CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Contract No. 210C/2022/23 WP005

PROFESSIONAL SERVICES FOR LAND PACKAGING AND DEVELOPMENT RIGHTS ACQUISITION OF ERF 2187, GREEN POINT:

THREE ANCHOR BAY MIXED USE DEVELOPMENT

STORMWATER MANAGEMENT PLAN REPORT

ORIGINAL

MARCH 2026

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Project Name: Professional Services for Land Packaging and Development Rights Acquisition of Erf 2187, Green Point: Three Anchor Bay Mixed Use Development for Property Development Department of City of Cape Town

Contract No: 210C/2022/23 WP005

This document has gone through a line of checking procedure, which forms part of our Quality Management System.

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1 INTRODUCTION

1.1 Project Proposal

The applicant, the City of Cape Town Property Development Department, is proposing a high-intensity mixed-use development on erf 2187 in Three Anchor Bay. The site is approximately 4.5 hectares in size, municipal-owned, and currently zoned as Public Open Space (OS2). The site is bounded by Sea Point Main Road (M61) to the south, Helen Suzman Boulevard and Beach Road (M6) to the north, and Three Anchor Bay Road to the west. These roads contribute to good connectivity in an east-west direction to and from the site. MyCiTi and Golden Arrow Bus Services are available within walking distance to the site.

Notwithstanding the site's prime location, the site is currently underutilised. The bowling clubs that used to occupy significant land on the site are no longer active and the club houses are now being leased for various other low-intensity community uses or are vacant. There are various sport and public recreational facilities in the vicinity of the site and the City's Spatial Development Framework earmarks the site for infill development that would ensure better utilisation of this well-located land parcel close the City CBD and regional community and recreational facilities.

The intention is for the site to be disposed of via a competitive bidding process after the municipality's in principle approval to transfer is obtained, and statutory processes in terms of NEMA and MPBL are concluded. The concept design includes residential, retail, commercial, civic and hotel development.

1.2 Existing Land uses to be retained

The proposed concept design retains the library, civic centre and hall and provision is also made to extend the library building, reconfigure internal spaces, accommodate other community and civic uses within the new additions and re-purposed spaces. The proposal includes a new building and outdoor space for a creche/ECD and the CPA parking on the site will be incorporated into the design. The electric substation will be moved to a different location to maximise the site's development potential.

1.3 Purpose of this report

The purpose of this Stormwater Management Plan Report (dated March 2026) prepared by EAS Infrastructure Engineers is to:

- Assess the existing stormwater infrastructure on the site, with specific focus on identifying the pipelines that require relocation away from the development footprint and into the road reserve.
- To provide a conceptual strategy for water quality treatment in line with City of Cape Town's various policies, Water Sensitive Urban Design (WSUD) and Sustainable Urban Drainage (SUDs) and integrate same into the surrounding stormwater system.

This report is one of a series of technical reports which either gave input to, or assess the proposals for the redevelopment of the site. Refer to the section below for a a list of specialists involved in the project, and the specialist reports that support this development proposal.

1.4 Project team and specialist reports

The following specialist investigations and assessments have been undertaken as part of preparing the project proposals.

Discipline	Company name	Assessment & Reports
Environment	Infinity	Basic Environmental Impact Assessment report
Heritage	Lize Malan & Cindy Postlethwayt	Heritage Impact Assessment report
Visual	David Gibbs	Visual Impact Assessment report
Architects and Urban Designers:	ACG Architects & Urban Design	Urban Design Concept, Urban Design report Urban Design guidelines
Socio-Economic Specialist:	Urban Econ	Socio-Economic Impact Assessment
Property Market	Urban Econ	Property Market Assessment report
Transport Engineers:	ITS	Transport Impact Assessment report
Civil Engineers:	EAS	Bulk Engineering Services Impact Assessment and Stormwater report
Electrical Engineers	BVI	Electricity Infrastructure Impact Assessment report
Town Planning	@Planning Town Planning	Town planning input & statutory application

2 SITE DESCRIPTION

The site's location is Erf 2187 in Green Point, Cape Town, which is shown in Figure 2.1 in the red highlighted area. The site has various infrastructure, including a library, Major and Minor Halls, roadways, parking, Glen Green Point sports center, Western Province Bridge Centre, Pinocchio Creche and a network of underground and overhead services.

Figure 2.1: Erf 2187 site location

3 TERRAIN DESCRIPTION

3.1 Topography and Climate

The site slopes naturally from South to North with Main Road on the Southern side (Higher) and Helen Suzman Boulevard on the Northern side (Lower). According to The South African Weather Service (SAWS), the prevailing climate conditions for the development area within Cape Town is classified as a Mediterranean climate, characterized by warm, dry summers and mild, wet winters. The site experiences a significant amount of rainfall during the winter months (June-September). Annual precipitation is approximately 505mm for the site. The natural ground levels ranges from approximately 7 to 15 meters above mean sea level.

3.2 Geology and Geotechnical Conditions

A Geotechnical investigation was conducted in February 2017 by HHO Consulting Engineers titled: "*Geotechnical Report on Subsurface Investigations*". According to this report, the site consists of fill materials, topsoil, transported soils and/or residual clay of various thicknesses and extents overlying phyllite rock of Malmesbury Group. Groundwater depths is varied between 2.0m and 3.1m below existing ground levels.

4 CITY OF CAPE TOWN DISCUSSIONS

Following engagements with the City of Cape Town departments regarding the existing stormwater infrastructure on site and the proposed stormwater strategy, the following points were noted:

- Due to the proximity of the development to the ocean, the attenuation of large storms greater than a 1 in 1 year storm are not required. However, the development will still need to comply with the City of Cape Town's Management of Urban Stormwater Impacts Policy and the Floodplain and River Corridor Management Policy.
- The CCT informed EAS that treatment of stormwater is required in the development before the stormwater enters the existing network.
- Due to the existing stormwater infrastructure crossing the site, the solution is to relocate them to the road reserves.
- Upon an enquiry by EAS regarding whether the maintenance of the stormwater treatment facilities, and related infrastructure would be the responsibility of the City Cape Town, it advised that this is a land ownership issue and if the CCT is responsible for the maintenance of the development's stormwater infrastructure then the it will require servitudes within the development.
- The portion of land within Erf 2187 where the blue-gum trees are located will be zoned Open Space 3.

5 CITY OF CAPE TOWN STORMWATER POLCIES

The CCT requires all developments (greenfield and brownfield) to plan and design stormwater systems using Water Sensitive Urban Design (WSUD) and Sustainable Urban Drainage Systems (SuDS) so as to improve runoff quality, control quantity, and encourage groundwater recharge where appropriate. A treatment-train approach is expected (source → local → regional measures).

This site is a brownfield development and the municipality's interim criteria set explicit pollutant-load reduction targets of 80% Suspended Solids (SS) and 45% Total Phosphorus (TP), using Best Management Practices sized to the ½ year, 24-hour water-quality storm. These targets are achieved on site where litter, oil and grease must be trapped at the source.

Stormwater systems must be submitted to and approved by the CCT. Where SUDs/BMPs are located on private property, the owner/body corporate must operate, maintain and monitor them, Council may audit and require remedial actions. Alignment with broader sustainability measures is encouraged.

The Stormwater Management By-law (2005) prohibits discharging anything besides stormwater to the system without written consent and prohibits actions that damage or pollute the system. The CCT may require environmental studies done and may require the owners to keep private stormwater systems functional.

For any development near watercourses/wetland, the Floodplain and River Corridor Management Policy (2009) gets a merit-based framework balancing flood risk, ecology and socioeconomics. It requires floodline determinations (typically 2-, 20-, 50- and 100-year storms), prohibits obstruction within high-hazard zones and places restrictions on development within the 50- and 100-year floodlines. In the policy, it is mentioned that a 24-hour extended detention of the 1-year storm event, up to the 10-year RI peak flow reduced to pre-development level, up to the 50-year RI peak flow reduced to existing development level and evaluation of the 100-year RI storm and it's impact upon the stormwater system. **However, it should be noted that due to the site's proximity to the ocean, the attenuation of stormwater is not required.**

WSUD measures must be integrated into spatial planning and should enhance amenity and biodiversity. Where infiltration is unsuitable, filtration-type SUDs with underdrain and waterproofing measures are acceptable, provided they meet the CCT's performance criteria. The development will comply with the policies and regarding the treatment, BMPs are proposed for the development in accordance with the Georgia Stormwater Management Manual (2001).

At this stage, the long-term ownership and maintenance responsibility for the proposed stormwater infrastructure within the development is unknown. Should any portion of the stormwater system be required to fall under the ownership and maintenance responsibility of the CCT, the municipality will require formal access rights, which may include the registration of a servitude, in accordance with the CCT's Stormwater Management By-law (2005).

6 CATCHMENT AND HYDROLOGICAL ANALYSIS

6.1 Pre-development Hydrology and existing stormwater network

Three Anchor Bay Erf 2187 is in close proximity to the Atlantic Ocean to the North. There are no other watercourse surrounding the site. The site was subdivided into multiple sub-catchments as shown in the layout (C5107_SW Catchments) attached in **Annexure A** and an extract of it shown in Figure 6.1. Each of the catchments are draining towards low points identified throughout the site. The general flow direction is south to north.

A topographical survey was conducted in 2017 which assessed the extent of the existing network within Erf 2187. The stormwater runoff is predominantly conveyed within the roadways into catchpits to the west of the site and to the north of the site which ultimately discharges into the Atlantic Ocean. It was found that a portion of the site on the western side drains westward. The existing pipe network to the west of the site are 300mm diameter pipes found within the roadway. The general center of the site drains northward. The existing pipe network to the north of the site is a 450mm diameter pipe which feeds into a 750mm diameter pipe which feeds into a 900mm diameter pipe ultimately discharging into the ocean. The portion to the east of the site drains northwards. East of the site, a 825mm diameter pipe crosses the site and connects onto the 750mm diameter pipeline. The existing stormwater network layout (C5102_Existing Stormwater Layout) is attached in **Annexure A**.

Figure 6.1 shows the extract of the sub catchments and the direction of the stormwater runoff on the existing ground currently at site. The red lines represents the catchment boundaries, and the arrows are the flow directions. The stormwater proposed strategy considered the natural falls and slopes in the site.

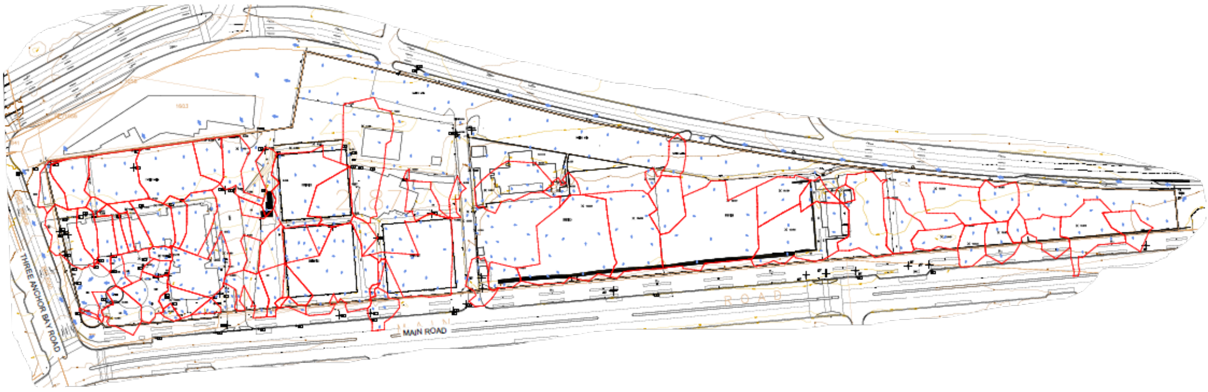


Figure 6.1: Catchment areas

6.2 Design Rainfall

The rainfall depth for the 0.5- and 1-year storm event is not available in the South Africa Ver 3 (July 2012) open-source software or the City of Cape Town's Rainfall grid therefore, the extrapolated rainfall data for these storm events was calculated using a log-linear frequency relationship using the City of Cape Town's rainfall grid's rainfall depths. The extrapolated data is shown in **Table 1**.

Table 1: Design Rainfall Estimation

Recurrence Interval	24hr Rainfall Depths (mm)
0.5	21.48
1	25.26
2	50.485
5	67.62
10	80.27
20	93.265
50	111.665
100	126.615
200	142.715

6.3 Peak Flow Estimation using the Rational Method

Peak runoff rates for the 0.5- and 1-year were estimated using the Rational Method. The method defines peak discharge as Q=CiA, where C is the runoff coefficient, i is the rainfall intensity and A is the contributing catchment area. The peak flow rates for each recurrence interval is presented in **Table 2**.

Table 2: Peak Flow Rates Information

Recurrence Interval	Peak Flow (m^3/s)
0.5	0.689
1	0.810

7 HYDROLOGICAL MODELLING

7.1 Modelling software

A stormwater hydrological and hydraulic model was developed with the aid of the Autodesk Storm and Sanitary Analysis (SSA) software. The EPA SWMM hydrological calculation method has been used to determine drainage area runoff.

These tools were selected based on their technical capabilities and compatibility with the project's requirements. SSA part of Autodesk Civil 3D integrates well with Civil 3D, which is used for the geometric layouts and design of the stormwater infrastructure. It allows for catchment delineation, rainfall-runoff simulation and hydrograph generation using South African rainfall data. While other hydrologic tools such as SWMM, HydroCAD or WMS are available, SSA was preferred due to its seamless integration with Civil 3D and reducing data transfer errors and improving workflow efficiency.

7.2 Model inputs and parameters

Parameters for catchment properties of a design storm are based on accepted norms or sound engineering judgement. Where possible the values have been calculated to ensure the best possible accuracy. All catchments are assigned a composite Curve Number (CN) and topographical information (size, slope, depression) from which the physical properties used in the model are derived. The CN is a simple, widely used, and efficient method of determining the fraction of precipitation that will translate to surface runoff. It is based on the drainage areas hydrological soil group, land use and hydrological condition (% impervious). A high CN value (98 for paved roads) causes nearly all precipitation to translate to runoff, whereas a low CN value (30 for sandy conditions) causes most of the precipitation to be captured as infiltration. Typical values are shown in Figure 7.1.

Description	Condition	A	B	C	D	Condensed Description
FULLY DEVELOPED URBAN AREAS	Vegetation					
Open space (lawns, parks, etc.)						
grass cover < 50%	Poor	68	79	86	89	< 50% grass cover
grass cover 50% to 75%	Fair	49	69	79	84	50 - 75% grass cover
grass cover > 75%	Good	39	61	74	80	> 75% grass cover
Impervious Areas						
Paved parking lots, roofs, driveways		98	98	98	98	Paved parking & roofs
Streets and roads						
Paved: curbs and storm sewers		98	98	98	98	Paved roads with curbs & sewers
Paved: open ditches (with right-of-way)	50% imp	83	89	92	93	Paved roads with open ditches
Gravel (with right-of-way)		76	85	89	91	Gravel roads
Dirt (with right-of-way)		72	82	87	89	Dirt roads
Urban Districts	impervious					
Commercial & business	85% imp	89	92	94	95	Urban commercial
Industrial	72% imp	81	88	91	93	Urban industrial
Residential Districts						
(by average lot size)	impervious					
1/8 acre (town houses)	65% impervious	77	85	90	92	1/8 acre lots
1/4 acre	38% impervious	61	75	83	87	1/4 acre lots

Figure 7.1: Typical CN values as extracted from Autodesk SSA

7.3 Hydrological characteristics

The software utilizes a “rainfall designer” to create a design storm for a specified storm distribution based on rainfall depth under a given scenario. The rainfall depth is provided in section 6.2. Stormwater or Time Distribution is a measure of how the intensity of rainfall varies over a given period. Using the rainfall data over a 24-hour period it will develop a synthetic rainfall distribution to use in lieu of an actual storm event. In South Africa we are generally guided by the Area Distribution graphs provided in the Roads Drainage Manual. The Type 1 distribution contains the lowest intensities, representing rainfall produced by a frontal or wide-spread rain situation, while the Type 4 distribution contains the highest intensities, typically convective thunderstorms in which virtually all the day's rain falls within a short duration. The Type 2 distribution has been used for Three Anchor Bay in line with Figure 3.3.2 of the Drainage Manual.

7.4 Interpretation of results

The analysis results are presented in **Annexure D**. The typical summary details are depicted below:

Link Summary

Element ID	Element Type	From (Inlet) Node	To (Out) Node	Length (m)	Average Slope (%)	Dia./ Height (m)	Manning's Roughness	Peak Flow (cms)	Design Capacity (cms)	Peak Flow Velocity (m/sec)	Peak Flow Depth (m)	Peak Flow Depth/ Total Depth Ratio	Reported Condition
P1	Pipe	MH240	MH245	12.56	1.6500	0.445	0.0120	0.31	0.38	2.54	0.32	0.72	Calculated

Average Slope	= Slope of pipe or channel
Dia./Height	= Size of pipe or channel
Peak Flow	= Maximum flow for the design storm
Design Capacity	= Maximum flow that the pipe or channel can convey
Peak Flow Velocity	= Maximum velocity within the pipe or channel
Peak Flow Depth	= Maximum depth of flow through the pipe or channel
Peak Flow Depth/Total Depth Ratio	= Ratio of actual flow vs capacity that is available within the pipe or channel

7.5 Results Summary

SSA was used to assess the existing and proposed site hydrology. The intent of the modelling is not attenuation, since the City confirmed attenuation is not required near the coast but rather to verify that the proposed bioswales can store the WQv. The detailed output results is attached in **Annexure D.**

The existing analysis indicates that the existing surface catchments produce modest peak flows under the 1-year storm event and behave as expected hydraulically. The key findings are as follows:

Catchment 1: Peak runoff rates = 0.04l/s

Catchment 2: Peak runoff rates = 0.97l/s

Catchment 3: Peak runoff rates = 1.49l/s

For the proposed analysis, the four bioswales were represented as lined bioretention storage units with engineered media, ponding depth of 0.30 m, and underdrains. SSA modelling verifies whether their storage, inflow, and hydraulic behaviour meet design intent.

For all bioswales, the peak HGL depths remain very small (0.07-0.09m), no flooding reported, ponding areas remain within the 0.30m allowable depth, all ponding volumes are below the designated WQv allocation, and no extended retention was recorded. The peak inflows remain well within allowable limits, and all units drain effectively through the underdrain network into the existing 750mm diameter pipe system.

The “outfall” in the SSA model is MH9 on the proposed stormwater drawings in **Annexure A** and in the SSA model it was temporarily treated as an outfall to isolate and quantify the development’s treated discharge entering the CoCT’s stormwater network. Additionally, the 2-,5- and 100-year return periods for both existing and proposed conditions have been modelled and is also presented in **Annexure D**. These runs were carried out to provide the City with further context on how the development performs across a wider range of storm events.

8 PROPOSED STORMWATER STRATEGY

The proposed stormwater strategy incorporates WSUD measures, including podium bioretention systems and grass-lined swales, to improve quality of stormwater. The proposed system is designed as a combination of source controls, locals and downstream controls, with the aim of treating the Water Quality Volume (WQv). In this development, attenuation is not required, and treatment becomes the primary design driver. For the methodology and modelling approach utilized refer to **Annexure D**.

GSMM notes that SUDs generally incorporate a range of possible stormwater treatment options. The selection of appropriate controls must be based on the unique characteristics and constraints of the development site. Therefore, it is essential that the advantages and limitations of each SUDs option are evaluated. In line with this approach, the following table summarizes the various SUDs measures and it's limitations relative to the site.

Table 3: SUDs Comparison

Control Type	Suitability	Reasoning
Green roofs	Yes	Treat at source, no ground space needed; ideal for brownfield developments.
Rainwater harvesting	Yes	Reduces runoff volume and pollutant load; simple to integrate; does not rely on soil profile.
Soakaways	No, possible only in small areas not above basement	Basement removes soil volume, infiltration not possible above slab. Groundwater is shallow and site has many services, further limiting feasible locations.
Permeable Pavements	No	CoCT does not favour them, high clogging risk, no storage layer possible.
Filer strips	No	Need large soil-based vegetated areas, cannot sit above basement, insufficient space.
Conventional Swales (Infiltrating)	No	Require Soil profile and long vegetated corridors, unavailable given the basement footprint and site constraints
Conveyance swales with impermeable base (non-infiltrating)	Yes (as conveyance)	Use along available corridors to spread flows, pre-settle coarse solids, and deliver evenly to engineered bioswales/bioretention units. No infiltration is attempted; they are lined.
Engineered podium bioswale/bioretention (lined with underdrain)	Yes (primary local and regional treatment)	Built over the basement slab as a podium bioretention unit; filtration through engineered media; adsorption; microbial processing; plant uptake; drains via underdrain to existing stormwater network. Compact, modular, high treatment performance. The bioretention cells are to be placed in strategic low-point green spaces to act as the site-scale polishing step before discharge to the relocated stormwater pipelines.
Infiltration trenches	No	Not feasible above slabs, maybe micro-applications where basement absent and services/groundwater allow but not relied upon.
Sand filers	Yes	Ideal in tight urban footprints, can be placed in podium/under paved areas, gravity discharge to network.
Detention Ponds	No	Attenuation not required due to immediate vicinity to the ocean

Retention Ponds	No	Requires large land areas, safety buffers and constant water surface, not feasible in this development and not required either.

Due to the presence of a full-footprint basement, natural infiltration is not possible. Therefore, engineered bioswales/bioretention planters remain effective in this context. A bioswale constructed above a basement can still effectively treat stormwater, even though it cannot infiltrate into the natural soil. When placed over a slab, the system functions as a podium bioretention unit. Stormwater is filtered through engineered media, undergoing pollutant adsorption, microbial activity, and plant uptake. It is then conveyed via underdrains to grid inlet manholes, which also serve as overflow chambers during major storm events, discharging into the existing stormwater network. The bioswales are lined with waterproofing and the underdrain is usually a perforated HDPE or PVC pipe wrapped in geotextile. Vegetation for the bioswales is selected for shallow rooting and coastal exposure.

8.1 Overall Treatment Train Concept

The treatment train consists of:

- Source controls at roof level (green roofs, rainwater harvesting).
- Conveyance control via kerb and channel.
- Primary treatment via engineered bioswales.
- Downstream overflow control via grass-lined swales.

❖ Source Controls

Green Roofs

Green Roofs are proposed to reduce runoff volumes, delay peak flows, and remove pollutants at source. They consist of a waterproofing membrane, root barrier, drainage layer, filter fabric, and 80–150 mm vegetation substrate. Green roofs contribute to WSUD objectives by reducing directly connected impervious area and absorbing first-flush contaminants. Routine maintenance includes weeding, checking plant cover, and inspection of drainage elements.

Rainwater Harvesting

Roof runoff can also be captured via rainwater harvesting tanks for non-potable uses. This reduces potable water consumption, intercepts first-flush pollutants, and decreases stormwater volumes entering the onsite system.

❖ Conveyance Controls

The conveyance of the stormwater will be via kerbs and channels directing runoff to the bioswales and overflow to the grass-lined swales along the low area of the development. The grass-lined swales are shallow-sloped and are used to slow down and spread the runoff providing additional treatment before entering the stormwater network and with the addition of the waterproofing membrane. The typical cross section is shown in the illustration below.

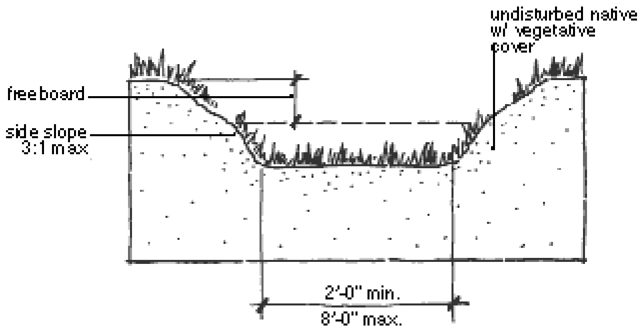


Figure 8.1: Typical swale cross-section

At each bioswale, a gravel diaphragm will intercept the runoff before it enters the treatment areas functioning as pretreatment zones and energy dissipators. These conveyance elements operate purely as conveyance and pretreatment, with no infiltration, due to the basement underneath.

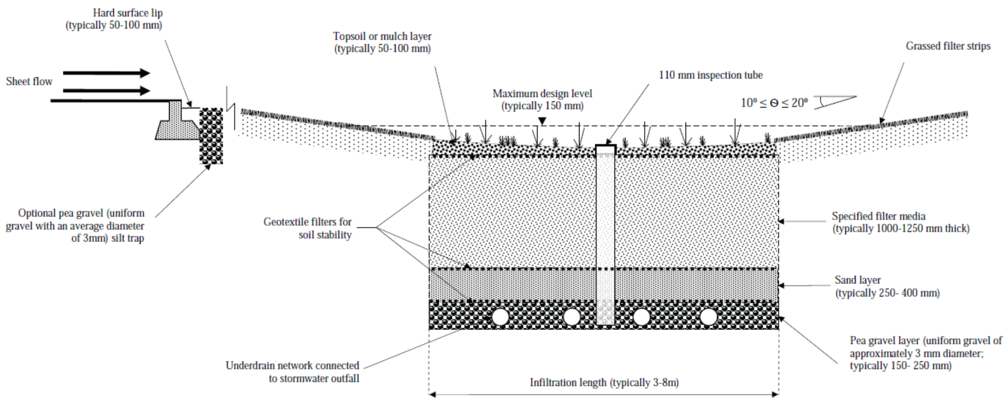
❖ Primary Treatment – Engineered Podium Bioswales/Bioretention areas

The core of the stormwater treatment strategy is a set of four lined bioretention cells located at the proposed green open spaces as shown on Layout C5106_Prop SW SUDs in **Annexure A**. Although infiltration is not possible, bioretention remains highly effective on basements because stormwater passes through engineered media where filtration, adsorption, microbial degradation, and plant uptake remove suspended solids, nutrients, hydrocarbons, and metals. The treated water is collected by an underdrain system and conveyed to the municipal stormwater network. The proposed Bioretention layer structure (Total Depth=1.25m) is presented in **Table 4**.

Table 4: Proposed bioretention layer structure

Layer	Depth
Freeboard	0.150m
Ponding Zone	0.300m
Filter Media	0.450m
Transition/Drainage layer	0.150m
Underdrain pipe envelope	0.160m
Waterproofing protection	0.040m
Total System Depth	1.25m

A typical cross-section of a bioswale extracted from The South African Guidelines for SUDs can be seen below in Figure 7.2 however for purposes of this development the bioswales will also include waterproofing membrane.



Long-section

Figure C7: General design for bio-retention areas
[after Wilson et al., (2004); Woods-Ballard *et al.*, (2007); Haubner *et al.*, (2001)]

Figure 8.2: Typical bioswale cross-section

A typical Schematic of the Bioretention areas is shown in the figure below

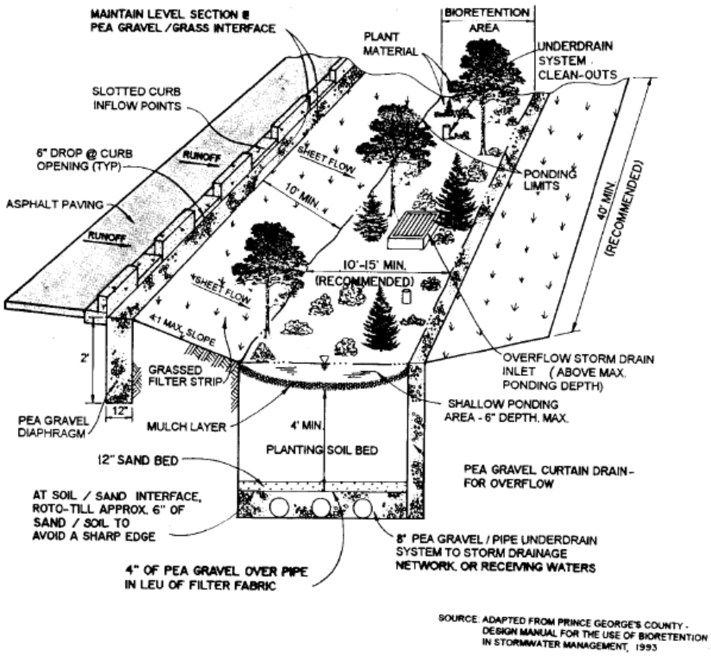


Figure 8.3: Typical bioswale schematic

8.2 Hydraulic Operation

The hydraulic configuration of the bioswales has been developed in accordance with the Georgia Stormwater Manual (GSMM) water-quality design methodology governing Water Quality Volume (WQv). The GSMM is a robust and internationally recognized framework for sizing bioretention facilities.

The WQv is calculated using the GSMM standard formula:

$$WQ_v = \frac{P \times R_v \times A}{12}$$

Where:

P = water quality rainfall depth (mm) for 0.5-year storm event over 24h

Rv = volumetric runoff coefficient, defined in the GSMM as

$$\boldsymbol{R_v = 0.05 + 0.009 \times I}$$

With I=%impervious cover

A = drainage area (m²)

The calculated WQv using the Peak Flow rates in **Table 2** for the site is 162m³. GSMM requires a 24-hour drawdown of the WQv through the filtration system. The calculated release rate is:

$$Q_{release} = \frac{162m^3}{24hr} = 0.00187\frac{m^3}{s}$$

GSMM encourages distributed controls, therefore the WQv is divided into four Bioswales as shown in **Table 5**. The area of the Bioswale was determined based on the available space within the green open area and the assigned WQv. Position of the Bioswales are shown in the layout (C5106_Prop SW SUDs) attached in **Annexure A**.

Table 5: Bioswales and assigned WQv

Bioswale	Area (m²)	WQv Assigned (m³)
A	265	40.5
B	135	40.5
C	50	40.5
D	90	40.5

Only the ponding zone may be used for water-quality storage. The depth of the ponding layer is 0.3m as shown in **Table 4**. Therefore, the Total Ponding Volume is as follows:

- Bioswale A: Ponding Volume = 79.5m³
- Bioswale B: Ponding Volume = 40.5m³
- Bioswale C: Ponding Volume = 15m³
- Bioswale D: Ponding Volume = 27m³
- The total ponding volume = WQv

The bioswales are not designed to handle major storm events therefore provision for overflow must be incorporated in the design. It is proposed to have a side-weir at the downstream end of the bioswale which will allow for stormwater to overflow into the proposed grid inlet manhole. The invert of the weir is placed at the maximum ponding depth as shown in the proposed stormwater layout (C5106_Prop SW SUDs) attached in **Annexure A**. The underdrain invert is located below the media/drainage layers and directly discharges into the overflow grid inlet manhole.

GSMM requires pretreatment to remove coarse sediments before entering the bioretention. Therefore, a 150mm deep x 500mm wide lined gravel diaphragm is proposed which will also act as an energy dissipator and flow spreader.

A full risk analysis supporting the proposed stormwater strategy is included in **Annexure E**.

8.3 Subsoil Drainage Concept

The geotechnical investigation identifies groundwater levels varying between approximately 2m and 3.1m below existing ground level. The development includes a basement therefore subsoil drainage must be provided to manage the groundwater ingress, protect the basement and maintain stability beneath the slab.

To ensure effective subsoil drainage, a perimeter of subsoil drainage will need to be installed below the lowest basement slab level. Generally, subsoil drainage is characterized as follows:

- 110mm to 160mm perforated HDPE subsoil underdrain pipelines laid to consistent falls to promote gravity drainage and surrounded by washed drainage stone.
- The perforated pipelines are surrounded in stone usually sized 19mm, and fully wrapped in a non-woven geotextile filter to prevent clogging in the pipe.
- These subsoils are installed adjacent to retaining walls, beneath the slab at low points and along groundwater interception zones.

All subsoil drains will discharge by gravity towards a dedicated groundwater pump/s located at the lowest point of the basement where all the pipes can easily gravitate to. The system will pump collected groundwater into the municipal stormwater system via a rising main. This is governed by the CCT’s Stormwater Management By-law.

Additional considerations include ensuring proper drainage, providing inspection and clean-out points at logical intervals for maintenance access, waterproofing, ensuring the discharge points, pumps and backflow controls integrate with the proposed stormwater relocation and downstream network.

9 WATER QUALITY TREATMENT PERFORMANCE

For our Brownfield development (<50000m²), Suspended solids = (TSS)≥80% and Total Phosphorus = TP≥45% removal, with the stormwater sized to the ½ year, 24h WQv and implemented via the treatment train discussed in Section 7.

Consistent with GSMM practice and CCT policy, performance is demonstrated by applying cumulative removal across SUDs, using best practice removal ranges published in the RSA SUDs Guidelines and the extract attached in **Annexure C**.

The WQv = 162m³ (1/2-year, 24h) is stored completely in the four bioswales (0.30m ponding layers), ensuring that the first flush runoff is detained and treated before discharge. Underdrains are throttled for the 24-hour drawdown consistent with best management practices.

At this stage of the project, it is appropriate to adopt conservative mid-range removal values from the RSA SUDs Guidelines. **Table 6** lists the factors used and should be confirmed during detailed design stages of the development.

Table 6: Factors for WQ treatment levels

SUDs unit in this project	TSS (%)	Hydrocarbons (%)	TP (%)	TN (%)	Heavy metals (%)	Comment
Gravel Diaphragm	15%	0-10%	5%	5%	10%	Coarse material interception and energy dissipation.
Grass lined swales	60%	70%	25%	30%	40%	**Annexure C** ranges for swales: TSS 60–90%, HC 70–90%,

						TP 25–80%, TN 30–90%, metals 40–90%, therefore mid-range is adopted.
Bioretention/ Bioswales	70%	65%	50%	45%	70%	**Annexure C** ranges for bioretention: TSS 50–80%, HC 50–60%, TP 50–60%, TN 40–50%, metals 50–90%, therefore mid-range is adopted

For SUDs units in series, cumulative pollutant removal is computed as follows:

$$Remaining\ load = Influent\ \times \Pi(1 - R_i) \rightarrow Total\ removal = 1 - \ \Pi(1 - R_i)$$

Where R_i is the removal efficiency of stage i. This equation is used for treatment-train assessment.

Using the adopted values in **Table 6** the following is calculated:

- TSS: $1 - (0.85 \times 0.40 \times 0.30) \approx 90\%$, meets CCT target (≥80%)
- TP: $1 - (0.95 \times 0.75 \times 0.50) \approx 64\%$, meets CCT target (≥45%)
- Hydrocarbons: $1 - (0.30 \times 0.35) \approx 90\%$, consistent with RSA SUDs Appendix B ranges for Bioretention and Swales
- Heavy metals: $1 - (0.60 \times 0.30) \approx 82\%,$ good reduction in the heavy metals.

9.1 Operations and Maintenance

The removal performance is sensitive to vegetation condition, sediment control and the media in the bioswales health; therefore, it is a priority to ensure inlet sediment removal, vegetation upkeep in the swales and bioretention facilities, periodic media surface rehabilitation, routine inspection of the overflow/underdrain infrastructure. Long-term performance is only achieved through sustained maintenance.

10 PROPOSED STORMWATER RELOCATION

The proposed development requires the relocation of existing municipal stormwater infrastructure to accommodate the proposed building footprint. As part of the stormwater strategy discussed in Section 7, the affected stormwater infrastructure are to be realigned and reconstructed to ensure that the capacity, functionality and downstream conveyance of the network is preserved. **Annexure B** provides the proposed stormwater layouts (C5104-1_Prop SW Relocation-Sheet 1 of 2 and C5104-2_Prop SW Relocation-Sheet 2 of 2). The relocation includes a 825mm diameter pipeline to be relocated however there are two options available for consideration. Option 1 is slightly moving the 825mm diameter pipeline away from the proposed building footprint and retaining its original crossing across the site in the proposed Open Space 3 zoned area. Option 2 is relocating the 825mm diameter pipeline to run parallel along the existing stormwater pipeline along Main Road and then deviating to the nearest access road to tie back onto the 750mm diameter pipeline. Option 2 was considered if there are any developable constraints that may be envisioned in future where the pipeline crossing the site may not be possible in the future development. However, if option 1 is preferred then this pipeline that will traverse the portion of land proposed for rezoning to Open Space 3 will require formal registered servitude.

The hydraulic performance of the relocated stormwater system has been evaluated to ensure compliance with acceptable design standards. Capacity checks were carried out on all relocated pipelines, and **Table 8** presents the calculated velocities and flow capacities. Additionally, a stormwater longsection drawing (C5105_Prop SW Longsections) is attached in **Annexure B**.

Table 7: Hydraulic capacity check for the relocated stormwater

Proposed Stormwater Pipe							Output (Mannings Equation ≈ $Q = \frac{1}{n}AR^{\frac{2}{3}}S^{\frac{1}{2}}$)		Comments
Pipe Name	Start Structure	End Structure	Length (m)	Slope (%)	Slope (1 in...)	Diameter	Velocity (m/s)	Design Flow (l/s)	
P1	MH1	MH2	71.026	0.61%	163.93	450	1.595	217.516	Acceptable self-cleansing velocity between 0.9m/s-3.5m/s
P2	MH2	MH3	54.417	1.23%	81.30	750	3.184	1206.274	
P3	MH3	MH4	56.19	1.09%	91.74	750	2.997	1135.565	
P4	MH4	MH5	58.143	0.50%	200.00	750	2.030	769.089	
P5	MH5	MH6	32.889	0.50%	200.00	750	2.030	769.089	
P6	MH6	MH7	33.941	1.00%	100.00	750	2.871	1087.656	
P7	MH7	MH8	34.479	1.04%	96.15	750	2.928	1109.218	
P8	MH8	MH9	68.336	0.50%	200.00	750	2.030	769.089	
P9	MH9	MH10	32.56	0.50%	200.00	750	2.030	769.089	
P10	MH10	MH11	27.731	0.63%	158.73	750	2.279	863.300	
P11	MH11	MH12	27.073	0.50%	200.00	750	2.030	769.089	
P12-Opt2	MH13	MH14-Opt2	30.612	0.50%	200.00	825	2.163	991.678	
P27-Opt1	MH13	MH2	52.45	0.30%	333.33	825	1.676	768.154	
P13-Opt2	MH14-Opt2	MH16-Opt2	64.961	0.50%	200.00	825	2.163	991.678	
P14-Opt2	MH15-Opt2	MH17-Opt2	43.175	0.50%	200.00	825	2.163	991.678	
P13 (1)-Opt2	MH16-Opt2	MH15-Opt2	67.098	0.50%	200.00	825	2.163	991.678	
P14 (1)-Opt2	MH17-Opt2	MH5	46.041	1.85%	54.05	825	4.161	1907.602	
P15	MH18	MH19	7.711	0.51%	196.08	375	1.291	122.300	
P16	MH19	MH20	19.849	0.50%	200.00	375	1.278	121.096	
P17	MH20	MH8	24.586	0.50%	200.00	375	1.278	121.096	
P18	MH21	MH20	6.678	1.00%	100.00	375	1.808	171.255	
P19	MH22	MH7	19.768	0.50%	200.00	375	1.278	121.096	
P20	MH23	MH6	21.517	0.50%	200.00	375	1.278	121.096	
P21	MH24	MH25	44.673	0.51%	196.08	375	1.291	122.300	
P22	MH25	MH26	30.291	0.50%	200.00	375	1.278	121.096	
P23	MH26	MH27	22.188	0.64%	156.25	375	1.446	137.004	
P24	MH28	MH25	24.136	1.70%	58.82	300	2.031	123.147	
P25	MH29	MH25	6.225	1.70%	58.82	300	2.031	123.147	
P26	MH30	MH26	4.722	1.70%	58.82	300	2.031	123.147	

11 STORMWATER GENERAL MAINTENANCE GUIDELINE

The following provides a guideline for the general maintenance of the system in the future to prevent flood risk and blockages during frequent storm events.

- Grid Inlets

Each grid inlet needs to be inspected and cleared of any buildup of silt, litter, or rubble that may impede the clear flow of water into the inlet.

- Piped System

Piped systems need to be checked in a systematic way to ensure they are clear of any obstructions and are able to flow at their full capacity. Any buildup of silt or other obstruction is to be removed by hand or by jetting.

- Grassed Swales

Inspect swales once every three months, and mow grass if required. Remove all litter during the monthly inspection.

- Green Roofs

Monthly inspection for the first year thereafter quarterly inspection. After major storms, ensure the downpipes/overflow channels are clear.

- Rainwater Harvesting Systems

Quarterly inspections to clean gutters, screens and remove sediment build-up in the tank sump if visible.

- Gravel Diaphragm

Monthly inspection for the first year thereafter quarterly inspection. After a major storm event or visible scour then repair is required.

- Bioswales/Bioretention facilities

Monthly inspections for the first year and then Quarterly inspections required to remove litter and maintain the vegetation. Sediment management and flush the underdrain if it starts to slow drain. A typical maintenance schedule for a bioretention area extracted from GSSM is shown below.

Activity	Schedule
• Pruning and weeding to maintain appearance. • Mulch replacement when erosion is evident. • Remove trash and debris.	As needed
• Inspect inflow points for clogging (off-line systems). Remove any sediment. • Inspect filter strip/grass channel for erosion or gullying. Re-seed or sod as necessary. • Trees and shrubs should be inspected to evaluate their health and remove any dead or severely diseased vegetation.	Semi-annually
• The planting soils should be tested for pH to establish acidic levels. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH.	Annually
• Replace mulch over the entire area. • Replace pea gravel diaphragm if warranted.	2 to 3 years

Additional Maintenance Considerations and Requirements

- The surface of the ponding area may become clogged with fine sediment over time. Core aeration or cultivating of unvegetated areas may be required to ensure adequate filtration.

Regular inspection and maintenance is critical to the effective operation of bioretention facilities as designed. Maintenance responsibility for a bioretention area should be vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.

Figure 11.1: Typical maintenance activities for bioretention areas

12 CONCLUSION AND RECOMMENDATION

The following conclusions and recommendations can be made:

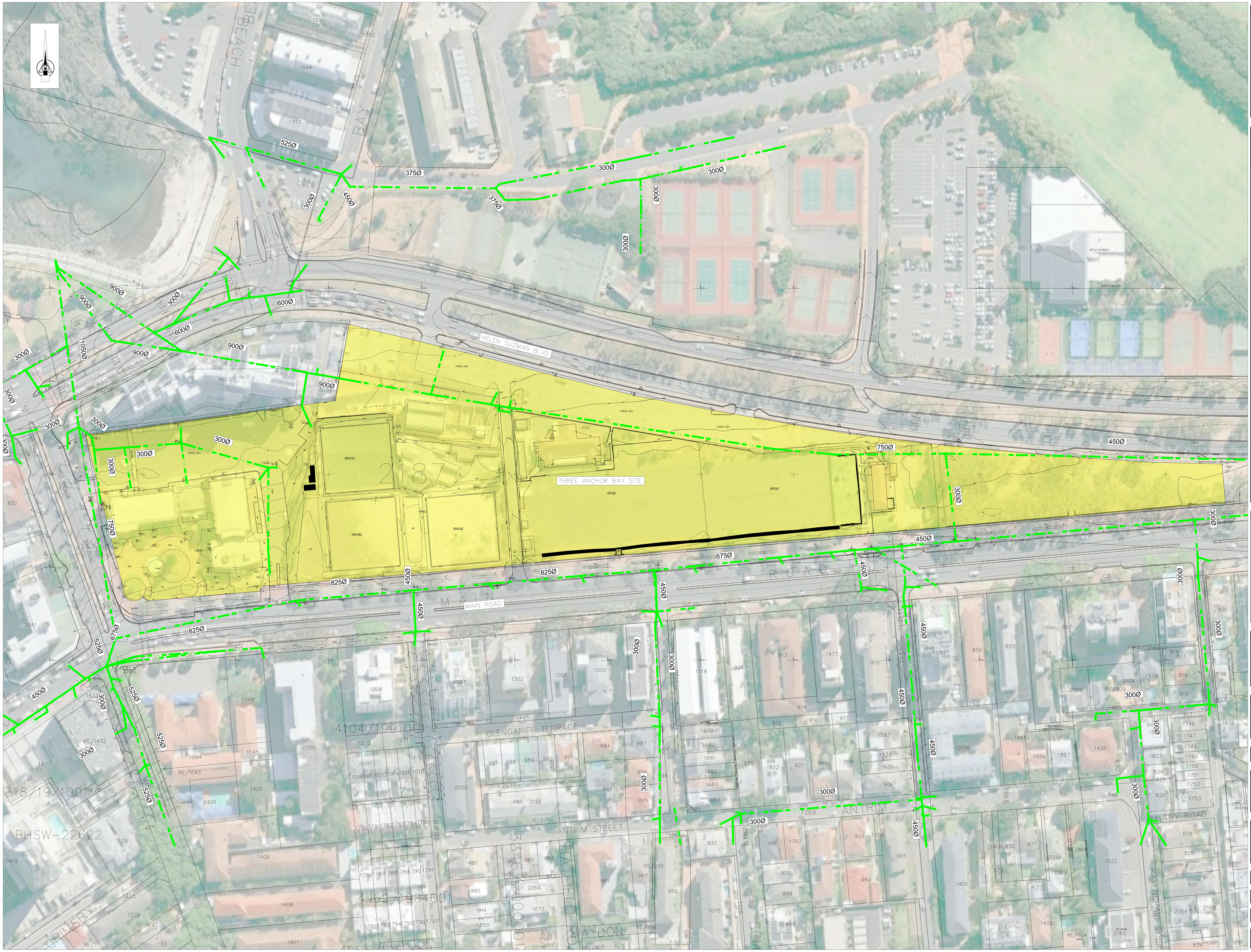
- The Three Anchor Bay redevelopment requires a treatment-focused stormwater strategy because attenuation of storms greater than 1 year is not required due to the site's immediate proximity to the Atlantic Ocean, as confirmed during discussions with the City of Cape Town.
- The existing municipal stormwater pipelines traversing the site must be relocated into the surrounding road reserves to protect the infrastructure and accommodate the proposed building footprint.
- The proposed conceptual stormwater strategy combines the use of green roofs, rainwater harvesting, pretreatment zones, lined grassed swales, and engineered podium bioretention/bioswales area which also meets the municipality's pollutant removal performance outcomes (≥80% TSS, ≥45% TP for brownfield sites).
- The long-term ownership and maintenance of the treatment facilities and relocated stormwater infrastructure remains undetermined. If any part is to be maintained by the City of Cape Town, servitudes and formal access rights will be required in accordance with the Stormwater Management By-law (2005).
- Confirm all invert levels, freeboard, grades and hydraulic connectivity during detailed design.
- Implement the maintenance guidelines to ensure long-term SUDs functionality.

We recommend that these stormwater management strategies, when approved by City of Cape Town, be used as a design guide for stormwater management that will serve the proposed development.

13 REFERENCES

- City of Cape Town Rainfall Grid Data and City of Cape Town GIS Data
- RSA SUDS Guidelines
- Georgia Stormwater Management Manual (GSMM), August 2001
- CoCT Management of Urban Stormwater Impacts Policy 2009 and Stormwater Management By-law 2005.
- CoCT Standards and Guidelines for Roads and Stormwater Ver 4.0, September 2024.
- HHO Consulting Engineers: *Geotechnical Report on Subsurface Investigations,* February 2017

ANNEXURE A: EXISTING AND PROPOSED STORMWATER LAYOUTS



All Dimensions And Levels Are To Be Verified On Site By The Contractor Before Commencing Any Work.

ON ORIGINAL

0 5 10 15 20 25 30 40 50 60 70 80 90MM

LEGEND

SW — EXIST. STORMWATER

EXIST. STORMWATER MANHOLE

SITE BOUNDARY

Rev	Date	Description	Chkd	Appd

CLIENT

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

CONSULT

INFRASTRUCTURE ENGINEERS
Suit 303, The Landing, Lower Burg Street, Cape Town
Tel: 021 418 2025
Admin@easengineers.co.za www.easconsulting.co.za

Consultant Signature

Project

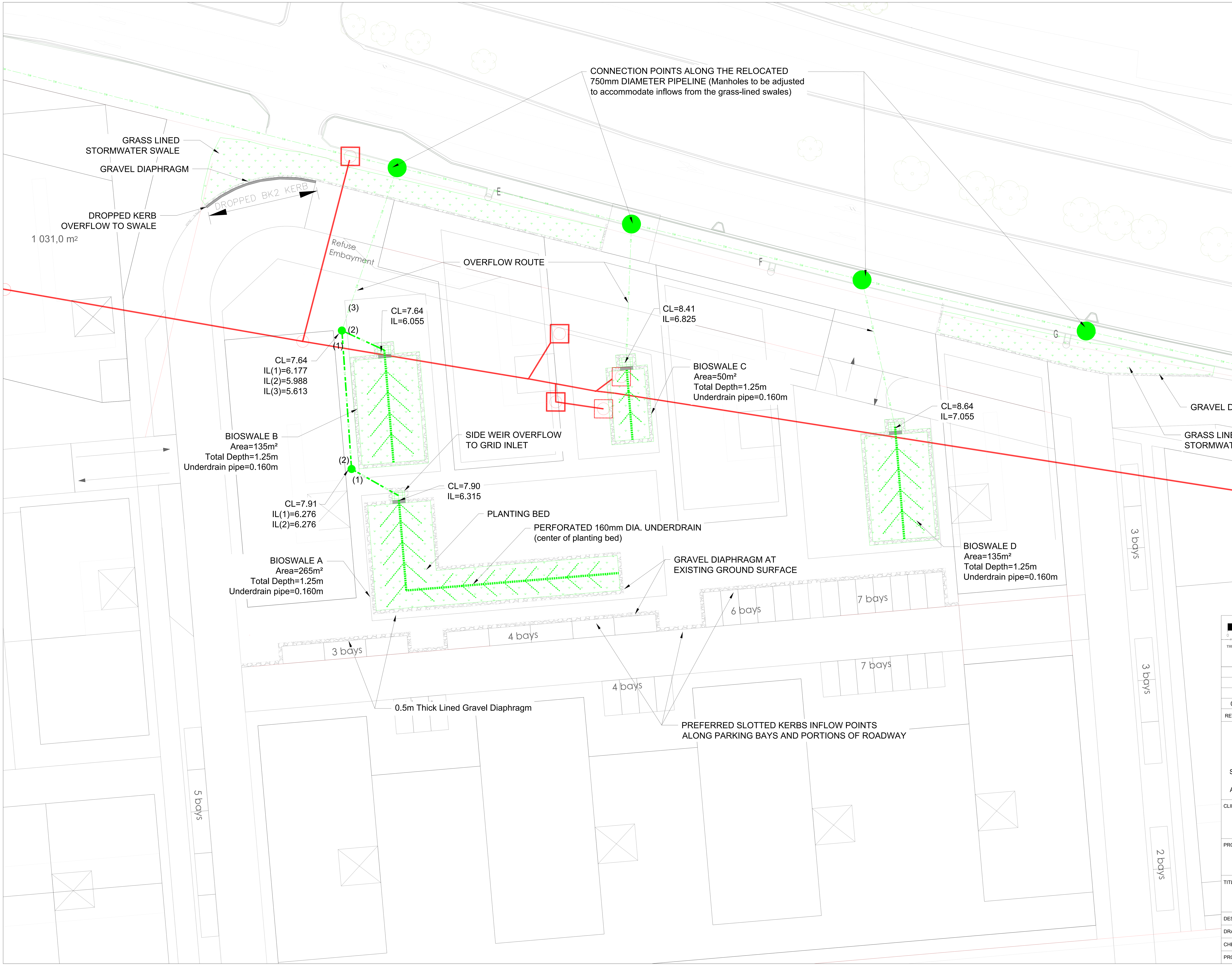
210C WP005 Erf 2187 Three Anchor Bay

Drawing Title

Existing Stormwater Layout

Design: A. Darries	Design Check: K. Naicker
Drawn: A. Darries	Design Approved: F. Ismail
Date: 17 March 2025	Scale: A1@1:650

Project No 24020i / Drawing. No C5102 / Revision 0



NOTES

1. EXISTING SERVICES ARE SHOWN BASED ON THE BEST AVAILABLE INFORMATION, BUT SHALL BE REGARDED AS DIAGRAMATIC ONLY. THE CONTRACTOR SHALL CONFIRM THE POSITION OF ALL UNDERGROUND SERVICES PRIOR TO COMMENCING WORK.
2. WHERE EXISTING TELECOMMUNICATION PIPES ARE AFFECTED BY THE WORKS, THEY SHALL BE CAREFULLY EXPOSED BY HAND AND PROTECTED BY A CONCRETE RAFT SLAB, OR RELOCATED, BY THE CONTRACTOR, AS ORDERED AND SUPERVISED BY RELEVANT TELECOMMUNICATION AUTHORITY.
3. STORMWATER PIPES ARE TO BE SPIGOT AND SOCKET CLASS 100D CONCRETE PIPES
4. ALL SEWER PIPES TO BE HEAVY DUTY CLASS 34 uPVC.
5. THE CONSULTANT WILL NOT BE HELD RESPONSIBLE FOR THE INACCURACY AND/OR MISSING EXISTING SERVICES INFORMATION
6. ALL EXISTING TELECOMS SERVICES TO BE RELOCATED IN SIDEWALK.
7. ROADS TO BE GRADED SUCH THAT THE RUNOFF WILL ENTER THE BIOSWALES AND THE OVERFLOW ROUTES WILL BE THE BOTTOM OF THE ACCESS ROADS

LEGEND

- EXIST. STORMWATER
- EXIST. STORMWATER MANHOLE
- PROP. STORMWATER
- PROP. STORMWATER MANHOLE
- PROP. STORMWATER UNDERDRAIN
- ABANDONED STORMWATER

50mm ON ORIGINAL
0 5 10 20 30 50

REV	DESCRIPTION	DATE
0	FOR INFORMATION ONLY	MAR 26

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CLIENT
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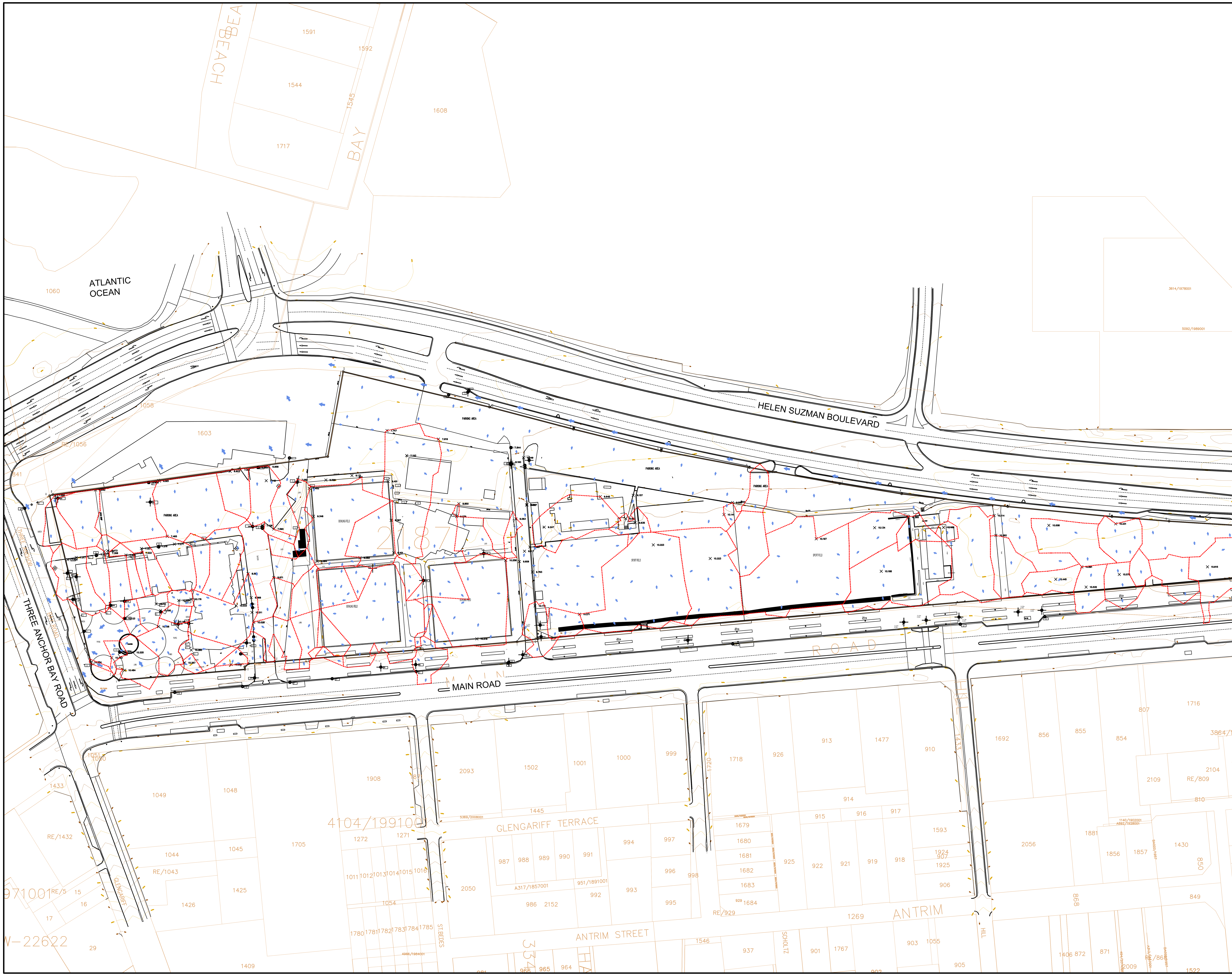
STAD KAAPSTAD

PROJECT
PROPOSED STORMWATER SuDS

TITLE
210C WP005_ERF 2187 THREE ANCHOR BAY

DESIGNED	KERINA NAICKER	CONSULTANT SIGNATURE	
DRAWN	KERINA NAICKER		
CHECKED	FAREED ISMAIL	DRWG. NO.	REV
PROJ No.	24020i	C5106	



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4. THE CONSULTANT WILL NOT BE HELD RESPONSIBLE FOR THE INACCURACY AND/OR MISSING EXISTING SERVICES INFORMATION

LEGEND

CATCHMENT AREA

FLOW DIRECTION

50mm ON ORIGINAL

0 5 10 20 30 50

REV	DESCRIPTION	DATE
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PROJECT

THREE ANCHOR BAY CATCHMENT AREAS

TITLE

210C WP005_ERF 2187 THREE ANCHOR BAY

DESIGNED	KERINA NAICKER	CONSULTANT SIGNATURE	
DRAWN	KERINA NAICKER		
CHECKED	FAREED ISMAIL	DRWG. NO.	REV
PROJ No.	24020i	C5107	

ANNEXURE B: RELOCATED STORMWATER LAYOUTS

NOTES

1. EXISTING SERVICES ARE SHOWN BASED ON THE BEST AVAILABLE INFORMATION, BUT SHALL BE REGARDED AS DIAGRAMATIC ONLY. THE CONTRACTOR SHALL CONFIRM THE POSITION OF ALL UNDERGROUND SERVICES PRIOR TO COMMENCING WORK.
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3. STORMWATER PIPES ARE TO BE SPIGOT AND SOCKET CLASS 100D CONCRETE PIPES
4. THE CONSULTANT WILL NOT BE HELD RESPONSIBLE FOR THE INACCURACY AND/OR MISSING EXISTING SERVICES INFORMATION

PIPE LIST–PROPOSED STORMWATER

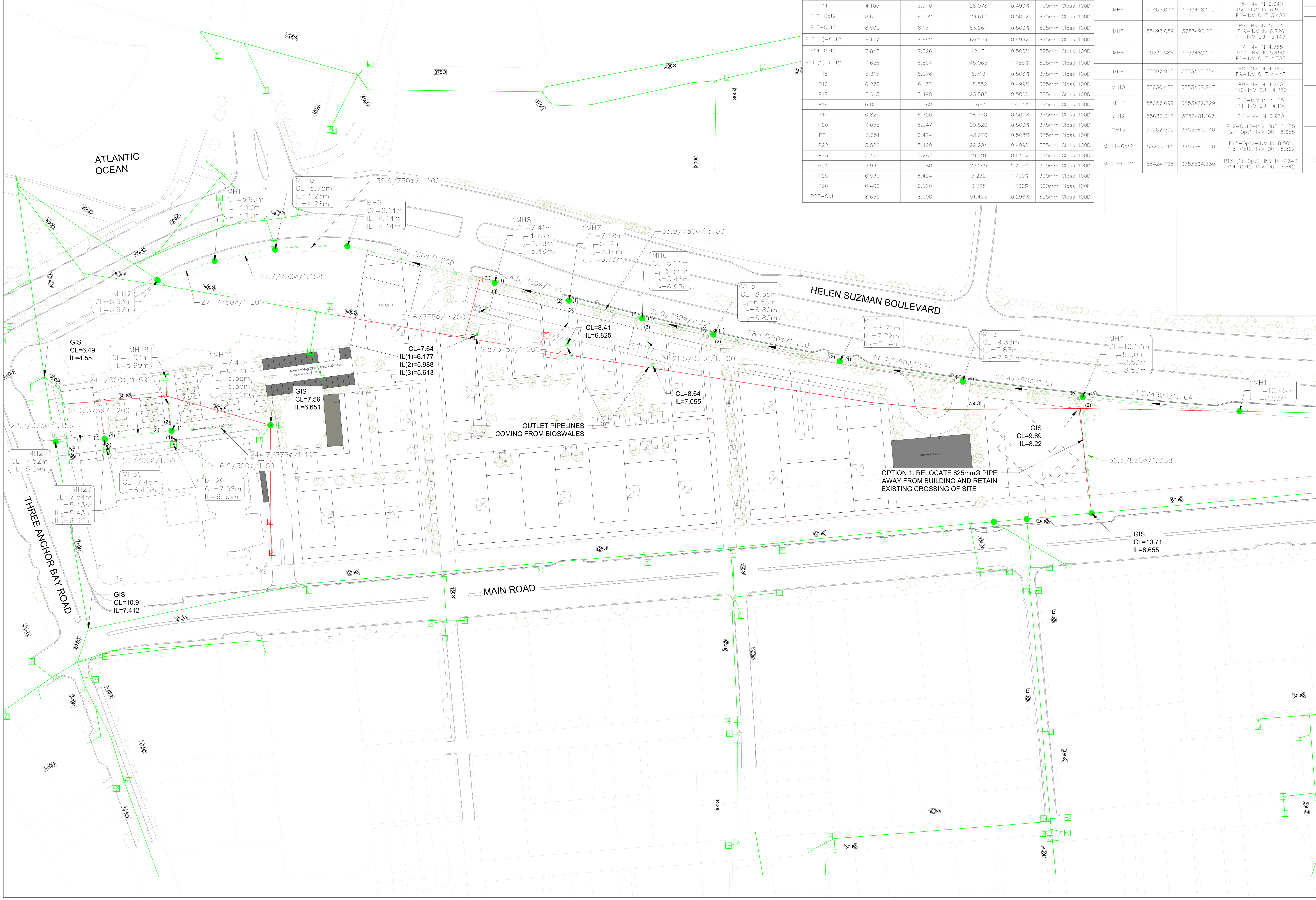
PIPE NAME	START INVERT LEVEL	END INVERT LEVEL	3D LENGTH TO INSIDE EDGES	SLOPE	DIAMETER AND CLASS
P1	8.933	8.500	70.030	0.610%	450mm Class 100D
P2	8.500	7.830	53.432	1.231%	750mm Class 100D
P3	7.830	7.220	55.202	1.086%	750mm Class 100D
P4	7.141	6.850	57.148	0.500%	750mm Class 100D
P5	6.804	6.640	31.894	0.499%	750mm Class 100D
P6	5.482	5.143	32.951	0.999%	750mm Class 100D
P7	5.143	4.785	33.489	1.038%	750mm Class 100D
P8	4.785	4.443	67.341	0.500%	750mm Class 100D
P9	4.443	4.280	31.564	0.501%	750mm Class 100D
P10	4.280	4.105	26.737	0.631%	750mm Class 100D
P11	4.105	3.970	26.078	0.499%	750mm Class 100D
P12–Opt2	8.655	8.502	29.617	0.500%	825mm Class 100D
P13–Opt2	8.502	8.177	63.967	0.500%	825mm Class 100D
P13 (1)–Opt2	8.177	7.842	66.103	0.499%	825mm Class 100D
P14–Opt2	7.842	7.626	42.181	0.500%	825mm Class 100D
P14 (1)–Opt2	7.626	6.804	45.065	1.785%	825mm Class 100D
P15	6.315	6.276	6.713	0.506%	375mm Class 100D
P16	6.276	6.177	18.852	0.499%	375mm Class 100D
P17	5.613	5.490	23.588	0.500%	375mm Class 100D
P18	6.055	5.988	5.683	1.003%	375mm Class 100D
P19	6.825	6.726	18.770	0.500%	375mm Class 100D
P20	7.055	6.947	20.520	0.500%	375mm Class 100D
P21	6.651	6.424	43.676	0.508%	375mm Class 100D
P22	5.580	5.429	29.294	0.499%	375mm Class 100D
P23	5.429	5.287	21.191	0.640%	375mm Class 100D
P24	5.990	5.580	23.145	1.700%	300mm Class 100D
P25	6.530	6.424	5.232	1.700%	300mm Class 100D
P26	6.400	6.320	3.728	1.700%	300mm Class 100D
P27–Opt1	8.655	8.500	51.453	0.296%	825mm Class 100D

PROPOSED STORMWATER MANHOLES SETTING–OUT DATA WGS84 (Lo19)

STRUCTURE NAME	Y	X	DETAILS
MH1	55195.976	3753540.081	P1–INV OUT 8.933
MH2	55266.711	3753533.652	P1–INV IN 8.500 P27–Opt1–INV IN 8.500 P2–INV OUT 8.500
MH3	55320.658	3753526.523	P2–INV IN 7.830 P3–INV OUT 7.830
MH4	55376.133	3753517.584	P3–INV IN 7.220 P4–INV OUT 7.141
MH5	55433.005	3753505.498	P4–INV IN 6.850 P14 (1)–Opt2–INV IN 6.804 P5–INV OUT 6.804
MH6	55465.073	3753498.192	P5–INV IN 6.640 P20–INV IN 6.947 P6–INV OUT 5.482
MH7	55498.059	3753490.201	P6–INV IN 5.143 P19–INV IN 6.726 P7–INV OUT 5.143
MH8	55531.586	3753482.155	P7–INV IN 4.785 P17–INV IN 5.490 P8–INV OUT 4.785
MH9	55597.925	3753465.754	P8–INV IN 4.443 P9–INV OUT 4.443
MH10	55630.450	3753467.247	P9–INV IN 4.280 P10–INV OUT 4.280
MH11	55657.699	3753472.399	P10–INV IN 4.105 P11–INV OUT 4.105
MH12	55683.312	3753481.167	P11–INV IN 3.970
MH13	55262.592	3753585.940	P12–Opt2–INV OUT 8.655 P27–Opt1–INV OUT 8.655
MH14–Opt2	55293.114	3753583.590	P12–Opt2–INV IN 8.502 P13–Opt2–INV OUT 8.502
MH15–Opt2	55424.735	3753594.330	P13 (1)–Opt2–INV IN 7.842 P14–Opt2–INV OUT 7.842

PROPOSED STORMWATER MANHOLES SETTING–OUT DATA WGS84 (Lo19)

STRUCTURE NAME	Y	X	DETAILS
MH16–Opt2	55357.860	3753588.873	P13–Opt2–INV IN 8.177 P13 (1)–Opt2–INV OUT 8.177
MH17–Opt2	55428.737	3753551.341	P14–Opt2–INV IN 7.626 P14 (1)–Opt2–INV OUT 7.626
MH18	55531.394	3753529.029	P15–INV OUT 6.315
MH19	55538.108	3753525.236	P15–INV IN 6.276 P16–INV OUT 6.276
MH20	55539.491	3753505.435	P16–INV IN 6.177 P18–INV IN 5.988 P17–INV OUT 5.613
MH21	55533.424	3753508.226	P18–INV OUT 6.055
MH22	55498.828	3753509.954	P19–INV OUT 6.825
MH23	55460.355	3753519.185	P20–INV OUT 7.055
MH24	55632.533	3753546.364	P21–INV OUT 6.651
MH25	55677.138	3753548.829	P21–INV IN 6.424 P24–INV IN 5.580 P25–INV IN 6.424 P22–INV OUT 5.580
MH26	55707.190	3753552.623	P22–INV IN 5.429 P26–INV IN 6.320 P23–INV OUT 5.429
MH27	55729.346	3753553.819	P23–INV IN 5.287
MH28	55679.655	3753524.825	P24–INV OUT 5.990
MH29	55676.254	3753554.991	P25–INV OUT 6.530
MH30	55706.435	3753557.284	P26–INV OUT 6.400



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REV	DESCRIPTION	DATE
0	FOR INFORMATION ONLY	MAR 26

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CLIENT
CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

PROJECT
PROPOSED STORMWATER RELOCATION ALONG HELEN SUZMAN BOULEVARD AND MAIN ROAD
SHEET 1 OF 2

TITLE
210C WP005_ERF 2187 THREE ANCHOR BAY

DESIGNED	KERINA NAICKER	CONSULTANT SIGNATURE	
DRAWN	KERINA NAICKER		
CHECKED	FAREED ISMAIL	DRWG. NO. C5104-1	REV
PROJ No.	24020i		

NOTES

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PIPE LIST–PROPOSED STORMWATER

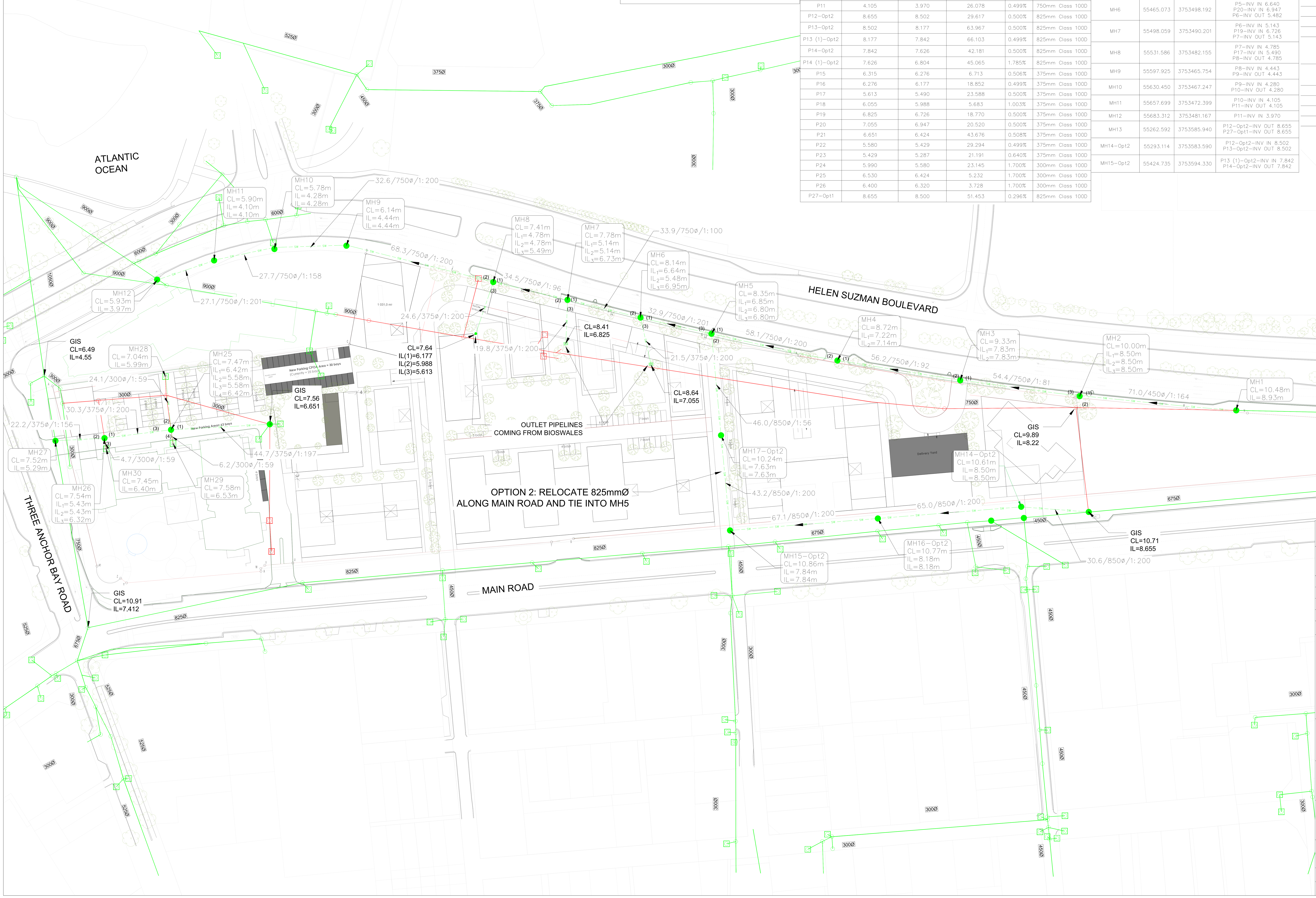
PIPE NAME	START INVERT LEVEL	END INVERT LEVEL	3D LENGTH TO INSIDE EDGES	SLOPE	DIAMETER AND CLASS
P1	8.933	8.500	70.030	0.610%	450mm Class 100D
P2	8.500	7.830	53.432	1.231%	750mm Class 100D
P3	7.830	7.220	55.202	1.086%	750mm Class 100D
P4	7.141	6.850	57.148	0.500%	750mm Class 100D
P5	6.804	6.640	31.894	0.499%	750mm Class 100D
P6	5.482	5.143	32.951	0.999%	750mm Class 100D
P7	5.143	4.785	33.489	1.038%	750mm Class 100D
P8	4.785	4.443	67.341	0.500%	750mm Class 100D
P9	4.443	4.280	31.564	0.501%	750mm Class 100D
P10	4.280	4.105	26.737	0.631%	750mm Class 100D
P11	4.105	3.970	26.078	0.499%	750mm Class 100D
P12–Opt2	8.655	8.502	29.617	0.500%	825mm Class 100D
P13–Opt2	8.502	8.177	63.967	0.500%	825mm Class 100D
P13 (1)–Opt2	8.177	7.842	66.103	0.499%	825mm Class 100D
P14–Opt2	7.842	7.626	42.181	0.500%	825mm Class 100D
P14 (1)–Opt2	7.626	6.804	45.065	1.785%	825mm Class 100D
P15	6.315	6.276	6.713	0.506%	375mm Class 100D
P16	6.276	6.177	18.852	0.499%	375mm Class 100D
P17	5.613	5.490	23.588	0.500%	375mm Class 100D
P18	6.055	5.988	5.683	1.003%	375mm Class 100D
P19	6.825	6.726	18.770	0.500%	375mm Class 100D
P20	7.055	6.947	20.520	0.500%	375mm Class 100D
P21	6.651	6.424	43.676	0.508%	375mm Class 100D
P22	5.580	5.429	29.294	0.499%	375mm Class 100D
P23	5.429	5.287	21.191	0.640%	375mm Class 100D
P24	5.990	5.580	23.145	1.700%	300mm Class 100D
P25	6.530	6.424	5.232	1.700%	300mm Class 100D
P26	6.400	6.320	3.728	1.700%	300mm Class 100D
P27–Opt1	8.655	8.500	51.453	0.296%	825mm Class 100D

PROPOSED STORMWATER MANHOLES SETTING–OUT DATA WGS84 (Lo19)

STRUCTURE NAME	Y	X	DETAILS
MH1	55195.976	3753540.081	P1–INV OUT 8.933
MH2	55266.711	3753533.652	P1–INV IN 8.500 P27–Opt1–INV IN 8.500 P2–INV OUT 8.500
MH3	55320.658	3753526.523	P2–INV IN 7.830 P3–INV OUT 7.830
MH4	55376.133	3753517.584	P3–INV IN 7.220 P4–INV OUT 7.141
MH5	55433.005	3753505.498	P4–INV IN 6.850 P14 (1)–Opt2–INV IN 6.804 P5–INV OUT 6.804
MH6	55465.073	3753498.192	P5–INV IN 6.640 P20–INV IN 6.947 P6–INV OUT 5.482
MH7	55498.059	3753490.201	P6–INV IN 5.143 P19–INV IN 6.726 P7–INV OUT 5.143
MH8	55531.586	3753482.155	P7–INV IN 4.785 P17–INV IN 5.490 P8–INV OUT 4.785
MH9	55597.925	3753465.754	P8–INV IN 4.443 P9–INV OUT 4.443
MH10	55630.450	3753467.247	P9–INV IN 4.280 P10–INV OUT 4.280
MH11	55657.699	3753472.399	P10–INV IN 4.105 P11–INV OUT 4.105
MH12	55683.312	3753481.167	P11–INV IN 3.970
MH13	55262.592	3753585.940	P12–Opt2–INV OUT 8.655 P27–Opt1–INV OUT 8.655
MH14–Opt2	55293.114	3753583.590	P12–Opt2–INV IN 8.502 P13–Opt2–INV OUT 8.502
MH15–Opt2	55424.735	3753594.330	P13 (1)–Opt2–INV IN 7.842 P14–Opt2–INV OUT 7.842

PROPOSED STORMWATER MANHOLES SETTING–OUT DATA WGS84 (Lo19)

STRUCTURE NAME	Y	X	DETAILS
MH16–Opt2	55357.860	3753588.873	P13–Opt2–INV IN 8.177 P13 (1)–Opt2–INV OUT 8.177
MH17–Opt2	55428.737	3753551.341	P14–Opt2–INV IN 7.626 P14 (1)–Opt2–INV OUT 7.626
MH18	55531.394	3753529.029	P15–INV OUT 6.315
MH19	55538.108	3753525.236	P15–INV IN 6.276 P16–INV OUT 6.276
MH20	55539.491	3753505.435	P16–INV IN 6.177 P18–INV IN 5.988 P17–INV OUT 5.613
MH21	55533.424	3753508.226	P18–INV OUT 6.055
MH22	55498.828	3753509.954	P19–INV OUT 6.825
MH23	55460.355	3753519.185	P20–INV OUT 7.055
MH24	55632.533	3753546.364	P21–INV OUT 6.651
MH25	55677.138	3753548.829	P21–INV IN 6.424 P24–INV IN 5.580 P25–INV IN 6.424 P22–INV OUT 5.580
MH26	55707.190	3753552.623	P22–INV IN 5.429 P26–INV IN 6.320 P23–INV OUT 5.429
MH27	55729.346	3753553.819	P23–INV IN 5.287
MH28	55679.655	3753524.825	P24–INV OUT 5.990
MH29	55676.254	3753554.991	P25–INV OUT 6.530
MH30	55706.435	3753557.284	P26–INV OUT 6.400



50mm ON ORIGINAL

0 5 10 20 30 50

REV	DESCRIPTION	DATE
0	FOR INFORMATION ONLY	MAR 26

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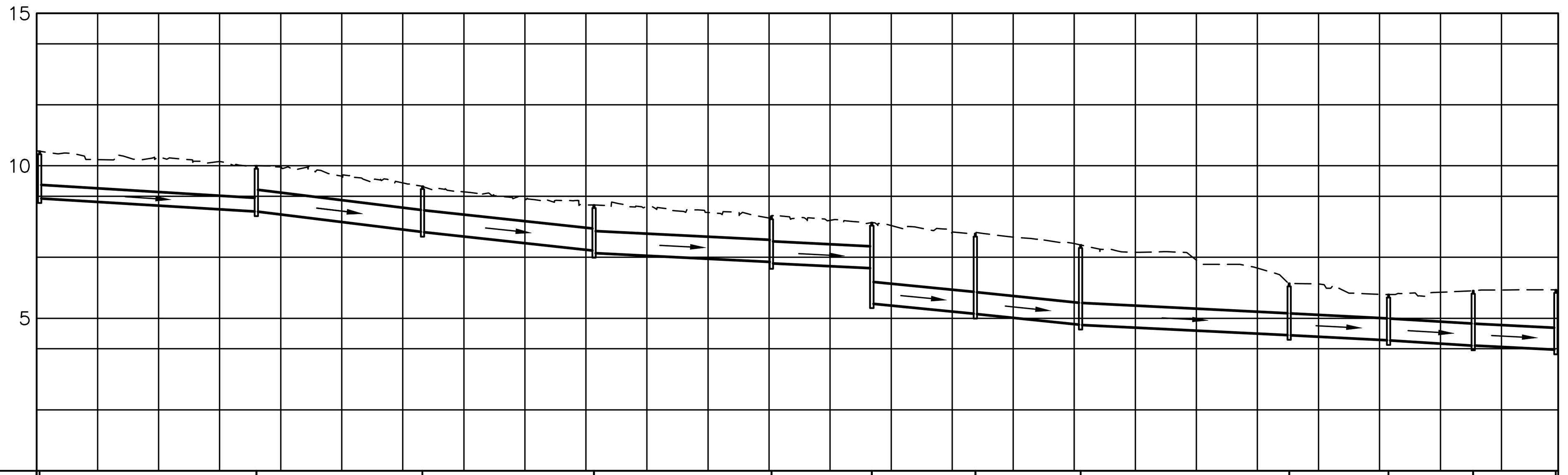
CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

PROJECT
PROPOSED STORMWATER RELOCATION ALONG HELEN SUZMAN BOULEVARD AND MAIN ROAD
SHEET 2 OF 2

TITLE
210C WP005_ERF 2187 THREE ANCHOR BAY

DESIGNED	KERINA NAICKER	CONSULTANT SIGNATURE	
DRAWN	KERINA NAICKER		
CHECKED	FAREED ISMAIL	DRWG. NO. C5104-2	REV
PROJ No.	24020i		

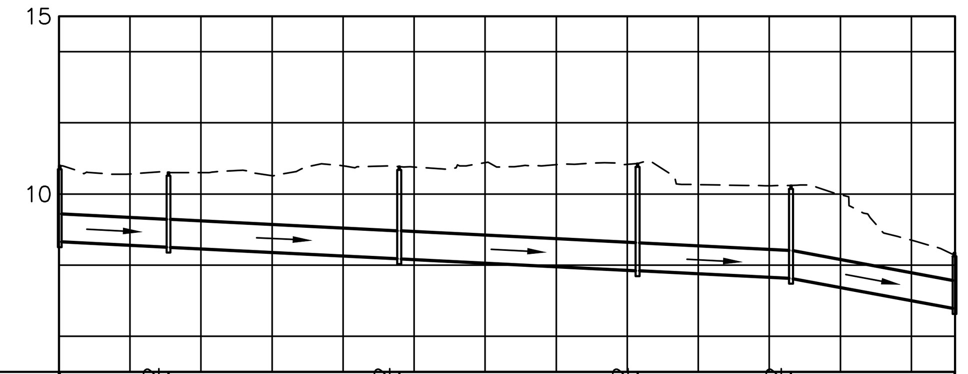


SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 0.000

Reference	MH1	450ø 100D	MH2	750ø 100D	MH3	750ø 100D	MH4	750ø 100D	MH5	750ø 100D	MH6	750ø 100D	MH7	750ø 100D	MH8	750ø 100D	MH9	750ø 100D	MH10	750ø 100D	MH11	750ø 100D	MH12
Ground Level	10.478		10.000		9.333		8.716		8.348		8.138		7.780		7.405		6.144		5.780		5.904		5.935
Pipe Invert Level	8.933		8.500 / 8.500		7.830 / 7.830		7.220 / 7.141		6.850 / 6.804		6.640 / 5.482		5.143 / 5.143		4.785 / 4.785		4.443 / 4.443		4.280 / 4.280		4.105 / 4.105		3.970
Slope / Length		0.61% 1:164.0 71.03m		1.23% 1:81.2 54.42m		1.09% 1:92.1 56.19m		0.50% 1:199.8 58.14m		0.50% 1:200.5 32.89m		1.00% 1:100.1 33.94m		1.04% 1:96.3 34.48m		0.50% 1:199.8 68.34m		0.50% 1:199.8 32.56m		0.63% 1:158.5 27.73m		0.50% 1:200.5 27.07m	

LONGSECTION FROM MH1 TO MH12

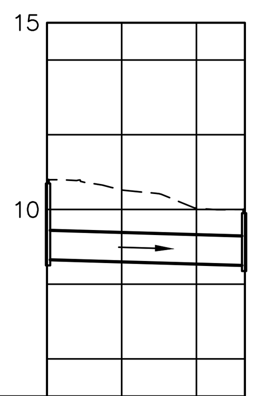


SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 5.000

Reference	MH13	850ø 100D	MH14–Opt2	850ø 100D	MH16–Opt2	850ø 100D	MH15–Opt2	850ø 100D	MH17–Opt2	850ø 100D	MH5
Ground Level	10.795		10.608		10.773		10.857		10.242		8.348
Pipe Invert Level	8.655		8.502 / 8.502		8.177 / 8.177		7.842 / 7.842		7.626 / 7.626		6.775
Slope / Length		0.50% 1:200.1 30.61m		0.50% 1:199.9 64.96m		0.50% 1:200.3 67.10m		0.50% 1:199.9 43.18m		1.85% 1:54.1 46.04m	

825mm DIA. RELOCATION - OPTION 2

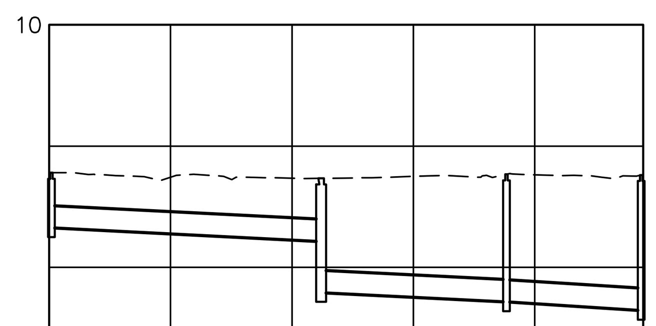


SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 5.000

Reference	MH13	850ø 100D	MH2
Ground Level	10.795		10.000
Pipe Invert Level	8.655		8.500
Slope / Length		0.30% 1:338.4 52.45m	

825mm DIA. RELOCATION - OPTION 1

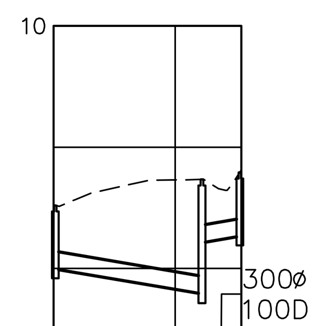


SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 5.000

Reference	MH24	375ø 100D	MH25	375ø 100D	MH26	375ø 100D	MH27
Ground Level	7.562		7.468		7.536		7.524
Pipe Invert Level	6.651		6.424 / 5.580		5.429 / 5.429		5.287
Slope / Length		0.51% 1:196.9 44.67m		0.50% 1:200.4 30.29m		0.64% 1:156.3 22.19m	

LONGSECTION FROM MH24 TO MH27

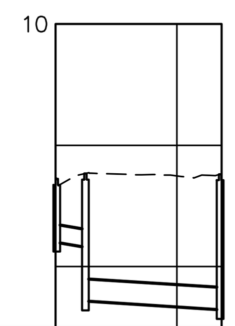


SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 5.000

Reference	MH28	300ø 100D	MH25		MH29
Ground Level	7.039		7.468		7.584
Pipe Invert Level	5.990		5.580		6.424 / 6.530
Slope / Length		1.70% 1:58.8 24.14m		1.70% 1:58.8 6.23m	

LONGSECTION FROM MH28 TO MH29



SCALES:
Horizontal 1:1000
Vertical 1:100

Datum 5.000

Reference	MH30	300ø 100D	MH26	375ø 100D	MH27
Ground Level	7.448		7.536		7.524
Pipe Invert Level	6.400		6.320 / 5.429		5.287
Slope / Length		1.70% 1:58.8 4.72m		0.64% 1:156.3 22.19m	

LONGSECTION FROM MH30 TO MH27

50mm ON ORIGINAL
0 5 10 20 30 50

REV	DESCRIPTION	DATE
0	FOR INFORMATION ONLY	MAR 26

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CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

PROJECT
PROPOSED STORMWATER RELOCATION LONGSECTIONS

TITLE
210C WP005_ERF 2187 THREE ANCHOR BAY

DESIGNED	KERINA NAICKER	CONSULTANT SIGNATURE	
DRAWN	KERINA NAICKER		
CHECKED	FAREED ISMAIL	DRWG. NO. C5105	REV
PROJ No.	24020i		

ANNEXURE C: RSA SUDS GUIDELINES APPENDIX B

Measured pollutant removal capacities of selected SuDS options and technologies
(after Debo & Reese, 2003; Minton, 2002; NCDWQ, 2007; Wilson *et al.,* 2004, Woods-Ballard *et al.,* 2007)

Option / Technology	Pollutant Removal (%)					
	TSS	**Hydro-carbons**	**TP**	**TN**	**Faecal Coli Forms**	**Heavy Metals**
Source controls						
Green roofs	60-95	-	-	-	-	60-90
Sand filters	80-90	50-80	50-80	25-40	40-50	50-80
Underground sand filters	75-90	-	30-60	30-50	40-70	40-80
Surface sand filters	80-90	-	50-60	30-40	-	-
Filter drains	50-85	30-70	-	-	-	50-80
Soakaways	70-80	-	60-80	25-60	60-90	60-90
Oil and grit separators	0-40	40-90	0-5	0-5	-	-
Modular geocellular structures	PS	PS	PS	PS	PS	PS
Stormwater collection and reuse	PS	PS	PS	PS	PS	PS
Local controls						
Bioretention areas	50-80	50-80	50-60	40-50	-	50-90
Filter strips	50-85	70-90	10-20	10-20	-	25-40
Infiltration trenches	70-80	-	60-80	25-60	60-90	60-90
Permeable pavements	60-95	70-90	50-80	65-80	-	60-95
Swales	60-90	70-90	25-80	30-90	-	40-90
Enhanced dry swales	70-90	70-90	30-80	50-90	-	80-90
Wet swales	60-80	70-90	25-35	30-40	-	40-70
Vegetated buffers *	50-85	70-90	10-20	10-20	-	25-40
Regional controls						
Constructed wetlands	80-90	50-80	30-40	30-60	50-70	50-60
Extended detention shallow wetland	60-70	-	30-40	50-60	-	-
Pocket wetland *	80-90	50-80	30-40	30-60	50-70	50-60
Submerged gravel wetland	80-90	-	60-70	10-20	-	-
Detention ponds *	45-90	30-60	20-70	20-60	50-70	40-90
Extended detention ponds	65-90	30-60	20-50	20-30	50-70	40-90
Infiltration basins	45-75	-	60-70	55-60	-	85-90
Retention ponds	75-90	30-60	30-50	30-50	50-70	50-80
Floating islands	-	-	-	-	-	-

PS - Product Specific; TSS - Total Suspended Solids; TP - Total Phosphorous; TN - Total Nitrogen
* Estimated values based on similar SuDS options

Disclaimer

The values quoted in this table have been collected from international literature. Removal efficiencies are dependent on a variety of factors including, *inter alia,* climate, pollution composition and concentration, technical design, and maintenance. As a result the values should be considered as a guide only to the relative performance of selected SuDS options and technologies. Where local data is available it should be used instead.

ANNEXURE D: SSA RESULTS

SN	Element ID	Description	Area	Drainage Node ID	Weighted Curve Number	Conductivity	Drying Time	Average Slope	Equivalent Width	Impervious Area	Impervious Area No Depression	Impervious Area Depression Depth	Impervious Area Manning's Roughness	Pervious Area Depression Depth	Pervious Area Manning's Roughness	Curb & Gutter Length	Rain Gage ID	Total Precipitation	Total Runon	Total Evaporation	Total Infiltration	Total Runoff	Peak Runoff	Time of Concentration
			(ha)			(mm/hr)	(days)	(%)	(m)	(%)	(%)	(mm)		(mm)		(m)		(mm)	(mm)	(mm)	(mm)	(mm)	(lps)	(days hh:mm:ss)
1	W1		0.01	W1_Outfall	0.72	0.0000	0.07	0.0001	2.51	0.07	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0019	0.02	0.04	0 02:20:14
2	W2		0.02	W2_Outfall	0.84	0.0000	0.07	0.0002	3.60	0.64	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0006	0.16	0.97	0 00:34:09
3	W3		0.03	W3_Outfall	0.83	0.0000	0.07	0.0002	3.65	0.58	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0007	0.15	1.49	0 00:49:48

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	W1_Outfall	-0.24	0.12		0.00	FREE	NO				0.00	
2	W2_Outfall	-0.06	0.09		0.00	FREE	NO				0.00	
3	W3_Outfall	0.03	0.03		0.00	FREE	NO				0.00	

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	1-Year Storm	Cumulative	mm	None	None	1	25.26	South Africa 24-hr, Type 2

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	W1_Outfall	-0.24	0.12		0.00	FREE	NO				0.00	
2	W2_Outfall	-0.06	0.09		0.00	FREE	NO				0.00	
3	W3_Outfall	0.03	0.03		0.00	FREE	NO				0.00	

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	2-Year Storm	Cumulative	mm	None	None	2	35	South Africa 24-hr, Type 2

SN	Element ID	Description	Area	Drainage Node ID	Weighted Curve Number	Conductivity	Drying Time	Average Slope	Equivalent Width	Impervious Area	Impervious Area No Depression	Impervious Area Depression Depth	Impervious Area Manning's Roughness	Pervious Area Depression Depth	Pervious Area Manning's Roughness	Curb & Gutter Length	Rain Gage ID	Total Precipitation	Total Runon	Total Evaporation	Total Infiltration	Total Runoff	Peak Runoff	Time of Concentration
			(ha)			(mm/hr)	(days)	(%)	(m)	(%)	(%)	(mm)		(mm)		(m)		(mm)	(mm)	(mm)	(mm)	(mm)	(lps)	(days hh:mm:ss)
1	W1		0.01	W1_Outfall	0.72	0.0000	0.07	0.0001	2.51	0.07	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0024	0.05	0.06	0 02:03:04
2	W2		0.02	W2_Outfall	0.84	0.0000	0.07	0.0002	3.60	0.64	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0007	0.25	1.44	0 00:29:58
3	W3		0.03	W3_Outfall	0.83	0.0000	0.07	0.0002	3.65	0.58	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0009	0.23	2.16	0 00:43:43

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	W1_Outfall	-0.24	0.12		0.00	FREE	NO				0.00	
2	W2_Outfall	-0.06	0.09		0.00	FREE	NO				0.00	
3	W3_Outfall	0.03	0.03		0.00	FREE	NO				0.00	

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	5-Year Storm	Cumulative	mm	None	None	5	47	South Africa 24-hr, Type 2

SN	Element ID	Description	Area (ha)	Drainage Node ID	Weighted Curve Number	Conductivity (mm/hr)	Drying Time (days)	Average Slope (%)	Equivalent Width (m)	Impervious Area (%)	Impervious Area No Depression (%)	Impervious Area Depression Depth (mm)	Impervious Area Manning's Roughness	Pervious Area Depression Depth (mm)	Pervious Area Manning's Roughness	Curb & Gutter Length (m)	Rain Gage ID	Total Precipitation (mm)	Total Runon (mm)	Total Evaporation (mm)	Total Infiltration (mm)	Total Runoff (mm)	Peak Runoff (lps)	Time of Concentration (days hh:mm:ss)
1	W1		0.01	W1_Outfall	0.72	0.0000	0.07	0.0001	2.51	0.07	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0030	0.12	0.08	0 01:49:22
2	W2		0.02	W2_Outfall	0.84	0.0000	0.07	0.0002	3.60	0.64	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0009	0.36	2.24	0 00:26:38
3	W3		0.03	W3_Outfall	0.83	0.0000	0.07	0.0002	3.65	0.58	0.25	0.0002	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0010	0.34	3.37	0 00:38:51

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation
					(m)			(m)
1	W1_Outfall	-0.24	0.12		0.00	FREE	NO	
2	W2_Outfall	-0.06	0.09		0.00	FREE	NO	
3	W3_Outfall	0.03	0.03		0.00	FREE	NO	

Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
(lps)	(lps)	(m)	(m)
		0.00	
		0.00	
		0.00	

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State
1	Three_Anchor_Bay		Time Series	100-Year Storm	Cumulative	mm	None

County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
None	100	89	South Africa 24-hr, Type 2

SN	Element ID	Description	Area	Drainage Node ID	Weighted Curve Number	Conductivity	Drying Time	Average Slope	Equivalent Width
			(ha)			(mm/hr)	(days)	(%)	(m)
1	W1		0.01	W1_Outfall	0.72	0.0000	0.07	0.0001	2.51
2	W2		0.02	W2_Outfall	0.84	0.0000	0.07	0.0002	3.60
3	W3		0.03	W3_Outfall	0.83	0.0000	0.07	0.0002	3.65

Impervious Area (%)	Impervious Area No Depression (%)	Impervious Area Depression Depth (mm)	Impervious Area Manning's Roughness	Pervious Area Depression Depth (mm)	Pervious Area Manning's Roughness	Curb & Gutter Length (m)
0.07	0.25	0.0002	0.0000	0.0005	0.0000	0.00
0.64	0.25	0.0002	0.0000	0.0005	0.0000	0.00
0.58	0.25	0.0002	0.0000	0.0005	0.0000	0.00

Rain Gage ID	Total Precipitation	Total Runon	Total Evaporation	Total Infiltration	Total Runoff	Peak Runoff
	(mm)	(mm)	(mm)	(mm)	(mm)	(lps)
Three_Anchor_Bay	0.89	0.00	0.0000	0.0044	0.39	0.44
Three_Anchor_Bay	0.89	0.00	0.0000	0.0011	0.75	4.82
Three_Anchor_Bay	0.89	0.00	0.0000	0.0014	0.72	7.77

Time of Concentration (days hh:mm:ss)
0 01:24:43
0 00:20:38
0 00:30:05

SN	Element ID	Description	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Pipe Shape	Pipe Diameter or Height	Pipe Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate	Lengthening Factor	Peak Flow	Time of Peak Flow Occurrence	Max Flow Velocity	Travel Time	Design Flow Capacity	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged	Max Flow Depth	Froude Number	Reported Condition
					(m)	(m)	(m)	(m)	(m)	(m)	(%)		(m)	(m)					(lps)			(lps)	(days hh:mm)	(m/sec)	(min)	(lps)			(min)	(m)		
1	64		MH_6	MH_7	0.33	0.07	0.01	0.05	0.00	0.01	0.0004	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	26.36	0.00	0.00	0.00	0.00	0.01	Calculated
2	64		MH_7	MH_8	0.34	0.05	0.00	0.05	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	13.18	0.00	0.00	0.00	0.00	0.01	Calculated
3	64		MH_8	MH_9	0.68	0.05	0.00	0.04	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:01	0.02	0.01	9.28	0.00	0.00	0.00	0.00	0.01	Calculated
4	A1		Bioswale_A	A1	0.08	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.47	0.02	0.01	0.00	0.00	0.01	> CAPACITY
5	A2		A1	A_B1	0.20	0.06	0.00	0.06	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
6	B1		Bioswale_B	A_B1	0.07	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	2.08	0.02	0.01	0.00	0.00	0.01	SURCHARGED
7	B2		A_B1	MH_8	0.25	0.06	0.00	0.05	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
8	C1		Bioswale_C	MH_7	0.20	0.07	0.00	0.07	0.02	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.44	0.02	0.01	0.00	0.00	0.01	> CAPACITY
9	D1		Bioswale_D	MH_6	0.22	0.07	0.00	0.07	0.01	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.45	0.02	0.01	0.00	0.00	0.01	> CAPACITY

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	MH_9	-0.24	0.24		0.04	NORMAL	NO		2.99	0.00	0.00	0.05

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Max (Rim) Elevation (m)	Max (Rim) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Ponded Area (m^2)	Evaporation Loss	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Peak Outflow (lps)	Peak Exfiltration Flow Rate (cmm)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Total Exfiltration Volume (1000-m^3)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)	Total Retention Time (seconds)
1	Bioswale_A	-0.06	0.11		0.06	0.08	0.02	0.08	0.01	2.65	0.00	0.18	0.18	2.66	0.00	0.08	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
2	Bioswale_B	-0.06	0.15		0.06	0.08	0.02	0.07	0.01	1.35	0.00	0.18	0.18	3.27	0.00	0.07	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
3	Bioswale_C	0.05	0.15		0.07	0.08	0.02	0.08	0.01	0.50	0.00	0.13	0.13	2.89	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00
4	Bioswale_D	0.12	0.11		0.07	0.09	0.02	0.08	0.01	1.35	0.00	0.13	0.13	2.87	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Ground/Rim (Max) Elevation (m)	Ground/Rim (Max) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Surcharge Elevation (m)	Surcharge Depth (m)	Ponded Area (m^2)	Minimum Pipe Cover (m)	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Maximum Surcharge Depth Attained (m)	Minimum Freeboard Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)
1	A_B1	-0.09	0.17		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	3.33	0.00	0.06	0.00	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
2	A1	-0.09	0.10		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	2.66	0.00	0.07	0.00	0.00	0.01	0.06	0.00	0 00:00	0 00:00	0.00	0.00
3	MH_6	0.12	0.19		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	2.87	0.00	0.07	0.02	0.00	0.01	0.07	0.01	0 00:00	0 00:00	0.00	0.00
4	MH_7	0.06	0.22		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	4.08	0.00	0.06	0.01	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
5	MH_8	-0.06	0.23		0.05	0.07	0.03	0.00	-0.05	0.07	0.00	0.00	0.02	3.53	0.00	0.05	0.00	0.00	0.02	0.05	0.00	0 00:00	0 00:00	0.00	0.00

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	1-Year Storm	Cumulative	mm	None	None	1	25.26	South Africa 24-hr, Type 2

SN	Element ID	Description	Area (ha)	Drainage Node ID	Weighted Curve Number	Conductivity (mm/hr)	Drying Time (days)	Average Slope (%)	Equivalent Width (m)	Impervious Area (%)	Impervious Area No Depression (%)	Impervious Area Depression Depth (mm)	Impervious Area Manning's Roughness	Pervious Area Depression Depth (mm)	Pervious Area Manning's Roughness	Curb & Gutter Length (m)	Rain Gage ID	Total Precipitation (mm)	Total Runon (mm)	Total Evaporation (mm)	Total Infiltration (mm)	Total Runoff (mm)	Peak Runoff (lps)	Time of Concentration (days hh:mm:ss)
1	W_A		0.00	Bioswale_A	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0002	0.21	0.18	0 01:10:08
2	W_B		0.00	Bioswale_B	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0002	0.21	0.18	0 01:10:08
3	W_C		0.00	Bioswale_C	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0002	0.21	0.13	0 00:54:58
4	W_D		0.00	Bioswale_D	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.25	0.00	0.0000	0.0002	0.21	0.13	0 00:54:58

SN	Element ID	Description	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Pipe Shape	Pipe Diameter or Height	Pipe Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate	Lengthening Factor	Peak Flow	Time of Peak Flow Occurrence	Max Flow Velocity	Travel Time	Design Flow Capacity	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged	Max Flow Depth	Froude Number	Reported Condition
					(m)	(m)	(m)	(m)	(m)	(m)	(%)		(m)	(m)					(lps)			(lps)	(days hh:mm)	(m/sec)	(min)	(lps)			(min)	(m)		
1	64		MH_6	MH_7	0.33	0.07	0.01	0.05	0.00	0.01	0.0004	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	26.36	0.00	0.00	0.00	0.00	0.01	Calculated
2	64		MH_7	MH_8	0.34	0.05	0.00	0.05	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	13.18	0.00	0.00	0.00	0.00	0.01	Calculated
3	64		MH_8	MH_9	0.68	0.05	0.00	0.04	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:01	0.02	0.01	9.28	0.00	0.00	0.00	0.00	0.01	Calculated
4	A1		Bioswale_A	A1	0.08	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.47	0.02	0.01	0.00	0.00	0.01	> CAPACITY
5	A2		A1	A_B1	0.20	0.06	0.00	0.06	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
6	B1		Bioswale_B	A_B1	0.07	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	2.08	0.02	0.01	0.00	0.00	0.01	SURCHARGED
7	B2		A_B1	MH_8	0.25	0.06	0.00	0.05	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
8	C1		Bioswale_C	MH_7	0.20	0.07	0.00	0.07	0.02	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.44	0.02	0.01	0.00	0.00	0.01	> CAPACITY
9	D1		Bioswale_D	MH_6	0.22	0.07	0.00	0.07	0.01	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.45	0.02	0.01	0.00	0.00	0.01	> CAPACITY

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	MH_9	-0.24	0.24		0.04	NORMAL	NO		2.99	0.00	0.00	0.05

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Max (Rim) Elevation (m)	Max (Rim) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Ponded Area (m^2)	Evaporation Loss	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Peak Outflow (lps)	Peak Exfiltration Flow Rate (cmm)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Total Exfiltration Volume ($1000\text{-}m^3$)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)	Total Retention Time (seconds)
1	Bioswale_A	-0.06	0.11		0.06	0.08	0.02	0.08	0.01	2.65	0.00	0.27	0.27	2.66	0.00	0.08	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
2	Bioswale_B	-0.06	0.15		0.06	0.08	0.02	0.07	0.01	1.35	0.00	0.27	0.27	3.27	0.00	0.07	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
3	Bioswale_C	0.05	0.15		0.07	0.08	0.02	0.08	0.01	0.50	0.00	0.20	0.20	2.89	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00
4	Bioswale_D	0.12	0.11		0.07	0.09	0.02	0.08	0.01	1.35	0.00	0.20	0.20	2.87	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Ground/Rim (Max) Elevation (m)	Ground/Rim (Max) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Surcharge Elevation (m)	Surcharge Depth (m)	Ponded Area (m^2)	Minimum Pipe Cover (m)	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Maximum Surcharge Depth Attained (m)	Minimum Freeboard Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)
1	A_B1	-0.09	0.17		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	3.33	0.00	0.06	0.00	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
2	A1	-0.09	0.10		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	2.66	0.00	0.07	0.00	0.00	0.01	0.06	0.00	0 00:00	0 00:00	0.00	0.00
3	MH_6	0.12	0.19		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	2.87	0.00	0.07	0.02	0.00	0.01	0.07	0.01	0 00:00	0 00:00	0.00	0.00
4	MH_7	0.06	0.22		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	4.08	0.00	0.06	0.01	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
5	MH_8	-0.06	0.23		0.05	0.07	0.03	0.00	-0.05	0.07	0.00	0.00	0.02	3.53	0.00	0.05	0.00	0.00	0.02	0.05	0.00	0 00:00	0 00:00	0.00	0.00

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	2-Year Storm	Cumulative	mm	None	None	2	35	South Africa 24-hr, Type 2

SN	Element ID	Description	Area (ha)	Drainage Node ID	Weighted Curve Number	Conductivity (mm/hr)	Drying Time (days)	Average Slope (%)	Equivalent Width (m)	Impervious Area (%)	Impervious Area No Depression (%)	Impervious Area Depression Depth (mm)	Impervious Area Manning's Roughness	Pervious Area Depression Depth (mm)	Pervious Area Manning's Roughness	Curb & Gutter Length (m)	Rain Gage ID	Total Precipitation (mm)	Total Runon (mm)	Total Evaporation (mm)	Total Infiltration (mm)	Total Runoff (mm)	Peak Runoff (lps)	Time of Concentration (days hh:mm:ss)
1	W_A		0.00	Bioswale_A	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0002	0.31	0.27	0 01:01:33
2	W_B		0.00	Bioswale_B	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0002	0.31	0.27	0 01:01:33
3	W_C		0.00	Bioswale_C	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0002	0.31	0.20	0 00:48:14
4	W_D		0.00	Bioswale_D	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.35	0.00	0.0000	0.0002	0.31	0.20	0 00:48:14

SN	Element ID	Description	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Pipe Shape	Pipe Diameter or Height	Pipe Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate	Lengthening Factor	Peak Flow	Time of Peak Flow Occurrence	Max Flow Velocity	Travel Time	Design Flow Capacity	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged	Max Flow Depth	Froude Number	Reported Condition
					(m)	(m)	(m)	(m)	(m)	(m)	(%)		(m)	(m)					(lps)			(lps)	(days hh:mm)	(m/sec)	(min)	(lps)			(min)	(m)		
1	64		MH_6	MH_7	0.33	0.07	0.01	0.05	0.00	0.01	0.0004	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	26.36	0.00	0.00	0.00	0.00	0.01	Calculated
2	64		MH_7	MH_8	0.34	0.05	0.00	0.05	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	13.18	0.00	0.00	0.00	0.00	0.01	Calculated
3	64		MH_8	MH_9	0.68	0.05	0.00	0.04	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:01	0.02	0.01	9.28	0.00	0.00	0.00	0.00	0.01	Calculated
4	A1		Bioswale_A	A1	0.08	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.47	0.02	0.01	0.00	0.00	0.01	> CAPACITY
5	A2		A1	A_B1	0.20	0.06	0.00	0.06	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
6	B1		Bioswale_B	A_B1	0.07	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	2.08	0.02	0.01	0.00	0.00	0.01	SURCHARGED
7	B2		A_B1	MH_8	0.25	0.06	0.00	0.05	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
8	C1		Bioswale_C	MH_7	0.20	0.07	0.00	0.07	0.02	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.44	0.02	0.01	0.00	0.00	0.01	> CAPACITY
9	D1		Bioswale_D	MH_6	0.22	0.07	0.00	0.07	0.01	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.45	0.02	0.01	0.00	0.00	0.01	> CAPACITY

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	MH_9	-0.24	0.24		0.04	NORMAL	NO		2.99	0.00	0.00	0.05

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Max (Rim) Elevation (m)	Max (Rim) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Ponded Area (m^2)	Evaporation Loss	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Peak Outflow (lps)	Peak Exfiltration Flow Rate (cmm)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Total Exfiltration Volume ($1000-m^3$)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)	Total Retention Time (seconds)
1	Bioswale_A	-0.06	0.11		0.06	0.08	0.02	0.08	0.01	2.65	0.00	0.37	0.37	2.66	0.00	0.08	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
2	Bioswale_B	-0.06	0.15		0.06	0.08	0.02	0.07	0.01	1.35	0.00	0.37	0.37	3.27	0.00	0.07	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
3	Bioswale_C	0.05	0.15		0.07	0.08	0.02	0.08	0.01	0.50	0.00	0.28	0.28	2.89	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00
4	Bioswale_D	0.12	0.11		0.07	0.09	0.02	0.08	0.01	1.35	0.00	0.28	0.28	2.87	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Ground/Rim (Max) Elevation (m)	Ground/Rim (Max) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Surcharge Elevation (m)	Surcharge Depth (m)	Ponded Area (m^2)	Minimum Pipe Cover (m)	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Maximum Surcharge Depth Attained (m)	Minimum Freeboard Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)
1	A_B1	-0.09	0.17		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	3.33	0.00	0.06	0.00	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
2	A1	-0.09	0.10		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	2.66	0.00	0.07	0.00	0.00	0.01	0.06	0.00	0 00:00	0 00:00	0.00	0.00
3	MH_6	0.12	0.19		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	2.87	0.00	0.07	0.02	0.00	0.01	0.07	0.01	0 00:00	0 00:00	0.00	0.00
4	MH_7	0.06	0.22		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	4.08	0.00	0.06	0.01	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
5	MH_8	-0.06	0.23		0.05	0.07	0.03	0.00	-0.05	0.07	0.00	0.00	0.02	3.53	0.00	0.05	0.00	0.00	0.02	0.05	0.00	0 00:00	0 00:00	0.00	0.00

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	5-Year Storm	Cumulative	mm	None	None	5	47	South Africa 24-hr, Type 2

SN	Element ID	Description	Area (ha)	Drainage Node ID	Weighted Curve Number	Conductivity (mm/hr)	Drying Time (days)	Average Slope (%)	Equivalent Width (m)	Impervious Area (%)	Impervious Area No Depression (%)	Impervious Area Depression Depth (mm)	Impervious Area Manning's Roughness	Pervious Area Depression Depth (mm)	Pervious Area Manning's Roughness	Curb & Gutter Length (m)	Rain Gage ID	Total Precipitation (mm)	Total Runon (mm)	Total Evaporation (mm)	Total Infiltration (mm)	Total Runoff (mm)	Peak Runoff (lps)	Time of Concentration (days hh:mm:ss)
1	W_A		0.00	Bioswale_A	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.37	0 00:54:42
2	W_B		0.00	Bioswale_B	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.37	0 00:54:42
3	W_C		0.00	Bioswale_C	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.28	0 00:42:52
4	W_D		0.00	Bioswale_D	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.28	0 00:42:52

SN	Element ID	Description	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (mm)	Rainfall Distribution
1	Three_Anchor_Bay		Time Series	100-Year Storm	Cumulative	mm	None	None	100	89	South Africa 24-hr, Type 2

SN	Element ID	Description	From (Inlet) Node	To (Outlet) Node	Length	Inlet Invert Elevation	Inlet Invert Offset	Outlet Invert Elevation	Outlet Invert Offset	Total Drop	Average Slope	Pipe Shape	Pipe Diameter or Height	Pipe Width	Manning's Roughness	Entrance Losses	Exit/Bend Losses	Additional Losses	Initial Flow	Flap Gate	Lengthening Factor	Peak Flow	Time of Peak Flow Occurrence	Max Flow Velocity	Travel Time	Design Flow Capacity	Max Flow / Design Flow Ratio	Max Flow Depth / Total Depth Ratio	Total Time Surcharged	Max Flow Depth	Froude Number	Reported Condition
					(m)	(m)	(m)	(m)	(m)	(m)	(%)		(m)	(m)					(lps)			(lps)	(days hh:mm)	(m/sec)	(min)	(lps)			(min)	(m)		
1	64		MH_6	MH_7	0.33	0.07	0.01	0.05	0.00	0.01	0.0004	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	26.36	0.00	0.00	0.00	0.00	0.01	Calculated
2	64		MH_7	MH_8	0.34	0.05	0.00	0.05	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.02	0.00	13.18	0.00	0.00	0.00	0.00	0.01	Calculated
3	64		MH_8	MH_9	0.68	0.05	0.00	0.04	0.00	0.00	0.0001	CIRCULAR	0.001	0.01	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:01	0.02	0.01	9.28	0.00	0.00	0.00	0.00	0.01	Calculated
4	A1		Bioswale_A	A1	0.08	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.47	0.02	0.01	0.00	0.00	0.01	> CAPACITY
5	A2		A1	A_B1	0.20	0.06	0.00	0.06	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
6	B1		Bioswale_B	A_B1	0.07	0.06	0.00	0.06	0.00	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	2.08	0.02	0.01	0.00	0.00	0.01	SURCHARGED
7	B2		A_B1	MH_8	0.25	0.06	0.00	0.05	0.01	0.00	0.0001	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.01	0.00	1.46	0.01	0.01	0.00	0.00	0.01	Calculated
8	C1		Bioswale_C	MH_7	0.20	0.07	0.00	0.07	0.02	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.44	0.02	0.01	0.00	0.00	0.01	> CAPACITY
9	D1		Bioswale_D	MH_6	0.22	0.07	0.00	0.07	0.01	0.00	0.0000	CIRCULAR	0.000	0.00	0.0000	0.0001	0.0001	0.0000	0.00	NO	0.01	####	0 00:00	0.03	0.00	1.45	0.02	0.01	0.00	0.00	0.01	> CAPACITY

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation	Boundary Type	Flap Gate	Fixed Water Elevation	Peak Inflow	Peak Lateral Inflow	Maximum HGL Depth Attained	Maximum HGL Elevation Attained
					(m)			(m)	(lps)	(lps)	(m)	(m)
1	MH_9	-0.24	0.24		0.04	NORMAL	NO		2.99	0.00	0.00	0.05

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Max (Rim) Elevation (m)	Max (Rim) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Ponded Area (m^2)	Evaporation Loss	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Peak Outflow (lps)	Peak Exfiltration Flow Rate (cmm)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Total Exfiltration Volume (1000-m^3)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)	Total Retention Time (seconds)
1	Bioswale_A	-0.06	0.11		0.06	0.08	0.02	0.08	0.01	2.65	0.00	0.37	0.37	2.66	0.00	0.08	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
2	Bioswale_B	-0.06	0.15		0.06	0.08	0.02	0.07	0.01	1.35	0.00	0.37	0.37	3.27	0.00	0.07	0.01	0.06	0.00	0 00:00	0.00	0.00	0.00	0.00
3	Bioswale_C	0.05	0.15		0.07	0.08	0.02	0.08	0.01	0.50	0.00	0.28	0.28	2.89	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00
4	Bioswale_D	0.12	0.11		0.07	0.09	0.02	0.08	0.01	1.35	0.00	0.28	0.28	2.87	0.00	0.08	0.01	0.07	0.00	0 00:00	0.00	0.00	0.00	0.00

SN	Element ID	X Coordinate	Y Coordinate	Description	Invert Elevation (m)	Ground/Rim (Max) Elevation (m)	Ground/Rim (Max) Offset (m)	Initial Water Elevation (m)	Initial Water Depth (m)	Surcharge Elevation (m)	Surcharge Depth (m)	Ponded Area (m^2)	Minimum Pipe Cover (m)	Peak Inflow (lps)	Peak Lateral Inflow (lps)	Maximum HGL Elevation Attained (m)	Maximum HGL Depth Attained (m)	Maximum Surcharge Depth Attained (m)	Minimum Freeboard Attained (m)	Average HGL Elevation Attained (m)	Average HGL Depth Attained (m)	Time of Maximum HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ha-mm)	Total Time Flooded (minutes)
1	A_B1	-0.09	0.17		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	3.33	0.00	0.06	0.00	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
2	A1	-0.09	0.10		0.06	0.08	0.02	0.00	-0.06	0.08	0.00	0.00	0.01	2.66	0.00	0.07	0.00	0.00	0.01	0.06	0.00	0 00:00	0 00:00	0.00	0.00
3	MH_6	0.12	0.19		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	2.87	0.00	0.07	0.02	0.00	0.01	0.07	0.01	0 00:00	0 00:00	0.00	0.00
4	MH_7	0.06	0.22		0.05	0.08	0.03	0.00	-0.05	0.08	0.00	0.00	0.01	4.08	0.00	0.06	0.01	0.00	0.02	0.06	0.00	0 00:00	0 00:00	0.00	0.00
5	MH_8	-0.06	0.23		0.05	0.07	0.03	0.00	-0.05	0.07	0.00	0.00	0.02	3.53	0.00	0.05	0.00	0.00	0.02	0.05	0.00	0 00:00	0 00:00	0.00	0.00

SN	Element ID	Description	Area	Drainage Node ID	Weighted Curve Number	Conductivity	Drying Time	Average Slope	Equivalent Width	Impervious Area	Impervious Area No Depression	Impervious Area Depression Depth	Impervious Area Manning's Roughness	Pervious Area Depression Depth	Pervious Area Manning's Roughness	Curb & Gutter Length	Rain Gage ID	Total Precipitation	Total Runon	Total Evaporation	Total Infiltration	Total Runoff	Peak Runoff	Time of Concentration
			(ha)			(mm/hr)	(days)	(%)	(m)	(%)	(%)	(mm)		(mm)		(m)		(mm)	(mm)	(mm)	(mm)	(mm)	(lps)	(days hh:mm:ss)
1	W_A		0.00	Bioswale_A	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.37	0 00:54:42
2	W_B		0.00	Bioswale_B	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.37	0 00:54:42
3	W_C		0.00	Bioswale_C	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.28	0 00:42:52
4	W_D		0.00	Bioswale_D	0.98	0.0000	0.07	0.0002	1.60	0.66	0.25	0.0001	0.0000	0.0005	0.0000	0.00	Three_Anchor_Bay	0.47	0.00	0.0000	0.0002	0.43	0.28	0 00:42:52

ANNEXURE E: METHODOLOGY AND MODELLING APPROACH

Hydrological and Hydraulic Modelling Tools

The following tools were used to perform the stormwater analysis:

1. Autodesk Civil 3D: used for defining the catchment boundaries and flow paths using surface analysis tools.

Data Sources

The following data sources were used in the modelling process:

1. Rainfall data from the "Design Rainfall Estimation in South Africa (Ver 3) Software.

Assumptions

The following assumptions were made during the modelling process:

1. The Rational Method is suitable for high-level peak discharge estimation.

Equations and Parameters

The following equations and parameters were used:

1. Rational Method – Q=CiA, where Q is the peak discharge (m^3/s), C is runoff coefficient, i is rainfall intensity (mm/hr), and A is catchment area (m^2).

Applicable Standards and Guidelines

The following engineering standards and guidelines were referenced and applied throughout the report:

1. SANRAL Drainage Manuel: used to guide the application of the Rational method for peak discharge estimation and stormwater design principles.
2. Neighbourhood Planning and Design Guide (Red Book, 2021): provided criteria for minor stormwater systems.
3. RSA SUDS Guidelines and GSMM: provided the criteria and basis for the SUDs treatment options applied to the development and also the water quality treatment guidelines.

Limitations and Assumptions

The following limitations and assumptions were considered during the design process:

1. Rainfall Data assumptions: The rainfall data was based on regionalized data from the South African Weather Services (SAWS) and the Design Rainfall Estimation in South Africa (Ver 3) software, including City of Cape Town's Rainfall Grid. It was assumed that these values represent the site but may not reflect localized microclimatic variations.
2. The assessments were carried out with the most recent topo survey available (2017). Minor adjustments to the inlet/outlet levels. Underdrain inverts, weir crest elevations, stormwater pipe cover will need to be confirmed during detailed design.
3. The extent of the basement is assumed to be a full-footprint basement slab as there isn't detail on the basement extents as yet therefore the design took the assumption that there is no natural infiltration that can occur in the SUDs units proposed. Therefore, all SUDs units are assumed to operate as lined systems. SUDs guidelines allows for adaptation of the design where infiltration is not possible due to site constraints.
4. The relocation of the stormwater pipelines used GIS invert levels on some of the pipes due to insufficient levels data from the Topo Survey.

ANNEXURE F: RISK ANALYSIS

Risk Category	Description	Potential Impact	Likelihood	Mitigation Measure
Flood Risk	Bioretention facilities may flood during major storm events	Localized ponding, reduced performance, risk to adjacent properties.	Medium	Ensure routine inspection and clearing of overflow structures.
Basement Constraint	No infiltration possible due to the basement, all systems rely on filtration and underdrain flow.	Slower drawdown if the media clogs, potential ponding and reduced treatment performance.	Medium	Strict media specifications, ensure underdrain has access for jetting and monitor drawdown per WSUD expectations.
High sediment loads during construction	Silt may enter bioswales before completion	Rapid clogging of media surface, compromised WQ treatment and costly rehabilitation.	High	Enforce erosion and sediment control during construction.
Inadequate Maintenance	SUDs components depend on ongoing maintenance	Blockages, reduced pollutant removal, long term failure	High	Adopt routine inspection, maintain vegetation, remove sediments and comply with CCT's ongoing maintenance requirements
Limited space for SUDs footprint	Compact buildings layout restricts available treatment area, reliance on precise grading	Reduced flexibility, risk of underperforming WQv treatment if areas are reduced.	Medium to High	Use distributed bioretention, gravel diaphragms, and lined swales for constrained urban sites.
Construction Phase Flooding	Temporary drainage disruption when manholes and pipes are relocated	Ponding, safety hazards, work delays.	Medium	Phase works to maintain temporary flow paths, avoid simultaneous removal of multiple inlets.