SURFACE WATER STUDY FOR SAB'S GLASS BOTTLE MANUFACTURING PLANT

SAB's Glass Bottle Manufacturing Plant

Prepared for: The South African Breweries (Pty) Limited (SAB)

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BASIS OF REPORT

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
ASTER GDEM	Advanced Spaceborne Thermal Emmission and Reflection Radiometer Global Digital Elevation Model
DDF	Depth Duration Frequency
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
GIS	Geographic Information System
GA	General Authorisation
HEC-RAS	Hydrologic Engineering Centres – River Analysis System
I-SWQG	In- Stream Water Quality Guidelines (Vaal Barrage)
LIDAR	Light Detection And Ranging
m amsl	Meters above mean sea level
MAP	Mean Annual Precipitation
mcm	Million Cubic Meters
PriSciNat	Professional Natural Scientist
SACNASP	South African Council for Natural Scientific Professions
SANRAL	South African National Road Agency
SANS	South African National Standard
SANAS	South African National Accreditation System
SAWQG	South African Water Quality Guidelines -
SCS	Soil Conservation Service
SWMP	Stormwater Management Plan
Tc	Time of Concentration
TWQR	Target Water Quality Range
UPD	Utility Program for Drainage
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012 Study
WWWTW	Waste Water Treatment Works
WUL	Water Use Licence

1. INTRODUCTION

1.1 BACKGROUND

SLR Consulting (South Africa) (Pty) Ltd (SLR), an independent firm of environmental consultants, has been appointed by The South African Breweries (Pty) Ltd (SAB) to undertake a Technical Specialist Surface Water Study to support an Environmental Impact Assessment (EIA) and a water uses General Authorisation (GA) for the construction and operation of a glass bottle manufacturing plant (the Project) in the Emfuleni Local Municipality of the Gauteng Province, South Africa.

The preferred site is located on a portion of portion 238 of farm Leeuwkuil 596 IQ, approximately three kilometres west of Vereeniging.

The surface water study which follows includes a baseline hydrological assessment, flood study, review of the conceptual stormwater management plan and water circuit for the proposed infrastructure to ensure compliance with best practice and relevant legislation.

This surface water study was project managed and reviewed by a suitably qualified and experienced Hydrologist registered with the South Africa Council for Natural Scientific Professions (SACNASP) as a Professional Natural Scientist (PrSciNat) in the field of Water Resources Science.

1.2 ENVIRONMENTAL LEGISLATION

The study will use the guidelines as set out in the National Water Act (NWA), Act 36 of 1998, (Part 3: Information on flood-lines, floods and droughts).

- "For the purposes of ensuring that all persons who might be affected have access to information regarding potential flood hazards, no person may establish a township unless the layout plan shows, in a form acceptable to the local authority concerned, lines indicating the maximum level likely to be reached by floodwaters on average once in every 100 years"

The Best Practice Guideline G1 (DWAF, 2006) has been adopted for this study, to manage flood risks and hazards. It is important to consider a range of flood events and to evaluate flood behaviour, peak flood discharges and peak flood levels of a specific site. The flood assessment falls within the IFC requirements.

1.3 SCOPE OF WORK AND REPORT STRUCTURE

This Surface Water Study includes the following:

- Baseline Hydrology - Section 2: presents the baseline hydrology of the site and surroundings including climate, storm intensities, regional and local topography, watercourse network, catchment delineation, flow data, wetlands, soils, vegetation, groundwater and water quality.

- Flood Hydrology - Section 3: presents estimates of the flood hydrology of the R28, R59 drainage channels and unnamed Vaal tributary in the vicinity of the site including methodologies for peak flow estimation and results which will inform the flood-line modelling.
- Hydraulic Flood Modelling - Section 4: presents hydraulic flood modelling undertaken for the watercourses of interest including methodology, software, results and the flood-lines associated with the 1:50 year and 1:100 year flood lines within the vicinity of the site.
- Conceptual Stormwater Management - Section 5.1 presents a review of the SWMP to manage flood risks to the operation and minimise risks of polluting any water resources.
- Water Circuit – Section 5.2: presents a review of the water circuit to understand the water consumption, waste water and water losses for operations.
- Discharge Assessment – Section 6 presents the results and conclusion of an additional discharge from the stormwater attenuation pond to the flood-lines associated with the 1:50 year and 1:100 year flood presented in Section 4.
- Conclusions and Impact Assessment – Section 7 presents a summary of the main conclusions and recommendations of this report alongside a qualitative assessment of the impacts of the project on the baseline surface water environment.
- References – Section 8: presents a list of the reference documents used for preparation of this report.

2. BASELINE HYDROLOGY

2.1 INTRODUCTION

In order to inform the flood study and to assess the impacts of the project, an understanding of the baseline hydrology is required. This section presents a comprehensive review of various information sources and defines the baseline climatic and hydrological conditions of the site and surroundings.

2.2 CLIMATE

2.2.1 Rainfall

No records of rainfall recorded at the site are available and as such rainfall data from the following sources was reviewed to characterise rainfall patterns at the site:

- Department of Water and Sanitation (DWS).
- Water Resources of South Africa 2012 Study (WR2012).

Average rainfall data for the project area is based on the nearest Department of Water and Sanitation (DWS) managed rain gauge station, which is Vaalplaats (DWS Reference: C2E001) and monthly rainfall data obtained from the Water Resources of South Africa manual, (WR2012) (Table 2-2 and Figure 2-2).

Details for rain gauge stations are summarised in (Table 2-1). The adopted Mean Annual Precipitation (MAP) for the project area is 659.2 mm and was obtained by calculating the average rainfall of the three rain gauges.

Table 2-1: Rain gauge information

Station Name	Distance from site (km)	Orientation	Quaternary Catchment	Recorded period	No of Years	Data Quality
C2E001	23	South	C22K	1930-2018	88	Mostly Complete
0438734 W	7	West	C22F	1926-2004	78	Mostly Complete
0438550 W	8.5	South West	C22J	1942-1991	49	Lots of gaps

Table 2-2: Monthly Average Rainfall

Month	Vaalplaats - C2E001 (mm)	438734 W (mm)	438550 W (mm)	Average (mm)
January	122.1	69.7	64.2	85.3
February	92.3	95.5	95.4	94.4
March	80.3	101.0	105.1	95.5
April	50.9	98.3	122.4	90.5
May	21.1	81.0	74.7	58.9
June	8	75.6	73.1	52.2
July	7.2	41.9	54.2	34.4
August	9.9	18.4	19.5	16.0
September	23.1	6.9	7.5	12.5
October	72.6	5.6	6.5	28.2
November	100.3	7.6	7.4	38.4
December	115.1	22.5	20.8	52.8
Total	702.9	624.1	650.8	659.2

The distribution of total annual rainfall recorded at Vaalplaats – C2E001 (assumed water year starts on 1 August) is presented in Figure 2-1. The Vaalplaats station was selected for the more detailed analysis due to being the longest and most complete rainfall record in the vicinity of the project area.

Figure 2-1: Distribution of Annual Rainfall Totals 1930 – 2018 Vaalplaats

As can be seen from Table 2-2 mean annual precipitation (MAP) is 659 mm. Figure 2-1 shows the large variation in annual rainfall where, half of the years' in the rainfall record experience between 605 mm (lower quartile) and 793 mm (upper quartile) of rainfall. Whilst the driest year experienced only 346 mm of rainfall and the wettest year experienced 1056 mm of rainfall.

A review of daily rainfall records from DWS rain gauge station Vaalplaats provides information on the wettest multi-day periods recorded within the region. The Vaalplaats rain gauge has a daily rainfall record from 1931 through until March 2018 (87 years).

A review of the wettest multi-day periods recorded are presented in Table 2-3, which shows the maximum depth of rain falling over consecutive days ranging from 1 to 180 days. As can be seen, the greatest depth of rain falling within a 30 day period was 377.1 mm which is almost 54 percent of the MAP, whilst the greatest depth within a 2 and 4 month period was 80% and 117% respectively. The 180 day depth was 933.4 mm which is 134% of the MAP. It is concluded that whilst MAP in this area is fairly low there has been significant rainfall on occasions.

Table 2-3: Wettest Periods Recorded on Consecutive Days

Days	Rainfall (mm)
1	158
2	174
3	174
4	177.6
5	184
6	185.5
7	194.9
15	273.1
30	377.1
60	558.3
120	822.3
180	933.4

2.2.2 Evaporation

Average monthly evaporation for the project site is based on the Vaalplaats (C2E001) Symonds Pan, sourced from DWS. Pan evaporation records are from 1931 to March 2018 (87 years), and a pan coefficient is used to convert S-pan evaporation to evaporation from open water such as a dam or pond, as presented in Table 2-4.

Table 2-4: Monthly Average Evaporation – Vaalplaats C2E001

Month	S-Pan Evaporation (mm)	Pan Coefficient*	Open Water Evaporation (mm)
January	178.8	0.84	150.2
February	147.1	0.88	129.4
March	135.7	0.88	119.4
April	102.2	0.88	89.9
May	78.4	0.87	68.2
June	59.2	0.85	50.3
July	64.8	0.83	53.8
August	92.5	0.81	74.9
September	129.1	0.81	104.6
October	161.3	0.81	130.7
November	168.6	0.82	138.3
December	180.1	0.83	149.5
Total	**1497.8**	**N/A**	**1259.2**

* *Surface Water Resources of South Africa 1990 - Volume 1 Appendices. WRC Report 298/1.1/94*

2.2.3 Storm Depth-Duration-Frequency (DDF)

Design storm estimates for the site for various annual probabilities and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002), The software extracts the storm depth-duration-frequency (DDF) data for the six closest rainfall stations, and was used to interpolate DDF data for the project area, as presented in Table 2-5.

Table 2-5: Storm Depth Duration Frequency (DDF) Estimates for the Project Site

Storm Duration	Rainfall depth (mm)						
	1:2yr	1:5yr	1:10yr	1:20yr	1:50yr	1:100yr	1:200yr
15 minutes	15.7	20.9	24.4	27.8	32.3	35.7	39.1
30 minutes	20.0	26.7	31.1	35.5	41.2	45.5	49.8

Storm Duration	Rainfall depth (mm)						
45 minutes	23.0	30.7	35.9	40.9	47.4	52.4	57.3
1 hour	25.5	34.0	39.6	45.2	52.4	57.9	63.4
1.5 hour	29.3	39.1	45.7	52.0	60.4	66.7	73.0
2 hour	32.4	43.2	50.5	57.5	66.8	73.7	80.8
4 hour	38.3	51.0	59.6	67.9	78.8	87.1	95.3
6 hour	42.2	56.3	65.7	74.9	86.8	95.9	105.0
8 hour	45.2	60.3	70.4	80.2	93.0	102.8	112.5
10 hour	47.7	63.6	74.2	84.6	98.1	108.4	118.7
12 hour	49.8	66.4	77.5	88.4	102.5	113.2	124.0
16 hour	53.4	71.1	83.1	94.7	109.8	121.3	132.8
20 hour	56.3	75.0	87.6	99.9	115.9	128.0	140.1
24 hour	58.8	78.4	91.5	104.3	121.0	133.7	146.4
2 day	62.6	83.5	97.5	111.1	128.9	142.4	155.9
3 day	70.7	94.2	110.0	125.4	145.5	160.7	176.0
4 day	76.6	102.1	119.2	135.9	157.6	174.1	190.7
5 day	81.5	108.7	126.9	144.6	167.8	185.3	202.9
6 day	85.7	114.3	133.5	152.1	176.5	194.9	213.5
7 day	89.5	119.3	139.4	158.8	184.3	203.5	222.9

2.3 HYDROLOGICAL SETTING

2.3.1 Introduction

South Africa is divided into 9 water management areas (National Water Resource Strategy, 2013), managed by its separate water board. Each of the water management areas (WMA) is made up of several quaternary catchments which relate to the drainage regions of South Africa.

The Water Resources of South Africa Manual WR2012 (WRC, 2012) shows that the project area falls within the Vaal WMA 5, and all runoff from the project area drains into the unnamed Vaal tributary which drains into the Vaal river and ultimately into the Orange River.

2.3.2 Regional Hydrology

The regional hydrological setting of the project site is indicated in Figure 2-2.

The WR2012 study, presents hydrological parameters for each quaternary catchment, and shows that the project area falls entirely within the quaternary catchment C22F, which has a catchment area of 440 km^2 and a mean annual runoff 9.91 million cubic meters (mcm), draining into the Vaal River.

2.3.3 Topography

Various sources of topographical data for the project area and surroundings were reviewed including:

- Site Topography Data – Lidar data points provided by the client for the project area.
- ASTER GDEM – the Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model features an elevation level taken on a 30 m grid.
- 20 m contours from the 1:50 000 topographical maps of South Africa.

The Project Area is located at elevations between 1440 – 1460 m amsl, the site generally slopes to the south-east.

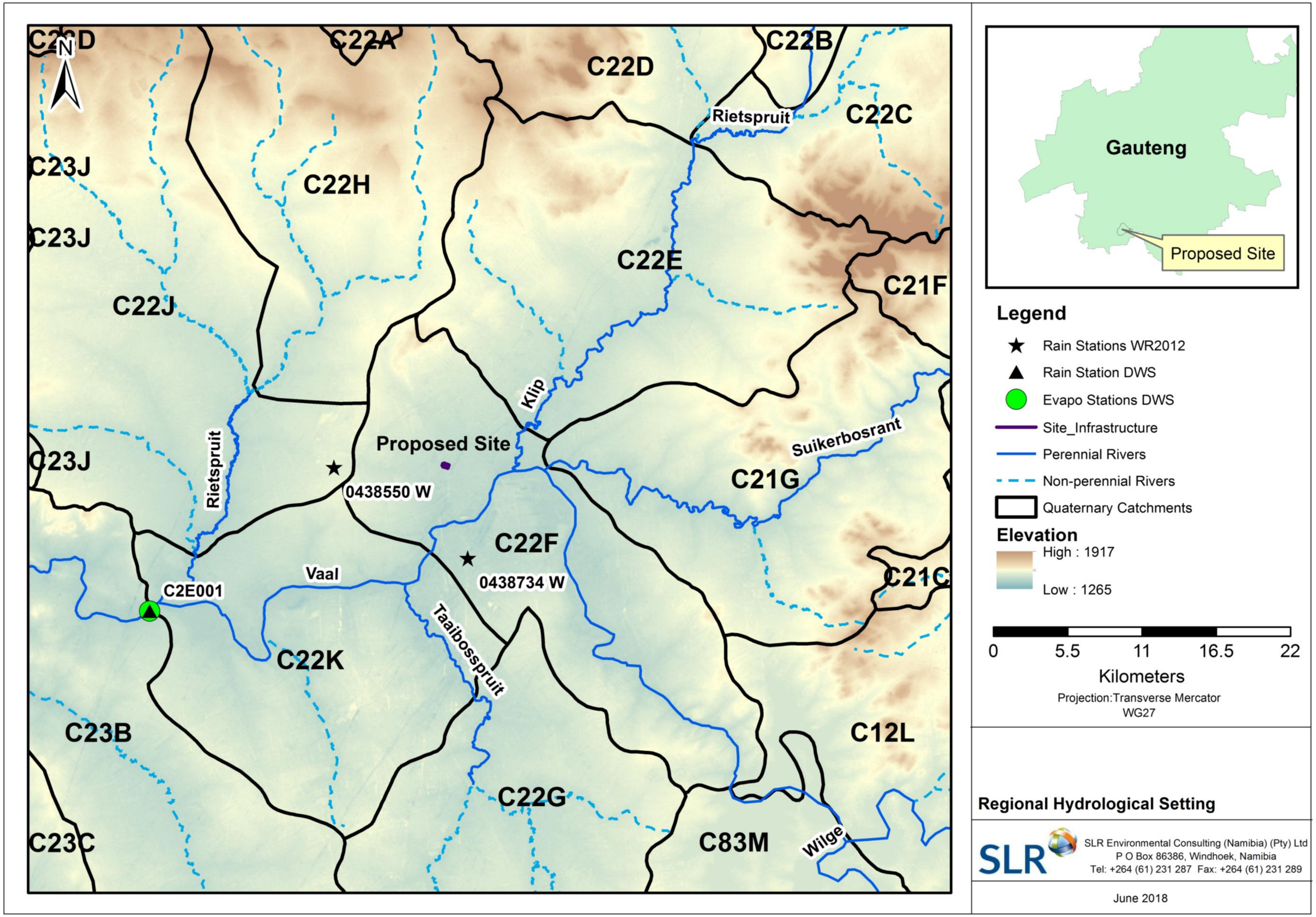


Figure 2-2: Regional Hydrological Setting

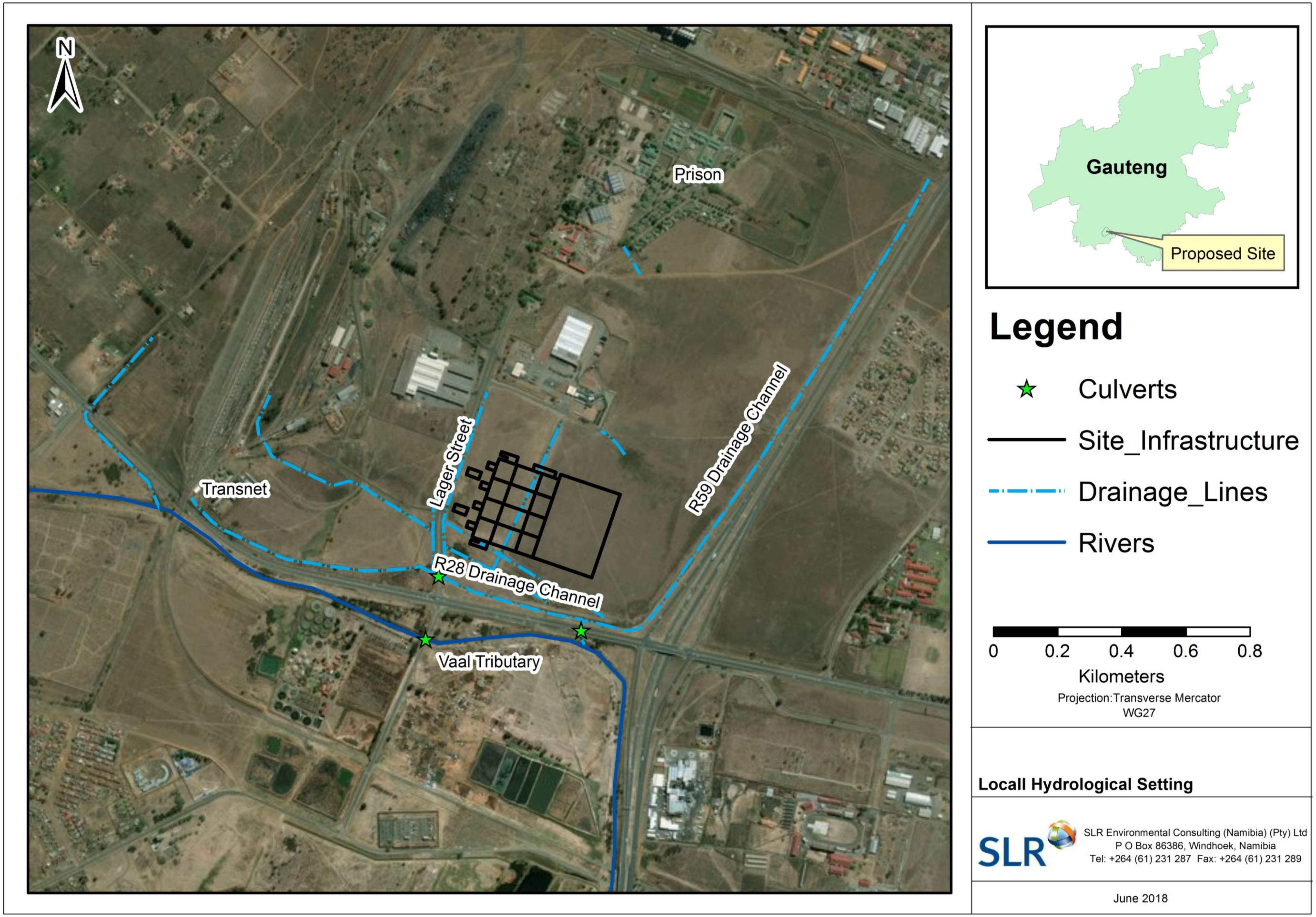


Figure 2-3: Local hydrology

2.3.4 Watercourse Network and Drainage Lines

The Project Site and surrounding areas are reliant on a network of excavated (man-made) drainage channels / drainage features, created to reduce the occurrence of water ponding at the surface, presumably during and following rainfall.

The main drainage features and watercourses in the vicinity of the site are presented in Figure 2-3 and are described as follows:

- R59 drainage channel – a concrete lined drainage channel (Figure 2-4) runs along the western side of the highway, and is assumed to be the receptor for stormwater from the site and the surrounding areas in addition to stormwater from the highway itself. The R59 drainage channel conveys flow to the south-west into the R28 drainage channel (discussed below).

Figure 2-4: R59 drainage channel close to the confluence with R28 drainage channel

- R28 drainage channel – an initially unlined drainage channel starts at the Transnet railway siding 150 m south-west of the site, and flows in an easterly direction along the northern side of the R28, and through a culvert beneath Lager Street (Figure 2-5). East of Lager Street, the channel is concrete lined and continues past the site boundary following the R28 until a culvert which conveys flows to the south, beneath the R28, into the Vaal tributary (Figure 2-3) (discussed below).

Figure 2-5: Culvert under Lager Street

Figure 2-6: Confluence of the R59 and R28 channels flowing underneath the R28 Road

- Vaal tributary – an un-named perennial river which flows in an easterly direction from the Vanderbijlpark industrial area (7km west of the site). This is the largest watercourse within close proximity of the site (~200 m south of the site) and flows along the southern side of the R28, past the Leeuwkuil Water Care Works, through a bridge beneath Lager Street, to a confluence with the R59/R28 drainage channel. Downstream of this confluence, the watercourse is concrete lined and flows in a southerly direction along the western side of the R59 (Figure 2-8), past Leeuwkuil dam to a confluence with Vaal River 4 km south of the site.

All stormwater runoff from the site will ultimately flow into the Vaal River, although the site will represent a very small proportion of the total catchment feeding into these water features.

Figure 2-7: Vaal tributary upstream of the confluence

Figure 2-8: Concrete lined Vaal tributary downstream of the confluence

The site is located in a relatively flat, slightly undulating area with many localised depressions found where stormwater will pond temporarily and infiltrate or evaporate following a storm event. Generally, the site is vegetated with short grasses (Figure 2-9), although the abovementioned depressions are often demarcated by different plant types, which is particularly apparent when reviewing historic aerial imagery taken through the summer months (wet season).

Figure 2-9: Site vegetated with grass cover

2.3.5 Site Drainage and Water Features

As shown on Figure 2-3, the site and surrounding areas feature a network of man-made drainage channels / drainage features to manage stormwater and prevent localised ponding and flooding, a breakdown of which is presented below:

- The northern side of the existing SAB depot features a perimeter drainage channel running around the outside of the fence. Ground levels inside of the SAB site appear to have been raised above the surrounding / natural ground levels outside of the site, presumably to prevent any flooding or inundation of the site during storm events.
- A drainage channel which has been excavated to drain stormwater from the SAB site access road and hardstanding areas within the SAB site runs through the proposed site infrastructure to the south-west, to a local depression which is frequently waterlogged.
- Another man-made drainage runs parallel to site infrastructure to the south of the site carrying water towards the R28 concrete lined drainage channel.

2.3.6 Wetlands

Based on the National Freshwater Ecosystem Priority Areas (NFEPA) wetland GIS metadata (SANBI, 2011) there are no wetlands within the site boundaries.

During the site visit, no unmodified surface water features were identified within the boundary of the site. Several locations within the areas immediately adjacent to the site were found which may remain wet / waterlogged for a period after rainfall events, but none which would be classified as natural surface water features (SAS, 2018).

2.3.7 Vegetation

The WR2012 shows the natural vegetation of the project area to be pure grassveld types. According to the Vegetation Map of South Africa (SANBI, 2006) the natural vegetation type of the quaternary catchment C22F consists mainly of pure grassveld.

2.3.8 Soils and Geology

WR2012 shows the project area to be situated in an area of "Porous unconsolidated sedimentary strata", with soils described as "moderate to deep, sandy loam".

SLR carried out a geotechnical investigation on the proposed site area between the 28th November and 11th December 2017 (SLR, 2018a). A total of twenty two (22) test pits were excavated with an Excavator, CAT 320D. All test pits were excavated to refusal depth or to the maximum reach of the machine.

The soil profile encountered across the proposed site was found to be generally uniform with topsoil described as dry, dark brown, medium dense, intact with some roots present, clayey sand, with thickness varying between 0.3 and 0.7 m. No outcropping sandstone or dolomite bedrock was encountered on site during test pitting (SLR, 2018a). Therefore the surface run-off is expected to be medium to low.

The geology of the site under investigation comprises shale; sandstone; coal and mudstone of the Ecca Group which is part of the Karoo Supergroup. The Karoo sediments, across the site, are underlain by dolomites of the Malmani Sub-group of the Chuniespoort Group, Transvaal Supergroup. The Ecca Group sediments encountered on site during the investigation consisted of intercalated shales and quartzitic sandstone, with the quartzitic sandstone predominating, and some occurrence of mudstone. The dolomite in the area is expected to be encountered at variable depths below the Ecca Group sediments.

2.4 WATER QUALITY

Two surface quality samples were collected from the Vaal Tributary on 20 August 2018 by an SLR specialist at locations, upstream and downstream of the project as presented in Table 2-6 and on Figure 2-10.

Table 2-6: Water Quality Sampling Locations

Site Name	Longitude	Latitude	Description
Upstream (P1)	27.894371°	-26.670107°	Located upstream of the Leeuwkuil Wastewater Treatment Works (WWTW), located 1.5 km south-west of the project site.
Downstream (P2)	27.905570°	-26.672968°	Located downstream of the confluence of the drainage channels from the proposed project area and Vaal tributary

The water quality samples were analyses at a South African National Accreditation System (SANAS) Accredited laboratory (Water Lab located in Pretoria, South Africa) and the results were benchmarked against the following standards:

- South African National Standard - SANS 241:2015 Drinking Water Standards.
- In stream water quality guidelines quality guidelines for the Vaal Barrage Reservoir catchment, 2003 (I-SWQG) from ideal catchments background quality up to unacceptable ranges).
- Target water quality standards set up in the South African Water Quality Guidelines - (SAWQG) 1996, where the Target Water Quality Range (TWQR) equal to the No Effect Range is that it specifies good or ideal water quality instead of water quality that is merely acceptable.
- The wastewater discharge water quality objectives (WQO) applicable to the wastewater discharged from the Leeuwkuil WWTWs into the Vaal River.

These standards fall within the requirements of the IFC Environmental, Health, and Safety (EHS) Guidelines - General EHS Guidelines: Environmental Wastewater and Ambient Water Quality which requires that should local regulatory requirements be available, the residual wastewater and stormwater from industrial processes should be disposed in compliance with these.

Although several parameters were analysed for, only those with published standards within the above have been summarised. The water quality results indicated the following:

- The two sites have very similar water quality for all parameters, despite the downstream location being after the WWTW (although the discharge point of the WWTW is not along this watercourse), and expected to have higher concentrations.
- The electrical conductivity (EC) exceeds all standards except the SANS 241 Aesthetic limits, and this is attributed to the elevated levels of ions, such as chloride, calcium, magnesium, manganese and sodium as detailed below. Furthermore, the elevated EC also translates to elevated total dissolved solids which exceed the SAWQG TWQR for domestic and irrigation use.
    - The elevated chloride, exceed the SAWQG TWQR for domestic and irrigation uses, I-SWQG and the WQO.
    - Calcium exceeded the SAWQG TWQR for domestic, but is ideal for livestock watering.
    - Magnesium exceeded the SAWQG TWQR for domestic uses as well as the Vaal Barrage I-SWQG Management targets.
    - Manganese exceeds the SAWQG TWQR for domestic and irrigation uses, I-SWQG and the SANS 241 for aesthetic limits.
    - Sodium, exceed the, the SAWQG TWQR for domestic and irrigation uses, I-SWQG and the SANS 241 for aesthetic limits.
    - The fluoride level exceeds the WQO and the ideal Vaal Barrage WQG.
- The elevated ions can be attributed to the diffuse anthropogenic sources located upstream of the WWTW where organic salts and inorganic matter can be washed off the streets and or discharge points from industrial sites upstream.
- The poor water quality draining from upstream is also evident in the elevated dissolved organic carbon higher than the 5mg/l SAWQG TWQR for domestic uses which is known to be naturally occurring or originate from domestic or industrial effluent discharges. Although it has no direct health implications, it is an indicator of the organic material content of the water as further supported by extremely high faecal coliforms (>100 000 counts/100ml) rendering the water unacceptable and unsafe for any use. The presence of faecal pollution could be emanating from the upstream communities although some may not be of human faecal origin but are almost definitely from warm-blooded animals.
- Selenium levels slightly exceed the SANS 241 Drinking water chronic limits. Selenium could be emanating from upstream industrial runoff as it is used in a variety of industrial processes i.e.

the manufactures of glass and ceramics, ink and paint pigments, plastics, rubber, photoelectric cells and various alloys.

The water quality results are presented in Table 2-7.

Table 2-7: Water Quality Results

Site Location	Date	Co-ordinates		Electrical Conductivity	pH	Chloride	Flouride	Alkalinity	Nitrate	Sulfate	Faecal Coliforms	Total Dissolved Solids	Dissolved organic Carbon	Aluminium	Arsenic	Boron	Bariun	Berillium	Calcium	Cadmium	Cobalt
				EC	pH	Cl	F	CaCO3	NO3	SO4				Al	As	B	Ba	Be	Ca	Cd	Co
		X	Y	mS/m	-	mg/l	mg/L	mg/l	mg/l	mg/l	Counts/100ml	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
RWQO	IWUL - Imali			<10	6.5-8.5	<25	<0.05	<40	<0.1	<20	0										
In-stream Water Quality Guidelines for the Barrage Reservoir Catchment, 2003	Ideal Catchment Background			<18	7.0-8.4	<5	<0.19	-	<0.5	<20	0										
	Acceptable Management Target			18-30	6.5-8.5	5-50	0.19-0.70	-	<0.5-3.0	20-100	<126			<0.3							
	Tolerable Interim Target			30-70	6.0-9.0	50-75	0.7-1.0	-	3.0-6.0	100-200	126-1000			0.3-0.5							
	Unacceptable			>70	<6.0; >9.0	>75	>1.0	-	>6.0	>200	>1000			>0.5							
SANS 241:2015 Drinking Water Standards	Aesthetic			170	-	≤ 300	-	-	-	250	-	1200	-	-	-	-	-	-	-	-	-
	Operational			-	5-9.7	-	-	-	-	-	-	-	-	0.3	-	-	-	-	-	-	-
	Chronic Health			-	-	-	≤ 1.5	-	-	-	-	-	-	-	0.01	2.4	0.7	-	-	0.003	-
	Acute Health			-	-	-	-	-	≤ 11	≤ 500	0	-	-	-	-	-	-	-	-	-	-
South African Water Quality Guidelines - (SAWQG), 1996- Target Water Quality	Domestic			70	6.0-9.0	100	1	-	6	200	0	450	5	0.15	10				32	5	
	Agriculture: Irrigation			40	6.5-8.4	100	2	-	-	-	1			0.5	0.1	0.5		0.1		0.01	0.05
	Agriculture: Livestock Watering			-	-	1500	2	-	100	1 000	200			5	1	5			1000	0.01	1
	Industrial			-	7.0-8.0	20	-	50	-	500	-	1600									
	Recreational			-	6.5-8.5	-	-	-	-	-	150										
	Aquatic Systems			-	-	-	0.75	-	-	-	-			0.01	0.01						
Upstream P1	Aug-18	27.894371°	-26.670107°	82.3	7.6	133.0	0.3	<5	<0.1	20.0	>100 000	468.0	16.0	< 0.100	< 0.010	0.1	0.3	< 0.010	148.0	< 0.010	< 0.010
Downstream P2	Aug-18	27.905570°	-26.672968°	83.9	7.6	131.0	0.3	<5	<0.1	17.0	>100 000	480.0	14.0	< 0.100	< 0.010	0.1	0.2	< 0.010	216.0	< 0.010	< 0.010

Site Location	Date	Co-ordinates		Chromium	Copper	Iron	Mercury	Potassium	Lithium	Magnesium	Manganese	Molybdenum	Sodium	Nichel	Lead	Antimony	Selenium	Silicon	Uranium	Vanadium	Zinc
				Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Si	U	V	Zn
		X	Y	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
RWQO	IWUL - Imali																				
In-stream Water Quality Guidelines for the Barrage Reservoir Catchment, 2003	Ideal Catchment Background									<8	-		<15								
	Acceptable Management Target					<0.5				8-30	<0.15		15-50								
	Tolerable Interim Target					0.5-1.0				30-70	0.15-0.2		50-100								
	Unacceptable					>1.0				>70	>0.2		>100								
SANS 241:2015 Drinking Water Standards	Aesthetic			-	-	0.3	-	-	-	-	0.1	-	200	-	-	-	-	-	-	-	5
	Operational			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Chronic Health			0.05	2	2	0.006	-	-	-	0.4	-	-	0.07	0.01	0.02	0.04	-	0.03	-	-
	Acute Health			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South African Water Quality Guidelines - (SAWQG), 1996- Target Water Quality	Domestic					0.1	1	50		30	0.05		200		10		20			0.1	3
	Agriculture: Irrigation			0.1	0.2	5			2.5		0.02	0.01	70	0.2			0.02		0.01	0.1	1
	Agriculture: Livestock Watering			1		10	1			500	10	0.01	2000	1	0.1		50			1	20
	Industrial					10					10							150			
	Recreational				0.8						0.18										
	Aquatic Systems														0.0005		0.002				0.002
Upstream P1	Aug-18	27.894371°	-26.670107°	< 0.010	< 0.010	0.05	< 0.010	2.8	0.1	42.0	0.3	< 0.010	201.0	< 0.010	< 0.010	< 0.010	0.05	23.0	< 0.010	< 0.010	0.1
Downstream P2	Aug-18	27.905570°	-26.672968°	< 0.010	< 0.010	0.04	< 0.010	3.9	0.1	66.0	0.2	< 0.010	188.0	< 0.010	< 0.010	< 0.010	0.07	19.8	< 0.010	< 0.010	0.1

Figure 2-10: Water Quality Sampling Sites Location

3. FLOOD HYDROLOGY

3.1 INTRODUCTION

In order to inform hydraulic modelling and flood-line delineation for the site and surroundings, an understanding of the flood hydrology of the watercourse of interest is required.

The following watercourses and drainage channels are modelled:

- R59 drainage channel which flows from north (1.3 km) to south, approximately 300m east of the Project Site, and which is the receptor for stormwater from the R59 highway, SAB Depot and site.
- R28 drainage channel which flows from west to east, approximately 100m south of the Project Site and which is the receptor for stormwater from the site, SAB Depot and from the R28 highway.
- Vaal tributary into which both of the above channels drain. High water levels during a flood event within the Vaal tributary may cause backwater effects that could influence the abovementioned drainage channels and cause flooding near to the Project Site.

The following section details the approach and the methods used in the development of a hydraulic model for the purpose of delineating the flood-lines.

3.2 HISTORIC DATA

There are no flow gauging stations on the Vaal tributary downstream of the site. The two nearest gauging stations are:

- C2H010: on the Vaal River, upstream of the confluence with the Vaal tributary 4km southwest of the project site, which was operational from 1900 - 1922.
- C2H280: 20 km downstream on the Vaal River with no available flow data.

Neither of the above gauging stations is considered useful for estimating peak flows for the Vaal tributary because of the limited available data and size of catchments.

3.3 METHODOLOGY

Peak flows for the smaller catchments (<15km^2) within the study area (presented in Figure 3-2) were estimated using both the Rational Method and the Soil Conservation Service (SCS) methods undertaken within HydroCAD version 10 stormwater modelling package.

Peak flow estimates for the larger catchments (>15km^2) were calculated by the Utility Program for Drainage (UPD) software by taking the average of the Rational, Alternative Rational, Unit Hydrograph, SDF and Empirical methods.

Figure 3-1 presents a conceptualisation of the watercourse network including the Vaal tributary, R28 and R59 drainage channels, for which peak flow estimates are needed to inform the hydraulic flood modelling discussed in section 4. The contributing catchments are shown in green hexagons and the watercourse channel reaches are shown in orange squares.

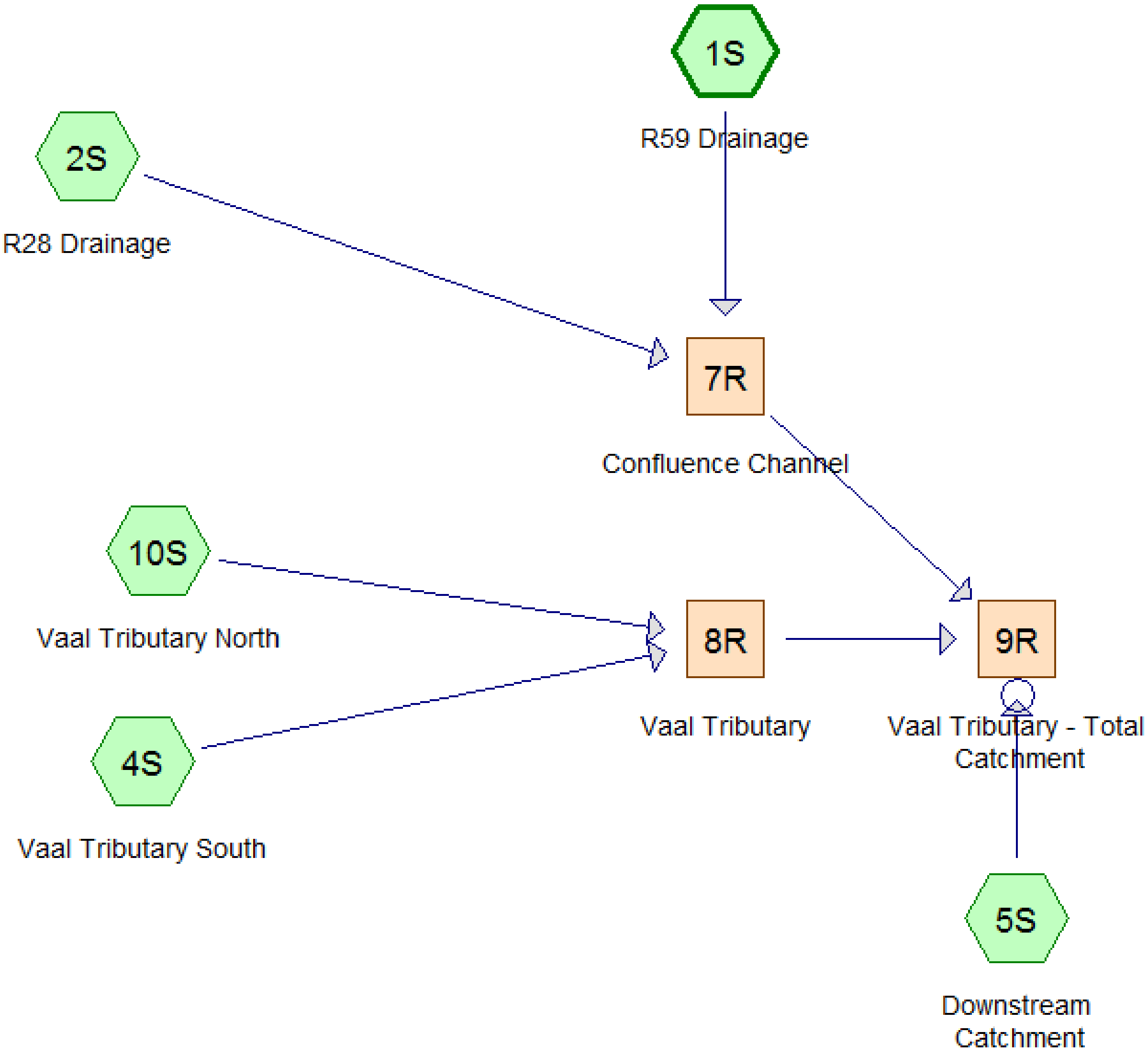


Figure 3-1: Conceptualisation of the Vaal Tributary Catchment

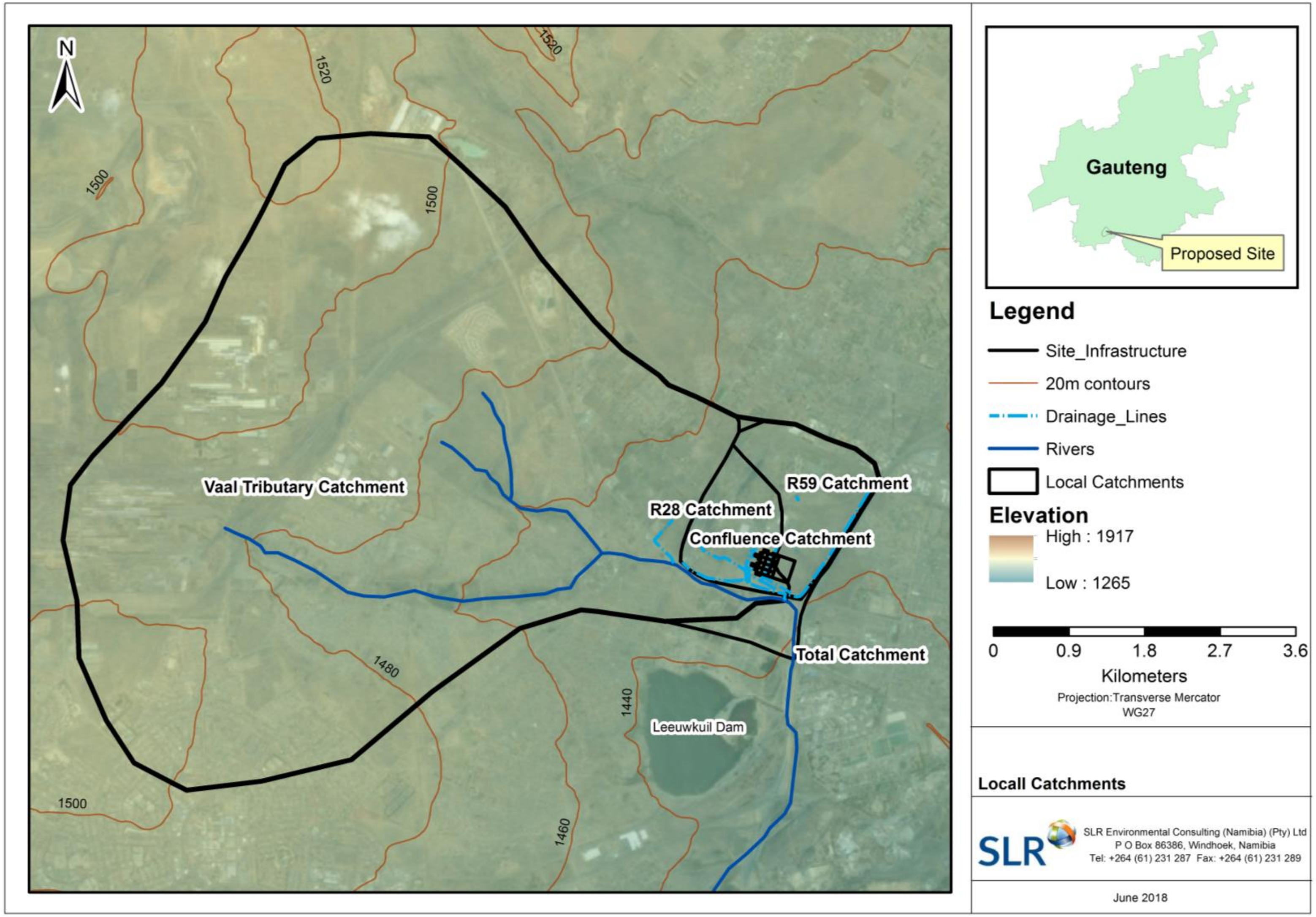


Figure 3-2 Local Drainage Catchments used for flood calculations

The different hydrological calculation methods applied for the peak flow calculations are summarised in Table 3-1 below. These methods are the most used and accepted methods in Southern Africa (SANRAL, 2013)

Table 3-1: Application and limitation of flood calculation methods (SANRAL, 2013)

Method	Input Data	Recommended maximum area (km^2)
Rational methods	Catchment area, watercourse length, average slope, catchment characteristics, design rainfall intensity	Usually <15, depends on method of calculating rainfall intensity
Unit Hydrograph method	Design rainfall, catchment area, watercourse length, length to catchment centroid (centre), mean annual rainfall, veld type and synthetic regional unit hydrograph	15 to 5 000
Standard Design Flood method	Catchment area, watercourse length, slope and SDF basin number	No limitation
SCS-SA method	Design rainfall depth, catchment area, Curve Number = f(soils, land cover) catchment lag	<30
Empirical method	Catchment area, watercourse length, length to catchment centroid (centre), mean annual rainfall	No limitation (Large area)

3.3.1 Time of Concentration

The Time of Concentration (Tc), which represents the rate at which runoff moves through a catchment, was calculated using the SANRAL Drainage Manual for channel and overland flow, as detailed within SANRAL Drainage Manual Sections 3.5.1.4 I and II. In channel flow routing is based on the Manning's Equation and the channel dimensions, roughness coefficient and longitudinal gradients are manually entered for each channel reach, based on a review of topographical data and aerial photography for the watercourse network. Overland flow is applicable to parts were the slope of a catchment is fairly even and where there is no clearly defined watercourse, run-off flows in thin layers over the uneven ground surface.

An aerial reduction factor (ARF) of 95% was applied for the Vaal tributary and Total Catchment (Not for the R28 and R59 catchment calculations which are <10km^2 in area) to account for the catchment specific worse-case storm intensity (when the storm duration = Tc) was used to estimate peak flows.

3.3.2 Input Parameters

The characteristics of each sub-catchment including the time of concentration or lag time for each catchment, and the in-channel travel time between sub-catchments is presented in Table 3-2.

Table 3-2: Flood hydrology – Catchment Characteristics

Name	Area (km2)	Rainfall intensity (mm/h)		Runoff Coefficient		Tc Channel (mins)	Combined Curve Number
		1:50 Years	1:100 Years	1:50 Years	1:100 Years		
R59 Drainage	1.92	40.3	44.5	0.32	0.39	94	68
R28 Drainage	1.44	42.6	47.1	0.34	0.41	85	69
Confluence Catchment	3.36	40.3	44.5	0.33	0.40	94	68
Vaal Tributary Catchment	38.97	23.1	25.5	0.31	0.35	182	N/A
Total Catchment	42.87	22.1	24.4	0.31	0.35	184	N/A

3.4 RESULTS

The peak flows for the points of interest are presented in Table 3-3 and Table 3-4.

Table 3-3: Peak flow estimates – Rational and SCS methods using HydroCAD

Sub-Catchment	Area (km^2)	Rational Method		SCS Method		Average	
		1:50 Year Flow (m^3/s)	1:100 Year Flow (m^3/s)	1:50 Year Flow (m^3/s)	1:100 Year Flow (m^3/s)	1:50yr Flow (m^3/s)	1:100yr Flow (m^3/s)
R59 Drainage	1.92	5.4	9.2	10.8	13.3	8.1	11.3
R28 Drainage	1.44	5.9	7.9	9.2	11.3	7.6	9.6
Confluence Catchment	3.36	12.3	16.5	19.9	24.5	16.1	20.5

Table 3-4: Peak flow estimates – using the UPD software

Sub-Catchment	Rational	Alternative Rational	Unit Hydrograph	Standard Design Flood	Empirical	Average
Vaal Tributary (1:50 Year)	116.5	122.0	111.8	196.1	38.6	117.0
Vaal Tributary (1:100 Year)	162.8	161.4	151.9	248.3	48.3	154.5
Total Catchment (1:50 Year)	127.6	133.5	122.0	214.4	41.6	127.8
Total Catchment (1:100 Year)	178.2	176.5	165.4	271.5	52.1	168.7

3.5 CONCLUSION AND RECOMMENDATION

The peak flows from the Rational Method and SCS Method differ and it is therefore recommended that the average of the two methods is taken to inform flood modelling.

The peak flows from the five different methods used in the UPD software also differ and it is therefore recommended that the average of the five methods is taken to inform flood modelling.

3.6 LIMITATIONS AND FURTHER WORK

It is not considered necessary to undertake any further work to improve upon the peak flow estimates presented above.

4. HYDRAULIC FLOOD MODELLING

4.1 INTRODUCTION

In order to inform the infrastructure layout for the project, understand and manage the risks of fluvial flooding to the operation associated with the R59 and R28 drainage channels, one dimensional steady state hydraulic modelling was undertaken and flood-lines for the Project Site and surroundings were delineated.

As noted previously, understanding influence of the Vaal tributary into which both of the above channels drain, is important as high water levels during a flood event within the Vaal tributary may cause backwater effects that could cause flooding north of the R28 in the vicinity of the Project Site.

The following section details the approach and the methods used for hydraulic flood modelling.

4.2 METHODOLOGY

4.2.1 Choice of software

HEC-RAS 5.0.3 was used for the purposes of modelling the flooding resulting from a 1:50 year or a 1:100 year flood event. HEC-RAS is a hydraulic programme used to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

HEC-GeoRAS is an extension of HEC-RAS which utilises the ArcGIS environment. The HEC-GeoRAS extension is used to extract the cross-sections and river profiles from a Digital Elevation Model (DEM) for export into HEC-RAS for modelling and is used again to project the modelled flood levels back onto the DEM to generate flood-lines associated with the modelled events.

4.3 TOPOGRAPHIC DATA

As discussed in Section 2, a detailed LiDAR survey of the site and surrounding was available and was used to generate a DEM of the site and modelled sections of the R59 drainage channel, R28 drainage channel and the Vaal tributary.

The DEM model forms the foundation for the HEC-RAS model and was used to extract elevation data for the river profile together with the river cross-sections. The DEM was also used to determine placement positions for the cross-sections along the river profile, such that the watercourse can be accurately modelled.

4.3.1 Model extents

The extent of the flood model is informed by the relevant hydraulic features which may impact flood levels in the vicinity of the proposed infrastructure and as such the model extends from 100 m north of the railway line north east of the site and extends 100 metres across the R59 main road as the eastern site boundary. To the south the model extends to cover 1.2 km of the Vaal tributary flowing from west to east on the southern side of the R28 road. A combined total of approximately 4 km of water channels were modelled.

4.3.2 Hydraulic Structures

One of the key objectives of the site visit undertaken was to determine the existence of any hydraulic structures within the modelled reaches, which need to be incorporated into the model. The notable hydraulic structures were (Figure 2-3):

- Bridge 1 – the bridge over the Vaal tributary under Lager Street (Figure 4-1) was input as 2 x 6m wide, 3.5m high box culverts, with a road deck at 0.5m above the top of the culverts.
- Culvert 2 – the culvert of the R28 Drainage channel flowing under Lager Street (Figure 4-2) was input as 2 x 2m wide, 1.8m high box culverts, with a road deck at 1m above the top of the culverts.
- Culvert 3 – the culvert at the confluence of the two concrete lined channels going underneath the R28 to join the Vaal tributary (Figure 4-3) was input as 2 x 3m wide, 2.5m high box culverts, with a road deck at 4m above the top of the culverts.

Figure 4-1: Bridge 1, the Vaal tributary under Lager Street

Figure 4-2: Culvert 2, R28 Drainage channel under Lager Street

Figure 4-3: Culvert 3, confluence of the two concrete lined channels under road R28

4.3.3 Roughness coefficients

The Manning's roughness factor n is used to describe the flow resistance / frictional characteristics of a specific surface. Based on the site visit undertaken, it was observed that R59 drainage channel, R28 drainage channel and the lower part of the Vaal tributary were lined with concrete on good excavated rock but contained some debris and therefore a roughness coefficient of 0.020 was assigned for stream centrelines, while floodplains consists of mostly short grass and was assigned a value of 0.030.

For the upper reach of the Vaal tributary a roughness coefficient of 0.035 was assigned as the stream was straight with no deep pools but contained lots of stones and weeds.

The culverts connected at angles and contained some debris and therefore were given a roughness coefficient of 0.013.

4.3.4 Boundary conditions

The peak flows and boundary conditions for the flood modelling are presented in Table 4-1. The methodology for estimating peak flows are discussed in Section 3, and the gradients for the normal flow conditions were measured from the DEM.

Table 4-1: Peak flows and downstream boundary conditions

Reach	1:50 Year Flow (m^3/s)	1:100 Year Flow (m^3/s)	Upstream Boundary	Downstream Boundary
R59 Drainage Channel	8.1	11.3	Normal Depth S = 0.0046	Confluence Catchment
R28 Drainage Channel	7.6	9.6	Normal Depth S = 0.0046	Confluence Catchment
Confluence Catchment	16.1	20.5	Confluence Catchment	Confluence with Vaal Tributary
Vaal Tributary Catchment	117.0	154.0	Normal Depth S = 0.0071	Confluence Catchment and Vaal Tributary
Total Catchment	127.0	168.0	Confluence Catchment and Vaal Tributary	Normal Depth S = 0.0013

4.3.5 Model Development

Development of the hydraulic model includes the following steps:

- Creation of a DEM from the topographical survey data;
- Generating cross-sections through the watercourses;
- Importing cross-sections, adding hydraulic structures and hydraulic modelling within HEC-RAS to generate flood levels at modelled cross-sections; and

- Importing flood levels and projecting levels onto the DEM to determine the flood inundation areas.

4.4 KEY ASSUMPTIONS

The following assumptions are made:

- Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate, which ignores the effects of storage within the watercourses and is considered a conservative approach;
- The topographic data provided was of a sufficient accuracy to enable hydraulic modelling at a suitable level of detail;
- The peak flow estimates adopted from Section 3 for the modelled events are realistic;
- The Manning's 'n' values used is considered suitable for use in the 1:50 year and 1:100 year events modelled, as well as in representing both the channel and floodplain;
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model;
- No flood protection infrastructure was modelled;
- The modelling of the adopted flow through the respective hydraulic structures was undertaken, whilst assuming no blockages were present; and
- No abstractions from the river section or discharges into the river section were taken into account during the modelling.

4.5 RESULTS

Figure 4-4 and Figure 4-5 presents the 1:50 and 1:100 year flood-lines around the site infrastructure for the R28 and R59 drainage channels in the vicinity of the Project Site.

The 1:50 year flood-lines are mostly narrow and contained in the R59 drainage channel. Some ponding can be observed in the north east at the beginning of the channel. This is due to lower laying ground in the area where water will accumulate after big storm events and evaporates with time. The true water level in this area might be less, the simulations was carried out by assigning the peak flow volume from the beginning of the channel, resulting in higher and more conservative flood-lines for the upper parts of the drainage channel. For the 1:50 year flood event water will be contained within the R28 drainage channel and flow eastwards to the confluence with the R59 drainage channel under the R28 road.

The 1:100 year flood-lines widens closer to the confluence of the R28 and R59 drainage channels under the road. The high water levels in the Vaal tributary causes backwater effects, thereby impeding the flow within the R59 and R28 drainage channels, and causing flooding of low lying areas to the south and east of the Project Site.

The entire infrastructure of the proposed project is situated outside of the 1:100 year flood-lines.

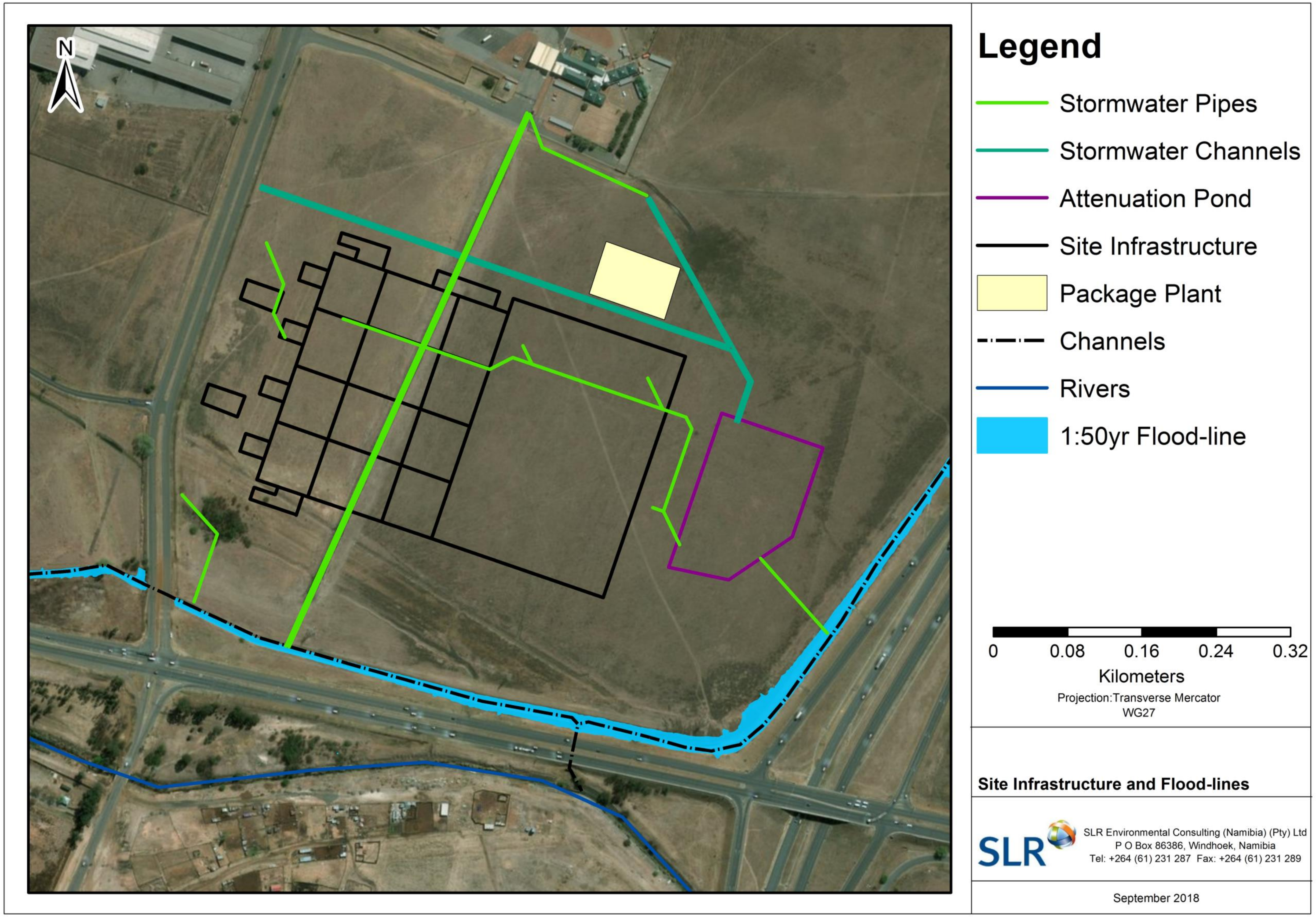


Figure 4-4: 1:50yr Flood-lines and infrastructure

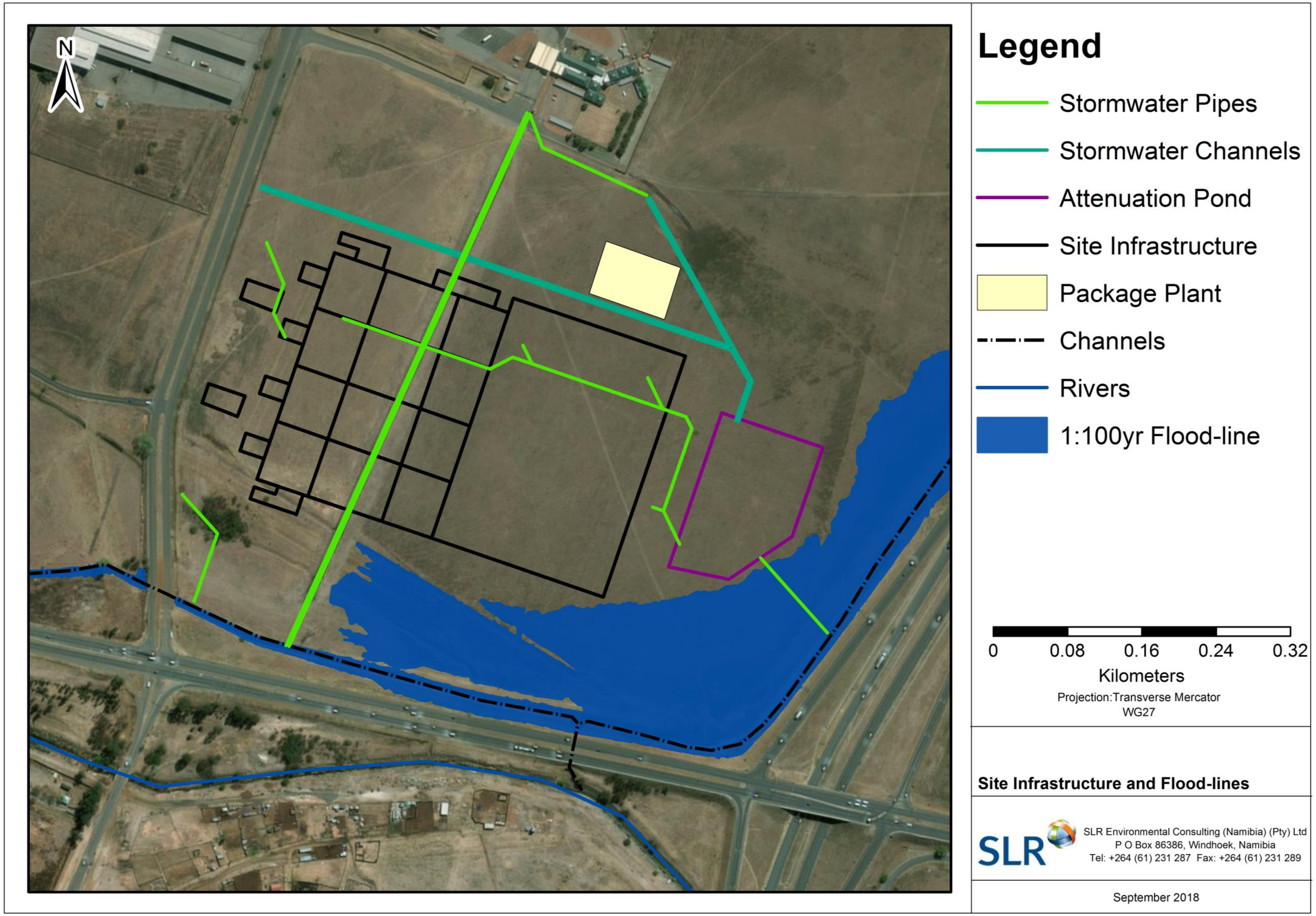


Figure 4-5: 1:100yr Flood-lines and infrastructure

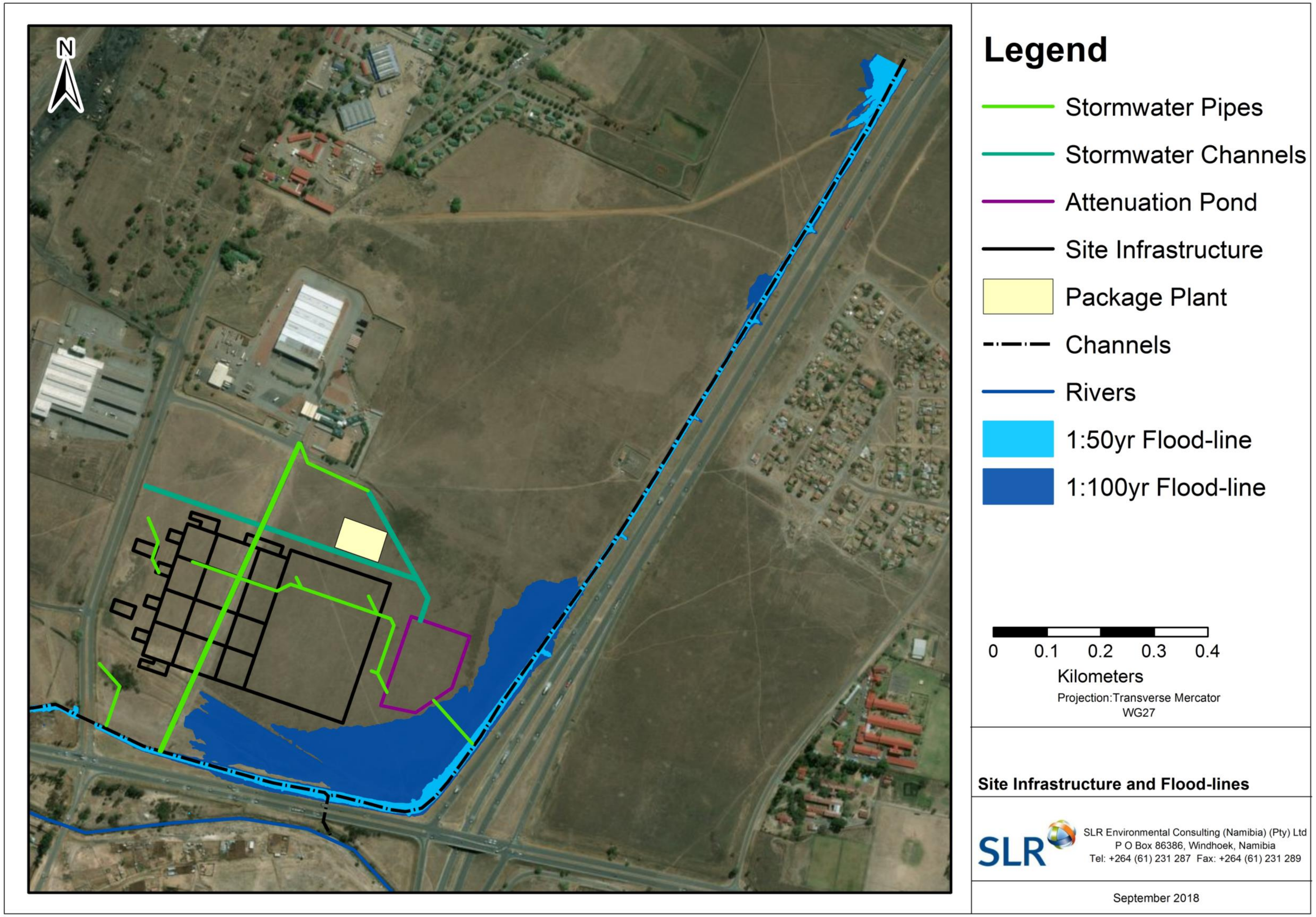


Figure 4-6: Flood lines in the proposed plant area

4.6 CONCLUSION AND RECOMMENDATIONS

As presented in Figure 4-5, the proposed site infrastructure will be located outside of the 1:100 year flood-lines from both the R59 and R28 drainage channels, thereby ensuring that there is no risk of fluvial flooding.

4.7 LIMITATIONS AND FURTHER WORK

Steady state hydraulic modelling was undertaken, which assumes the flow is continuous at the peak rate. This is a conservative approach as is ignores the effect of storage within the system and therefore produces higher flood levels than would be expected to occur in reality. In addition to pure conveyance, in-channel and floodplain flood storage exhibit a large influence on flood levels and floodplain extents within the low gradient watercourses such as the study catchment. As such, the steady state modelling will result in worse case (conservative) estimates of flooding, and resultant flood levels and floodplain extents would decrease if unsteady state modelling were undertaken using an inflow hydrograph as opposed to continuous peak flow.

The high resolution topographical data available has allowed an accurate hydraulic model to be developed and the flood-lines, whilst conservative, are considered to be robust and fit for purpose. No further work is considered necessary.

5. WATER MANAGEMENT

In order to inform the impact assessment a review of the proposed water management principals and infrastructure designs is presented below.

5.1 STORMWATER MANAGEMENT

5.1.1 Introduction

The stormwater management (SWMP) plan was developed by SCIP Engineering Group (Pty) Ltd and addresses the stormwater management within the project area.

5.1.2 Stormwater Management Principals

Runoff Reduction

Two types of storms were considered during the development of the SWMP namely, storms of low and high severity. The main focus of the SWMP is predominantly for the low severity, but high frequency storms.

The current soil channel that conveys stormwater from the elevated SAB Depot to the north of the proposed site will be diverted and directed along the northern perimeter of the site into the proposed attenuation pond.

Any place in the site boundaries where ponding occasionally occurs will be addressed by sloping the natural ground level when developing the site.

Stormwater generated by the site will mainly be conveyed to the attenuation pond after which it will be discharged into the R59 concrete lined channel at pre-development or greenfield rates (for the 1:25 year return period storm) to ensure the impacts of increased hardstanding, including increased downstream flood risk, are mitigated.

Water Quality Treatment

Only clean storm water will be released from the plant. All potentially dirty operational areas will be under roof or isolated with dedicated catchments and sumps. All effluent from the plant will be conveyed through the package sewage plant and all necessary precautions will be implemented in order to ensure that no plant effluent will drain into the storm water system.

Water Quantity Management

Stormwater drainage will be managed on the ground surface, whereafter an underground piped drainage system not smaller than 450 mmØ will be installed for the 1:5 years return period storm. The accumulated run-off from each catchment area will be conveyed by means of the underground pipeline system and a proposed channel. This channel will then discharge into a new attenuation pond. The existing storm water channel running through the site will be diverted and directed along the northern perimeter of the site. The stormwater from this channel will be discharged into the new proposed attenuation pond.

5.1.3 Design Standards

Attenuation Pond

Attenuation ponds are designed to balance the difference in flow between the pre-development and post-development storm water run-off, for the 1:5 and 1:25 year return period storms respectively.

The final pond size will accommodate a volume of 350 m^3/ha or the 1:25 year post-development run-off accumulated by the site, whichever is the greatest. According to the SWMP, the attenuation pond overflow will accommodate the 1:50 year flood, while storage is calculated using the 1:25 year post-development run-off, the pond will cover an area of 12 500 m^2 with a maximum depth of 1m.

Stormwater Management Plan

The design standards used for the SWMP are in line with the Emfuleni Municipal standards and are summarised below (SCIP, 2018):

- Size stormwater pipes for the 1: 5 year pre-development flood;
- Piped system should have 450 mm diameter as minimum pipe diameter and should be placed within the road reserves;
- All pipes to be concrete pipes with SABS 677 specification;
- Maximum stormwater velocity in pipelines should be 4.5 m/s and 3 m/s on the roads;
- Minimum stormwater velocity in pipelines should be at least 0.8 m/s and a minimum gradient of 0.5% should be maintained;
- The minimum kerb inlet length should be 1800 mm;
- Channels should be designed for gradually varied flow (adjusting the dimensions, velocity and slope of the channel accordingly);
- Energy dissipation should be considered during design to protect the existing environment in and around channels as well as at the outlet structures of pipes and ponds;
- Attenuation pond capacity should not be less than 350 m^3/ha and should be able to hold the 1: 25 year post-development flood;
- The overflow at the attenuation pond should be able to handle the 1:50 year flood;
- Attenuation ponds should be grassed (side slopes 1:3) and fenced off;

- Attenuation ponds should not be deeper than 1.5 m if possible; and
- All services will be in accordance with the Guidelines for Human Settlement Planning and Design (Red Book).

5.1.4 Conclusion and recommendation

The stormwater drainage will consist of surface flow, a piped stormwater network, a new concrete lined channel and a new attenuation pond (Figure 5-1)

Figure 5-1: SWMP for the proposed site (SCIP, 2018)

5.2 WATER CIRCUIT

5.2.1 Introduction

In order to understand the impacts of the development on the baseline conditions, a review of water uses and discharges has been undertaken the findings from which are presented below.

5.2.2 Water Management Principals

The water circuit includes water consumption, waste water and water losses for the following operations:

- Industrial water consumption;
- Cooling tower loss;
- Utilities; and
- Storage water.

Estimated Water Consumption

All water will be obtained from the municipal supply, a water use summary for fresh water consumption is provided in Table 5-1.

Table 5-1: Water Consumption (ABInBev, 2018)

Summary	Water Consumption (m^3/h)
Required maximum flow rate after one (1) furnace	15,70
Required maximum flow rate after two (2) furnaces	14,10
Required normal operation flow rate for both furnaces	29,80
Required flow in case of no electricity	47,53
Required maximum flow rate for both furnaces (Everything on max at same time)	67,60

In addition provision is made for a combination of 1 000 m^3 on-site water storage for industrial and fire water as well as 82 m^3 and 120 m^3 for cooling and cullet water respectively.

Water Treatment and waste

The effluent water quantities are summarised in Table 5-2

Table 5-2: Effluent quantities

Summary	Effluent quantity (m^3/h)
Social effluent (Average)	5,00
Process effluent (Average)	2,50

A summary of the water balance is presented below:

- Water supplied = 67.6m^3/hr
- Social effluent = 5m^3/hr

- Process effluent = 2.5m^3/h
- Additional water loss = 60.1m^3/h

6. DISCHARGE ASSESSMENT

6.1 INTRODUCTION

The pre-development flood-lines for the Project Site and surroundings were delineated based on a 1:100 and 1:50 year peak flows and are presented in Section 4. These were used to inform the infrastructure location, understand and manage the risks of fluvial flooding to the operation associated with the R59 and R28 drainage channels.

Attenuated stormwater would be released into the existing channel along the R59 (see Section 5.1). Treated domestic sewage would either be used for irrigation purposes and/or discharged to the environment. The discharge point is likely to be into the existing channel along the R59. It is understood that the municipality may not authorise discharge of sewage effluent even if it is treated. Thus, irrigation with the sewage effluent is an alternate option, unless an understanding can be reached in order to discharge the treated effluent into the storm water system.

Assuming that all treated effluent is discharged to the environment via the existing channel along the R59 (worst-case discharge volumes), the discharge flow rates from the project, as provided from the designs and SWMP, would be as follows:

- Treated Sewage Effluent = 200 kl/day (0.0023 m^3/s).
- Stormwater attenuation pond outflow = 6.5 m^3/s.

As shown above the treated sewage effluent from the project would be small relative to the overall stormwater discharge into the R59 channel. For the purposes of understanding the impact of the additional flows on the project and existing infrastructure this flow has been added to the stormwater discharge. It is additionally noted that a second project may be independently developed on the adjacent property. This development, known as Project Jordan could potentially have the following discharge flow rates:

- Stormwater attenuation pond outflow = 6.45 m^3/s
- Treated Sewage effluent = 6 kl/day (0.000069 m^3/s)
- Treated Industrial effluent = 5652 kl/day (0.065 m^3/s)

The assessment presented here investigates the potential impact of both project's discharges on peak flows.

From a potential pollution perspective, any discharge to the environment would meet discharge standards before being released and would be done in line with applicable approvals

6.2 ASSUMPTIONS

The following assumptions are made:

- The steady state hydraulic modelling as undertaken in Section 4 remained unchanged as the base model with peak flows adopted from Section 3 for the modelled events are realistic;
- The Manning's 'n' values used is considered suitable for use in the 1:50 year and 1:100 year events modelled, as well as in representing both the channel and floodplain;
- A mixed flow regime which is tailored to both subcritical and supercritical flows was selected for running of the steady state model;
- No flood protection infrastructure was modelled;
- The modelling of the adopted flow through the respective hydraulic structures was undertaken, whilst assuming no blockages were present; and
- Discharges into the drainage channel from Project Site and Project Jordan were taken into account as additional high velocity inflows during the modelling.

6.3 REVISED FLOW AND RELATED FLOOD-LINES

The flow data changes modelled are presented in Table 6-1 below, with the inflow river stations RS 1059.994 for the proposed potential upstream Project Jordan inflows and RS 419.8976 for the Glass Bottle manufacturing plant inflows from the respective storm water attenuation dams.

Table 6-1: Flow data and location of flow data changes (with flows from the two storm water attenuation dams included)

Channel	River Station (RS) *	1:50 flow m^3/s	1:100 flow rates m^3/s
R59 Drainage Channel	1820.063	8.1	11.3
R59 Drainage Channel	1059.994	14.6	17.8
R59 Drainage Channel	419.8976	21.1	24.3
R28 Drainage Channel	639.9999	7.6	9.6
Confluence Catchment	68.20753	29.1	33.5

Channel	River Station (RS) *	1:50 flow m^3/s	1:100 flow rates m^3/s
Vaal Tributary	1080	117.0	154.5
Total Catchment	392.4659	140.8	181.7

*this is the river station on the channel where the flow is introduced HECRAS boundary conditions

The proposed stormwater discharge (6.5 m^3/s) from the Glass Bottle manufacturing plant contributes 58% more flow to the 1:100 peak flow of 11.3 m^3/s into the R59 channel. Combined with the additional discharge from the Project Jordan (6.5 m^3/s), the flows in a 1:100 year storm event will double.

The data illustrates that upstream on the R59 drainage channel, the discharges will not significantly alter the floodlines (as presented in Figure 6-1), the 1:100 flow and discharge from Jordan operations into R59 is contained without overtopping the channel.

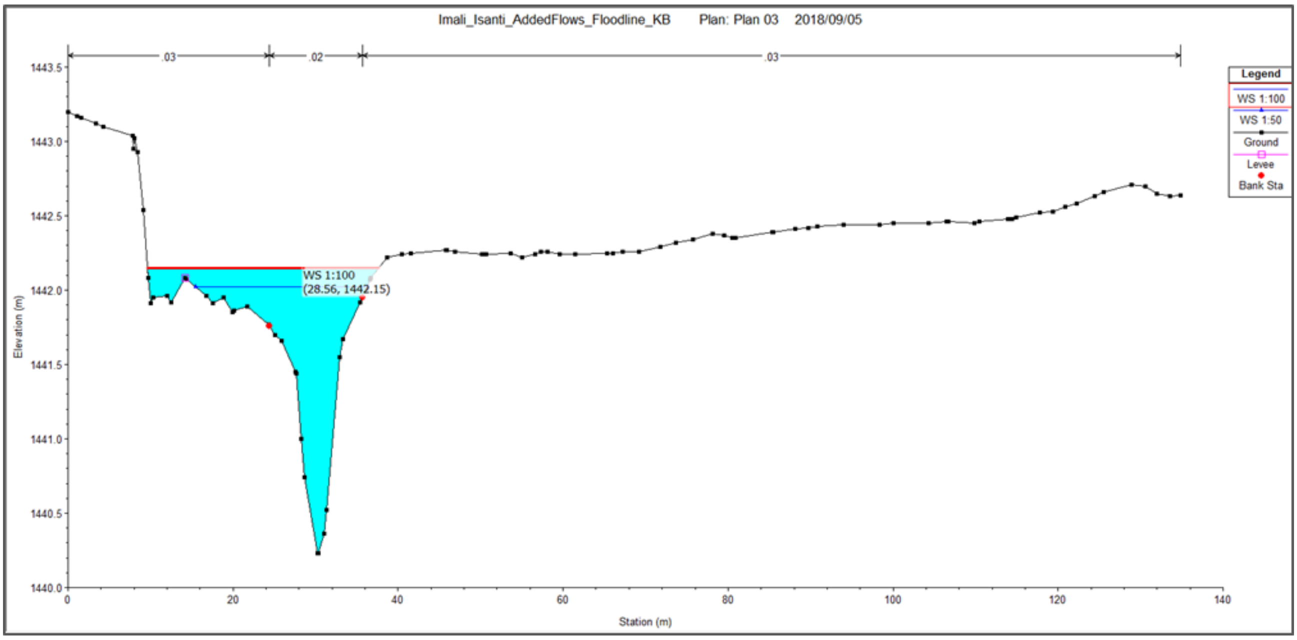


Figure 6-1: Cross-section at River Station 1059.994

Further downstream, the flood water surface and levels (floodlines) are wider, overtopping the R59 channel as shown in Figure 6-2 at a cross section 419.89. The flood water levels reach a maximum water surface elevation of approximately 1441.07 mamsl.

The R28 Drainage channel is also overtopped with the maximum water surface elevation reaching approximately 1440.94 mamsl. This could result in the project's attenuation pond as well as the south eastern corner of the Glass Bottle manufacturing plant site being flooded in the 1:100 year flood lines.

The flood lines overtopping was observed in the initial flood-lines presented in Section 3 and Section 4 (1:50 and 1:100 peak flows) before the discharge and therefore the discharge (from both projects) resulted in an increase in water surface elevation between 20 to 45 cm.

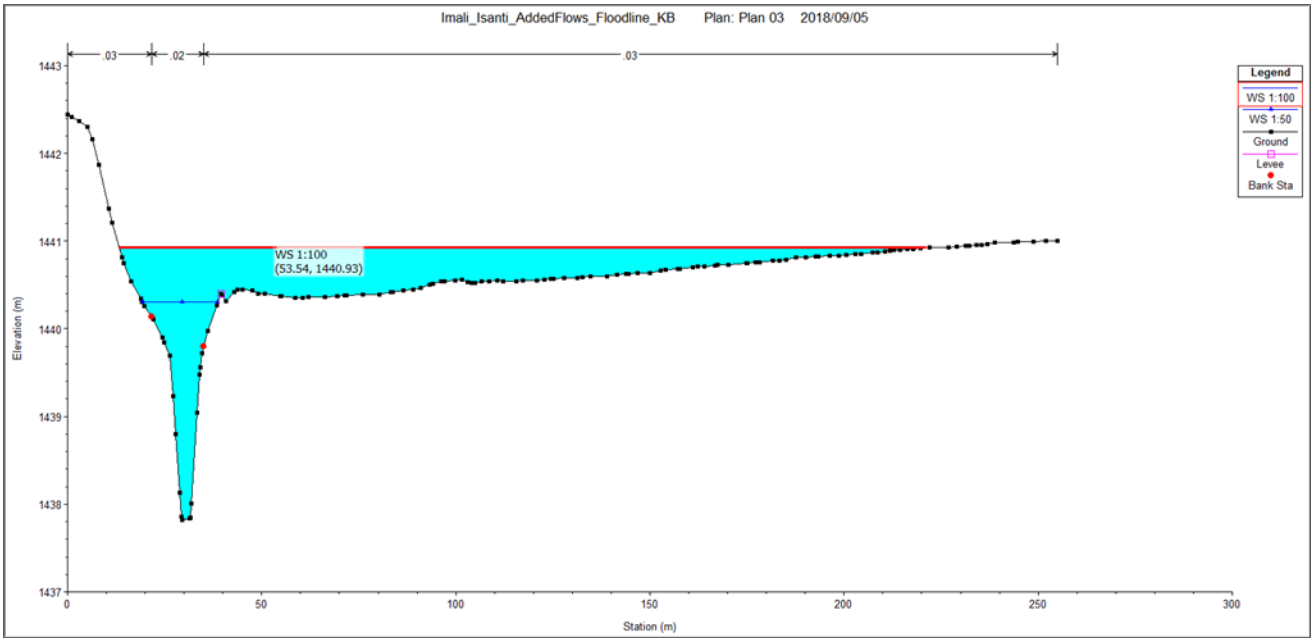


Figure 6-2: Cross-section at River Station 419.89

The potential extent of the 1:50 and 1:100 with the additional discharges (from Project Jordan and the Glass Bottle Manufacturing Plant) is presented in

Figure 6-3 .

6.3.1 Attenuation Outflow reduction assessment

Informed by a scenario analysis the outflows from the attenuation pond to the R59 channel can be reduced such that when combined with the 1:100 pre development flood peaks, the infrastructure does not flood.

Table 6-2 summarises scenarios and conclusions made based on comparison of general ground surface elevation and the HECRAS modelled water surface elevation.

Table 6-2: Summary of the discharge scenarios mitigation measures

Component	Current Base Case – (m^3/s)	Scenario 1- 25% reduction (m^3/s)	Scenario 2 - 50% reduction (m^3/s)	Scenario 3 - 75% reduction (m^3/s)
Discharge from potential Project Jordan	6.45	5.0	3.3	1.7
Discharge from Glass Bottle manufacturing	6.5	5.5	3.3	1.6
Conclusion	Potential Flooding	Potential Flooding	Potential Flooding	No flooding

In the case where Project Jordan is not developed, it is likely that a reduction of the discharge rate from the Glass Bottle manufacturing plant's attenuation pond to less than 3.5 m^3/s would prevent real change to the pre-development floodline.

If both the Glass Bottle manufacturing plant and Project Jordan are developed, it is likely that a 75% decrease of the anticipated discharge rate from the attenuation ponds would be required to prevent change to the pre-development floodlines (i.e. no project infrastructure would be flooded). To achieve substantial reductions in the stormwater outflow rate would require significantly larger attenuation ponds, which would occupy much larger areas.

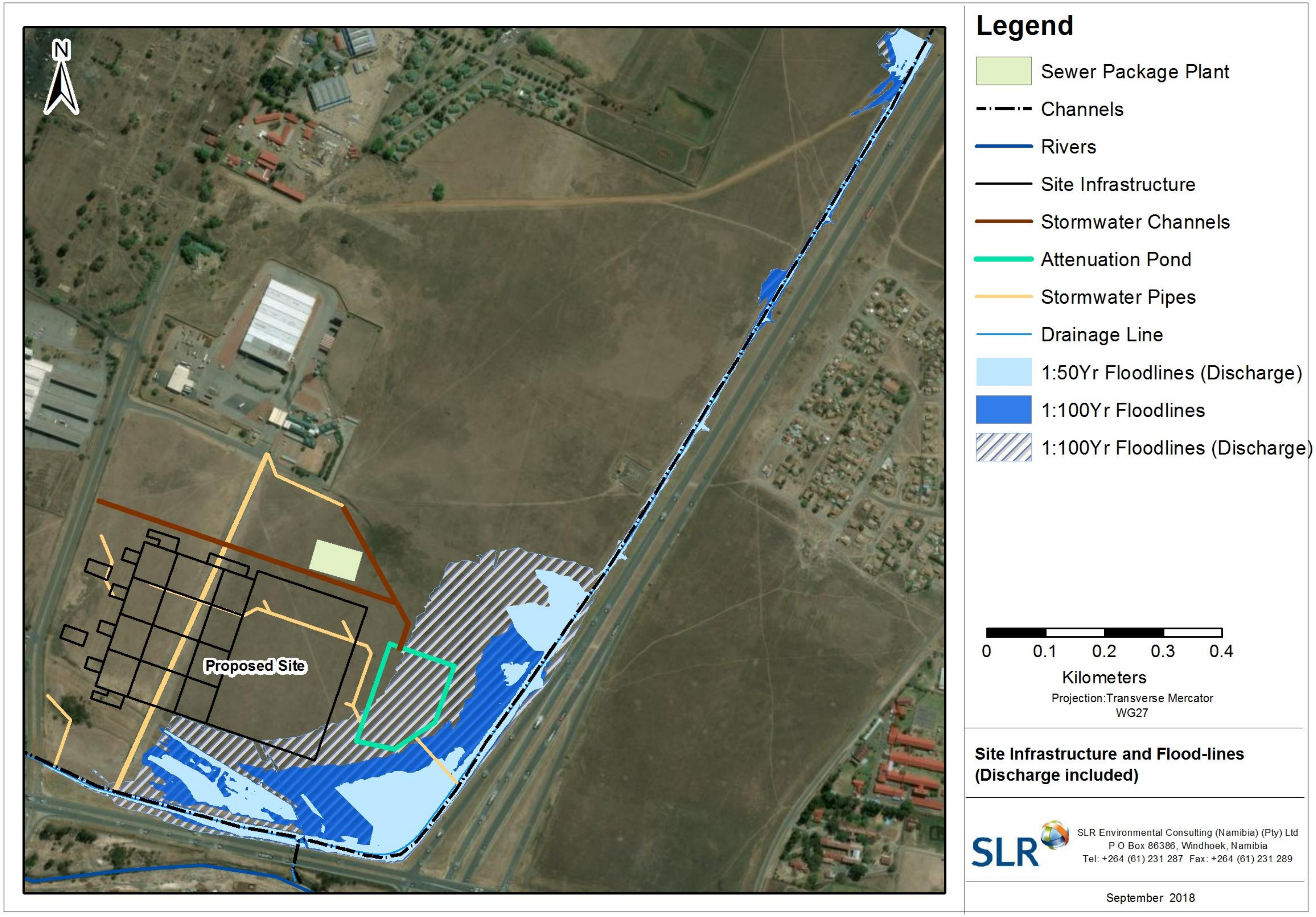


Figure 6-3: Post development Flood-lines and infrastructure

6.4 RECOMMENDATIONS

To minimise or reduce chances of the site being inundated, as informed by the flood-lines determined for the 1:100 storm event with discharges from both projects, the following could be considered.

- Raising the plant platform to at least 1441.07 m amsl which is approximately 0.82 cm above the average natural ground level in the south western portion of the site.
- Clad the outer embankments of the storm water attenuation pond to protect them from erosion in from fluvial flows.
- Raise the embankments of the storm water attenuation pond to above 1441.07 m amsl on the R59 side and above 1440.9 m amsl on the R28 side.
- Reduce the outflows from the attenuation pond to the R59 channel (see analysis in Section 6.3.1 above).

6.5 DISCHARGE CHANNEL DESIGN

6.5.1 Design Standards

Informed by the proposed discharge rates and project's local topography, the channel to discharge effluent (potentially) and stormwater from the site to the existing channels is designed. The channel was sized using the Manning's equation to ensure that the flow capacity of the channel is enough to convey a maximum discharge flow of 6.6 m^3/s and the channel sizing uniform along their entire length. If the outflow from the attention pond is reduced then the size of the channel can be reduced.

The channel should be lined with low permeability material or concrete lined to be able to resist erosion.

6.5.2 Recommended Channel Design

The typical cross section of the discharge channel size, in order to accommodate the design flows, is presented in

Table 6-3 together with the illustration of the channel cross section shown in Figure 6-4.

Table 6-3: Discharge Channel Design Characteristics

Channel Shape		Trapezoidal
	Unit of measurement	
Design flow	m^3/s	6.6
Left side slope	m	2
Normal depth	m	1
Right side slope	m	2
Bottom width	m	2.5
Channel Slope	m/m	0.002
Roughness Coefficient (n)	$s/m^{1/3}$	0.015
Top width	m	3.5
Flow Area	m^2	3
Wetted Perimeter	m	4.736
Hydraulic Radius	m	0.4
Velocity	m/s	2.2
Flow Type	m^3/s	Subcritical

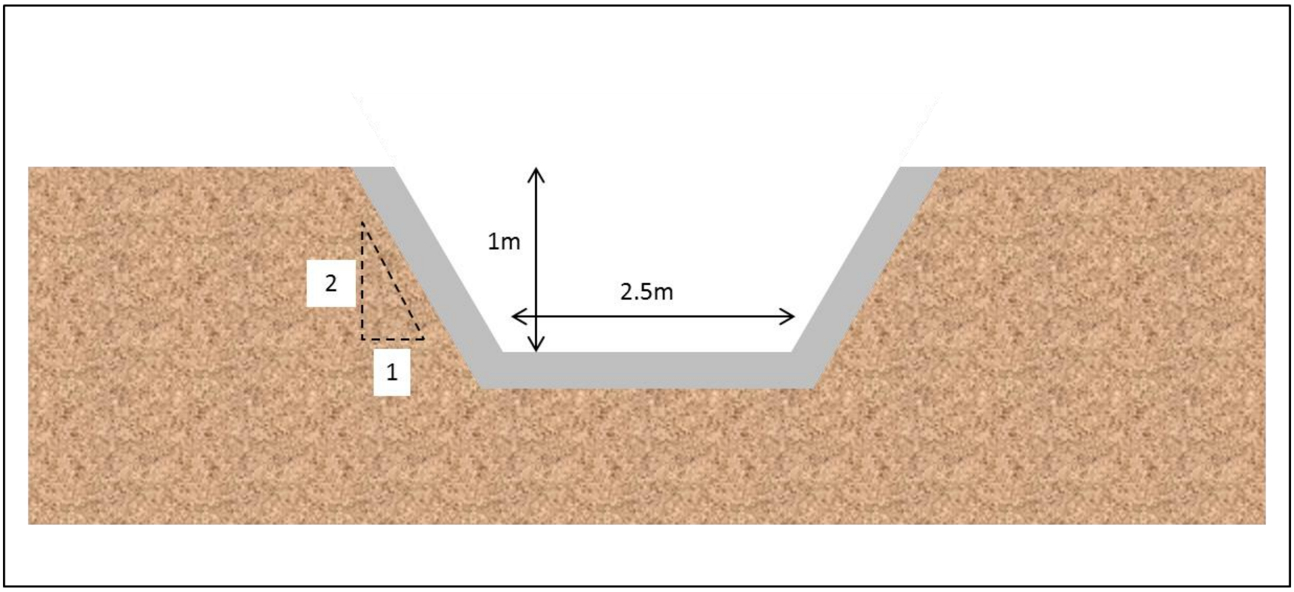


Figure 6-4: Discharge Channel Design

It is important that the channel slope should allow for uniform flow away from the site as much as is possible, and prevent backwater effect at the Project Site. At the same time velocity control may be necessary at the outlet into the existing R59 channel, to prevent channel degradation and erosion and should be investigated during detailed design when the invert levee and channel slopes are finalised..

6.6 CONCLUSIONS

The projects' discharge flows under the 1:100 year return event of approximately 6.6 m^3/s (comprised largely of stormwater) is anticipated to increase the flood water level in the existing channels by approximately 20 to 30 cm. When combined with the increased flows from Project Jordan (approximately 6.5 m^3/s) the discharges under the 1:100 year return event are expected to increase the flood water level at the project site by as much as 45 cm. The increase flood water heights can largely be attributed to the increased post-development stormwater flow rates combined with backwater as a result of the downstream culvert and the Vaal tributary. The attenuation pond and the most easterly portion of the glass bottle manufacturing plant's warehouse would be within the post-development 1:100 year floodline.

6.7 RECOMMENDATIONS FOR FURTHER WORK

It is recommended that the channel lining are confirmed during the detailed design to account for finer variation in the channel gradient which may impact upon the water depth and channel velocities.

It is recommended that maintenance of the channel should be undertaken throughout its operation to ensure design flows.

7. IMPACT ASSESSMENT AND MITIGATION

This surface water study report presents a comprehensive description of the baseline hydrology of the site and surroundings which may be impacted by the proposed project. The site layout and project infrastructure has been reviewed in the context of the baseline hydrology to identify unmitigated impacts. The project infrastructure includes various mitigations by design measures, and where considered necessary a series of additional mitigation measures are recommended to ensure residual impacts of the project are minimised.

The potential unmitigated impacts (unrealistic worse-case scenario), and residual impacts of the project after considering the mitigation measures proposed within this report are qualitatively assessed and presented in Table 7-1.

Table 7-1: Qualitative Impact assessment

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Pre development - no discharges considered						
Impact on availability of Surface Water Resources - Unmitigated	The project's water will be supplied only by municipal infrastructure (a licensed water supplier), who will be responsible for assessing and monitoring the impacts of abstraction on surface water resources separately. No water will be abstracted from nearby surface water resources. The project will therefore not directly have an impact on the surface water resources availability within the project's catchment area.					

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Alteration of drainage patterns causing flood risks - Unmitigated	The project will introduce large areas of impermeable land cover, which could if not mitigated, increase the volume/speed of runoff generated during a storm event. This could result in the flooding of downstream systems (flash floods). Without considering the flood-lines the site could have a high severity impact on drainage patterns, by locating infrastructure within the flood-lines. Where any discharges take place (depending on the discharge flow and rate) this could influence flood-lines in the vicinity of the project site, contributing to the risk of flooding. Where developments take place downstream of the site and within the same sub-catchment, discharges (depending on the discharge flow and rate) could increase the risk of flooding to those developments.	Impacts will be for a short period, only during / following flood events, Very Low	Impacts could stretch downstream - Medium	Medium	Without mitigation there could be a high probability of impacting the baseline flows downstream.	Medium

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Alteration of drainage patterns causing flood risks - Mitigated	A stormwater management plan has been developed to ensure that post-development stormwater flows do not exceed pre-development flows up to 1:25 year. An attenuation pond will be used to balance the increased runoff volumes generated by the project. Site infrastructure is located outside the 1:100 flood-lines. Release rates of attenuated stormwater under the 1:100 year event should not exceed 3.5 m^3/s (if the only major infrastructure), or 2 m^3/s if other development is planned. Alternatively, elevate the plant platform by ~ 80 cm (at the lowest elevation). Upgrading of storm water channels, if required, should be considered in consultation with other developers.	Impacts will be for a short period, only during / following flood events – Very Low	Would be restricted to the pre-development flood-lines – Very Low	Very Low	Probability of impacts is Low	Negligible

Issue	Severity	Duration	Extent	Consequence	Probability	Significance
Impact on Quality of Surface Water - Unmitigated	Without mitigation, the project could have a severe impact on surface water quality by earth works, spillages of hazardous materials, construction of the discharge channel, discharge of effluent or discharge of dirty stormwater runoff	Impacts could be long term for the lifetime of the project - High	Impacts could stretch far downstream - high	High	Without mitigation there could be a high probability of impacting the quality of surface water resources.	High
Impact on Quality of Surface Water -Mitigated	During earthworks and construction of the discharge drainage channel, implement erosion control measures and schedule the construction to be completed within the dry season. This would result in a low severity impact. Ensure containment of hazardous materials and implement spill response and clean up. With the implementation of a stormwater management plan and effluent treatment (to meet discharge limits) prior to release to the environment, the site will have a low severity impact on downstream surface water quality.	The overall low impacts will continue for the life of project	Impacts will be local only	Low	Probability of impacts are Low	Low

8. CONCLUSIONS

The surface water study includes a baseline hydrological assessment, flood study, review of the conceptual stormwater management plan and water circuit for the proposed infrastructure to ensure compliance with best practice and relevant legislation.

The project area falls entirely within the quaternary catchment C22F, which has a catchment area of 440 km^2 and a mean annual runoff 9.91 million cubic meters (mcm), draining into the Vaal River. The Project Site and surrounding areas are reliant on a network of excavated (man-made) drainage channels / drainage features, created to reduce the occurrence of water ponding at the surface, presumably during and following rainfall. The man-made channels include the R59 drainage channel, which runs along the eastern side of site and the R28 drainage channel, running along the southern boundary of the site. These channels join, and then pass through a culvert which conveys flows beneath the R28 road into an unnamed perennial tributary of the Vaal River, which is concrete lined at the confluence.

Two surface quality samples were collected on 20 August 2018 by an SLR specialist at locations, upstream and downstream of the project. Water quality samples were analysed at a SANAS accredited laboratory and the results were benchmarked against various standards including the SANS 241:2015 Drinking Water Standards and the in-stream water quality guidelines quality guidelines for the Vaal Barrage Reservoir catchment. The two sites have very similar water quality for all parameters. Electrical conductivity (EC) exceeds all standards except the SANS 241 Aesthetic limits, and this is attributed to the elevated levels of ions, such as chloride, calcium, magnesium, manganese and sodium as detailed below. The elevated ions can be attributed to the diffuse anthropogenic sources located upstream of the WWTW where organic salts and inorganic matter can be washed off the streets and or discharge points from industrial sites upstream.

Stormwater management measures are proposed to ensure that stormwater run-off will have minimal effects on the natural flow regime, up to the 1:25 year storm event. This study demonstrates that the project site infrastructure is located outside of the 1:50 and 1:100 year flood-lines. The project's water circuit is closed, meaning no abstraction from or discharges to the natural environment will take place, the processes will rely on potable water supplied by a licensed water supplier. Sewage from the plant will be treated in a Lilliput® type Domestic Sewage Effluent Treatment System. The treated effluent will be irrigated on the site or released to the environment. The design for the sewage treatment is to treat to DWS general discharge standards, there will thus be minimal water quality impacts.

Considering the proposed discharges into the R59 drainage channel from the Project Site and from Project Jordan, additional potential impacts are identified and mitigation measures are recommended to ensure residual impacts of the project are minimised. The higher discharge rate (~ 6.5 m^3/s) at the 1:100 year storm return would increase the flood height and would have a limited effect on the low-lying areas of the Project Site. Limiting the projects discharge rate to less than 3.5 m^3/s would likely prevent any flooding risk. However, when combined with proposed discharges from Project Jordan the potential flood height could inundate portions of the plant and the attenuation pond. This can be attributed to increased stormwater flow rates and the backwater as a result of the downstream culvert being at the same invert level as the channels and the Vaal tributary. If both projects are developed, a reduced outflow rate from (both) attenuation ponds would be required to prevent flooding of the Project Site. A discharge rate of approximately 2 m^3/s at the 1:100 year storm event would have negligible impacts on pre-development flood-lines. Alternatively the plant platform could be raised above the flood water surface elevation by lifting it by approximately 80 cm (at the lowest elevation). Upgrading of stormwater channels, if required, should be considered in consultation with other developers.

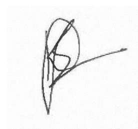
Subject to the implementation of adequate design measures to prevent discharge of contaminated stormwater or effluent (by pre-treatment) into the surface water, as well as the regulation of post-development stormwater discharges (at flood returns greater than 1:50 year events), the project can be allowed to continue.

Chenai Makamure & Gerhard Jacobs

(Report Author)

Kevin Bursey

(Project Manager)



Kevin Bursey

(Reviewer)

9. REFERENCES

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Appendix A: NEMA Regulation (2014) Appendix 6 Summary

NEMA Regs (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 1.1.
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B.
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix C.
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.4.
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	April 2018.
A description of the methodology adopted in preparing the report or carrying out the specialised process	Numerous methodologies discussed throughout the report to document baseline conditions and management measures.
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Baseline hydrological conditions are discussed in Section 2.
An identification of any areas to be avoided, including buffers	Flood-lines presented in Figure 4-4, 4-5, 4-6
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 4-4, 4-5, 4-6.
A description of any assumptions made and any uncertainties or gaps in knowledge;	Assumptions discussed in Sections 4.4,
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Discussed within the EIA.
Any mitigation measures for inclusion in the EMPr	N/A
Any conditions for inclusion in the environmental authorisation	N/A
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	See Section 6.
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Water management measures are presented in Section 4 and 5.
A description of any consultation process that was undertaken during the course of carrying out the study	N/A
A summary and copies if any comments that were received during any consultation process	N/A
Any other information requested by the competent authority.	N/A

Appendix B: Technical Specialist's CV

KEVIN BURSEY

PRINCIPAL HYDROLOGIST

Hydrology, Africa

Qualifications

BSc	2002	Majors in Hydrology and Soil Science, University of KwaZulu-Natal,
BSc (Hons)	2003	Hydrology, University of KwaZulu-Natal, South Africa
MSc	2009	Hydrology, University of KwaZulu-Natal, South Africa
Pr.Sci.Nat		Reg. No. 114422 (Water Resources)

9.1 EXPERTISE

- Environmental Impact Assessments
- Storm Water Management Plans
- River diversions
- Floodlines
- Water balances
- Mine water management
- Geographic Information Systems (GIS)
- Water quality modelling

Kevin is a Principal Hydrologist who has been managing his own projects over the past years. He has extensive knowledge of database management, catchment monitoring and the technologies associated with this. He has done a lot of work entailing floodlines, designing pollution control dams, stormwater management plans and water balances as well as some work involving dam break analysis and EIA's. Kevin has experience in a number of African countries.

He also has project experience in river diversions, culvert sizing and water quality and flow monitoring programmes.

Kevin has worked on many mines and power stations during his time as an environmental and hydrological consultant.

He started work with SLR as from July 2018.

9.2 PROJECTS

Projects that Kevin has worked on prior to starting at SLR

Unki TSF Flood Routing and Wall Raising Study (2018)	This project entailed raising the current height of the TSF and routing the various Return Period flood events onto the TSF and reporting the water level on the TSF. Kevin calculated the stormwater runoff, routed the flood events onto the TSF, and informed the water level and distance from the TSF wall of the flood event.
Mogalakwena Platinum Mine GN 704 Audit (2018)	Kevin conducted a GN 704 Audit for the Mogalakwena Platinum Mine complex. He also suggested mitigations and management measures required to bring the mine complex to an acceptable level of compliance with GN 704.
Modikwa Platinum Mine Water Balance and River Crossings Audit (2018)	Kevin undertook an update of the Modikwa Platinum Mine Water Balance for the whole complex. He also completed an audit of the various river crossings associated with the mine and suggested mitigations and management measures required to minimise the impact of the mine on the watercourses.
St Helena TSF Flood Routing Study (2017)	Kevin completed a study where he routed the various Return Period flood events onto the TSF and reported the water level on the TSF as well as informed the required sizing required for the penstock, as well as the pipes conveying the storm water away from the penstock.
Sibanye Stillwater GN 704 Audit for the Rustenburg Complex (2017)	Kevin conducted a GN 704 Audit for the Sibanye Stillwater Platinum Mine complex in Rustenburg. He also suggested mitigations and management measures required to bring the mine complex to an acceptable level of compliance with GN 704.

BECSA Douglas Colliery Water Make Study (2015)	Report the findings detailing the areas delineated, the clean and dirty water makes associated with each of the voids and the overall water make of the mine. Kevin's role was to delineate catchment for clean, spoils, levelled spoils, ramps and pits, dirty and rehabilitated areas. Review them with the mine. Use the catchment areas to calculate the amounts of clean and dirty water make reporting to the voids by runoff and seepage through the workings or flowing into clean water areas. Management of the project.
Eskom's Majuba Power Station Coal Stockyard facility SWMP (2015)	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP. Kevin's role included determining flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).
Kendall Power Station Ash Dump Facility SWMP (2015)	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP. Kevin's role was to determine flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).

	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP.
ACT coal discard dump facilities SWMP (2015)	Kevin's role included determining flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).
Sishen Gamogara River Flow Restauration (2014 - 2015)	Review calculated floodpeaks for various methods used in the study and suggest improvements. Review the floodpeaks report. Kevin's role was to review calculated floodpeaks for various methods used in the study and suggest improvements. Review the floodpeaks report.
Rosherville engineering design (2014)	A technical memorandum summarising the storm water runoff characteristics of the storage area and the revised storm water chute size. Kevin's role included calculating the storm water runoff off a container storage area. Calculate the depth and width of the storm water chute, which functions as a weir and conveys storm water from the storage area.

Dingelton/Kathu Relocation Surface Water Study Project (2014)	A report detailing the findings of the study including the pre- and post-development storm water runoff volumes into the pans as well as an impact assessment on the effect that the urbanisation has had. Kevin's role included calculating the storm water runoff for the two pans being assessed prior to development and post development. Calculate whether the modified storm water runoff, from the urbanised area, would flood the modified pan area. Suggest modifications to the proposed system whereby the pans can be kept as pristine as possible considering the urban development surrounding it. Perform an impact assessment on the effect that urbanisation has on the pans. Write a report detailing the findings of the study.
PBD Calmasil Conceptual SWMP Project (2014)	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP. Kevin was responsible for determining flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).
Kleinkopje Colliery Surface Flood Risk Management Plan (SFRMP) (2013 - 2014)	Write a Surface Flood Risk Management Plan report and a presentation of the findings. Kevin had to identify and quantify flooding risks around the Kriel Colliery. These will include a review of floodlines, dam and pit flooding, dam and coal discard dump dam breaks, flooding of the plant areas, decanting from underground mining areas and the suitability of the storm water conveyance structures. Compile a risk assessment using the Anglo American risk assessment matrix. Write a Surface Flood Risk Management Plan report and present the findings

Sasol Shandoni Floodlines (2013 - 2014)	Review of Floodline Report and Floodline Drawings. Kevin's role included site work to see hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodline.
New Denmark De-Stoning Plant Project (2013 - 2014)	Surface water study report as well as an IWWMP report. Kevin was responsible for site work to see hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodline. Assess the water quality and flows of the local water resources. Include the proposed De-Stoning Plant and update the current water balance for the entire mine. Perform an impact assessment that the project would potentially have on the water resources. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD). Write a surface water report and an IWWMP report
New Largo Colliery Weir Construction Project (2013)	Short report describing the reasons why certain proposed weir sites should preferred over others. Kevin had to advise New Largo Colliery on which of the proposed catchments should be utilised to construct five flow monitoring weirs to assess the effect of mining on the localised water resources.
Landau Schoongezight Lifex Project (2013)	A surface water study report had to be compiled. Kevin's work on the project included site work to see hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodline. Assess the water quality and flows of the local water resources. Perform an impact assessment that the project would potentially have on the water resources. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD). Write a surface water study report.

Damtshaa Mine (Debswana) Stormwater Management Plan (SWMP) in Botswana (2012)	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP. Kevin's role was to determine flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).
Letlhakane Mine (Debswana) Stormwater Management Plan (SWMP) in Botswana (2012)	Stormwater Management Plan (SWMP) Report and conceptual drawings of the associated contributing catchments, conduits, silt trap and PCD that are detailed in the SWMP. Kevin's role was to determine flood peaks for delineated catchment areas. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD).
Rand Uranium Tailings Storage Facility Floodline for EIA (2011)	Floodline Report and Floodline Drawings. Kevin's work included site work to see hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodline
Machana Vuzi Surface Water Assessment and Hydrological Baseline Monitoring Programme in Mozambique (2011)	Surface Water Monitoring Report. Kevin's role including setting up and implementing a surface water monitoring programme for rainfall, water quality and flow measurements. Process water quality data and assess the data against WHO water quality guidelines. Use flow monitoring equipment and process the data into a discharge for the respective river or stream.
Ahafo North Mine – Stage II Water Source Options Assessment in Ghana (2011)	EIA Report detailing the findings of the study. Kevin was responsible for determining monthly flow regimes in certain rivers surrounding the mine. Calculate the impact that the abstractions would have on the monthly river flow dynamics.

Zambezi Coal's Coal Project EIA in Mozambique (2010 – 2012)	Quarterly Surface Water Monitoring Report containing monthly water qualities and flows for 12 sites. Kevin was responsible for setup, manage and run a surface water monitoring programme for water quality and flow measurements. Collect and deliver water quality samples to the laboratory for analysis. Process water quality data and assess the data against RWQO's for the Taaibosspruit. Use flow monitoring equipment and process the data into a discharge for the respective river or stream.
Exxaro's Strategic Water Assessment of various South African Mines (2010 – 2012)	Assessment of the potential water problems facing Exxaro Mines in South Africa and compiling a report quantifying the water volumes and qualities of their mines. Kevin's work included quantifying water volumes and qualities in voids and underground workings at various Exxaro Mines in South Africa. Use this information to quantify potential treatment costs for mine rehabilitation and identify financial risks at the various mines.
Platreef Platinum Mine EIA (2010 – 2011)	Surface Water Study for the development of a new mine and compiling report. Kevin's role included site work assessing hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodlines. Assess the water quality and flows of the local water resources. Perform an impact assessment that the project would potentially have on the water resources. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD). Setup, manage and run a surface water monitoring programme for water quality and flow measurements. Collect and deliver water quality samples to the laboratory for analysis. Process water quality data and assess the data against RWQO's for the Taaibosspruit. Use flow monitoring equipment and process the data into a discharge for the respective river or stream. Write a surface water study and report

	The project included determining 1:50 and 1:100 year Return Period floodlines for mine development and infrastructure placement. Develop clean and dirty water separation framework and undertake a conceptual design and sizing of the stormwater infrastructure. Also a Surface Water Study for the development of a new mine. Kevin's responsibilities included site work assessing hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodlines. Assess the water quality and flows of the local water resources. Perform an impact assessment that the project would potentially have on the water resources. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD). Setup, manage and run a surface water monitoring programme for rainfall, water quality and flow measurements. Collect and deliver water quality samples to the laboratory for analysis. Process water quality data and assess the data against the WHO water quality guidelines. Use flow monitoring equipment and process the data into a discharge for the respective river or stream. Write a surface water study and report
Riversdale's Benga Coal Project EIA in Mozambique (2009 – 2010)	
	The project entailed determining 1:50 and 1:100 year Return Period floodlines for mine development and infrastructure placement. Develop clean and dirty water separation framework and undertake a conceptual design and sizing of the stormwater infrastructure. Also a Surface Water Study for the development of a new mine. Kevin's responsibilities included site work for hydraulic characteristics and culverts. Determine flood peaks and use the HecRas backwater model to determine the 1:50 and 1:100 year Return Period floodline. Assess the water quality and flows of the local water resources. Perform an impact assessment that the project would potentially have on the water resources. Undertake conceptual design and size stormwater separation infrastructure including clean water diversion drains, dirty water collection drains, silt traps and sizing of a Pollution Control Dam (PCD). Setup, manage and run a surface water monitoring programme for water quality and flow measurements. Collect and deliver water quality samples to the laboratory for analysis. Process water quality data and assess the data against RWQO's for the Taaibosspruit. Use flow monitoring equipment and process the data into a discharge for the respective river or stream. Write a surface water study and report.
Tenke Fwaulu ESIA in the Democratic Republic of Congo (2008 – 2009)	

Environmental Feasibility Study of the natural flows along the Rufiji River at Stieglers Gorge in Tanzania (2008)	Hydrological analysis of naturalised flows along the Rufiji River at Stieglers Gorge to determine the potential impact of a dam. Kevin had to quantify the historical flows in the Rufiji River to assess the potential impact that the proposed dam would have on the naturalised flows in the river at various locations.
Updating of the Water Balance around the Anglo American Platinum mines in the Rustenburg area (2007)	An assessment of the stormwater infrastructure was carried out around the entire mine area including stormwater diversion drains, stormwater collection drains, raw water dams, pollution control dams, sumps, flood protection berms and bunding around the plant areas. Kevin's responsibilities included reviewing reports, locating and assessing the entire stormwater infrastructure and compiling one combined report of the stormwater infrastructure for the entire mine complex including shafts, plant areas and refinery.

9.3 MEMBERSHIPS

Member	Golden Key International Honours Society

9.4 PUBLICATIONS

9.5	Kevin has been involved in presenting papers at SANCIAHS (South African National Committee of the International Association of Hydrological Sciences) in 2003. The symposium was held in Port Elizabeth, South Africa. SW-GW interaction at small scales: implications for low flow estimates (Presented on behalf of Simon Lorentz by Kevin Bursey). www.ru.ac.za/institutes/iwr/SANCIAHS/reports/GW_SW_reportB.ppt
9.6	Kevin also presented his MSc project at SANCIAHS (South African National Committee of the International Association of Hydrological Sciences) in 2009. It was held in Pietermaritzburg, South Africa. Quantifying Hydrological Fluxes of Contributing Hillslopes in the Weatherley Catchment, N E Cape, South Africa.

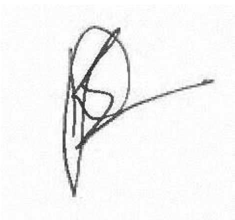
Appendix C: Declaration of Independence

The independent Environment Assessment Practitioner

I, Kevin Bursey, declare that I:

- Act as an independent Environmental Practitioner for the Isanti Project.
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014.
- Have no and will not have any vested interest in the proposed activity proceeding.
- Have no and will not engage in conflicting interests in the undertaking of the activity.
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2014.
- Will ensure that information containing all relevant facts in respect of the application are distributed or made available to interested and affected parties and the public.

Signature of Specialist:



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