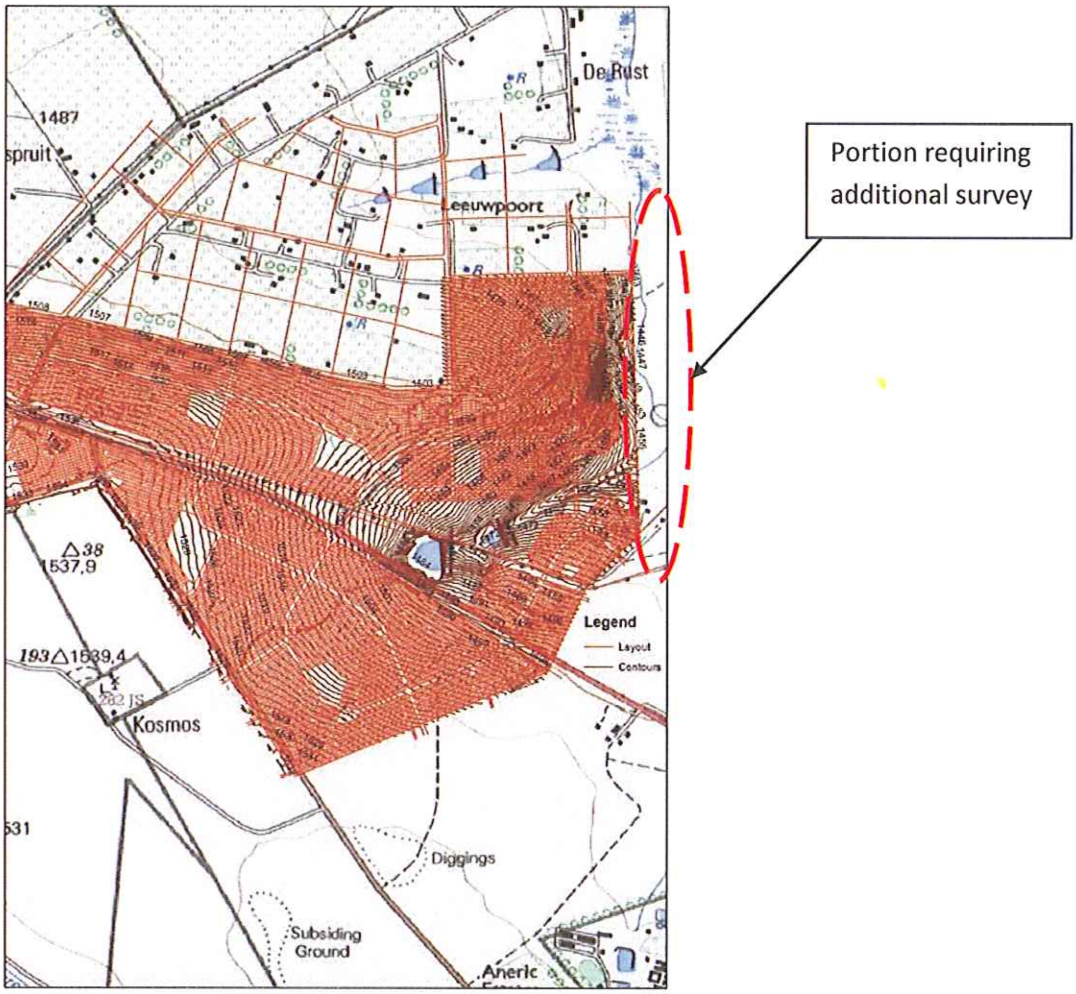


Figure 1: Locality map of Siyanqoba layout within Leeuwpoort cadastral map

2. METHODOLOGY

The procedure involved the following:

- The catchment area of the **Blosbokspruit** tributary was estimated to be $5km^2$;
- A flood peak analysis was undertaken to determine the 50 year and 100 year recurrence interval flood peaks for the **Blosbokspruit** tributary using flood anlaysis tools in Utility drainage software);
- The flood peaks and the cross-sections derived from 10m contours of the study area (Appendix A) were used as inputs to the HEC-RAS backwater programme to determine the surface water elevations for the 1: 50 and 1: 100 year floods peaks; and
- The floodlines were plotted on 1:50 000 map.

Limitations and assumptions

- The catchment is ungauged and the national database (WR90 flows) for B11K was scaled to the point where the tributary meets main river and this is the only section where cross section data was available. There were no cross-sections for the main **Blosbokspruit river,** on the right side of the property development limiting the flood line determination to the tributary.
- Manning's *n* coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Chow et al., 1988).

3. FLOOD CALCULATION

A suit of flood analyses methods are available from the utility drainage software (http://www.sinotechcc.co.za/). However not all of the methods are applicable and therefore a suitable approach was chosen. Alexander (2002) developed a 'Standard Design Flood' (SDF) method, which is in effect a calibrated Rational Method or probabilistic-based approach to the application of the Rational Method, which is widely used for catchments greater than $15km^2$. However, independent studies have shown that the method results in very conservative design flood. Thus, other methods to estimate design floods must be used in conjunction with the Standard Design Flood methodology to ensure the results from the SDF method are reasonable. For catchments smaller than $15km^2$, the rational method and alternative rational method has been widely used world wide. Another approach to flood design estimation is the unit hydrograph which is detailed in most hydrology texts (e.g. Chow et al., 1988). The method assumes a characteristic linear response from a catchment and hence may not be accurate for estimating large floods. However, careful use can provide good flood estimates. A limitation of a unit hydrograph approach is the assumption of spatial uniformity of rainfall (Chow et al., 1988). An advantage of the method is the estimation of the entire hydrograph, which is important where storage within a catchment has a significant impact on floods. Given this background and that the catchment is 5.8km^2 and has two dam storages the unit hydrograph, the rational and the alternative rational methods were used. The results from the three methods are very similar and the design values of the rational method were selected for further analysis into hydraulic modelling for it has 100.8m^3/s flood for the 1:100.

The following characteristics were used in flood calculations:

Catchment characteristics:

Area of sub-catchment	= 5.8 km^2
Length of longest watercourse	= 1688m
Distance to catchment centroid	= 1901m
10-85 height difference (E10=1460m;E85=1485m)	= 25m
Average catchment slope	= 0.03m/m
Main channel slope (1485m-1460m)/(0.75*1688m)	= 0.0197
Sub-catchment Mean Annual Precipitation	=686mm

Table 1 shows the rainfall intensities for the site and Table 2 shows the flood calculations

Table 1: Rainfall Intensities (mm/hr)

Recurrence interval	Rational	Alternative Rational	Unit Hydrograph
50 years	147.4	151.6	89.9
100years	180.4	174.6	110.7

Table 2: Flood peaks (m^3/s)

Recurrence interval	Rational	Alternative Rational	Unit Hydrograph
50 years	75.8	77.8	72.6
100years	100.8	97.6	100.3

4. FLOODLINE MODELLING

4.1 HEC RAS model set up

Cross sectional data was obtained from 1m contour interval map for the **Blosbokspruit** tributary from the headwaters to approximately 100m before its junction with the main river (Appendix A). The flood assessment could not be extended beyond the mentioned boundaries due to absence of contours for the rest of the river network in this catchment. A schematic geometry of the assessed reach showing location of 12 cross sections separated with a maximum of 100m and two storage reservoirs used in the flood analysis is presented in Figure 2.

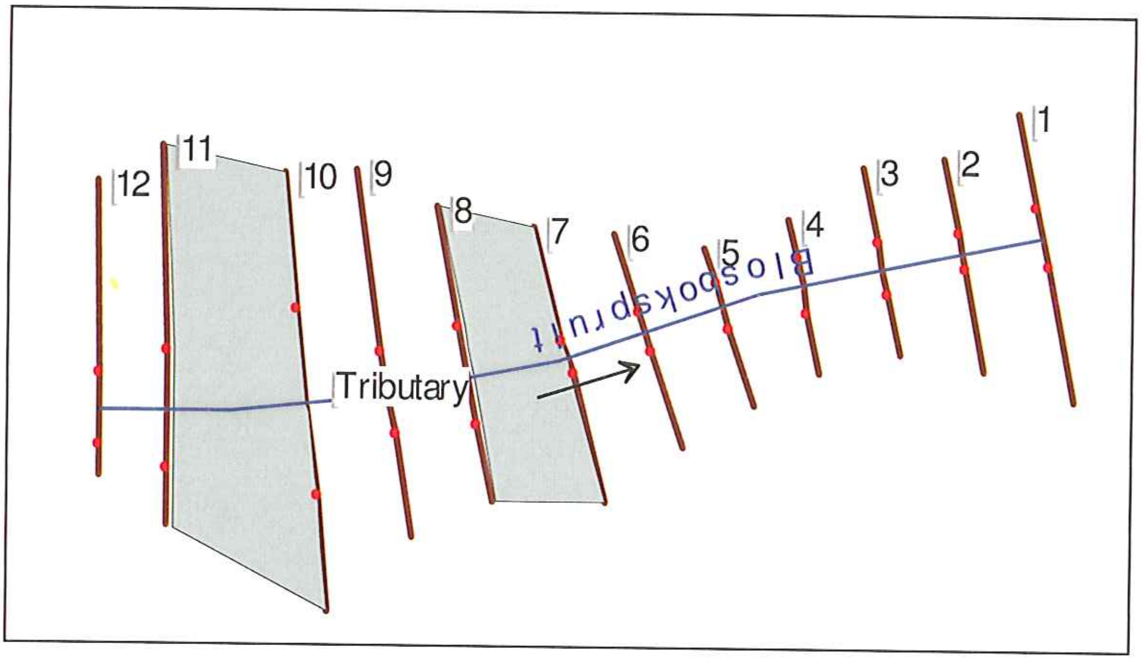
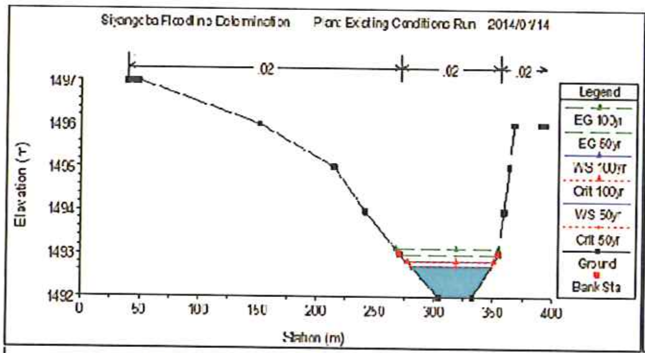
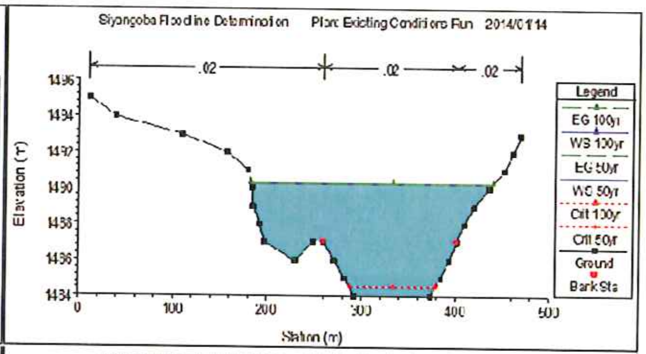
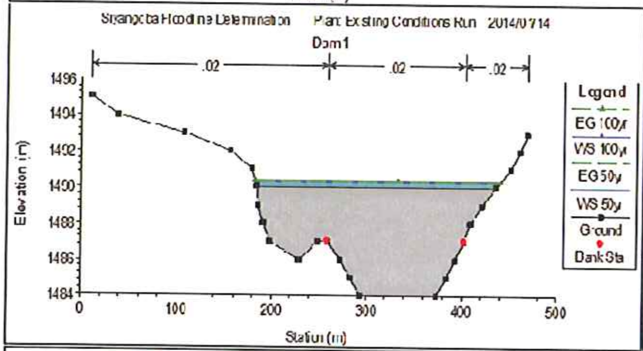


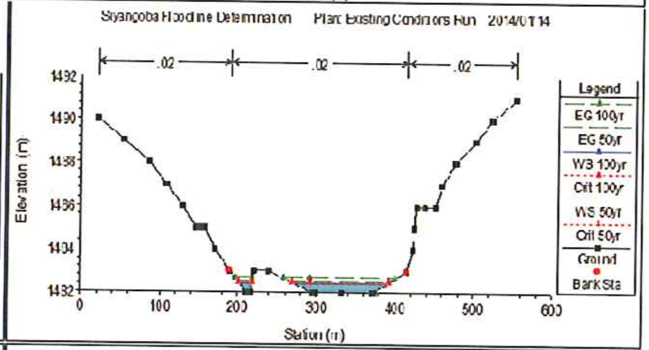
Figure 2: Schematic map of position of cross-sections and storage reservoirs in HECRAS model

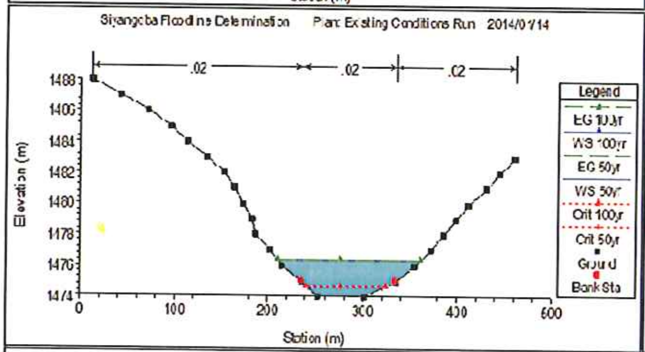
The cross sections constructed in HEC-RAS model for this river reach are presented in Figure 3. Manning's roughness coefficients were estimated at 0.02 both for the natural channel and the floodplain which is a typical wetland with very short grass. Figure 4 shows the longitudinal profiles surface water elevations.

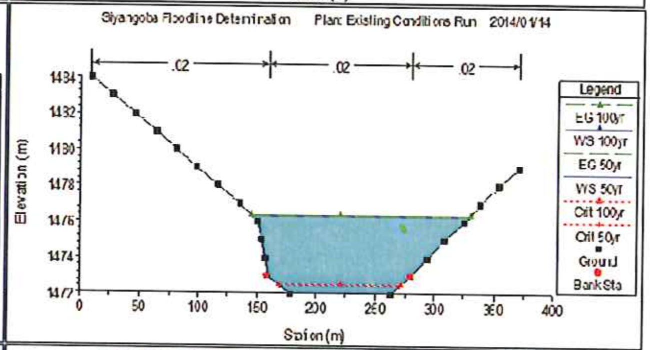

Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
EG 50yr
WS 100yr
Crit 100yr
WS 50yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)

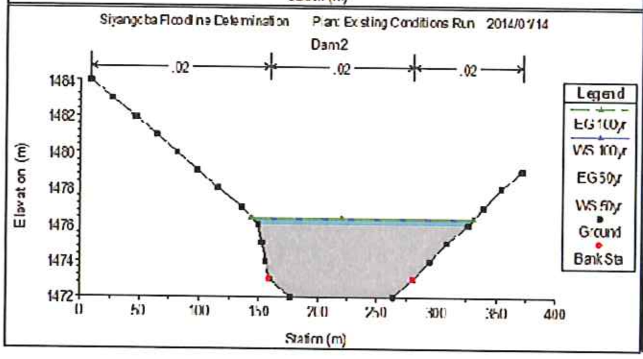

Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
WS 100yr
EG 50yr
WS 50yr
Crit 100yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)

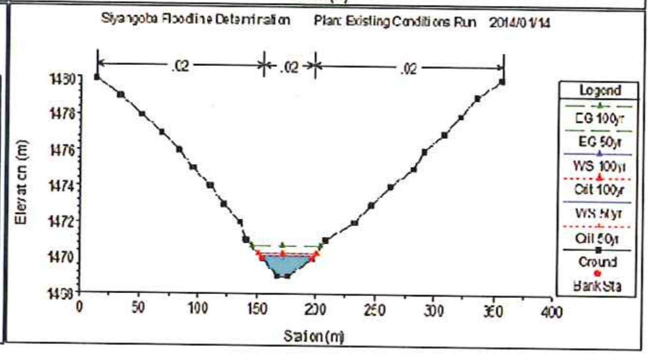

Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
Dam1
.02 .02 .02
Legend
EG 100yr
WS 100yr
EG 50yr
WS 50yr
Ground
Bank Sta
Elevation (m)
Station (m)


Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
EG 50yr
WS 100yr
Crit 100yr
WS 50yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)


Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
WS 100yr
EG 50yr
WS 50yr
Crit 100yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)


Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
WS 100yr
EG 50yr
WS 50yr
Crit 100yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)


Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
Dam2
.02 .02 .02
Legend
EG 100yr
WS 100yr
EG 50yr
WS 50yr
Ground
Bank Sta
Elevation (m)
Station (m)


Siyangoba Floodline Delemination Plan: Existing Conditions Run 2014/01/14
.02 .02 .02
Legend
EG 100yr
EG 50yr
WS 100yr
Crit 100yr
WS 50yr
Crit 50yr
Ground
Bank Sta
Elevation (m)
Station (m)

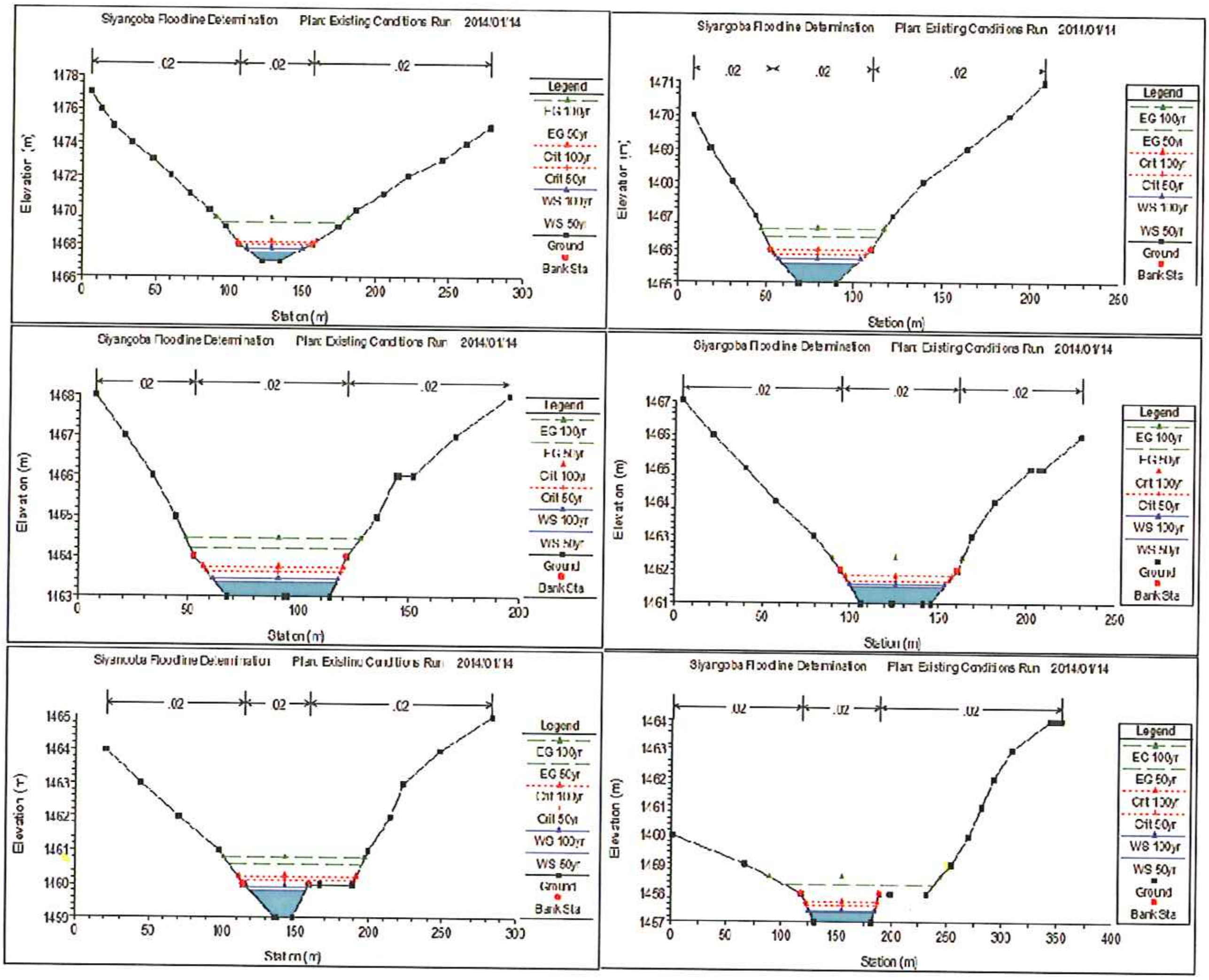


Figure 3: Cross sections along the Blosbokspruit tributary

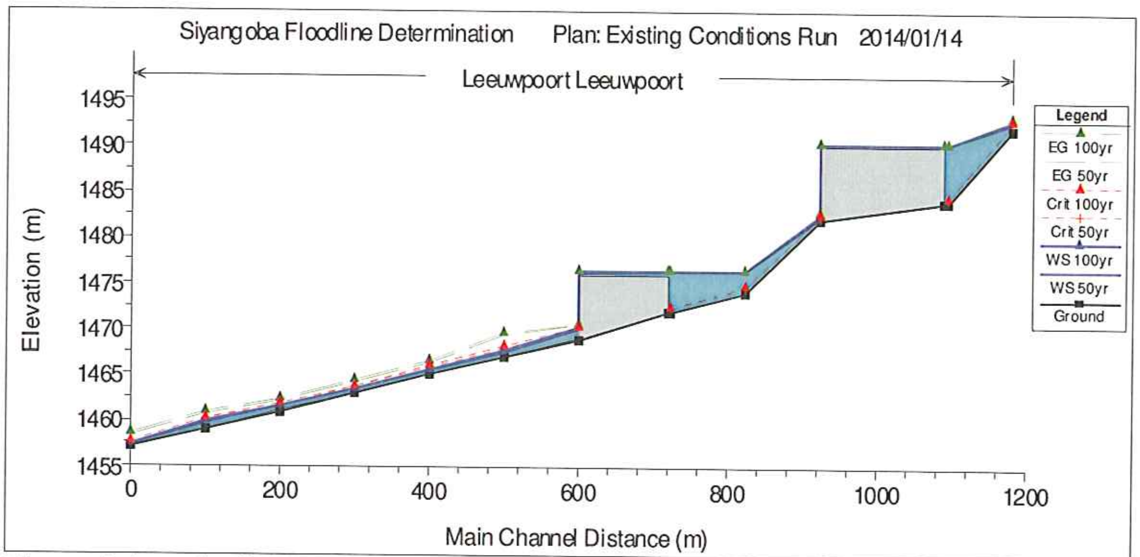
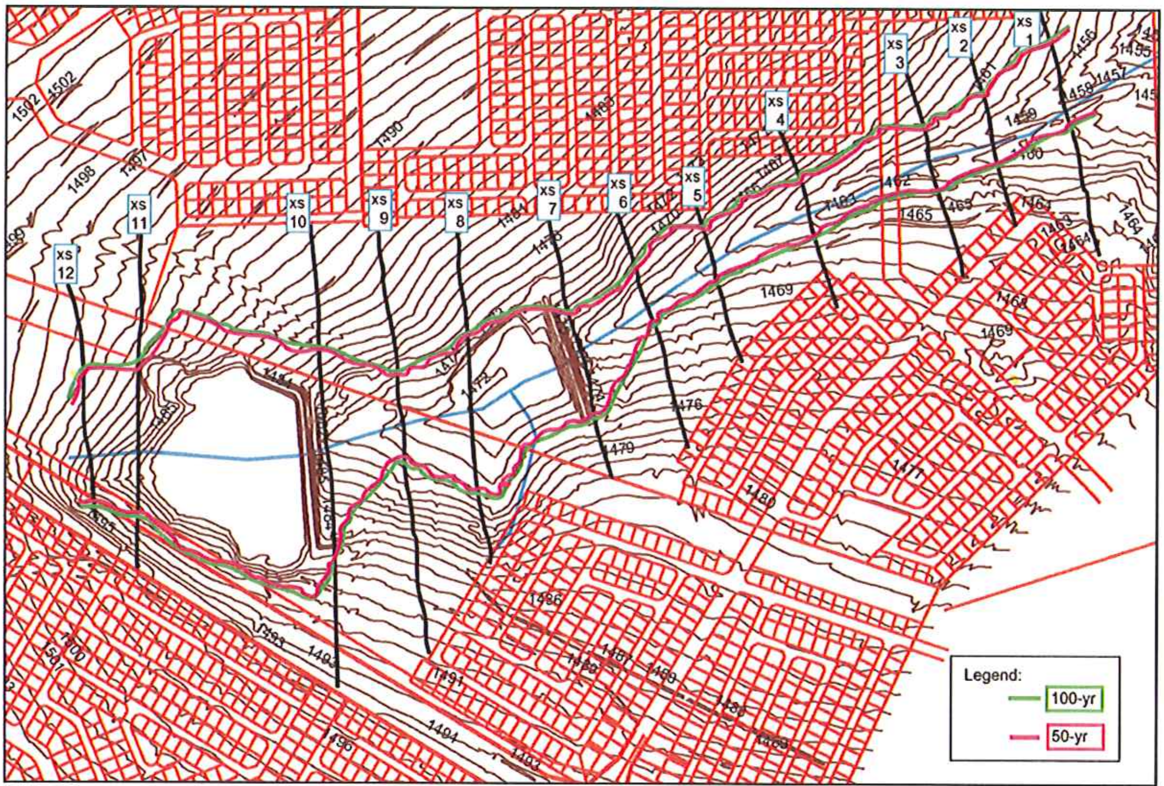


Figure 4: Longitudinal water surface elevations for 1:50-year and 1:100-year profiles of the tributary of Blosbokspruit River

4.2 Floodline determination

The floodlines were calculated using US Army Corp of Engineers HEC-RAS model. A schematic map plot to show determined lateral extents of floodlines for the 1:50-year and 1:100-year return periods is shown on a map with 1m contours in Figure 5. However, detailed output in Table 3, where it shows the 1:50-year floodline has a total head of 1492.96 mamsl while the 1:100-year floodline has an elevation of 1493.12 mamsl. The 1:50- and 1:100-year flood levels, velocities and flood widths are also presented in Table 3 for the different river stations (chainages) from the HEC-RAS output.



NB: Not to scale

Figure 5: Schematic map of floodlines for two profiles (1:50-year and 1:100-year) of the tributary of Blosbokspruit River

Table 3: HEC-RAS output summary of the tributary of Blosbokspruit River

River: BLOSBOKSPRUIT												
Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
Tributary	12	50yr	75.8	1492	1492.71	1492.71	1492.96	0.00499	2.23	33.93	67.38	1.01
Tributary	12	100yr	100.8	1492	1492.83	1492.83	1493.12	0.00484	2.39	42.12	73.77	1.01
Tributary	11	50yr	75.8	1484	1490.24	1484.44	1490.25	0	0.08	1104.51	257.13	0.01
Tributary	11	100yr	100.8	1484	1490.29	1484.53	1490.3	0	0.1	1117.39	258.14	0.01
Tributary	10.5		Inl Struct									
Tributary	10	50yr	75.8	1482	1482.39	1482.39	1482.56	0.00583	1.79	42.31	131.52	1.01
Tributary	10	100yr	100.8	1482	1482.47	1482.47	1482.66	0.00553	1.93	52.34	140.39	1.01
Tributary	9	50yr	75.8	1474	1476.3	1474.56	1476.31	1.8E-05	0.34	239.15	150.03	0.08
Tributary	9	100yr	100.8	1474	1476.36	1474.66	1476.37	2.9E-05	0.44	248.3	151.87	0.1
Tributary	8	50yr	75.8	1472	1476.31	1472.42	1476.31	1E-06	0.14	600.53	184.25	0.02
Tributary	8	100yr	100.8	1472	1476.37	1472.5	1476.37	2E-06	0.18	612.07	185.95	0.03
Tributary	7.5		Inl Struct									
Tributary	7	50yr	75.8	1469	1470.09	1470.09	1470.43	0.00442	2.57	29.59	45.43	0.99
Tributary	7	100yr	100.8	1469	1470.24	1470.24	1470.64	0.00407	2.81	36.41	48.77	0.99
Tributary	6	50yr	75.8	1467	1467.58	1467.99	1469.26	0.04688	5.75	13.19	34.07	2.95
Tributary	6	100yr	100.8	1467	1467.68	1468.13	1469.54	0.04362	6.04	16.68	37.84	2.91
Tributary	5	50yr	75.8	1465	1465.61	1465.85	1466.36	0.01673	3.83	19.78	43.35	1.81
Tributary	5	100yr	100.8	1465	1465.7	1465.99	1466.62	0.01766	4.24	23.76	46.51	1.9
Tributary	4	50yr	75.8	1463	1463.37	1463.61	1464.21	0.02827	4.07	18.61	55.11	2.24
Tributary	4	100yr	100.8	1463	1463.44	1463.73	1464.45	0.02701	4.45	22.64	56.73	2.25
Tributary	3	50yr	75.8	1461	1461.48	1461.67	1462.09	0.01555	3.48	21.77	52.13	1.72
Tributary	3	100yr	100.8	1461	1461.55	1461.79	1462.32	0.01614	3.88	25.95	54.2	1.79
Tributary	2	50yr	75.8	1459	1459.79	1460.09	1460.57	0.01467	3.9	19.42	37.46	1.73
Tributary	2	100yr	100.8	1459	1459.91	1460.22	1460.8	0.01425	4.17	24.19	41.41	1.74
Tributary	1	50yr	75.8	1457	1457.31	1457.58	1458.29	0.03894	4.39	17.27	58.15	2.57
Tributary	1	100yr	100.8	1457	1457.37	1457.69	1458.57	0.03804	4.85	20.79	59.25	2.61

5. CONCLUSIONS AND RECOMMENDATIONS

From the available map and modelled water surface elevations respective floodlines for 1:50-year and 1:100-year events are estimated at 1492.71 and 1492.83 mamsl, at the stream segment upstream of dam. Energy gradelines that provide an indication of total head for similar flood events on this segment stand at 1492.96 and 1493.12 mamsl. At the afore-mentioned location, flood levels for the two profiles do not encroach into existing developments as indicated by contours on the provided topographical map. Downstream of the two storage dams, floodlines are observed to be very close to infrastructure, though no encroachment is occurring. This occurs at the mid-segment of the tributary where flood levels range between 1460.57 to 1464.45 mamsl for both the 1 in 50-yr and 1 in 100-yr events. Flood attenuation by upstream storage dams and the wetland is visibly demonstrated by lowering flood peaks in the downstream direction. It is recommended that all infrastructure and construction related activities remain outside of the maximum stipulated flood levels. The recommended design event is 1:100-year and design heights for the upstream, middle and downstream segments are determined to be 1493.12, 1469.5 and 1458.57 mamsl to avoid structure inundation. The floodline for the main river just outside of property on the right side of map in Appendix A, marked was not determined as there were no contour lines. In order to understand that section of the river and if will be any structural developments, then further investigation will be required for the section. It is recommended a survey be conducted for that area to enable flood line determination for the main river outside property development.

6. REFERENCES

ALEXANDER WJR (2002a) The Standard Design Flood. *J. S. Afr. Inst. Civ. Eng.* **44** (1) 26–31.

CHOW VT, MAIDMENT DR and MAYS LR (1988) *Applied Hydrology.* McGraw-Hill, New York, USA.

APPENDIX A: A 1:50000 topographical map of Siyangoba catchment showing 1m contours and position of cross sections