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1 in 100 Year Flood line Assessment Report

1 in 100 Year Floodline Determination for the Proposed BCR Projects (Pty) Ltd Prospecting Rights
On Zwartfontein 814 Farm and Moordkopje 813 Farm
Magalakwena Local Municipality, Waterberg District, Limpopo Province

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EXECUTIVE SUMMARY

BCR Projects (Pty) Ltd is currently in the process of applying for a non-invasive prospecting right to minerals in the platinum group metals. The proposed site is located on farm Zwartfontein 814 and farm Moordkopje 813.

The National Screening Tool, as required by the National Environmental Management Act (NEMA, Act no.107 of 1998) 2014 Environmental Impact Assessment regulations (2014 EIA Regulations, GNR 982 GG 38282 dated 4 December 2014, as amended), identified the requirement for a Hydrological Assessment. In terms of the National Water Act No. 36 of 1998 and GN 704 Government Gazette 20119 dated 4 June 1999 it was interpreted that the 1 in 100 year floodline would be the most pertinent study to undertake at this stage of the development. The main purpose of this study is to determine, from the information at a desktop level, the sensitivity of the site and based on this information, the potential impacts and make a recommendations to reduce the potential on site risks.

From the desktop study undertaken, based on the information available and the legislative context (outlined in more detail in Section 2), the sensitivity of this area to the proposed mine and the associated support infrastructure has been identified as high (Section 10). However, the impacts of the non-invasive activities proposed for the site have been identified as low.

From the desktop assessment, to further decrease the impacts of the proposed non-invasive prospecting activities that may be undertaken during the prospecting phase recommendations risk have been made (section 11). It should be noted that this assessment has been undertaken with the knowledge that no construction of infrastructure, or mining activities, will take place at this stage. The plan of study for the desktop assessment was as follows:

- Undertake a 1 in 100 year floodline which will determine the possible extent of the 1 in 100 year flood, thereby facilitating the appropriate planning for the prospecting phase to ensure that no infrastructure or activities are located in this high risk area.

From the result of this study it was determined that the sensitivity of the area would classified as high if activities were to occur within 100m of the 1 in 100 year floodline determination (Section 10). However, as indicated above the activities are low impact and will have negligible effect on the sensitivity of the system take place outside the 100m buffer.

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1. INTRODUCTION

Non-invasive prospecting activities for platinum group metals has been proposed on the Remainder of Moodrkoppies No. 813 and Zwartfontein No. 814 in Limpopo. The site is adjacent to Anglo American Platinum – Mogalakwena mine.

BCR Projects (PTY) LTD wishes to apply for prospecting rights in terms of Section 16 of the Mineral and Petroleum Resources and Development Act (28 of 2002) as amended by the Mineral and Petroleum Resources Development Amendment Act (49 of 2008). Through application process and submission in line with the requirements, a flood assessment is required. The proposed development is located on the following farm portions:

Ptn	Farm No.	Farm Name	Latitude	Longitude	Area (m^2)	SG Code	Deed
Rem	813	Moordkopje	-23.989243	28.864044	2 067	T0LR00000000081300000	T1149/1885
Rem	814	Zwartfontein	-23.953964	28.843247	2 007	T0LR00000000081400000	BC32687/1999PTA

The key requirements for this study are as follows:
1. Desktop hydrological assessment.
2. Catchment analysis.
3. Design flood investigation.
4. Reporting (report & maps in pdf format).

The layout of the site in relation to the adjacent mining area can be seen in Figure 1 with current activities on the in Figure 2.

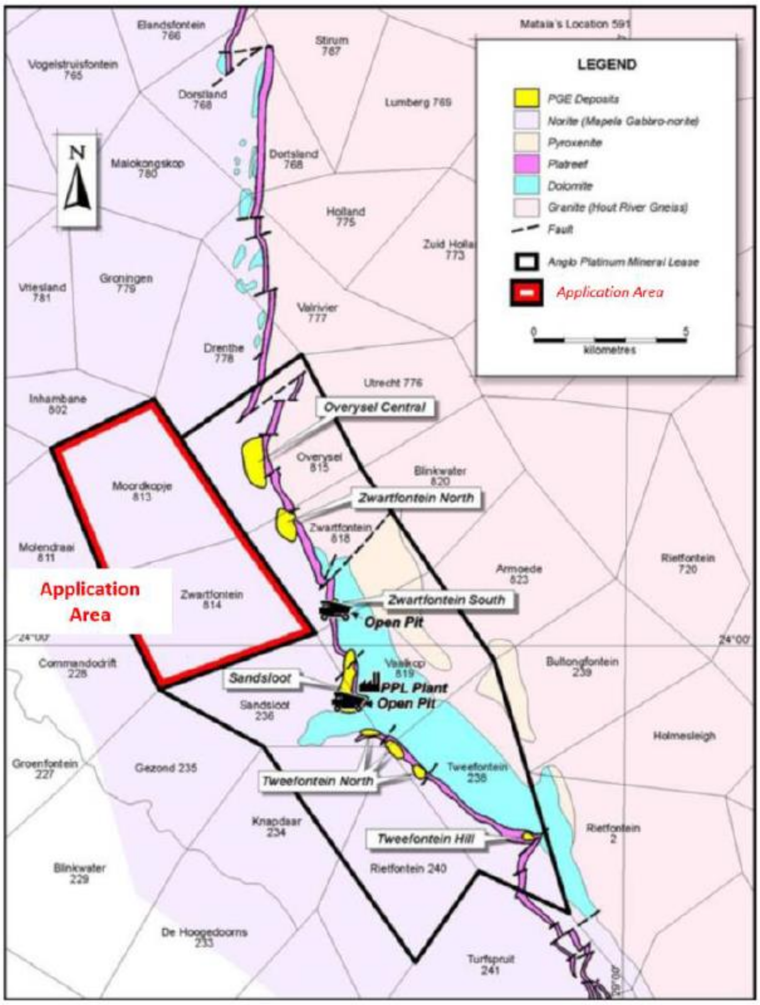

Figure 1. Location of proposed prospecting site

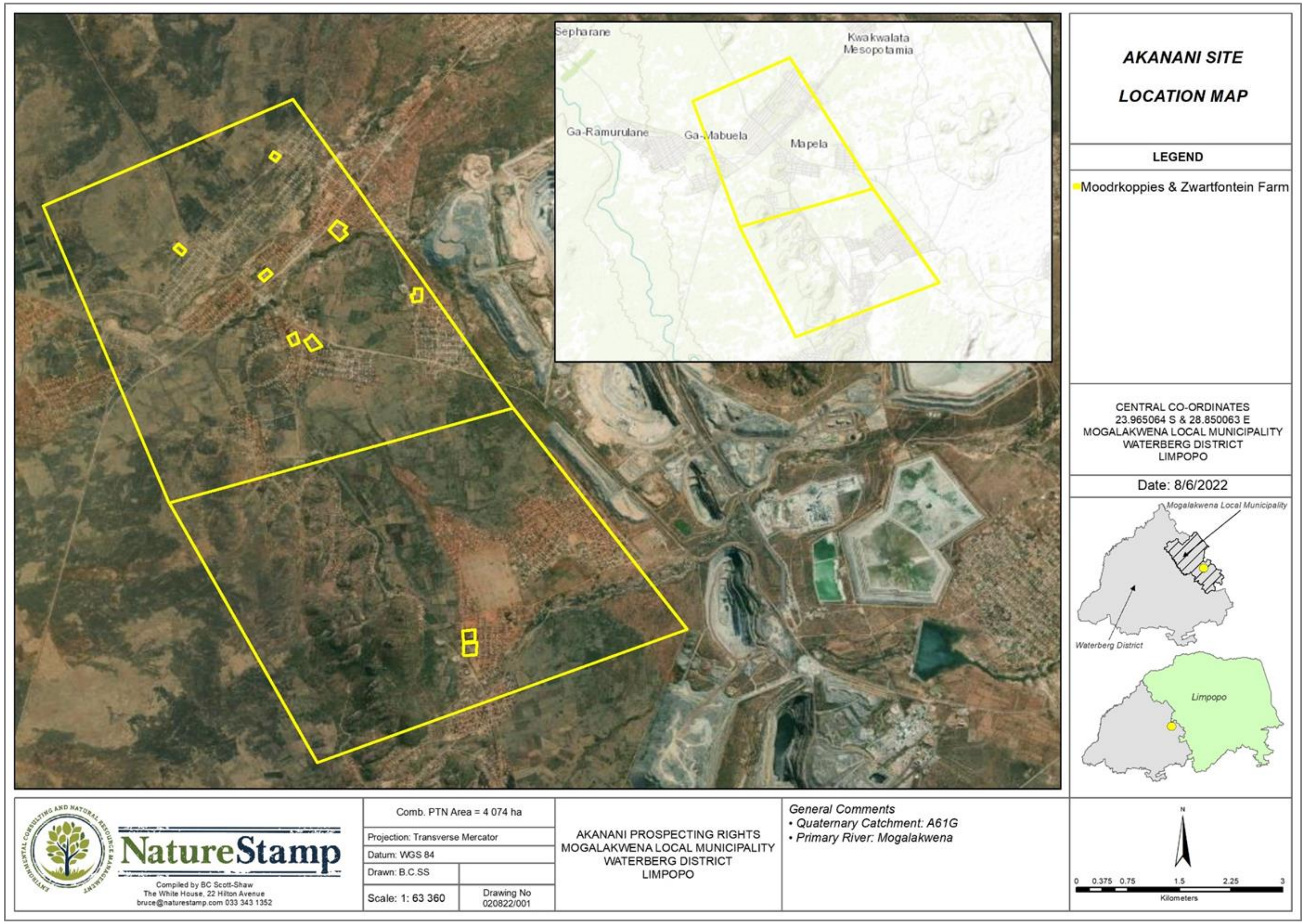

Figure 2. Locality map of the proposed site

2. LEGISLATIVE CONTEXT

As a result of the Screening Report generated by the National Screening Tool, as required by the National Environmental Management Act (NEMA, Act no.107 of 1998) 2014 Environmental Impact Assessment regulations (2014 EIA Regulations, GNR 982 GG 38282 dated 4 December 2014, as amended), the requirement for a Hydrological Assessment has been identified. The Screening Report at the time did not specify predetermined sensitivities relating to the hydrological environment associated with the proposed prospecting right application.

No specific assessment protocol has been prescribed for the Hydrological theme, therefore GN 320 (GG 43110 dated 20 March 2020) applies to this report and the main outcome and purpose is to confirm the current use of land and the environmental sensitivity of the site and inform the required Site Sensitivity Verification Report (SSVR).

In addition, the general protocols require that in the case where no set protocols for a theme has been determined, the specialist assessment must be conducted in line with Appendix 6 of the NEMA 2014 EIA Regulations.

In terms of the National Water Act No. 36 of 1998 the main purpose is to ensure that water is distributed fairly and used in an equitable manner, while also ensuring that water, as a scarce resource, is used in a sustainable manner to ensure benefit for all users. As such the following sections from the National Water Act No. 36 of 1998 apply to this project:

- Chapter 3: Protection of Water Resources
    - Part 4: Pollution prevention:
        - Section 19: Prevention and Remedying the Effects of Pollutions
    - Part 5: Emergency Incidents
        - Section 20: Control of Emergency Incidents
- Chapter 4: Water Use
    - Part 1: General Principles
        - Section 21: Water Use

GN 704 Government Gazette 20119 dated 4 June 1999 was created in addition to the National Water Act No. 36 of 1998 to ensure the protection of water resources in relation to mining activities. In terms of this particular mining right application GN 704 relates more specifically to the locality of mining activities and infrastructures such as dams or reservoirs within the 1 in 100 year flood line or within 100 metres of any water course. Furthermore GN 704 states that any dirty water system must have the capacity to ensure that it is not likely to spill into any clean water system more than once in 50 years. Additionally, all in terms of GN 704 all appropriate measures must be taken to ensure that there will be no pollution of any water course or damage to riparian areas in the vicinity of the mining activities proposed.

3. TERMS OF REFERENCE

The Scope of work to be undertaken for a desktop a 1 in 100 year floodline determination is as follows:

a. Hydraulic analysis, illustrated by the:
- Catchment delineation;
- Analysis or derivation of peak flow events (using observed flow or design methods);
- Compilation of the river reach model and flood line using HEC-RAS and HEC-geoRAS;
- Backwater calculations and findings;
- Determination of the flood risk and flood hazard throughout the study site; and
- Recommendation of mitigation options associated with the hydraulic analysis.

b. Consolidate results in a report with:
- 1:50 and 1:100 Flood line maps
- A final flood line report; and
- Recommendation of mitigation options associated with the hydraulic analysis.

4. GAUGED VS UNGAUGED CATCHMENTS

Flood hydrology assessments can be limited if the information available is scant. In the Mogalakwena area (which, in recent years experienced a severe drought) most of the smaller tributaries (excluding large rivers) do not flow all year round as they have done in the past. This can be explained by changes in land use through intensification and increased areas under crops or commercial forests, an increase in water extraction (irrigation, dams, industrial needs and human needs), cyclic drought and climate change. Much of the flow in these rivers is not always accurately recorded by weirs. When a flood hydrology assessment is undertaken, depending on the data available, either gauged or ungauged catchments can be assessed. Gauged data are the most accurate approach assuming that the data quality is reliable and over a long period of time. In the absence of such data, an ungauged catchment is assessed using observed rainfall. This data (assuming it is of good quality) is used as an input to a rainfall-runoff model. The design flood is determined using a statistical analysis of the rainfall and the catchment characteristics.

In large catchment areas the antecedent moisture content is important for 1:100 year flood events. If the catchment is very dry before such an event, dams may fill up first from the flood waters and part of the rainfall may infiltrate, resulting in a reduced flow through the system, whereas a saturated catchment would result in a shorter lag time and a larger flow volume in the channel. This can lead to a difference in a simulated flood using **design rainfall (ungauged)** and a flood using **observed streamflow (gauged)**. Furthermore, the large flood events are often poorly recorded in weirs due to poor maintenance and overtopping.

For the study area, streamflow data was not available. As such, a detailed rainfall and flow assessment was undertaken to determine the design events.

5. STUDY SITE

The site is located within Quaternary Catchment A61G; falling under the Limpopo Water Management Area (WMA) and the Lepelle Northern Water Board. The proposed area is located on a heavily modified tributary of the Mogalakwena river (Class C: Moderately Modified).

The Mogalakwena is highly degraded due to the presence of settlements, rubbish dumps and mining that have encroached along the edge and impacted upon of this watercourse. Given the vulnerable state of these watercourse systems, and their associated high population, all catchments areas contributing to this system should be given extra attention and precaution regarding development proposals.

Rainfall in the region occurs in the summer months (mostly December to February), with a mean annual precipitation of 500 mm (observed from rainfall station 0676597 W). The reference potential evaporation (ET_o) is approximately 2 217 mm (A-pan equivalent, after Schulze, 2011) and the mean annual evaporation is between 1 800 – 2 000 mm, which exceeds the annual rainfall. This suggests a high evaporative demand and a water limited system. Summers are hot and winters are cool. The mean annual temperature is approximately 29.5 ºC in summer and 8.8 ºC in the winter months (Table 2). The underlying geology of the site is Goudplaats-Hout River Gneiss and the soils overlain are sandy-clay-loam ranging from Mispah, Glenrosa to Oakleaf form in this particular area. Much of the soils identified on site were transported material and highly modified.

Table 1 Mean monthly rainfall and temperature observed at Mogalakwena (derived from historical data)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Rainfall (mm)	81	69	46	25	5	0	0	0	3	31	68	83	**500**
Minimum Temperature (ºC)	112.	12.1	9.2	5.9	1.8	-1.8	-0.6	0.2	1.6	6.9	7.9	10.0	**6.8**
Maximum Temperature (ºC)	37.8	38.8	36.4	35.1	32.7	28.9	28.2	32.3	36.2	37.5	38.2	37.4	**38.8**

6. METHODOLOGY

The following methodology was followed in order to meet the objectives as detailed in the terms of reference. The assessment of these systems considered the following databases where relevant:

Table 2 Data type and source for the assessment

Data Type	Year	Source/Reference
Aerial Imagery	2016	Surveyor General
1:50 000 Topographical	2011	Surveyor General
2 m Contour	2010	Surveyor General
River Shapefile	2011	EKZNW
Geology Shapefile	2011	Durban Geological Sheets/National Groundwater Archive
Land Cover	2014	EKZNW
Water Registration	2013	WARMS - DWS

*Data will be provided on request

6.1. Site Visit

As this is a desktop study no site visit was undertaken and all assessments were undertaken using aerial and Google Earth imagery.

A pre-development state was assessed. The current condition was assessed as follows -

- The vegetation characteristics of the watercourse were assessed for the determination of the Manning's n-values;
- The presence and dimensions of any crossings, such as culverts and bridges, that would act as a barrier to a flood event and that may be damaged during the occurrence of such an event were noted;
- The overall state of drainage channels, streams and rivers was assessed;
- The slope of the study site as well as evidence of flood damage and erosion around the site were noted;
- The state of existing gauging stations (nearby) was assessed to determine if the structure is accurately recording streamflow (e.g. evidence of under cutting or damaged features); and
- The elevation at the water level and crossing level in order to verify contour data.

The watercourse systems were flowing at the time of the site visit. As a result, a full river profile was undertaken. Depth poles were used to measure the depth of the channel where possible.

6.2. Critical Catchment Delineation and River Reach Analysis

The critical contributing catchment area was determined for use in both the watershed delineation tool, the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) HEC-HMS and the Soil & Water Assessment Tool (SWAT) models. The sub-catchments were delineated using the 30 m contour that was used as input to the watershed tool (Figure 3).

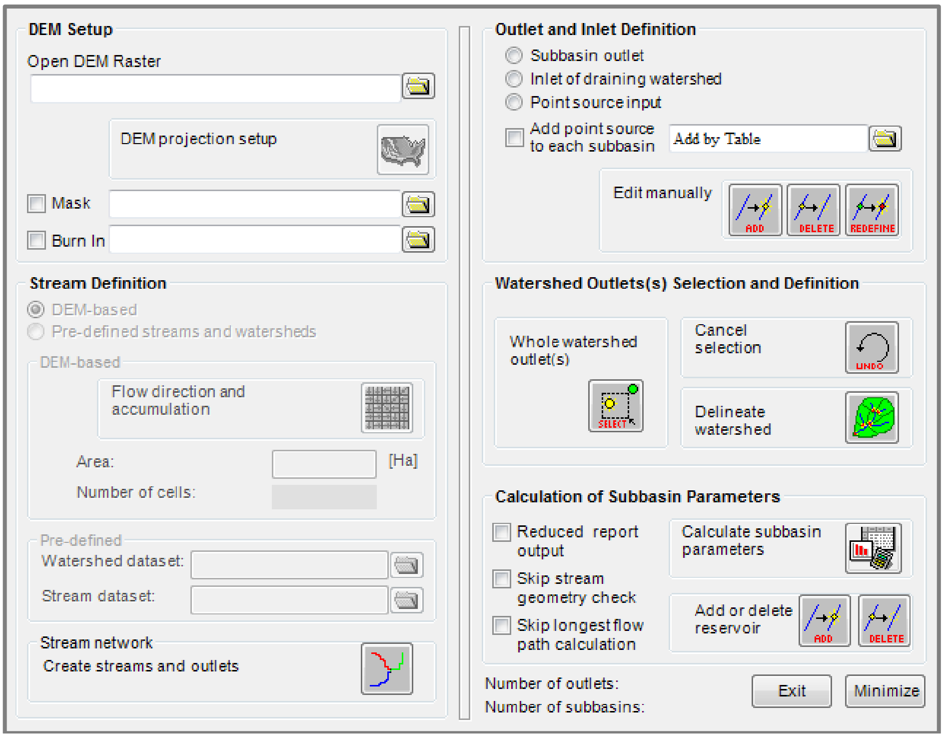

Figure 3. Soil Water Assessment Tool (*SWAT*) watershed delineation tool for sub-catchment delineation and stream network creation

6.3. Design Flood Determination

The peak flows for the 1:10, 1:50 and 1:100 flood events were calculated for the catchments using the rational method, the SCS-SA model and the Standard Design Flood Method as outlined in the SANRAL Drainage Manual (2013). The 1:10 and 1:50 year events were included for comparative reasons even though they were not a required output. The SCS-SA model is a hydrological storm event simulation model suitable ideally for application on catchments that have a contributing catchment of less than 30 km^2. The model has been used widely both internationally and nationally for the estimation of flood peak discharges and volume (Schulze *et al*., 1992). The type of surface in the drainage basin is also important. The Rational Method becomes more accurate as the amount of impervious surface, such as pavements and rooftops, increases. As a result, the Rational Method is most often used in urban and suburban areas (ODOT Hydraulics Manual, 2014).

6.4. Flood Line Determination

Modelling of the flood lines was undertaken using the U.S. Army Corps of Engineers' HEC-RAS v5.05 programme, which is commonly used throughout South Africa. Numerous cross sections were created throughout the contributing area (Figure 5). Ineffective areas/hydraulic structures were digitized and included in the model. Land use coverage was used to determine the Manning's n-values in a GIS platform. Each cross section may have had numerous values on either side of the channel depending on the site characteristics. Manning's N-values were obtained from the HEC-RAS Hydraulic Reference Manual (2010) for the channel areas (a value of between 0.04 and 0.08 was used depending on the presence or absence of rock features and debris as shown in Figure 4). Design flood values were used as an input for the relevant reaches.

Figure 4. Photos giving an example of the land cover and river channels on this site on which Mannings values were based.

Given the slope of the catchment and the distance to downstream hydrological infrastructure, no inundation within the study site would occur from external features on the watercourse. As such, Normal Depth was selected for the reach boundary conditions. The slope of the channel was used as the value for the backwater calculation of the initial condition. Some inundation structures were included in the cross sections where there were structures present (Figure 5).

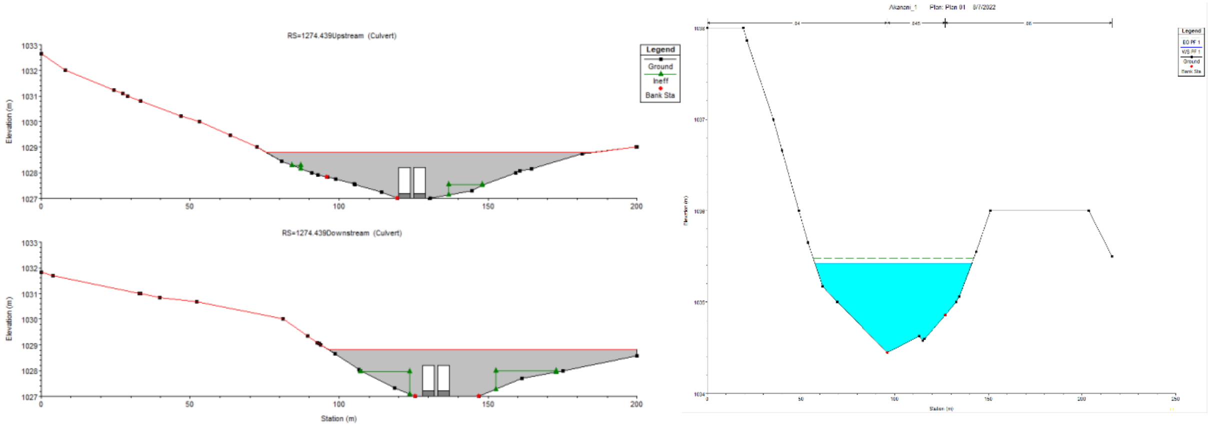

Figure 5. Longitudinal profile and channel cross sections developed for a section of the rivers in question

6.5. Flood Line Determination for Minor Channels

As Hydrologic Engineering Center's River Analysis System (HEC-RAS) and HEC-geoRAS are highly sensitive to the resolution of the terrain data used in the model, small non-perennial channels such as drainage lines are often not captured within the model. In most cases the flood output is not required for such channels as the flood generated would be negligible. However, it is good practice to ensure that all channels or drainage lines are adequately covered. As such, the author has developed a simple model to generate a flood depth through GIS. The model considers the flood generated for nearby smaller catchments and applies and area weighted correction. The model generates a flood height based on this estimation within the existing terrain model. Figure 6 provides a schematic of this model.

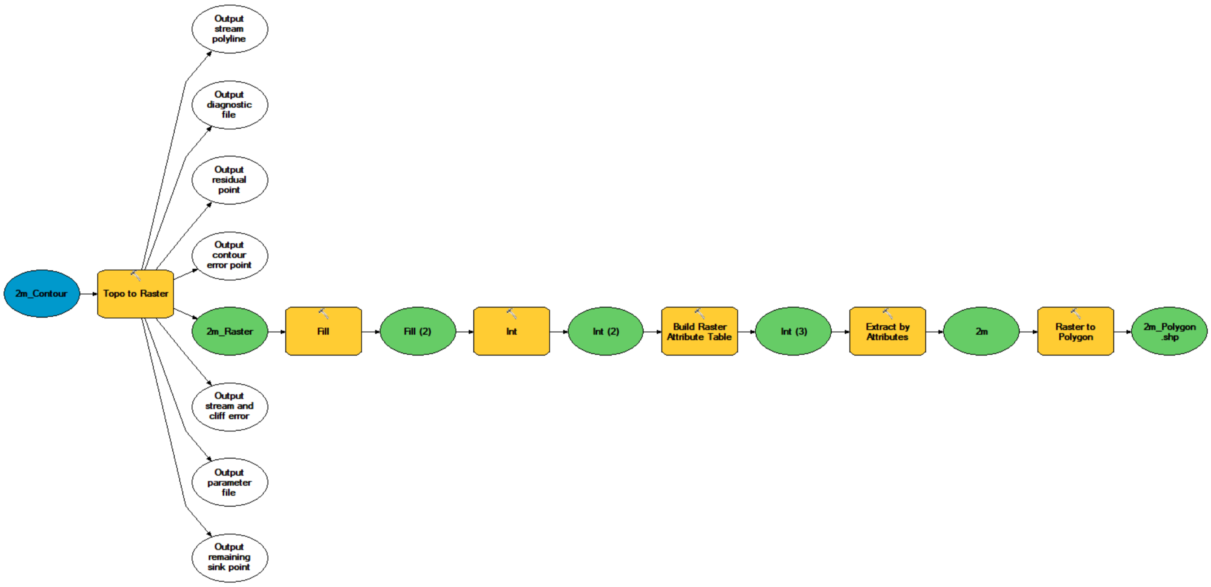

Figure 6. GIS model for flood generation in small channels

7. LIMITATIONS AND ASSUMPTIONS

In order to apply generalized and often rigid design methods or techniques to natural, dynamic environments, a number of assumptions are made. Furthermore, a number of limitations exist when assessing such complex hydrological systems. The following constraints may have affected this assessment:

- Manning's n - values (the channels roughness coefficient) was estimated. However, n- values in areas outside of the study area were estimated using a desktop approach due to the extent of the catchment.
- 2 meter contour interval data and Digital Elevation Models (DEMs) were used in the design flood estimation (development of the elevation model). However, this information was derived from the 30m DEM as such as any uncertainty within the DEM will be carried through into the modelling. Ideally an accurate survey of the area should be made available to ensure an accurate floodlien determination..
- Given the setting of the site (low flow during the site visit) it was difficult to determine which channels would be fully active in a flood and which are remnant channels which have since been bypassed. HEC-geoRAS and HEC-RAS models cannot be used to a very high level of accuracy on smaller non-perennial systems as they are usually used on larger catchment areas.

There was little to no data on flows out of the system. The catchment is very small and the watercourse associated with the site has been transformed.

8. RESULTS AND DISCUSSION

A detailed desktop assessment was undertaken for the site. This was the point of departure for the calculation of design flood volumes. These adopted values were then used in the HEC-RAS and HEC-geoRAS models to route this flood event through the channel.

8.1. Desktop Hydrological Assessment

A detailed assessment of the climate was undertaken. Rainfall stations were considered based on their proximity to the site (contributing catchment), altitude and length/reliability of the data record. The long-term mean annual rainfall of the site that was used in the design was 481 mm (Table 4).

Table 3.Comparison of values from some of the rainfall stations that were assessed during the data analysis

Station No.	Observed MAP (mm)	Years	Altitude (m)	Station Name
0676705 W	481	50	1082	N/A
0633482 W	635	41	1052	Groenfontein
0633393 W	630	59	1204	Zaaiplaas
0677259 W	427	55	1295	Bergzicht
0633881 A	603	66	1094	Potgieterus

8.2. Allowable Abstractions and Water Registration

Quaternary Catchment (QC) site: A61G (Limpopo/Mogalakwena). According to GN 538 (2016), the General Authorization (GA) limits for this QC are as follows–

- Abstraction of surface water: 2 000 m^3 / year @ 1 l/s from throughout the year
- Storage of water: 2 000 m^3
- Groundwater abstraction: 0 m^3/ha/year (allowed under GA).

These limits show that this catchment area is water limited and restricted water use applies.

8.3. Catchment

Contour lines were used to calculate the slope of each of the banks. These were further improved through height measurements taken on-site. The soils and geology were obtained from GIS layers obtained from the Soil Science department at the University of KwaZulu-Natal (UKZN). Various vegetation databases were used to determine the likely or expected vegetation types (Mucina & Rutherford, 2006; Scott-Shaw & Escott, 2011). A number of recognized databases were utilized in achieving a comprehensive review, and allowing any regional or provincial conservation and biodiversity concerns to be highlighted.

This site is dominated by Makhado Sweet Bushveld (SVcb 20, Mucina and Rutherford, 2006). This occurs within the sub-escarpment savanna biome. The desktop analysis revealed that the area is largely transformed, with the possibility for some flagged fauna and flora (e.g. red data species and endangered wildlife) being found from the C-plan, SEA and MINSET databases. However, this does not necessarily mean that rare or endangered species will occur in the area of interest. The following information was collected for the vegetation unit SVcb 20 (Mucina & Rutherford, 2006; Scott-Shaw & Escott, 2011):

- **Distribution:** Limpopo Province: Straddling the Tropic of Capricorn, occurs on the plains south of the Soutpansberg, east of the Waterberg and on the apron surrounding the Blouberg and Lerataupje Mountains, and north of the Polokwane Plateau and west of the escarpment, with extensions to Mokopane to the south and to the north near Vivo.
- **Altitude:** about 850–1 200 m (Figure 8).
- **Vegetation & Landscape Features:** Slightly to moderately undulating plains sloping generally down to the north, with some hills in the southwest. Short and shrubby bushveld with a poorly developed grass layer (Figure 7).
- **Geology & Soils:** The area is underlain by the gneisses and migmatites of the Hout River Gneiss (Randian Erathem) and the potassium-deficient gneisses of the Goudplaats Gneiss (Swazian Erathem). Sandstones and mudstones of the Matlabas Subgroup (Mokolian Waterberg Group) are also found. Soils include deep, greyish sands, eutrophic plinthic catenas, red-yellow apedal freely drained soils with high base status, clayey in bottomlands. Land types mainly Bd, Bc, Ae and Ia.
- **Climate:** Summer rainfall with very dry winters. MAP about 350–550 mm. Frost fairly infrequent. Mean monthly maximum and minimum temperatures for Mara-Agr 36.5°C and –0.8°C for November and June, respectively. See also climate diagram for SVcb 20 Makhado Sweet Bushveld.

Table 4 Land cover area for the contributing catchment areas

Land Cover	Catchment 1 Area (ha)	Catchment 1 Percentage	Catchment 2 Area (ha)	Catchment 2 Percentage
Bare Ground	638.23	2.84	480.52	9.90
Cultivated commercial annual crops non-pivot	17.13	0.08	0.00	0.00
Cultivated commercial permanent orchards	72.31	0.32	10.04	0.21
Cultivated subsistence crops	2591.68	11.55	331.91	6.84
Degraded	730.05	3.25	226.33	4.66
Grasslands	2102.50	9.37	84.46	1.74
Low shrubland	458.67	2.04	171.43	3.53
Mines	1004.03	4.47	819.52	16.89
Plantations / Woodlots	0.27	0.00	0.00	0.00
Settlements	1751.94	7.80	698.82	14.40
Thicket /Dense bush	377.41	1.68	130.62	2.69
Waterbodies	51.62	0.23	2.20	0.05
Wetlands	5.94	0.03	3.33	0.07
Woodland/Open bush	12646.17	56.34	1893.12	39.01
Total	**22447.94**	**100.00**	**4852.30**	**100.00**

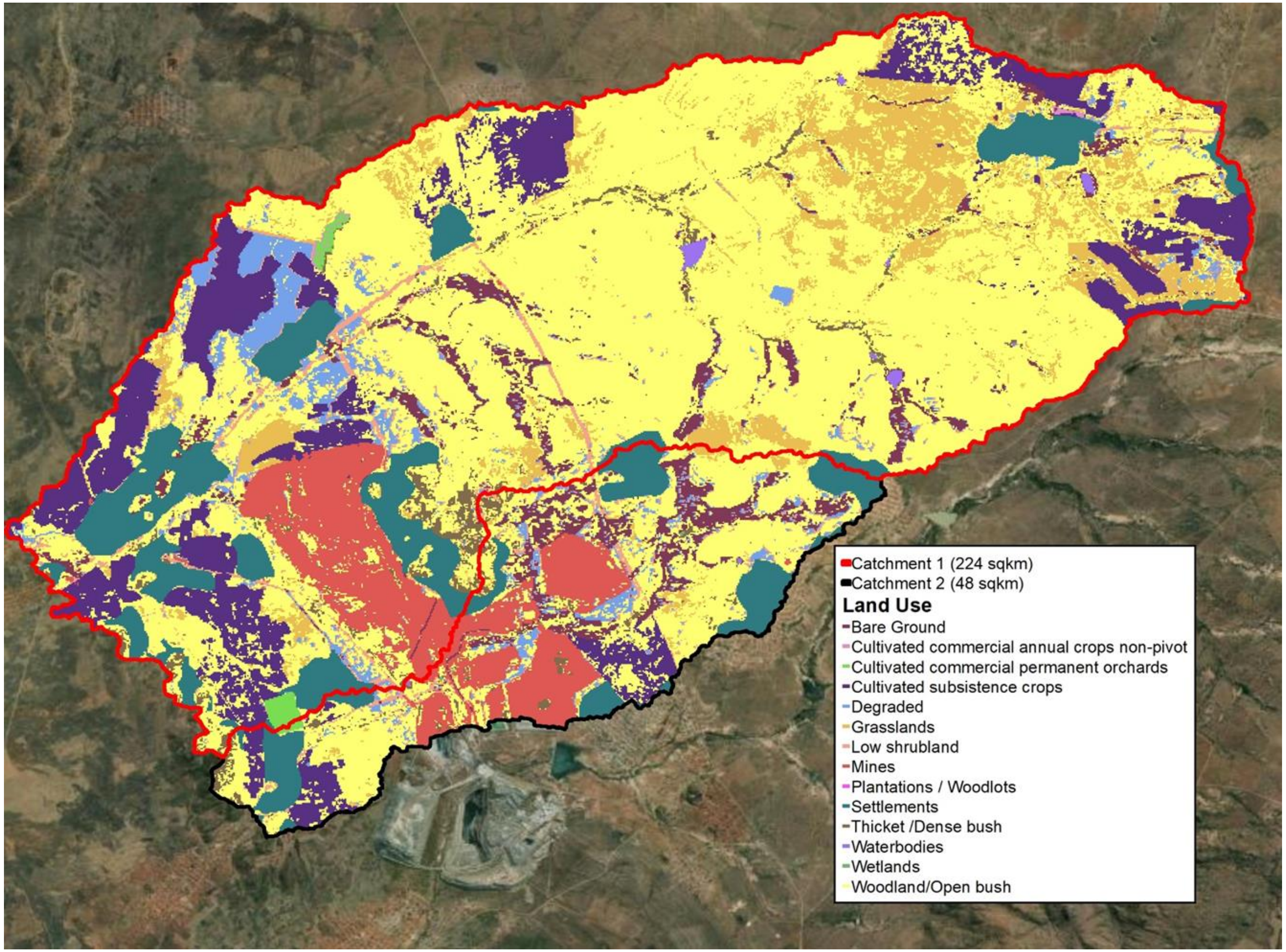

Figure 7. Existing land use for the catchment area of the proposed site

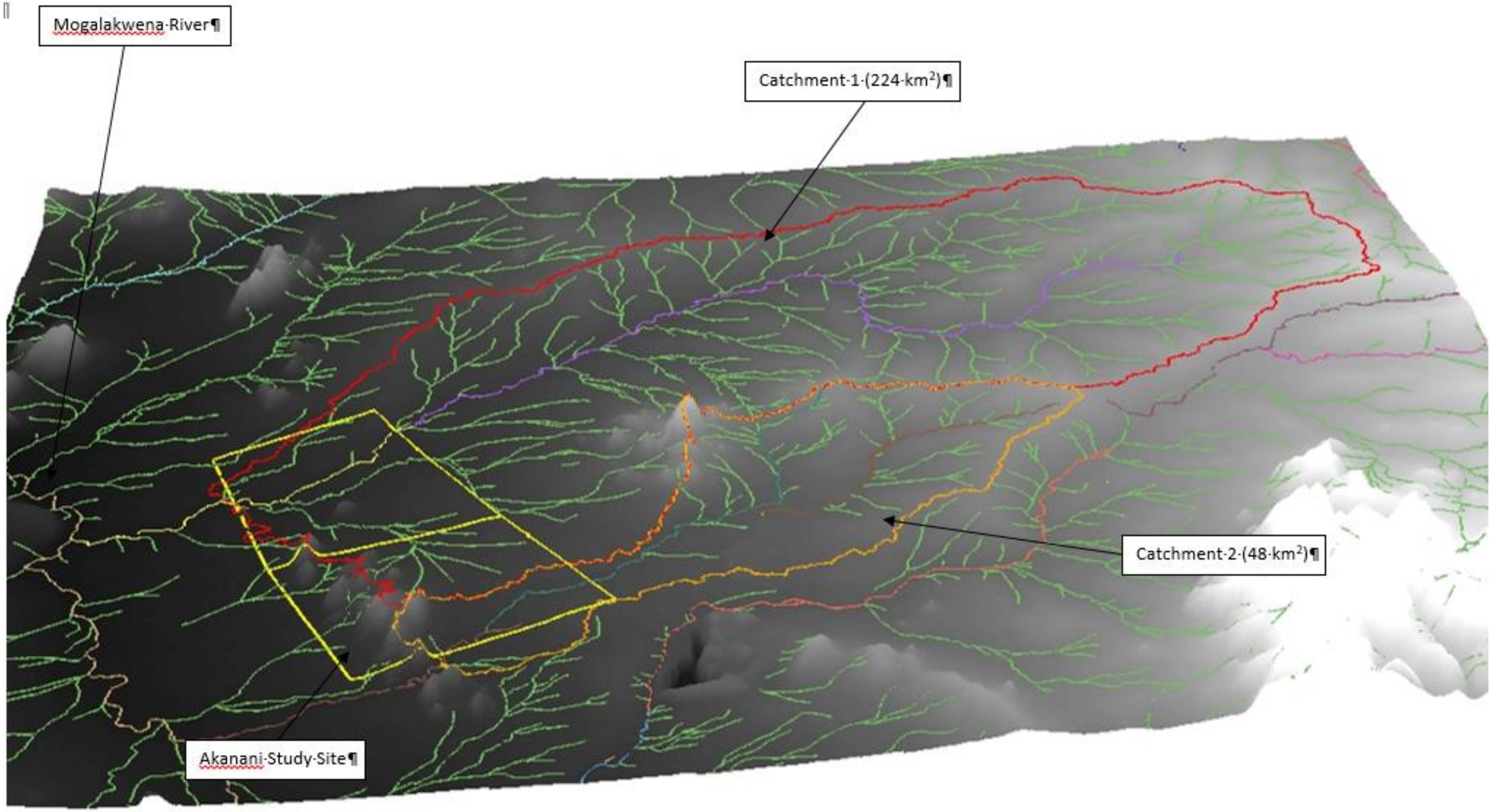

Figure 8. Exaggerated (x3) Digital Elevation Model (DEM) of the catchment surrounding the proposed site

8.4. Design Rainfall

Design rainfall differs from mean annual rainfall as it is rainfall associated with an events rainfall depth for a specified storm duration and a recurrence interval (frequency of occurrence). The design rainfall used is dependent on the method used to determine the peak discharge. The SCS-SA method use 1 day-rainfall for various return periods while the Rational and SDF Methods use rainfall intensity linked to the catchments Time of Concentration (Tc) and Storm Duration.

The results of the design rainfall analysis are summarised below:

Table 5 Comparison between the various one-day design rainfall estimation techniques available for the study site

Return Period	**Design Rainfall Depth (mm)**		
	SDF	**SCS-SA (using DRE)**	**Rational**
10 Year Return Period	96.71	102	96.71
50 Year Return Period	150.3	155	150.3
100 Year Return Period	175.34	181	175.34

8.5. Design Peak Discharge

The design runoff results obtained for the 1:20, 1:50 and 1:100 year flood events for the various river reaches are summarized in Table 7. The populated calculation sheets for the Rational, SDF and SCS methods can be seen in Annexure A, B & C. The high contrast in values is due to the catchment size limitations of the design approaches. It is expected by the authors that the estimates from the SDF are unrealistic. This is likely due to build up nature of the catchment areas and rainfall value that may not be representative of the entire catchment (the area is known for localised storm events). Furthermore, the lack of vegetation and the presence of roads has resulted in a much shorter time of concentration than what would have occurred in past decades. The design values indicate that the larger design events were vastly different between models whereas the smaller more frequent events were similar between models. This is likely due to the recommended catchment areas that these models are designed for. Given the results, the rational model was considered to be the most appropriate model if design rainfall were to be used, based on the larger catchment area, while the SCS-SA method was used for the smaller catchment 2.

Table 6 Adopted design peak discharge values ($m^3.s$-1) run through HEC-RAS for the catchment area

Peak Discharge ($m^3.s^{-1}$)	Return Period						
	2	5	10	20	50	100	200
Rational	81.397	141.130	193.242	257.015	376.318	501.860	574.963
SDF	14.65	67.10	116.19	173.28	261.13	337.35	421.04
SCS-SA	37.4	74.8	107.8	147.4	212.3	268.0	334.5

8.6. Hydraulic Modelling

Various hydraulic models were produced in HEC-RAS and exported to HEC-geoRAS by importing river centreline, cross sections, water surfaces and flow data from GIS layers and the hydrologic model. This allowed for inundation mapping and flood line polygons to be generated. The water surface TIN was converted to a GRID, and then the actual elevation model was subtracted from the water surface grid. The area with positive results (meaning the water surface is higher than the terrain) illustrated the flood area, whereas the area with negative results illustrated the dry areas not inundated by the flood. Inundation can be seen at various locations such as around bends.

The 1:2, 1:5, 1:10, 1:20, 1:50, 1:100 and 1:200 year combined flood hydrograph showed a moderate time of concentration and a high combined peak. The 1:100 year flood extent (Figure 9) for the current state indicated that the low lying banks and some floodplain areas surrounding the site are within the flood extent. However, **most of the area is not within the flood extent**. The proposed development should take cognisance of likely flood areas. The flood extents that fall within the site boundary are small and the velocity risk of damage would be very low due to the very gentle slope of the catchment. As such, if a flood event were to occur, the site would be at low/minimal risk of damage but may be inundated with slow flowing water.

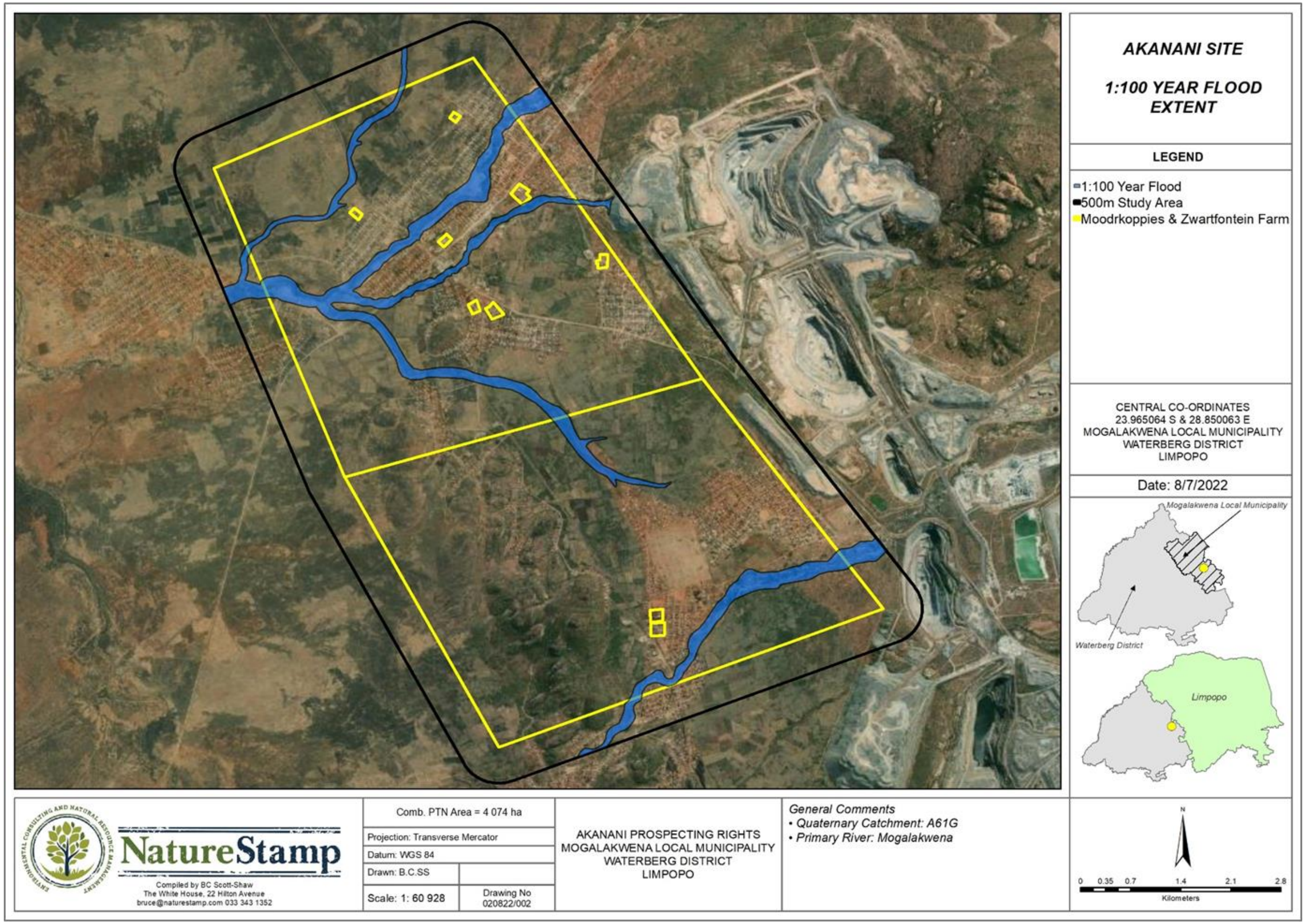

Figure 9. 1:100 year flood extent for the proposed site

9. IMPACT ASSESSMENT

This site proposed activity on this site is non-invasive prospecting for platinum metals group. It should be noted that at this stage that there is no plan yet available for location of the proposed activities, or site layout plan should this proceed beyond the prospecting stage. As such the prospecting activities have been identified as low impact due their non-invasive methods and should have negligible effect on the hydrology of the system if they remain outside the 100m buffer of the 1 in 100-year flood line. If activities take place within the 100m buffer then they should be kept to minimum, to ensure that the riparian land scape, which impacts on the hydrology of the system, is not disturbed.

10.SUMMARY OF DESKTOP VERIFICATION

It should be noted that as this is a prospecting study and at this stage there is no site plan available. As such the sensitivity will be based only on proximity to the river and the floodline that has been determined.

The table below shows a summary of findings.

Screening Tool Sensitivity	Verified Sensitivity	Outcome Statement/Plan of Study	Relevant Section Motivating Verification
Surface Hydrological Assessment			
N/A	High, but only within the 100m buffer of the floodline	Compliance and Mitigation Plan	NWA 36 of 1998, Section 19, 20 and 21 GN 704

From the information provided by client regarding the proposed activities, as well as the biophysical and legislative information reviewed in this report the sensitivity of the water resources in relation to the proposed activity was considered to be high, within the 100m buffer of the floodline. As stated in the previous section, the impacts of the activities are low and if the activities remain outside this buffer then sensitivity will be low.

A high sensitivity classification is defined as a water resource that is located in the vicinity of a high risk activity such as mining. In this instance **if** prospecting occurs within 100m of the 1 in 100 year floodline it will be considered high sensitivity.

In the context of this study this area was classified as high sensitivity due to the following:

- Water courses are located downstream of the proposed activity. As such any spillage of pollutants or incidents could result in these chemicals entering the water system.
- Potentially there will be a removal and replacement of the current surface vegetation on site. Until the closure of the prospecting site a large portion of this site could be exposed to the elements which could result in considerable erosion and therefore, potential pollution of the downslope water courses.

11.MITIGATION MEASURES

11.1. Spill Management Plan

The proposed development should employ best practise stormwater management practises, as outlined below –

- Implementation should take place during the dry season wherever possible. Activities should stop during heavy rains.
- Vegetation clearing should be limited as much as possible and plants rescued for rehabilitation.
- Directing clean stormwater towards natural drainage lines, contours and dispersing over grassed, flat areas (preferably the existing watercourses).
- Vehicles and equipment must be kept outside of watercourse buffers.
- Vehicles and equipment must be kept clean and serviced off site.
- Staff/workers on-site must be educated on identifying potential erosion areas and best practice guidelines.
- Energy dissipating measures with regards to stormwater management would be installed where necessary to prevent soil erosion.
- The engineer or contactor must ensure that only clean stormwater runoff enters the environment.
- Drainage should be controlled to ensure that runoff from the project area does not culminate in off-site pollution, flooding or result in any damage to properties downstream, of any stormwater discharge points.
- Infrastructure must have the following:
    - Completely lined storage infrastructure (concrete bunded area), with the capacity to contain 120% of the total amount of petrochemicals stored within a specific tank;
    - Spills must be completely removed from the site;
    - Valves / taps to contain or release any spillage collected from storage tanks; and
    - Fire extinguisher equipment installed within each facility.

Furthermore, as guided by the DWS, the following soil erosion measures should be put into place –

- Erosion control measures should be put in place to minimize erosion along the construction/implementation areas. Extra precautions must be taken in areas where the soils are deemed to be highly erodible.
- Soil erosion onsite should be prevented at all times, i.e. post- construction activities.
- Erosion measures should be implemented in areas prone to erosion such as near water supply points, edges of slopes etc. These measures could include the use of sand bags, hessian sheets, retention or replacement of vegetation if applicable and in accordance with the EMPR and the biodiversity impact assessment.
- Where the land has been disturbed during implementation, it must be rehabilitated and re-vegetated back to its original state after completion.

- Stockpiling of soil or any other material used during the construction phase must not be allowed on or near slopes, near a watercourse or water body. This is to prevent pollution of the impediment of surface runoff (further details are provided in the EMPr).

In order to reduce the potential impact of spills on site the following must be adhered to:

- Emergency numbers are provided on site – e.g. Spilltech, fire department, ambulance, etc.;
- Spill cleaning kits such as a Drizit kit are available on site;
- All chemicals on site are recorded in the inventory of hazardous substances;
- Equipment, machinery and vehicles are regularly checked and maintained in good order;
- Machinery and equipment maintenance is undertaken in designated areas;
- Drip trays are to be placed underneath machinery and equipment during maintenance;

In the instance of a spill on site the following procedure must be followed:

1. Locate the source of the spill;
2. Stop the spill and prevent further spreading;
3. The appropriate oil sponge, absorbent or spill kit (e.g. DriZit) can then be used to clean and remove the spilled substance(s);
4. Spills from trucks/tractors must be contained within a concreted site area and prevented from spreading;
5. Spilled petrochemicals can then be cleaned up and removed using the appropriate oil sponge, absorbent or spill kit (e.g. DriZit);
6. The spill must be reported to the site manager / supervisor and ECO;
7. Depending on the significance of the spill, the incident may also need to be reported to the DEDTEA and DWS.

11.2. Erosion Control Plan

There is an overlap between the storm water management and erosion control. The erosion control is particularly relevant during construction and at certain locations during operation. The removal of vegetation also leaves the site at a higher risk.

- Immediately rehabilitate eroded areas:
    - Install protective structures, e.g. geotextiles;
    - Plant indigenous grasses on any open areas;
    - Ensure the slope remains gentle and stable;
    - Use vegetation plugs, rock packs or gabions where erosion is visible;
    - Immediately revegetate the area.
- Ensure that steeper areas are avoided and that the vegetation remains at these sites.
- Continual erosion monitoring should occur by a trained staff member.

The site should take into account the following erosion control mechanisms:

- Geotextiles;
- Gabion baskets;
- Soil binding chemicals;
- Hydroseeding techniques;
- Vegetation plugs;

- mulch

To ensure rehabilitation is effective, it is vital that the working area is managed correctly during the implementation phase. An important part of this management will be that careful preservation and management of soil stockpiles should be implemented from the start of the site. The following points have been provided for use with the rehabilitation actions:

- Top- and subsoil stockpiles (used for road levelling and bank lifting) must not be stockpiled within 100m or within the 1:100 year floodplain of a watercourse.
- Naturally occurring vegetation removed by site clearance operations may be grubbed in with the topsoil for stockpiling.
- The topsoil shall not be buried or rendered in any other way inappropriate for rehabilitation use.
- Topsoil stripping (in widening and new development areas) shall not occur in wet weather and during stripping and stockpiling, the topsoil shall not be subject to a compaction force greater than 1 500kg/m^2 and shall not be pushed for more than 50m.
- Topsoil shall also only be handled twice, once to strip and stockpile, and secondly to replace, level, shape and scarify if necessary.
- Top soil stockpiles must be protected against erosion and a record kept of all top soil quantities and should there be shortfalls of topsoil required for rehabilitation, adequate replacement material from commercial sources should be obtained as approved by the Engineer (preferably from areas identified with sourced excess topsoil).
- Equally, excess topsoil shall be landscaped and stabilized in accordance to the requirements of the Engineer and in consultation with the Contractor’s Land Rehabilitation Specialist.
- Topsoil stockpiles should not be stockpiled for longer than 6 months. If this can’t be avoided, the stockpiles will need to be enriched or upgraded prior to rehabilitation. The Contractor shall consult with the Engineer with regards to matching preconstruction conditions or existing adjacent conditions.
- All stockpiles left for extended periods of time shall be stabilized using approved vegetation cover or other erosion control measures.

Any excess subsoil must be removed from the road fringe once back filling is completed, and spoiled at an agreed spoil site (spoil sites to be agreed between landowner, ECO and Engineer).

12.REASONED OPINION OF ISSUING AN EA

Due to the non-invasive nature of the proposed prospecting, there is no reason identified why the EA should not be issued. However, should the scope of the proposed prospecting change to intrusive the following must be considered:

- The current activities on the proposed prospecting site have a considerable impact on the water resources both onsite and downstream in terms of water quality. From the satellite imagery and the current land use map (Figure 7), there is considerable degradation and subsistence farming occurring which result in a deterioration of this system. As such it possible that there currently pollutants in the form of sediments and possibly agricultural chemicals in the river system. This would have to be checked during a site visit. This highlights that the risks associated with prospecting on this site, in that due to the exposed soil surface it may be more vulnerable to deterioration as a result of prospecting activities even if they are non-invasive. Hence, it is recommended that the activities within the 100m buffer be kept to minimum and the mitigation plan and measures be followed.

- Despite the disturbance of the natural vegetation on this site there are still areas in which this vegetation is present. As there is no site layout available at this stage it should be noted that if these areas of natural vegetation are selected for prospecting then the sensitivity increases as these areas are still intact, when compared with other degraded areas on the site. If the prospecting proceeds to more invasive methods and eventually a mining site is proposed then it is recommended that the site be re-assessed with this information available.

13.REFERENCES

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14.APPENDIX A: RATIONAL METHOD

Description of Catchment	**Akanani**		
River detail	**Mogalakwena Tributary**		
Calculated by	**BCSS**	**Date**	**1-Aug-22**

Physical characteristics						
Size of catchment (A)	**224**	km²	Rainfall Region			
Longest Watercourse	**29**	km	**Area Distribution Factors**			
Average slope (S_{av})	**0.002**	m/m	Rural (α)	Urban (β)	Lakes (γ)	
Dolomite Area ($D_{\%}$)	**0**	%	**0.8**	**0.2**	**0**	
Mean Annual Rainfall (MAR)	**875**	mm				
Catchment Characteristics	**Flat/permeable**	%				
r - look up from Table 3C.3	**Thick grass cover**	0.8				

Rural (1)				**Urban** (2)			
Surface Slope	**%**	**Factor**	**C_s**	**Description**	**%**	**Factor**	**C_2**
Vleis and Pans	**10**	0.05	0.005	**Lawns**			
Flat Areas	**25**	0.11	0.028	Sandy, flat (<2%)	**5**	0.075	0.004
Hilly	**40**	0.2	0.080	Sandy, steep (>7%)		0.175	-
Steep Areas	**25**	0.3	0.075	Heavy soil, flat (<2%)		0.15	-
Total	100	-	0.188	Heavy soil, steep (>7%)		0.3	-
Permeability	**%**	**Factor**	**C_p**	**Residential Areas**			
Very Permeable	**30**	0.05	0.015	Houses	**35**	0.4	0.140
Permeable	**35**	0.1	0.035	Flats		0.6	-
Semi-permeable	**25**	0.2	0.050	**Industry**			
Impermeable	**10**	0.3	0.030	Light industry	**20**	0.65	0.130
Total	100	-	0.130	Heavy Industry		0.75	-
Vegetation	**%**	**Factor**	**C_v**	**Business**			
Thick bush and plantation	**55**	0.05	0.028	City Centre		0.825	-
Light bush and farm-lands	**37**	0.15	0.056	Suburban	**25**	0.6	0.150
Grasslands	**7**	0.25	0.018	Streets	**15**	0.825	0.124
No Vegetation	**1**	0.3	0.003	Maximum flood		1.00	-
Total	100	-	0.104	Total	100	-	0.548

Time of concentration (T_c)	**Defined Watercourse**	Notes:
Overland flow	Defined watercourse	*Pre-development Run-off*
$T_c = 0.604\left(\frac{rL}{\sqrt{S_{av}}}\right)^{0.467}$	$T_c = \left(\frac{0{,}87L^2}{1000S_{av}}\right)^{0.385}$	*Latitude:* *29°31'* *Tc =* *Longitude:* *31°11'* *9.70207935*
11.2 Hours	9.7 Hours	

Run-off coefficient							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**

Run-off coefficient, C_1 ($C_1 = C_s + C_p + C_v$)	0.421	0.421	0.421	0.421	0.421	0.421	0.421
Adjusted for dolomitic areas, C_{1D} ($= C_1(1\text{-}D_{\%})+C_1D_{\%}(\Sigma(D_{factor} \times C_{s\%}))$)	0.421	0.421	0.421	0.421	0.421	0.421	0.421
Adjustment factor for initial saturation, F_t	0.5	0.55	0.6	0.67	0.83	1	1
Adjusted run-off coefficient, C_{1T} ($= C_{1D} \times F_t$)	0.2105	0.23155	0.2526	0.28207	0.34943	0.421	0.421
Combined run-off coeffiecient C_T ($= \alpha C_{1T} + \beta C_2 + \gamma C_3$)	0.2779	0.29474	0.31158	0.335156	0.389044	0.4463	0.4463
Rainfall							
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Point Rainfall (mm), P_T	**45.67**	**74.66**	**96.71**	**119.57**	**150.83**	**175.34**	**200.88**
Point Intensity (mm/hour), P_{iT} ($=P_T/T_C$)	4.7	7.7	10.0	12.3	15.5	18.1	20.7
Area Reduction Factor (%), ARF_T	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Average Intensity (mm/hour), I_T ($= P_{iT} \times ARF_T$)	4.7	7.7	10.0	12.3	15.5	18.1	20.7
Return period (years), T	**2**	**5**	**10**	**20**	**50**	**100**	**Max**
Peak flow (m³/s),	81.397	141.130	193.242	257.015	376.318	501.860	574.963

15.APPENDIX B: SDF METHOD

Description of catchment	**Akanani**						
River detail	**Mogalakwena Tributary**						
Calculated by	**BCSS**				**Date**	**01 August 2021**	
Physical characteristics							
Size of catchment (A)	**224**	km²	Time of Concentration (T_C)	$T_c = \left(\frac{0{,}87\,L^2}{1000\,S_{av}}\right)^{0{,}385}$		**9.70**	hours
Longest watercourse (L)	**29**	km					
Average slope (S_{av})	**0.002**	m/m					
SDF basin (0)#	**2**		Time of concentration, t (= 60 T_C)			**582**	minutes
2-year return period rainfall (M)	**62**	mm	Days of thunder per year (R)			**44**	days/year
TR102 n-day rainfall data							
Weather Service station	**Autoriteit**		Mean annual precipitation (MAP)			**450**	mm
Weather Service station number	**675 125**		Coordinates				
Duration (days)	Return period (years)						
	2	5	10	20	50	100	200
1	**62**	**93**	**117**	**145**	**187**	**223**	**264**
2	**74**	**111**	**140**	**173**	**222**	**265**	**313**
3	**80**	**122**	**156**	**193**	**250**	**300**	**355**
7	**94**	**144**	**183**	**225**	**289**	**344**	**405**
Rainfall							
Return period (years), T	2	5	10	20	50	100	200
Point precipitation depth (mm) $P_{t,T}$	**45.67**	**74.66**	**96.71**	**119.57**	**150.83**	**175.34**	**200.88**
Area reduction factor (%), ARF (= (90000-12800lnA+9830lnt)$^{0.4}$)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Average intensity (mm/hour), I_T (= $P_{t,T}$ x ARF / T_C)	**4.71**	**7.70**	**9.97**	**12.32**	**15.55**	**18.07**	**20.70**
Run-off coefficients							
Calibration factors	C_2 (2-year return period) (%)		**5**	C_{100} (100-year return period) (%)			**30**
Return period (years)	2	5	10	20	50	100	200
Return period factors (Y_T)	0	0.84	1.28	1.64	2.05	2.33	2.58
Run-off coefficient (C_T), $C_T = \frac{C_2}{100} + \left(\frac{Y_T}{2{,}33}\right)\left(\frac{C_{100}}{100} - \frac{C_2}{100}\right)$	**0.05**	**0.14**	**0.19**	**0.23**	**0.27**	**0.30**	**0.33**
Peak flow (m³/s), $Q_T = 0.278 \times C_T I_T A$	**14.65**	**67.10**	**116.19**	**173.28**	**261.13**	**337.35**	**421.04**

16.APPENDIX C: SCS-SA RESULTS FOR CATCHMENT 2

CATCHMENT NAME : Catch2
PROJECT NO : Akanani
RUN NO : 1
TOTAL CATCHMENT AREA (km^2) : 48.00
STORM INTENSITY DISTRIBUTION TYPE : 3
CATCHMENT LAG TIME (h) : 2.91
COEFFICIENT OF INITIAL ABSTRACTION: 0.10

CURVE NUMBERS:	Initial	Final
Sub-catchment 1	79	79.2
Sub-catchment 2	67	66.8
Sub-catchment 3	82	81.7
Sub-catchment 4	83	77.6
Sub-catchment 5	68	64.3

RETURN PERIOD (YEARS)	2	5	10	20	50	100	200
DESIGN DAILY RAINFALL DEPTH (mm)	58	83	102	123	155	181	211
DESIGN STORMFLOW DEPTH (mm)							
Sub-catchment 1	22.3	40.7	56.1	74.0	102.3	126.1	154.1
Sub-catchment 2	12.0	25.2	37.0	51.5	75.4	96.2	121.2
Sub-catchment 3	25.0	44.5	60.5	79.0	108.1	132.3	160.7
Sub-catchment 4	20.7	38.4	53.3	70.8	98.6	122.1	149.7
Sub-catchment 5	10.4	22.6	33.8	47.5	70.5	90.5	114.8
TOTAL RUNOFF DEPTH (mm)	15.9	31.0	44.1	59.7	85.2	106.9	132.9
DESIGN STORMFLOW VOLUME (millions m^3)							
Sub-catchment 1	0.1	0.2	0.3	0.4	0.5	0.6	0.7
Sub-catchment 2	0.1	0.2	0.3	0.4	0.7	0.8	1.0
Sub-catchment 3	0.2	0.4	0.5	0.6	0.9	1.1	1.3
Sub-catchment 4	0.1	0.3	0.4	0.5	0.7	0.9	1.1
Sub-catchment 5	0.2	0.4	0.6	0.9	1.4	1.7	2.2
TOTAL STORMFLOW VOLUME (millions m^3)	0.8	1.5	2.1	2.9	4.1	5.1	6.4
COMPUTED CURVE NUMBER	72.2	71.9	71.7	71.6	71.4	71.3	71.3
PEAK DISCHARGE (m^3/s)	37.4	74.8	107.8	147.4	212.3	268.0	334.5

****
RETURN PERIOD (years) = 2
DESIGN RAINFALL (mm) = 58
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 72.2
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 37.36
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
704.	0.118	118.
736.	4.653	4653.
768.	10.469	10469.
799.	16.834	16834.
831.	23.529	23529.
863.	30.433	30433.
894.	37.352	37352.
926.	37.362	37362.
958.	35.413	35413.
990.	32.727	32727.
1021.	29.621	29621.
1053.	26.228	26228.
1085.	22.624	22624.
1116.	18.854	18854.
1148.	14.947	14947.
1180.	10.927	10927.
1211.	6.879	6879.
1243.	5.390	5390.
1275.	4.608	4608.
1307.	4.074	4074.
1338.	3.674	3674.
1370.	3.358	3358.
1402.	3.099	3099.
1433.	2.882	2882.
1465.	2.666	2666.
1497.	2.436	2436.
1529.	2.190	2190.
1560.	1.924	1924.
1592.	1.638	1638.
1624.	1.330	1330.
1655.	1.049	1049.
1687.	0.806	806.
1719.	0.600	600.

1750.	0.427	427.
1782.	0.285	285.
1814.	0.174	174.
1846.	0.091	91.
1877.	0.035	35.
1909.	0.005	5.

****
RETURN PERIOD (years) = 5
DESIGN RAINFALL (mm) = 83
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.9
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 74.83
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
641.	0.001	1.
672.	0.058	58.
704.	0.629	629.
736.	10.106	10106.
768.	21.896	21896.
799.	34.670	34670.
831.	48.025	48025.
863.	61.655	61655.
894.	74.827	74827.
926.	74.028	74028.
958.	69.677	69677.
990.	64.013	64013.
1021.	57.600	57600.
1053.	50.681	50681.
1085.	43.388	43388.
1116.	35.802	35802.
1148.	27.977	27977.
1180.	19.986	19986.
1211.	12.129	12129.
1243.	9.457	9457.
1275.	8.067	8067.
1307.	7.123	7123.
1338.	6.416	6416.
1370.	5.857	5857.
1402.	5.401	5401.
1433.	5.020	5020.
1465.	4.640	4640.
1497.	4.238	4238.
1529.	3.808	3808.
1560.	3.344	3344.
1592.	2.846	2846.
1624.	2.310	2310.
1655.	1.822	1822.
1687.	1.400	1400.
1719.	1.041	1041.
1750.	0.740	740.
1782.	0.495	495.
1814.	0.301	301.
1846.	0.157	157.
1877.	0.061	61.
1909.	0.009	9.

****
RETURN PERIOD (years) = 10
DESIGN RAINFALL (mm) = 102
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.7
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 107.79
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
609.	0.002	2.
641.	0.040	40.
672.	0.236	236.
704.	1.346	1346.
736.	15.280	15280.
768.	32.373	32373.
799.	50.803	50803.
831.	69.963	69963.
863.	89.360	89360.
894.	107.789	107789.
926.	106.078	106078.
958.	99.506	99506.
990.	91.149	91149.
1021.	81.776	81776.
1053.	71.718	71718.
1085.	61.155	61155.
1116.	50.198	50198.
1148.	38.939	38939.
1180.	27.504	27504.

1211.	16.385	16385.
1243.	12.745	12745.
1275.	10.859	10859.
1307.	9.581	9581.
1338.	8.625	8625.
1370.	7.871	7871.
1402.	7.255	7255.
1433.	6.740	6740.
1465.	6.228	6228.
1497.	5.687	5687.
1529.	5.108	5108.
1560.	4.486	4486.
1592.	3.816	3816.
1624.	3.097	3097.
1655.	2.443	2443.
1687.	1.877	1877.
1719.	1.396	1396.
1750.	0.993	993.
1782.	0.663	663.
1814.	0.404	404.
1846.	0.211	211.
1877.	0.081	81.
1909.	0.012	12.

****
RETURN PERIOD (years) = 20
DESIGN RAINFALL (mm) = 123
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.6
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 147.40
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
577.	0.004	4.
609.	0.041	41.
641.	0.179	179.
672.	0.617	617.
704.	2.495	2495.
736.	21.874	21874.
768.	45.378	45378.
799.	70.577	70577.
831.	96.636	96636.
863.	122.847	122847.
894.	147.399	147399.
926.	144.437	144437.
958.	135.110	135110.
990.	123.457	123457.
1021.	110.484	110484.
1053.	96.623	96623.
1085.	82.109	82109.
1116.	67.102	67102.
1148.	51.738	51738.
1180.	36.204	36204.
1211.	21.232	21232.
1243.	16.481	16481.
1275.	14.031	14031.
1307.	12.372	12372.
1338.	11.132	11132.
1370.	10.154	10154.
1402.	9.357	9357.
1433.	8.690	8690.
1465.	8.028	8028.
1497.	7.329	7329.
1529.	6.582	6582.
1560.	5.779	5779.
1592.	4.916	4916.
1624.	3.989	3989.
1655.	3.146	3146.
1687.	2.418	2418.
1719.	1.797	1797.
1750.	1.278	1278.
1782.	0.854	854.
1814.	0.520	520.
1846.	0.271	271.
1877.	0.104	104.
1909.	0.015	15.

****
RETURN PERIOD (years) = 50
DESIGN RAINFALL (mm) = 155
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.4
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 212.33
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)

514.	0.001	1.
546.	0.018	18.
577.	0.084	84.
609.	0.256	256.
641.	0.658	658.
672.	1.625	1625.
704.	4.971	4971.
736.	33.403	33403.
768.	67.413	67413.
799.	103.637	103637.
831.	140.880	140880.
863.	178.069	178069.
894.	212.331	212331.
926.	207.070	207070.
958.	193.084	193084.
990.	175.929	175929.
1021.	156.981	156981.
1053.	136.838	136838.
1085.	115.835	115835.
1116.	94.201	94201.
1148.	72.140	72140.
1180.	49.944	49944.
1211.	28.768	28768.
1243.	22.282	22282.
1275.	18.951	18951.
1307.	16.700	16700.
1338.	15.018	15018.
1370.	13.694	13694.
1402.	12.613	12613.
1433.	11.710	11710.
1465.	10.815	10815.
1497.	9.871	9871.
1529.	8.864	8864.
1560.	7.781	7781.
1592.	6.618	6618.
1624.	5.370	5370.
1655.	4.234	4234.
1687.	3.254	3254.
1719.	2.419	2419.
1750.	1.720	1720.
1782.	1.149	1149.
1814.	0.700	700.
1846.	0.365	365.
1877.	0.140	140.
1909.	0.020	20.

****

RETURN PERIOD (years) = 100
DESIGN RAINFALL (mm) = 181
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.3
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 267.98

****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
482.	0.002	2.
514.	0.025	25.
546.	0.097	97.
577.	0.266	266.
609.	0.616	616.
641.	1.322	1322.
672.	2.844	2844.
704.	7.577	7577.
736.	43.823	43823.
768.	86.824	86824.
799.	132.445	132445.
831.	179.183	179183.
863.	225.637	225637.
894.	267.980	267980.
926.	260.572	260572.
958.	242.491	242491.
990.	220.548	220548.
1021.	196.435	196435.
1053.	170.885	170885.
1085.	144.314	144314.
1116.	117.008	117008.
1148.	89.228	89228.
1180.	61.366	61366.
1211.	34.953	34953.
1243.	27.038	27038.
1275.	22.984	22984.
1307.	20.245	20245.
1338.	18.201	18201.
1370.	16.592	16592.
1402.	15.279	15279.
1433.	14.183	14183.
1465.	13.097	13097.
1497.	11.952	11952.
1529.	10.731	10731.

1560.	9.420	9420.
1592.	8.011	8011.
1624.	6.499	6499.
1655.	5.125	5125.
1687.	3.938	3938.
1719.	2.927	2927.
1750.	2.081	2081.
1782.	1.390	1390.
1814.	0.846	846.
1846.	0.442	442.
1877.	0.170	170.
1909.	0.024	24.

****
RETURN PERIOD (years) = 200
DESIGN RAINFALL (mm) = 211
STORM DISTRIBUTION TYPE = 3
CURVE NUMBER (computed) = 71.3
LAG TIME (h) = 2.9
PEAK DISCHARGE (m^3/s) = 334.45
****

TIME (minutes)	DISCHARGE (cubic metres/sec)	(litres/sec)
482.	0.034	34.
514.	0.117	117.
546.	0.296	296.
577.	0.639	639.
609.	1.265	1265.
641.	2.405	2405.
672.	4.657	4657.
704.	11.149	11149.
736.	56.773	56773.
768.	110.504	110504.
799.	167.303	167303.
831.	225.298	225298.
863.	282.685	282685.
894.	334.454	334454.
926.	324.326	324326.
958.	301.263	301263.
990.	273.548	273548.
1021.	243.230	243230.
1053.	211.202	211202.
1085.	177.971	177971.
1116.	143.894	143894.
1148.	109.303	109303.
1180.	74.710	74710.
1211.	42.116	42116.
1243.	32.542	32542.
1275.	27.649	27649.
1307.	24.346	24346.
1338.	21.882	21882.
1370.	19.943	19943.
1402.	18.362	18362.
1433.	17.042	17042.
1465.	15.734	15734.
1497.	14.358	14358.
1529.	12.889	12889.
1560.	11.313	11313.
1592.	9.621	9621.
1624.	7.805	7805.
1655.	6.154	6154.
1687.	4.729	4729.
1719.	3.515	3515.
1750.	2.499	2499.
1782.	1.669	1669.
1814.	1.016	1016.
1846.	0.531	531.
1877.	0.204	204.
1909.	0.029	29.