Neil LYNERS and Associates (RF) (Pty) Ltd

Consulting Engineers & Project Managers

GROENKLOOF ONTWIKKELINGS (PTY) LTD

STORMWATER MANAGEMENT PLAN

For a Housing Development on Glenwood Avenue in the George Municipal Area

September 2019

19109CG

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GROENKLOOF ONTWIKKELINGS (PTY) LTD

SYNOPSIS

Neil Lyners and Associates (RF)(Pty) Ltd was appointed by Groenkloof Ontwikkeling (Pty) Ltd for the preparation of a Stormwater Management Plan for the proposed Housing Development on Portion 3 of Farm Kraaibosch No. 195 on Glenwood Avenue in the George Municipal Area. The area under investigation was analysed with relevant codes of practice, policy and guidelines in mind. The need to provide a system that is effective, sustainable and that result in runoffs of good water quality was foremost when approaching the concept of the drainage system. For this reason the design is reviewed using "The South African Draft Guidelines for Sustainable Urban Drainage Systems". Sustainable Urban Drainage Systems (SUDS) focuses on sustainability by attempting to imitate the natural hydrological cycle.

PROJECT 19109CG – STORMWATER MANAGEMENT PLAN

REV	DESCRIPTION	ORIG	REVIEW	LYNERS APPROVAL	DATE	CLIENT APPROVAL	DATE
	DRAFT	WO	FvE		2019-10-04	N/A	

CONTENTS

1. INTRODUCTION

1.1 APPOINTMENT

Neil Lyners and Associates (RF)(Pty) Ltd was appointed by Groenkloof Ontwikkelings (Pty) Ltd for the preparation of a Stormwater Management Plan for the proposed Housing Development on Portion 3 of Farm Kraaibosch No. 195.

1.2 AVAILABLE INFORMATION

The following information was made available to Lyners:

a) Detail of proposed erf-layout in digital and hardcopy format.

b) 1:50 000 Topographical Maps of the study area.

c) George Municipality aerial survey of the property, containing a digital terrain model.

Field observations were done in addition to the above information in order to evaluate stormwater drainage patterns.

A digital plan was generated, showing contour and cadastral information of the study area, see Annexure B – Study Area Drawing 19109CG/SW/1. Information regarding the proposed development of the study area was incorporated in the investigation.

1.3 EXECUTION OF THE APPOINTMENT

The area under investigation was analysed with relevant codes of practice, policy and guidelines in mind. Current stormwater management systems were assessed in order to reduce the impact of the proposed development on future operations. Local control mechanisms for the required flood return periods will be implemented where necessary, in order to ensure that capacities of regional drainage systems are not exceeded. The need to provide a system that is effective, sustainable and that result in runoffs of good water quality was foremost when approaching the design of the drainage system.

The report looks at legal aspects, management of stormwater runoffs as well as recommendations regarding an effective drainage system.

1.4 LEGAL ASPECTS REGARDING STORMWATER

1.4.1 General

The applicable legal rules or norms with respect to drainage in South Africa are mainly contained in three sources, namely the common law, amended law (law announcement) and the statute law. The interpretation and quotation of the above fall outside the scope of this report, but a few essential points,

regarded as important in the planning of drainage systems, often appear in the amended law and are summarised as follows:

- Nobody shall interfere with the natural flow of water in rural areas without statutory authority (authorised regulation);
- Statutory authority is no remission of responsibility to provide drainage works in a reasonable way. The conception "reasonable way" is determined and evaluated on the basis of three factors, namely the environmental factor, the cost factor and the degree of safety;
- To refrain from acting in a "reasonable way" where it is required, will be considered as illegitimate conduct.

In order to stay within the law and act in a legitimate way, should the possibility of interfering with natural flow exist, it will be advisable to negotiate with lower lying property owners and to conclude an agreement before any construction works commence.

Provisions of the following environmental standards, legislation as well as municipal regulations are applicable:

- National Water Act, Act No 36 of 1998
- National Environmental Management Act, Act No 107 of 1998
- Environmental Conservation Act, Act No 73 of 1989
- Water Services Act, Act No 30 of 2004

1.4.2 Prevailing norms of storm water drainage

Comprehensive guidelines known as "Guidelines for the Provision of Engineering Services in Residential Townships" (July 1983) by the former Department of Community Development, as well as "Guidelines for the Provision of Engineering Services and Amenities in Residential Township Development" (1994) by the National Housing Council were published and have in general been accepted as the norm for the provision of engineering services in urban areas.

The following documents have been accepted in addition to the above-mentioned guidelines:

- Guidelines for Human Settlement Planning and Design, (2005) – CSIR Building and Construction Technology
- The South African Draft Guidelines for sustainable Urban Drainage Systems (SUDS) that was drafted for as part of the Water research Commission of South Africa (WRC) project K5/1826: Alternative technology for Stormwater Management.

- George Municipality's General Considerations to be included in a Stormwater Management Plan. (Annexure C)

In the light of the general application and support of the above-mentioned guidelines, it is accepted as minimum acceptable standards for stormwater drainage. Any deviation from these standards should be justified on the basis of environmental, economical and risk analysis.

For the purpose of this report these guidelines will thus apply throughout as reference and any deviation from that will be motivated.

2. TERRAIN

2.1 LOCALITY AND BACKGROUND

The proposed Groenkloof development is situated approximately 4 km from and to the south-east of the George CBD, and adjacent to Glenwood Avenue in the Kraaibosch area at 22°29' east and 33°59' south in the Western Cape. Refer to Annexure A - Locality Plan 19109CG/A/1.

The Site, Farm 195/3 is situated on Glenwood Avenue with Knysna road parallel to the South.

In November 2011 the Department of Environmental Affairs & Development Planning issued an Environmental Authorization in respect of the application for the construction of the Groenkloof mixed used development. In condition 7.5 and 7.7 of the authorisation they require that stormwater management measures such as water saving devices, erosion prevention and pollution control measures be included in the development. They further state that these measures should be to the satisfaction of the George Municipality prior to submission thereof to the Department.

In May 2012 the George Municipality approved the rezoning, subdivision and consent uses of the site. Condition 21 of the Directorate Civil Engineering requires that a Stormwater Management Plan be submitted and approved by the relevant departments/authorities.

2.2 TOPOGRAPHY

The study area lies between ±219 and ±148 above mean sea level (MSL). The site has a gradual natural fall to the middle of the site and to the northern side towards the Saasveld Road (Main Road 355). Stormwater is discharged from the site via an existing culvert under the Saasveld Road (Main Road 355) into the Klein Zwart River.

2.3 EXISTING INFRASTRUCTURE

The existing downstream off-site stormwater culverts crossing the respective road will receive the storm water from the site.

Provision will be made for external runoff entering the proposed development where applicable. See Study Area drawing 19109CG/SW/1 in Annexure B indicating these minimal off-site areas.

3. HYDROLOGY

3.1 RUNOFF CALCULATIONS

Various approved methods are used to execute hydrological calculations, with each based on its own set of data. The results of these methods can vary considerably as they only provide an approximation of actual events. Computer models, utilising of these methods, will be used to calculate peak flows for the site under investigation. These results can then be compared to calculations based on the rational method. Please see Annexure D.

3.2 RISKS – COST CONSIDERATIONS AND DESIGN FLOOD FREQUENCIES

Although runoff calculations are performed with great care, it is still possible that the capacity of a system could be exceeded because of non-hydrological reasons. There has to be a limit to the elimination of probabilities as costs could become unrealistically high in comparison with the benefit of lower costs.

Although the relationship between function, risk, original cost and maintenance cost plays a major role in determining the design flood frequency, it is assumed in general that the following flood frequencies should be provided for under normal circumstances:

a) Minor system which is the system of pipes, culverts and channels which provides capacity for more regular storms of a smaller nature.

i)	Residential	:	1:2 to 1:5 years
ii)	Institutional	:	1:5 years
iii)	High value general business, industrial areas and public works	:	1:5 years
iv)	Central business district	:	1:5 to 1:10 years

b) Major system which usually consists of streets, pipe culverts, box culverts and open channels and is in place to deal with more severe storms.

The capacity of these facilities would be theoretically tested to determine the influence of a major storm in the area in order to eliminate possible shortcomings.

Should the major system be insufficient to accommodate major floods, improvements should be considered and alternative detention facilities be provided. The major system will be designed to accommodate the 1:50 year storm.

4. STORMWATER DRAINAGE AND CONTROL SYSTEMS

4.1 GENERAL

4.1.1 Purpose and principles

As mentioned in paragraph 3.2, stormwater systems can be categorised into two systems, namely major and minor systems. The purpose and principles of stormwater control does not always necessitate minor and major floods being accommodated in a single system. In relatively small catchments the peak runoff and runoff volume of both the minor and major floods are usually of such low magnitude that they can be accommodated in a single system. As catchment areas increase in size, so it becomes less practical and more expensive to retain a single system. In such cases separate minor and major systems should be provided.

4.1.2 Minor system

The primary goal of minor systems is to ensure convenience of nearby residents and the safety of traffic during normal rain showers.

The minor system usually consists of road drainage channels and kerbs, kerb inlets, grid inlets, manholes, pipes, box culverts and small open channels for the rapid discharge of runoffs to the major drainage system.

The sizing of the elements are determined on the basis of short duration, high intensity storms taking into account concentrated flow entering the minor system.

4.1.3 Major system

The major system will seldom be utilised to its full capacity as its purpose is to convey and control large floods.

If justified by costs or natural conditions, the major and minor flows could be accommodated in the same facility. Natural or manmade channels and large diameter culverts are examples.

4.1.4 Recommendations regarding design principles and considerations

Although dealt with in the “Guidelines for Provision of Engineering Services in Residential Townships”, it is imperative to emphasize a few aspects viewed as policy standpoints with regards to higher lying developments:

- New developments shall not adversely affect the safety risk within existing developments;
- Pollution of the major discharge system as a result of sedimentation, refuse, effluent and other chemical waste shall be actively controlled.

- In order to exercise a degree of control over new developments, the design assumptions, calculations and results shall be submitted to the Local Authority at completion of the detail design phase of the project.

4.2 SUSTAINABLE URBAN DRAINAGE SYSTEMS

4.2.1 General

In order to ensure the sustainability and environmental integrity of a stormwater management plan, it is advisable to consult "The South African Draft Guidelines for Sustainable Urban Drainage Systems".

Sustainable Urban Drainage Systems (SUDS) focuses on sustainability by attempting to imitate the natural hydrological cycle, something that conventional drainage systems does not focus on. Once an area is developed, the natural permeability of the area is generally reduced as free draining surfaces are replaced with impermeable surfaces such as roofs, roads and paved areas. This process, together with the fact that subsoil is usually compacted during development reduces the infiltration capacity of the area. As development also results in loss of vegetation, the evapotranspiration of the area is also reduced.

Conventional drainage systems are more focused on reducing flooding and possible flood damage to an area (flood attenuation). The focus of the SUDS process is on flood attenuation as well as promoting more natural, sustainable drainage systems.

4.2.2 SUDS PROCESSES

The SUDS principle can be broken up into the following three key areas:

i) Water quantity;

ii) Water quality; and

iii) Biodiversity

These processes will now be discussed briefly.

4.2.2.1 Water quantity management

Stormwater quantities can be managed through inter alia the following processes that will be implemented:

- Capturing rainwater for supplementary water uses on site;
- Detaining stormwater before subsequent release;
- Conveyance of stormwater (transfer from one location to another);

- Long-term storage in a specified infiltrating area in the form of retention which will drain slowly and
- Stormwater detention to protect receiving watercourses in the event of flooding.

4.2.2.2 Water quality management

Water quality is promoted through cleaning or polishing of stormwater. This can be achieved through inter alia the following processes that will be implemented:

- Sedimentation – reducing flow velocities of stormwater runoff to allow sediment particles to fall out of suspension;
- Removal of nutrients and metals through plant-uptake and
- Photosynthesis – breakdown of organic pollutants through extended exposure to ultra-violet light.

4.2.2.3 Biodiversity management

Biodiversity management is promoted through the following controls that will be implemented:

- Health and safety plans and implementation to prevent injury or death to people;
- Environmental risk assessment and management to promote longevity of the system;
- Recreation and aesthetics – enhancing visual appearance by creating attractive open spaces and
- Education and awareness – distribution of knowledge about stormwater management among interested and affected parties.

4.2.3 SUDS SELECTION

4.2.3.1 Selection basics

To successfully manage stormwater a number of treatment processes may be required. This multiple process treatment is referred to in the SUDS guideline as a treatment train. A variety of options or combinations of options may be necessary according to the individual requirements of the site. The three key points where intervention is required are as follows:

- Source controls – manage stormwater runoff as close to its source as possible;
- Local controls – manage stormwater runoff in the local area; and
- Regional controls – manage combined stormwater runoff from several developments. ***(Not applicable to this area since the final run-off is discharged directly into river systems and no regional controls are available downstream of the site.)***

a) Source controls

Source control alternatives that were considered include:

- Green roofs;
- Sand filters;
- Soakaways; and
- Stormwater collection and reuse.

Green roofs are roofs covered in vegetation. The vegetation serves to delay runoff peaks as well as decrease runoff volumes. Green roofs also improve the biodiversity of post development areas. The limitations of this method of control includes a high set up cost due to the need to contract experienced professionals regarding the effects on the structure as well as vegetative requirements; the need for regular maintenance; and the possibility of roof failure if detained water leads to failure of waterproofing membranes. Due to these limitations this alternative will not be implemented.

Sand filters are generally utilised to improve the quality of stormwater runoff. They comprise of a sedimentation chamber as well as a filtration chamber. Filtration through the sand bed coupled with microbial action in the medium leads to removal of suspended particles, heavy metals and smaller particulates in stormwater runoff. Sand filters are expensive to implement, are generally unattractive and prone to clogging. Due to these reasons as well as the underlying clay conditions this alternative will not be recommended.

Soakaways are excavated pits filled with a porous medium, like course aggregate. Soakaways are used for temporary storage of stormwater, which is then allowed to infiltrate into the ground. Soakaways are suitable in most climatic conditions; significantly reduces runoff volume; and has design lives of up to 20 years if maintained correctly. This control is only suitable to small areas where infiltrating water will not adversely affect foundations of adjacent structures. There is also a need for regular maintenance. Due to the proposed development's large areas and quantities of run-off as well as the clay soils this alternative cannot be used.

Stormwater collection and reuse reduces runoff which reduces the potable water consumption rates of a development. Stormwater collection is also a good way to attenuate flood peaks. Storage facilities are easy to find and quick to install, but may not be aesthetically pleasing. Water harvesting will therefore be implemented by means of water tanks that will be required at the proposed buildings on the site.

b) Local controls

Local control alternatives that were considered inter alia include:

- Headwalls with energy dissipators and gabion mattresses (See Annexure D);

ANALYSIS OF THE PROPOSED STORMWATER DRAINAGE SYSTEM, IDENTIFICATION OF PROBLEM AREAS AND PROPOSED MANAGEMENT PLAN FOR WATER QUANTITY AND WATER QUALITY

As part of the on-site water quantity and water quality management, the Stormwater Management Plan considerations of the George Municipality, as included in Annexure C, will be incorporated in the Services Report and the detail stormwater design phase of the development.

4.3 WATER QUANTITY MANAGEMENT

4.3.1 General

The portion of the site bordering MR 355 (Saasveld Road) has a natural fall to the northern side towards MR 355 (Saasveld Road). The portion of the site bordering the Glenwood Avenue also has a natural fall to the north side towards the MR 355 (Saasveld Road). The proposed earthwork design will retain the natural fall in order to convey stormwater to the respective sides of the site. The Study Area Drawing 19109CG/SW/1 in Annexure B depicts the planned direction of stormwater flows.

4.3.2 Buildings on individual lots

In order to create a more sustainable stormwater management system, a source control in the form of stormwater collection tanks at the buildings, will be used on site in order for stormwater to be reused for irrigation purposes. These tanks will be placed “in-line” on the building’s gutter system. The tanks will make use of an inlet by-pass system which ensures that the initial roof runoff is not collected in the tanks. This ensures that any pollutant build up on roofs will not be flushed into the collection tanks by the first rains, the so-called first flush phenomenon.

The buildings on the individual lots will be equipped with a surrounding pipe network to accommodate downpipes. The remainder of the stormwater on site will be accumulated within catch pits and grid inlets.

4.3.3 Site Area

An underground piped or open channel storm water system will collect the internal minor flood stormwater from the individual lots and convey these waters to the proposed detention facilities at the downstream ends of the site before discharged at a reduced run-off rate from the site.

The proposed road system, parking areas and open channels will be designed to make provision for conveyance of larger storms (storms in excess of the minor flood) towards the culvert under Saasveld Road and the Klein Zwart River respectively. (See Study Area Drawing 19109CG/SW/1 in Annexure B).

An existing detention pond may be retained to detain storm water. This stormwater is received directly by the Klein Zwart River and not by any downstream properties.

4.4 WATER QUALITY MANAGEMENT

SUDS water quality design is based on the implementation of various control methods which forms a treatment train. If water goes through more than one treatment process there is more chance of prevention of pollution at a particular site.

Utilising the concept of a treatment train, water quality will first be addressed by street and parking cleansing for removal of litter and sand sized-particles. Secondly the detention facility will control pollution as well as flooding by causing biological transformations and the settlement of solids.

Thirdly the water quality will be improved by the vegetation in the retention ponds; as wetlands, marsh areas and reed beds are capable of absorbing pollutants within certain limits. They also have the added advantage of producing a unique eco-system. The possibility of an island with trees that should attract birdlife is also being considered for ponds.

As a fourth measure in the treatment train, the design of the detention pond shapes and volumes will be based on decreasing the travel time of stormwater runoff through the pond to enhance the water quality benefits.

As a fifth and final measure the storm water discharged from the ponds will be further cleansed by the vegetated, erosion protected open channel systems downstream of the ponds.

In addition to the above, the treatment train proposed for the building area will consist of stormwater collection and re-use tanks and oil/water separators will be required at wash bays of motor related

Regular sweeping of paved areas will act as preventative measures, preventing litter and other pollutions from entering the stormwater system in the first place.

The pollutant removal capabilities of inter alia detention ponds as listed in “The South African Draft SUDS Guideline” are tabulated below:

Table 1: Pollutant removal capability of permeable pavements and detention ponds

Pollutant removal capability (%)	Control Measure: Detention ponds*
Total Settleable Solids	45 – 90
Hydro-carbons	30 – 60
Total Phosphorous	20 – 70
Total Nitrogen	20 – 60
Faecal Coli Forms	50 – 70
Heavy Metals	40 – 90

* Estimated values based on similar SUDS options

Disclaimer:

The values quoted in this table may be used to assess the general relative performance of selected SUDS options and technologies so as to minimise the risk of stormwater runoff pollutants entering receiving watercourses. The values should not be considered or used as absolute values as the performance of SUDS and SUDS Treatment trains is subject to many complex variables that are site specific. These values should be used to support judgement when assessing the risk of system failure and to compare the relative performance between combinations of different SUDS Treatment trains.

5. CONCLUSION

We would like to thank Groenkloof Ontwikkelings (Pty) Ltd, the George Municipality and the Department of Environmental Affairs & Development Planning for their willing assistance in gathering information to prepare this stormwater management plan.

We trust that the investigation, the management plan and the recommendations contained in this report will be to the satisfaction of Groenkloof Ontwikkelings (Pty) Ltd. We also thank you for the opportunity to submit this report.

6. REFERENCES

1. Water Research Commission of South Africa, Project K5/1826: Alternative technology for Stormwater Management, ***The South African Draft Guidelines for Sustainable Urban Drainage Systems (SUDS)***
2. George Municipality's General Considerations to be included in a Stormwater Management Plan.
3. Guidelines for Human Settlement Planning and Design, (2005) – CSIR Building and Construction Technology

Annexure A – Locality Plan (19109CG/A/1)

SCALE@A1

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All dimensions must be verified on site before any work commences. Report any discrepancies to the Engineer.

No.	DESCRIPTION	INITIALS	DATE
	REVISIONS		

DESIGNED	KEL/YMO	08/2019
DRAWN	WO	08/2019
CHECKED	TVE	08/2019

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CLIENT REPRESENTATIVE
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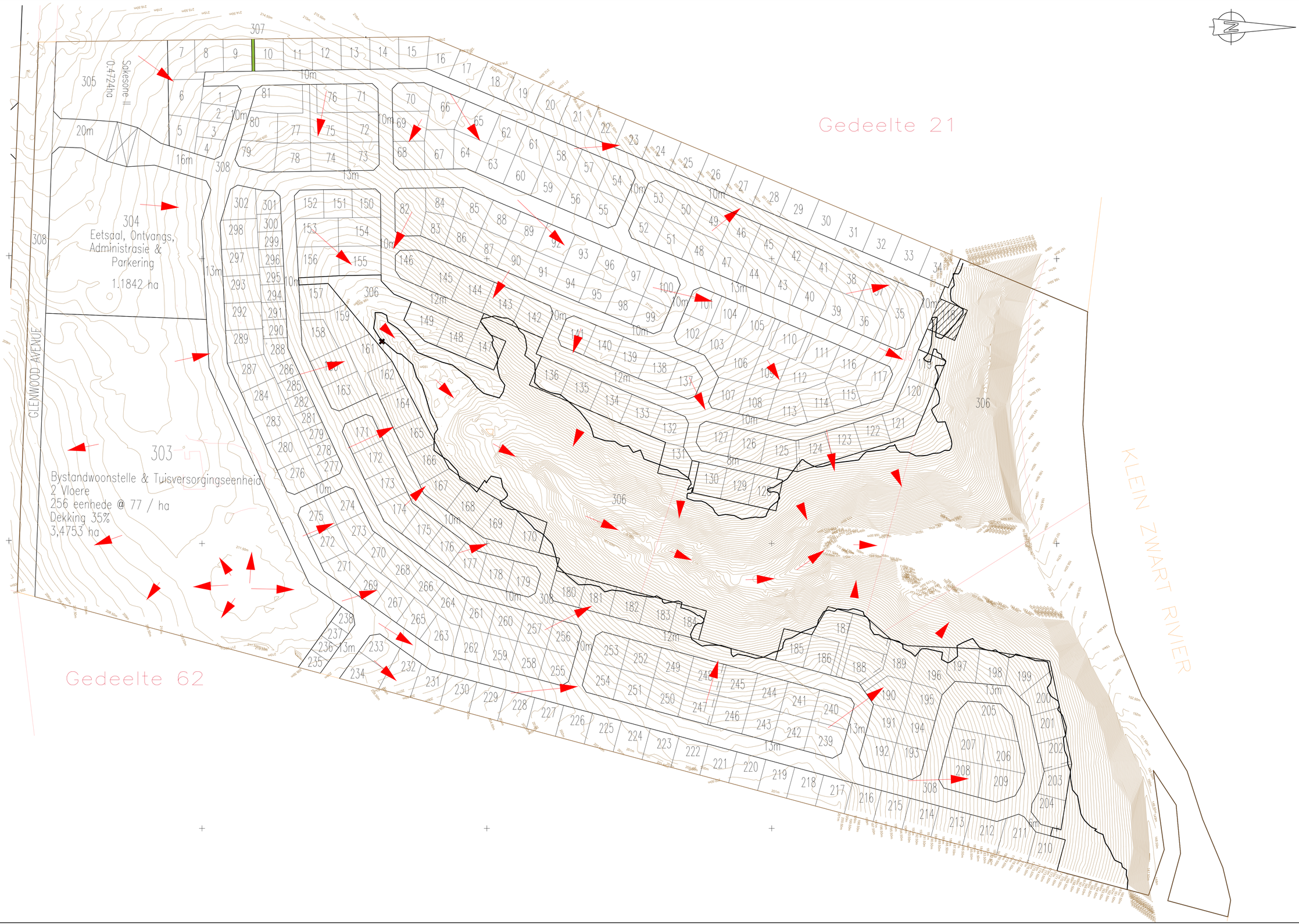
CLIENT

PROJECT
Kraaibosch 196-3 - Groenkloof Ontwikkeling

TITLE
LOCALITY PLAN

SCALE	1:3500
SHEET	
CONTRACT No.	
PROJECT No.	C1910GC
DRAWING No.	C1910GC - 01
REV.	A
DATE OF PRINT ISSUE	

Annexure B: Study Area Drawing (19109CG/SW/2)



SCALEBAR

REV	DESCRIPTION	DATE	REV BY	CHKD
A	FOR APPROVAL	14/08/2019	WO	FvE

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CHECKED	FvE	2018

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PROJECT

Kraaibosch 195-3 - Groenkloof Ontwikkeling

TITLE

SW STUDY AREA

SCALE	SHEET
1:250	-
CONTRACT No.	PROJECT No.
19109CG	19109CG

DRAWING No. 19109CG/SW/1 REV A

DATE OF FIRST ISSUE: -

Annexure C: George Municipality's general considerations to be included in storm water management plans

GEORGE MUNICIPALITY

STORMWATER MANAGEMENT PLAN - GENERAL CONSIDERATIONS TO BE INCLUDED

1. Storm water control systems for construction purposes will be constructed before any construction commences on the site. As construction progresses, the storm water control measures are to be monitored and adjusted to ensure complete erosion control and appropriate runoff control at all times during construction. Construction activities should be undertaken in such a manner earthworks on site are to be kept to an absolute minimum.

2. All services required by the development shall be designed to withstand the effects of flooding without risk of environmental pollution, or risk of damage, injury or loss to the property owner, residents and general public.

3. An owner of a property on which a private/public storm water system is located-

   a) May not carry out any activity which will or which, in the opinion of the HOA/Governing Body/Municipality, could reasonably be expected to adversely affect the functioning of such storm water system;

   b) Must keep such storm water system functioning effectively (at own cost); and

   c) The HOA/Governing Body is responsible for (in the case of a private service) the refurbishment and reconstruction of storm water systems when required.

4. For a private service, the HOA/Body Corporate / Private entity shall ensure that no person will be permitted to –

   i) Discharge, place or permit to enter into the storm water system –

      a) Anything other than storm water;

      b) Anything likely to damage the storm water system or interfere with the operation thereof;

      c) Anything likely to pollute the water in the storm water system.

   ii) Discharge from any place, or place onto any surface, any substance other than stormwater, where that substance could reasonably be expected to find its way into the storm water system;

5. The internal vehicle driveways and parking areas shall be designed and constructed to direct run-off away from the buildings/residences to eliminate the potential impact of storm water on property.

6. The developer will ensure the registration of a servitude on the property title for the public/private storm water drains for the purposes of maintenance and access.

7. The owners/body corporate must keep such storm water servitude open and accessible for purposes of maintenance; and ensure the system functions effectively.

8. For the maintenance of private drainage systems, it is the responsibility of a HOA / Body Corporate / private entity to-

   a) Properly maintain in good working order at all times, the private storm water drainage network on the premises. This includes all pipes, gutters, storm water detention devices or other components as well as the drainage network itself.

   b) Ensure that all open storm water drains are kept clear of any obstruction that impedes or is likely to impede the free flow of water, for a distance of at least 3 meters from the nearest margin of the storm water drain;

   c) Ensure there will be no adverse effect on the quality of storm water which previously flowed beyond the boundaries of the property on which the activity occurs; or,

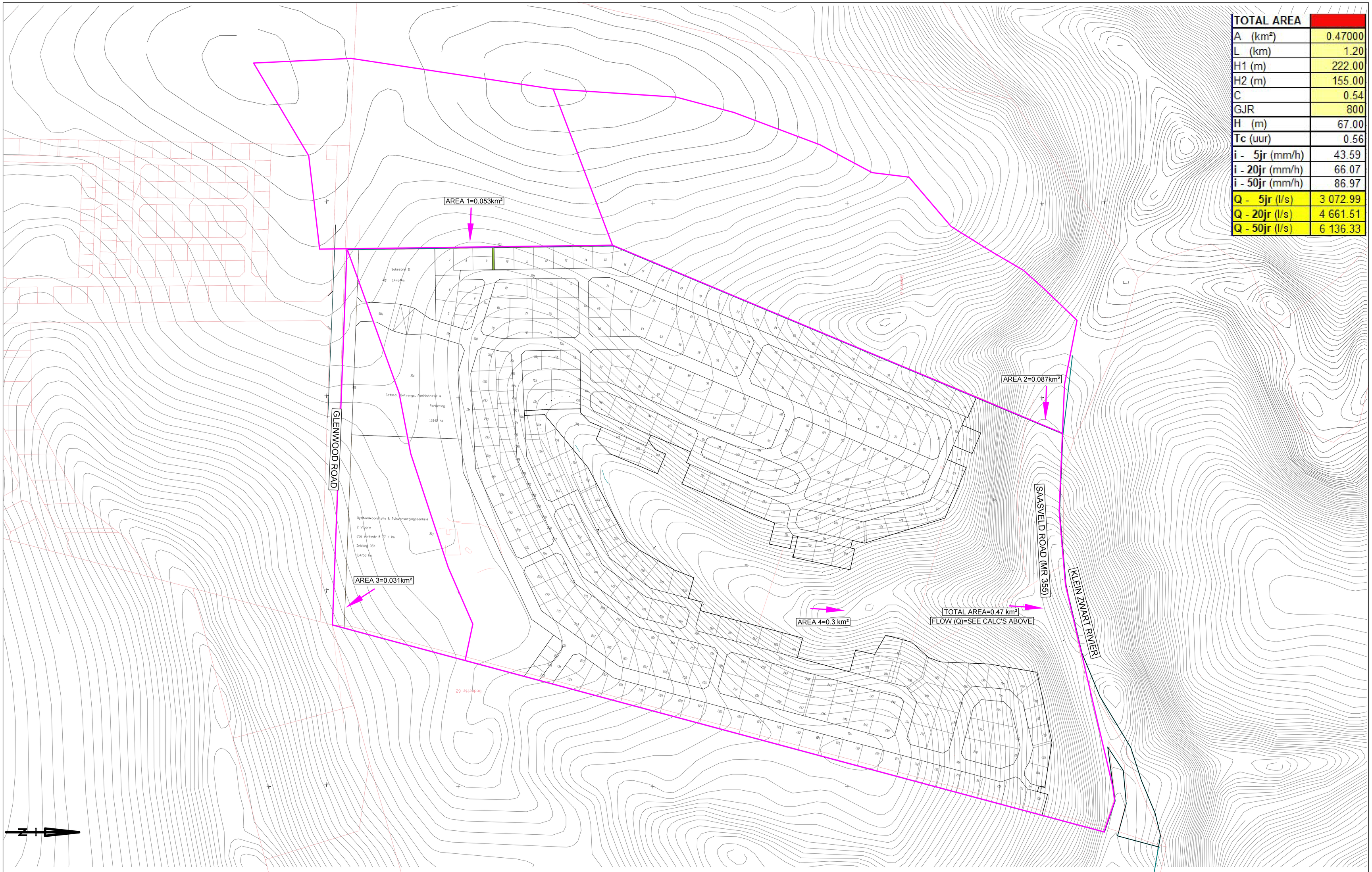
   d) Ensure the flow of an storm water entering the property will not be adversely effected; or,

   e) Ensure the point of discharge from the property is not altered.

   f) Ensure no owner or occupier of the land on either side of any open drain shall deposit, or cause or permit to be deposited any material or thing that could cause or likely to cause obstruction within the drain.

Annexure D: Stormwater Run-off layout, Calculations and Headwall detail

TOTAL AREA	
A (km²)	0.47000
L (km)	1.20
H1 (m)	222.00
H2 (m)	155.00
C	0.54
GJR	800
H (m)	67.00
Tc (uur)	0.56
i - 5jr (mm/h)	43.59
i - 20jr (mm/h)	66.07
i - 50jr (mm/h)	86.97
Q - 5jr (l/s)	3 072.99
Q - 20jr (l/s)	4 661.51
Q - 50jr (l/s)	6 136.33



SCALEBAR

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A	PRELIMINARY DESIGN	17/09/2019	WO	FvE

REVISIONS

DESIGNED	WO	08/2019
DRAWN	WO	08/2019
CHECKED	FvE	08/2019

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SIGNATURE:_____ DATE:

CLIENT

Groenkloof Ontwikkelings (PTY) LTD

PROJECT

C19109G Kraaibosch 195-3 - Groenkloof Ontwikkeling

TITLE

STORMWATER RUNOFF AREAS

SCALE	SHEET
1:1250	
CONTRACT No.	PROJECT No. C19109G

DRAWING No. -

REV A

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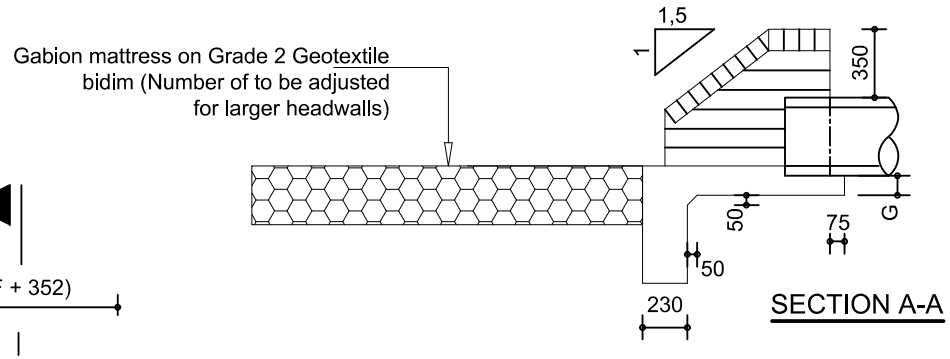
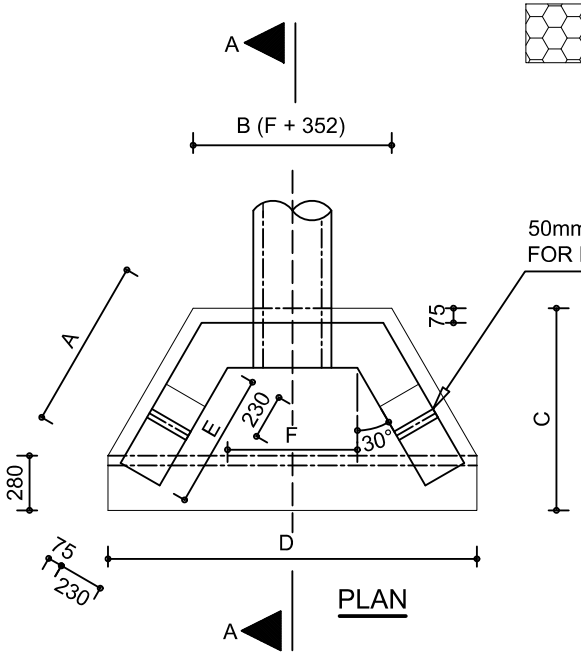
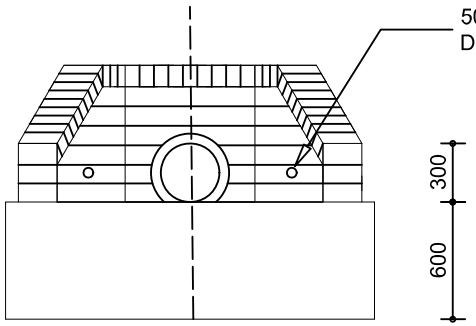


SECTION A-A

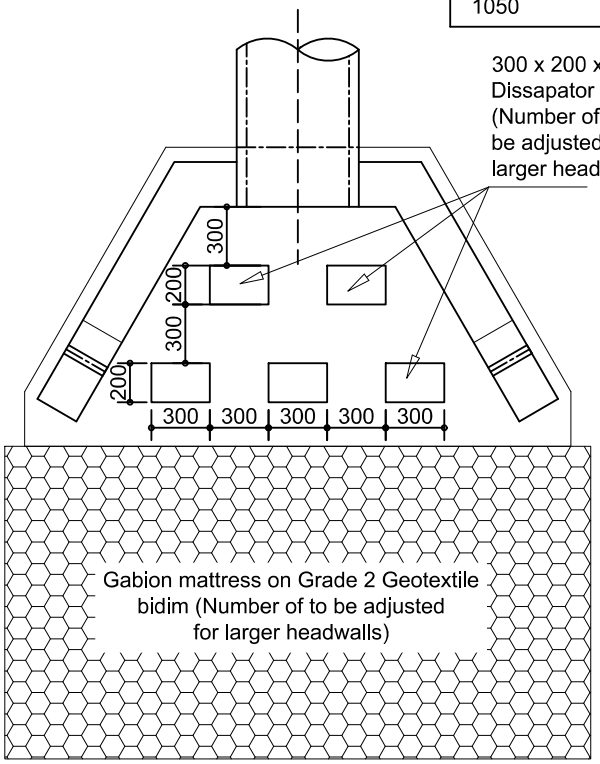
HEAD- AND WINGWALL DIMENSIONS (mm)							
NOM.PIPE DIA	A	B	C	D	E	F	G
300	872	1017	1035	1889	715	665	150
375	1070	1103	1207	2173	894	751	150
450	1260	1185	1371	2445	1084	833	200
525	1445	1265	1531	2710	1266	913	200
600	1645	1352	1705	2008	1469	1000	300
750	2024	1516	2033	3540	1848	1164	300
1050	2581	1757	2515	4338	2370	1405	300



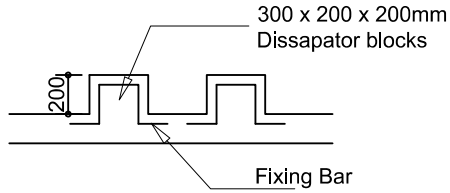
PLAN



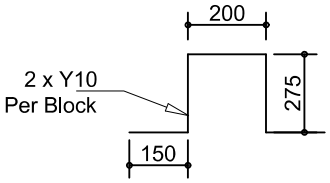
FRONT



PLAN-BLOCK DISSAPATORS



SECTION-BLOCK DISSAPATORS



FIXING BAR

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PROJECT

TYPICAL DETAIL OF PIPE CULVERT IN AND OUTLET STRUCTURE (BRICK)

SCALE
N.T.S

DRAWING No.
STE/SW-77C