REZONING AND DEVELOPMENT OF ERF 464

Stormwater Management Plan

George Municipality

Reference: 504255

Revision: 1

31 January 2020

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Document control record

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Contents

1 INTRODUCTION

1.1 Brief

George Municipality identified the need for the development of Erf 464 into various development categories. The George area has seen a period of rapid growth in recent years. The demand for additional tertiary education facilities with ancillary facilities as well as residential spaces and commercial properties has increased.

The proposed development will entail earthworks, the installation of utility services and the construction of roads and bridges.

Aurecon will be responsible for the design of roads and civil services for the proposed development which includes the necessary infrastructure to collect and control stormwater runoff where required.

George Municipality is in the process of submitting an Environmental Authorization and Re-zoning Application for the proposed development of Erf 464.

1.2 General

The proposed development is situated opposite the Madiba Drive towards the North-East of the George CBD and adjacent to the existing Garden Route Dam. A locality plan of the development area is given in Figure 1. The climate is moderate, with rainfall occurring mainly during autumn within the mean annual precipitation being in the order of 662mm. The temperature ranges from 18.2ºC in July to 27.6ºC in February.

Figure 1: Locality Plan

The proposed Site Development Plan is attached hereto. The development can be divided into the following broad categories:

A land use breakdown of the site is given in Table 1. The Site Development Plan for the proposed development is attached as Annexure A.

Table 1: Land use scheme Erf 464

Zoning	Land use Description	Extent (+/- ha)	% of Total (Approximated)
Community Zone I	Campus – University/Research institute/ Academy	13.66	12
Business Zone I	Waterfront commercial development	4.15	4
General Residential Zone VI	Hotel	1.55	1
General Residential Zone II	Medium density residential/Group housing	5.47	5
General Residential Zone IV	Apartments / Flats / Student Housing	4.84	4
Single Residential Zone VI	Free standing dwelling houses	5.76	5
Open Zone II	Recreational Spaces / Sport fields	7.57	6
Open Zone II	Parks / Natural Assets / Preservation Areas	67.90	57
Transport Zone II	Roads	7.60	6
TOTAL		**118.5 (ha)**	**100%**

2 OBJECTIVES OF REPORT

The objective of this statement is to:

- Analyse the local catchment area in order to:
  - Determine the 1: 5 year (minor system), 1:50 (major system) year flow rates at points of interest, and;
  - Determine preliminary size of stormwater drainage pipes, culverts and / or channels within the proposed development.
- Make recommendations with respect to the discharge of runoff.
- Propose methods (structural controls) for removing, reducing, or retarding runoff flows, and preventing targeted stormwater runoff constituents, pollutants and contaminants from reaching receiving waters.
- Propose operation and maintenance procedures.
- Prepare drawings showing the outlet structure components and possible mitigating measures for stormwater drainage and erosion control.
- Determine of 1:50 and 1:100 year floodlines (Refer to Annexure C).

3 DESIGN CRITERIA AND STANDARDS

3.1 Design criteria

The following documents will serve as a base for the detail design criteria and standards:

- Guidelines for Human Settlement Planning and Design (“Red Book”); and
- City of Cape Town Management of Urban Stormwater Impacts Policy – Version 1.1, 2009.

- South African Guidelines for Sustainable Drainage Systems (Armitage et al., 2013) which was based on a review of international guidelines and includes typical designs (Appendix C)

3.2 Construction specifications

All materials and workmanship shall comply with the specifications as set out in the South African National Standards for Civil Engineering (SANS).

3.3 Stormwater

The stormwater system forms an integral part of the road and urban planning layout. The system rests on three legs, the minor system, the major system and an emergency system. Minor storms are catered for in the pipe system while Major storms are routed through a linked system of roads and public open spaces using attenuation techniques. The emergency system recognizes failure of the minor and major system by storms greater than provided for in the major system or in the event of malfunction of the minor system by providing continuous overland flow routes to minimize flooding of residential areas.

3.4 Minimum design criteria for stormwater system

The criteria to be used for the design of the system are the following:

- Minor system: 5 year return period conveyed in an underground pipe system. Preferably the overland flow shall not exceed 200m;
- Major system: 50 year return period. The difference between the 5 year and 50 year to be conveyed in the road prism with a flow depth not exceeding 150mm within the road reserve width;
- The minimum gradients for pipelines will be designed to give a minimum velocity of 0.7m per second with the pipe flowing full;
- The maximum velocity used is 3.5m per second;
- Major storm water overflows are to be provided to convey the excess storm water from the streets into designated public open spaces;
- Storm water flow velocities in road ways will be kept as low as possible and related to the surface finish to prevent scour and erosion; and
- Roads will be graded to ensure free and continuous flow to the main storm water system and to prevent localised ponding at intersections.

3.5 Pipelines

- Storm water pipes will generally be Class 50D, 75D or 100D as required by the loading and installation conditions;
- Pipes are generally laid on Class C bed;
- The minimum cover on pipes is 0.80m within road reserves; and
- The minimum pipe diameter will be 375mm for longitudinal runs and catch pit connections

3.6 Roads

The road system forms an integral part of the local area plan.

3.6.1 Design Criteria

The design criterion for roads is as follows:

- Road reserve widths are 20m, 16m, 13m, 10m, and 8m;

- Design life of the roads is 20 years;
- Sub-grade CBR – 15 to 20;
- Sub-base CBR – 45 minimum (processed crushed stone);
- Base course CBR – 80 minimum (processed crushed stone);
- Surfacing - Asphalt, cape seal or paving dependant on aesthetic requirements;
- Minimum road longitudinal grade 0.45 %;
- Minimum road cross fall of 2 % depending on final road surfacing type;
- Road widths will be 4.5m in 8m reserves, between 4,5m – 6,4m in up to 16m reserves, 7,4m – 8m in up to 20m reserves;
- Subgrade, Subbase and Base materials will be imported;
- Subsurface drainage, where applicable, will be installed;
- Combination kerbs, CK5 and/or a combination of a barrier kerb, BK1 and Channel, C1 will be provided on the low side of all roads and precast concrete channels at intersections or road crossings to drain stormwater towards catch pits.
- Barrier kerbs will be installed around bell mouths. Bellmouth radiuses will be a minimum of 4m; and
- All stormwater drains will be provided with a sand trap of at least 500mm deep.

4 EXISTING STORMWATER NETWORK

No formal stormwater exists within the boundaries of the proposed development. However, a catchment source point is located towards the lower side of the proposed development area. The Garden Route dam is also located towards the northern side of the proposed development area. This area of the proposed development forms part of the catchment source point, where stormwater flows through a portion of the area towards the larger catchment area watercourse. The stormwater drains from the catchment source point and accumulates stormwater as the watercourse is fed from other catchment areas. The stormwater then flows into the dam.

5 RUNOFF CALCULATION

The proposed site is currently undeveloped and can be categorised as a “Greenfield Development”. Therefore, the proposed development is expected to increase the amount of stormwater runoff due to additional hard surfaces being constructed. Table 2 shows the summary of stormwater runoff calculations. According to guidelines laid down by the City of Cape Town (CoCT), and to support Water Sensitive Urban Design Principles, all runoff from new hard surfaces created shall be treated to improve the quality of runoff and the quantity as well as the rate of runoff shall be controlled.

Table 2: Stormwater runoff summary

Description	Erf 464					
MAP (mm)	849mm					
Area	118.5ha					
Design Period	1:5 years					
Runoff Q (l/s)	Pre-Development			Post Development		
	1:5	1:50	1:100	1:5	1:50	1:100
	3247	9376	13764	13142	30394	37866
Dispersal	Existing Dams			Existing Dams		

6 PROPOSED DESIGN

A Conventional piped system is proposed for this development. Aurecon believes that the Conventional Strategy is the most appropriate for this development. However, Sustainable Drainage Systems Strategy (SuDS) will also be used to compliment the conventional system.

6.1 Conventional Stormwater Strategy

The proposed Conventional Stormwater layout can be seen on DRG-CC-0004-A and will be finalised as soon as the layout has been approved. The final stormwater will be confined to a network of pipes, culverts and concrete channels where applicable. Annexure A shows the proposed extent of the development as well as proposed coverage.

The internal stormwater network will be designed in such a manner that it follows the natural topography of the site and dispersed through several outlet structures directing the water while preventing erosion. See Annexure B for an example of a typical Energy Dissipating outlet Structures. Conventional stormwater networks consisting of stormwater Catch Pits, Manholes and Energy Dissipating Headwalls will convey the stormwater generated in the area into the proposed stormwater outlets and silt retention structures to minimize the peak runoff towards the existing detention areas.

If required, indigenous vegetation will be established to the specifications of stormwater wetlands plant material contained in various publications to assist in reducing the risks of erosion and the establishment of wetlands for the purpose of stormwater attenuation at outlet points if required during detail design. This will also assist in the filtration and treatment of stormwater.

The Figures below show a variety of options that can be utilised to minimise erosion and silt as well as to eliminate litter and sediment discharge into the Swart River that is flowing along the Southern edge of the proposed site and the Garden Route Dam towards the North. Figure 2 shows an erosion mat that can be used to prevent soil erosion allowing vegetation to grow through the mat; this can be utilised for both surface runoff as well as underground systems. Figure 3 shows an erosion control pavement method in the form of grass blocks that can also be used along river banks and slopes. Figure 4 shows a typical gabion wall that can be use along the Swart River bank. Annexure B shows Typical examples of Energy Dissipation and silt retention structures. Litter traps can be constructed at strategic locations to reduce the litter load into the stormwater reticulation system. A clear image of a litter trap can be seen on Figure 5.

The preliminary design stage stormwater mitigation measures as described in this report may slightly change from what is presented during the Detail Design stage.

Figure 2: Erosion mat

Figure 3: Erosion control pavement/ grass blocks

Figure 4: Typical Gabion wall and indigenous vegetation used for erosion control

Figure 5: Litter Trap for trash and pollution control

6.2 SuDS

The goal of a SuDS system should be to mimic the natural hydrological cycle and treat runoff water quality to predevelopment levels. A SuDS system should do this through a number of sequential interventions in the form of a 'treatment train' – typically considered four intervention points. These are (Armitage et al., 2013):

- **'Good housekeeping'** which ensures that as much as possible is done to minimise the release of pollutants – such as solid waste – into the environment where it may subsequently be transported by stormwater.
- **Source Controls** which manage stormwater runoff as close to its source as possible, usually on site. Typical SuDS options include: green roofs, rainwater harvesting, permeable pavements and soakaways.
- **Local Controls** which manage stormwater runoff in the local area, typically within the road reserves. Typical SuDS options include: bio- retention areas, filter strips, infiltration trenches, sand filters and swales.
- **Regional Controls** which manage the combined stormwater runoff from several developments. Typical SuDS options include: constructed wetlands, detention ponds and retention ponds.

1.1.1 ‘Good Housekeeping’

It is important to acknowledge the challenges the developers/municipalities face with respect to managing litter. However, in terms of the management of stormwater – both pollution and flooding – solid waste management is critical. While SuDS systems are designed to treat and improve water quality, overloading them is likely to cause failure – as it does for conventional systems. Thus, it is important that solid waste management generally is optimally managed – not just within the stormwater system. This includes, *inter alia*, the following:

- Adequate provision of ‘rubbish’ bins;
- Use of ‘shipping’ containers
- General litter collection / area cleaning; and
- Maintenance and cleaning of the stormwater system.

Figure 6: Solid waste ‘shipping’ container being used to collect and store solid waste.

1.1.2 Source Scale

Rainwater harvesting tanks, Green roofs, permeable pavements, soakaways may be considered. The advantage of such an approach is that it will increase the development’s resilience to the effects of water shortages, and aid in reducing peak flows. The reduction in peak flows would likely only be realised for smaller recurrence interval events – and is therefore an expensive option unless it forms part of a broader Water Sensitive Urban Design / Water Wise strategy.

1.1.3 Local Scale

The use of a piped stormwater system may not be sufficient for the entire development. Other areas will require systems to prevent erosion and control runoff within the road reserve. As an alternative to using piped stormwater system, it is proposed that an open channel rather be placed along the edge of the road reserve as can be seen in Figure 1. Once adequate water, solid waste, sanitation and maintenance interventions have been put into place, the roadside open channel can be retrofitted with a swale as shown in Figure 2. A similar concept could be developed for offline bio retention areas – where a concrete detention facility is developed and in time converted to a bio retention garden. The option selected would depend on the layout of the site, the available road reserve and whether the municipality/developer is willing to buy-in to a long-term vision of operating and maintaining a SuDS system on the site.

South African Guidelines for Sustainable Drainage Systems (Armitage et al., 2013) highlight a number of other “SuDS” options (e.g. Sand filters, Infiltration trenches etc.) that could be utilised.

It is important to note that, in particular, the proposed site has very steep slopes. As such, there is a need to ensure adequate erosion protection during storm events.

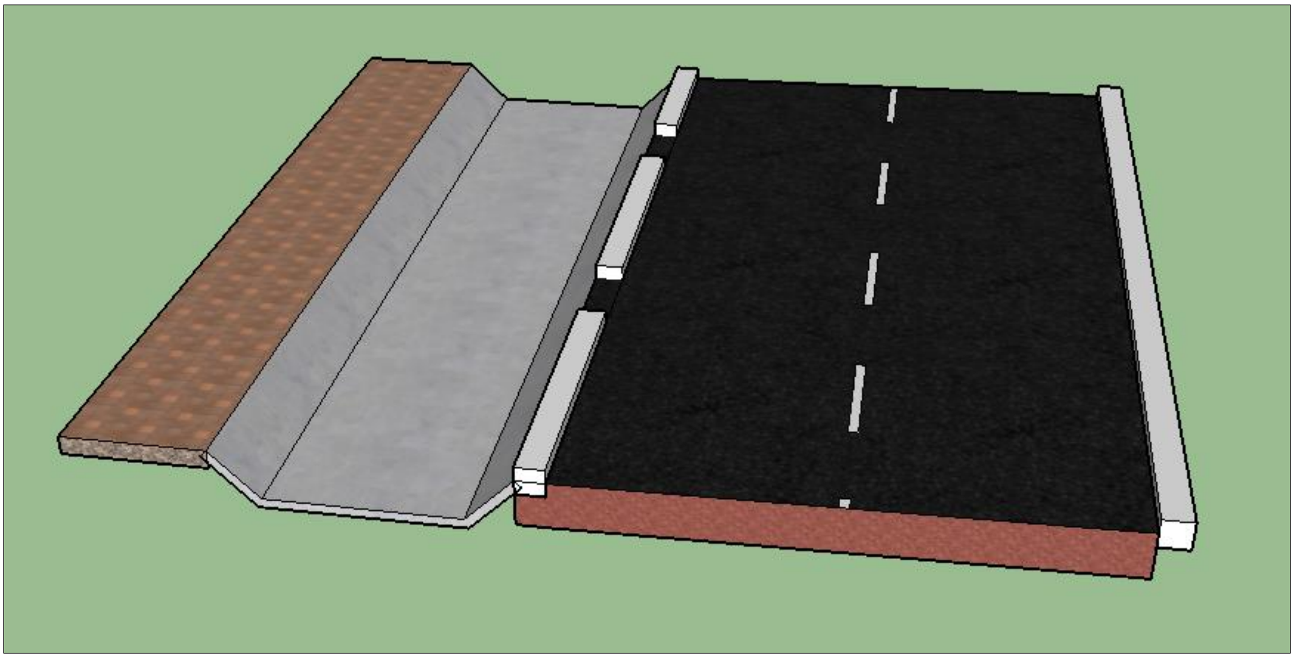


Figure 1: Roadside channel - short term

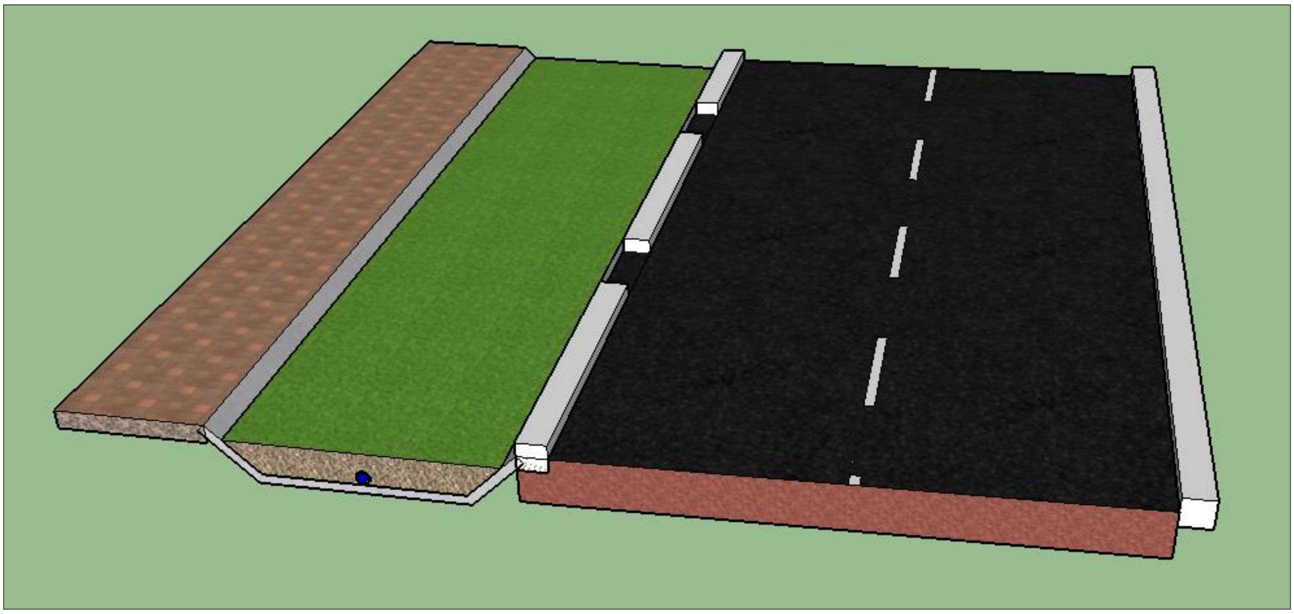


Figure 2: Roadside channel retrofitted with swale – long term

1.1.4 Regional Scale

Litter traps may be used were necessary. Litter traps will need to be designed based on a more in-depth study, but these traps could form part of the structures, and may be incorporated into architectural features such as ponds (i.e. modified inlet / outlet structure), although this would be up to the design team.

Should the client and design team prefer to remain with a conventional piped system – despite the reasonable probability of it blocking, high maintenance requirements, and the consequent negative environmental impacts – it is recommended that the regional scale (Section 1.1.4) stormwater controls are still implemented. These controls will then become the only means of attenuating the runoff to pre-development levels and likely result in these facilities requiring additional maintenance. Additionally, the litter traps will, with such a design provide the majority of the water quality improvement.

If, such an approach is adopted, Aurecon would suggest the installation of “tree pits” / “catch pit bio retention” systems (Figure 3) be seriously considered. Including these in the design should offer limited attenuation, a degree of treatment (filtration and bio filtration) and prevent litter blocking the main piped network. The advantage of ‘tree pits’ is that they do not take up a significant amount of additional space and can be designed with overflows so that the functionality of the conventional stormwater drainage system is not lost. Furthermore, they also offer some amenity and ‘green’ the environment.

As with the SuDS approach above, the success of ‘tree pits’, within the context for which it is intended, it would need to be tested.

Figure 3 ‘Tree pit’ (http://urbanwater.melbourne.vic.gov.au/projects/raingardens/little-collins-street-tree-pits/)

The proposed site access roads, Point A and Point B (as shown on the attached drawing no. AF1016-01) are in positions where increased risks of road failures may be created. If heavy rainfalls or floods may occur, water will pond above the road fill, and may cause weakening and/or erosion of the subgrade. A cross channel such as a Culvert will be used to prevent water from flowing along the road surface. Culverts are by far the most commonly used channel crossing structure in cases such as these. A thorough analysis has been conducted to determine the type of culverts to be used at the crossings (Refer to Annexure C). Regardless of the type of culvert, the culvert must conform to proper design standards with regards to alignment with the channel, capacity, debris control, and energy dissipation.

7 FLOODLINES

The proposed development is not being affected by a pre-determined floodline, but in certain areas such as the access roads are limited by portions of watercourse drainage lines, rivers and buffer zones adjacent to watercourse that drain into the larger system and Garden Route Dam. Refer Figure 5 below extracted from the Freshwater Habitat Assessment: Phase 1, done by Sharpe Environmental Services 31 January 2019.

Refer to Annexure C for a detailed floodline determination report and drawing no. AF1016-01 is herein attached.

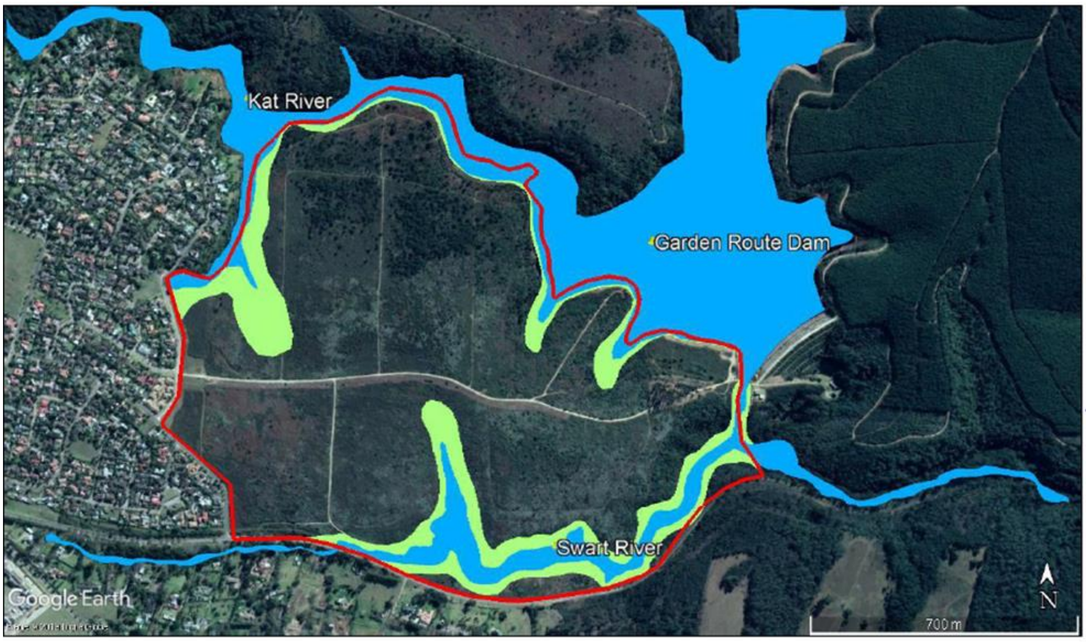


Figure 5: Typical Gabion wall used for erosion control

8 SPATIAL PLANNING CONSIDERATIONS

It is proposed that the SDP take cognisance of the required stormwater management.

This includes:

- Provision of stormwater escape routes between erven to direct minor and major flows towards the existing watercourse area;
- Roads linking the proposed site with the existing/proposed access road should not restrict stormwater run-off;
- No erven should be constructed too close to the existing watercourse to impede overland flows or be infringing on the National Water Act (1998) Section 144; and
- Incorporation of the existing watercourses into the final SDP.

9 STORMWATER MANAGEMENT TECHNIQUES: DURING CONSTRUCTION

The stormwater surface run-off water will be managed carefully during construction.

The following management techniques will be implemented:

- Temporary cut-off channels and berms;
- Routing of run-off towards the existing watercourse and current drainage routes;
- Erosion protection by means of gabions, Reno mattresses, Geofabric and/or any combination thereof;
- Compliance with a site specific Environmental Management Plan;
- Provision for dealing with water, in accordance with SABS 1200, will be stipulated in the Project Specification and Contract Documents. Of specific importance will be the following clauses:

  i. Clause 5.5 in SABS 1200 A;
  ii. Clause 5.3 in SABS 1200 AA;
  iii. Clause 5.1.3 in SABS 1200 D; and
  iv. Clause 5.1.2 in SABS 1200 DB.

10 STORMWATER MANAGEMENT TECHNIQUES: POST CONSTRUCTION

The factors to consider in Stormwater Management falls broadly into two main categories, namely those related to quantity and those related to quality.

Any development brings about changes to the natural environment of a site, which in turn has an effect or disrupts the natural hydrological cycle. Changes include, among other:

- Increase in impermeable surfaces (roads, roofs etc.) resulting in lower infiltration, higher run-off volumes and velocities;
- Changes to natural flow routes through earthworks, infrastructure and shaping of terrain; and
- Changes to local water course environment and ecology;

The management of the increased run-off volumes and velocities is important as it can be detrimental to the receiving drainage system and communities downstream of the site, as it could cause severe erosion, property damage and even loss of life.

By restricting peak flows to pre-development levels, the status quo of the catchment is maintained. This could be achieved through the implementation of the following recommended practices, as described below.

10.1 Proposed stormwater control measures

According to the CoCT's "Management of Urban Stormwater Impacts Policy" all stormwater management systems shall be planned and designed in accordance with best practice criteria and guidelines laid down by Council, to support Water Sensitive Urban Design principles and the following specific sustainable urban drainage system objectives:

- Improve quality of stormwater runoff;
- Control quantity and rate of stormwater runoff;
- Encourage natural groundwater recharge.

In consideration of the site topography, parking lots may need more energy dissipation measures. A bioretention system is proposed so that stormwater runoff can be spread throughout the site to prevent erosion and encourage infiltration. Figure 10 shows a typical example of a bioretention structure. Bioretention structures have the following advantages:

- Treats the stormwater
- Provide reduction of total suspended solids
- Beneficial for oil and grease treatment
- Provide groundwater recharge
- Provide infiltration of treated stormwater

Figure 10: Typical Stormwater Bioretention System at a parking area

10.2 Infiltration

By dispersing the run-off to numerous small outfalls spread across the proposed site, the recharge of the underground water table is promoted thus reducing the risk of erosion.

As mentioned above, open cut-off channels will be used where the site permits. Channels with longitudinal slopes flatter than 4% will be earth channels and those between 4% and 10% will be grass lined channels. Both earth and grass channels promote infiltration. For slopes steeper than 10% (1:10) the channels will be stone pitched or lined with either concrete or Reno mattresses to prevent scouring or erosion. The utilization of Reno mattresses creates a high friction factor and thereby reduces the velocity of stormwater. Refer to Annexure B for further information regarding energy dissipation.

The installation of Reno mattresses and gabion boxes in steep sloping channels acts as energy dissipaters and stilling basins. These structures are also used as silt traps to prevent the loss of silt to the natural water courses. Silt that gets trapped on the Reno mattresses acts as a growing medium for vegetation which thereby accelerates the re-establishment of natural vegetation. This rehabilitated vegetation also acts as a dissipation medium, resulting in attenuated run-off.

10.3 Attenuation

Attenuation functions by the principle of allowing large flows of water to enter a facility but limiting the outflow by having a small opening at the low point in the facility. The difference between in- and outflows is directed to a catchment area where the water is flowing towards the river.

Attenuation are already available on site in the form of the dam adjacent to the proposed site.

10.4 Screening runoff

The use of screening devices are the most common strategies of stormwater and requires regular maintenance. The following can, but not limited to be used to screen runoff;

- Catch basins: Clean all catch basins and sediment traps before heavy rains. Regular cleaning of the devices throughout the wet-season.
- Gabions: Can be used to protect the stormwater drains or slow and screen the water. The gabions need to be cleaned by a power-washer in every 2 to 3 years to remove accumulated debris and dirt.
- Sediment pond/trap: a widening in a channel that allows water to slow enough to drop its heavier particles. These areas can be permeable or not, vegetated or not. Sediments collected in the collected from these areas will need to be removed in every 2 to 5 years depending on use.

Figure 11 below shows a typical example of a stormwater debris screen device that can be used to trap all debris at the outlet strictures. A netting trash trap may also be an alternative to the debris screen device to effectively manage solid waste at the outlet structures.

Figure 11: Stormwater Debris Screen device

In addition to the screening methods, the following maintenance procedures may be considered:

- Litter clearing: A litter clean-up is to take place regularly.
- Cleaning of silt traps: The sedimentation forebays as well as the aprons of the outlet headwalls must be inspected, with one of the inspections taking place just before the first seasonal rains. These must be inspected for build-up of silt, dirt, mud and similar material. All silt and other material must be removed and disposed of at a suitable waste drop-off site. Care must be taken to ensure that no silt enters the stormwater system during the cleaning process.
- Cleaning of kerbs and channels: Sand, litter and refuse should be removed from kerbs and channels.
- Cleaning of pipes: Refuse should be removed from pipes on a regular basis. Sand and silt should also be removed by using high pressure jetting.

- Cleaning of covers and frames: The covers and frames should be inspected and need to be replaced, repositioned or repaired where necessary.
- Headwalls inspection: The headwalls should be inspected regularly or after each rain. The blockage should be removed, and the natural growth trimmed to allow free drainage of water.
- Monitor ponding or slow drainage: The position of the ponding should be logged and monitored regularly especially after rainfalls. If occurrence increases request subsurface drain to be inspected and repaired if necessary.

10.5 Operation and maintenance

Responsibility

Once the stormwater treatment and attenuation facilities have been constructed, the operation, maintenance and monitoring will remain the responsibility of the developer/property-owner or municipal maintenance staff.

The development of a maintenance plan should form part of the design process and line up with the catchment's stormwater, litter and water quality management plan/s. To guarantee the structure is practical and will be financially manageable, it is advisable that the maintenance plan is tranlated into a Life-Cycle costing model to allow the municipal budget suitably. Failure to guarantee adequate maintenance is likely to lead to system not to function properly.

11 CONCLUSION AND RECOMMENDATIONS

The planning of stormwater design elements must always be seen as a holistic process which incorporates much more than the infrastructural elements required in adequately dealing with stormwater. It affects a range of environmental goals and management principles and aims not only to mitigate negative impacts, but actively promote positive modifications in its application.

The design approach to be adopted for the proposed development and as discussed above, can be summarised as follows:

- Promotion of on-site infiltration;
- Minimise concentration of stormwater;
- Maintain pre-development run-off levels as far as possible;
- Enforcement of management principles;
- Identify escape routes for major floods;
- Responsible discharge of stormwater into downstream systems; and
- Allowing for the necessary attenuation.

Certain aspects will require further consideration during the detail design stage, they are:

- Stormwater needs to be responsibly conveyed to the existing watercourse;
- Stormwater collected along the watercourse needs to be able to reach the existing drainage infrastructure downstream;
- The site development plan needs to adequately provide for servitudes to accommodate major flows; and
- Maximisation of attenuation of the rainwater to ensure that most water can be retained.

The following mitigation measures need to be considered for water pollution:

- Develop, implement and monitor catchment litter management and water quality strategy;
- Ensure adequate provision of sanitation services;
- Ensure adequate provision of solid waste management services;
- Where possible make use of a SuDS treatment train to manage water quality;
- Install local / regional litter traps (as suggested in the report); and
- Ensure that all attenuation facilities have adequate forebay's with extended attenuation to allow for adequate sedimentation
- Develop a stormwater management plan that incorporates the management of peak flows, litter and water quality. Such a plan should incorporate a lifecycle costing of the required maintenance to ensure that adequate resources are available so that design, once implemented, can be adequately managed – and perform as intended.

As indicated in this report, the proposed site's stormwater will be managed in a responsible manner and be safely discharged into the surrounding drainage system, without any detrimental impacts to the environment or communities.

The application of this Plan on this particular project will lead to:

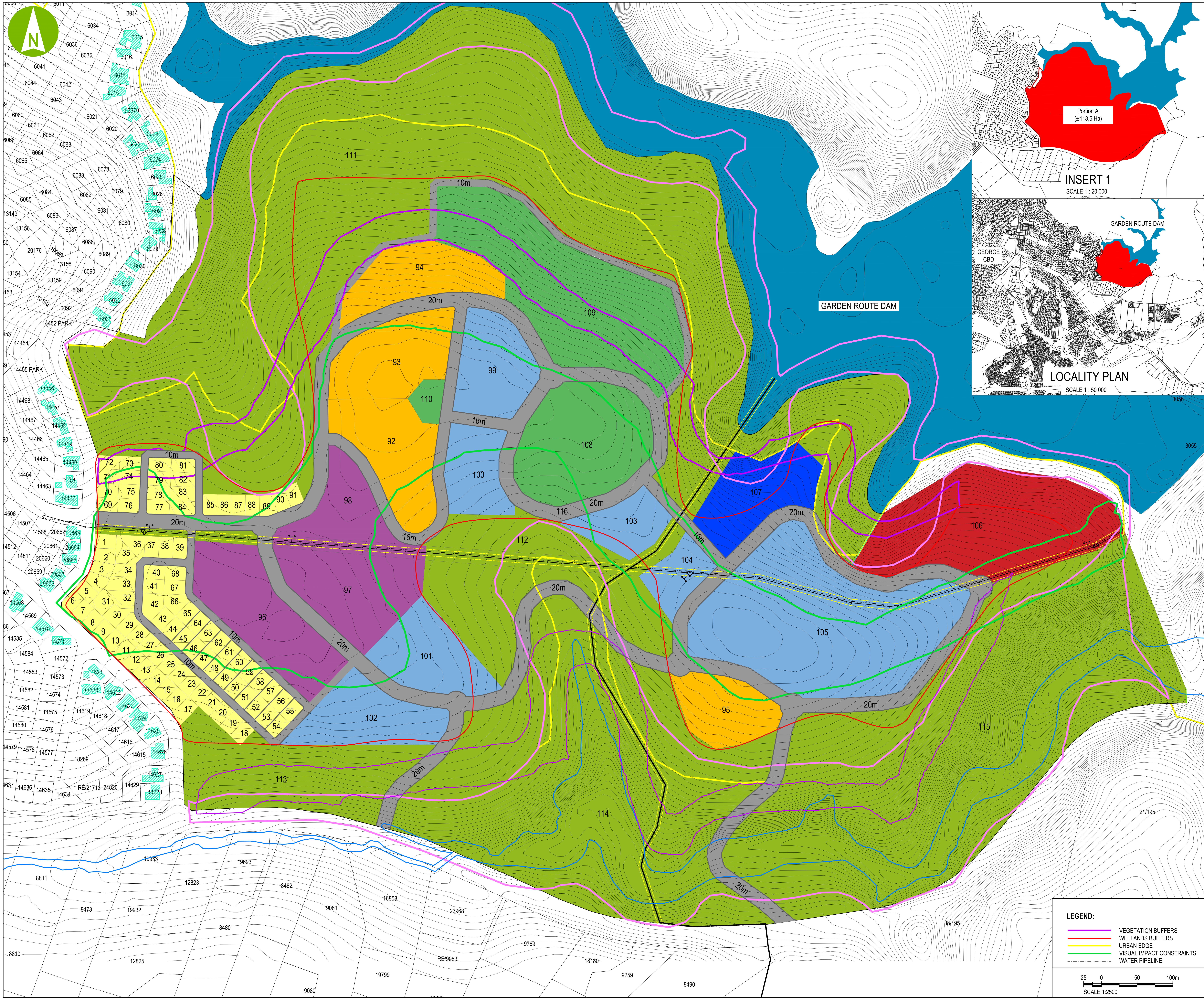
- Minimisation of the impacts of stormwater from new developments on receiving waters such as watercourses, wetlands, coastal waters, etc; and
- Prevention of further degradation of receiving waters by stormwater draining from existing developments, as well as in the long term the reversal of current undesirable stormwater impacts.

We trust that we have provided sufficient information for your purposes and look forward to hearing from you shortly.

Please do not hesitate to contact us should you require any further information

Annexures

Annexures A: Site Development plan (SDP)



APPLICATION FOR REZONING AND SUBDIVISION IN TERMS OF SECTION 15 OF THE GEORGE MUNICIPALITY LAND USE PLANNING BY-LAW, 2015

Application is being made for:

1. The subdivision of the Remainder of Erf 464, as shown on Insert 1, as follows:
   1.1.1 Portion A = ± 118.50 Ha
   1.1.2 Remainder
2. The rezoning of the above mentioned Portion A from Undetermined to a subdivisional area.
3. The subdivision of the above mentioned subdivisional area as shown on plan and set out in Table 1 below.
4. The permanent departure from the standard Zoning Scheme Provisions as set out in Chapter 8 of the George Integrated Zoning Scheme By-Law, 2017, in terms of parking requirements of "Business Premises" from 6 bays per 100m2 GLA to 4 bays per 100m2 GLA, and
5. Consent Use to permit a Conference Facility on the portion zoned as Community Zone 1, Boarding Houses on the respective portions zoned as General Residential Zone IV and Shops on the respective portions zoned as General Residential Zone VI as primary use

Remarks

1. The detail design of the development on the Waterfront business site will be dealt with as a separate task involving professional engineering and architectural input.
2. Architectural Guidelines will be drawn up to aesthetics of all development components.

SITUATED IN THE MUNICIPALITY AND ADMINISTRATIVE DISTRICT OF GEORGE

TABLE I

	Zoning	Land Use	Ptn No's	Number	Area (Ha)	%
	Community Zone 1	Campus - University / Research Institute / Academy	99-105	7	12.51	11%
	Business Zone 1	Waterfront Commercial Development	106	1	4.15	4%
	General Residential Zone VI	Hotel	107	1	1.55	1%
	General Residential Zone III	Medium Density Residential / Group Housing	96-98	3	5.47	5%
	General Residential Zone IV	Apartments / Flats / Student Housing	92-95	4	5.99	5%
	Single Residential Zone I	Free Standing Dwelling Houses	1-91	91	5.76	5%
	Open Space II	Recreational Spaces / Sports Fields	108-110	3	7.57	6%
	Open Space III	Parks / Natural Assets / Preservation Areas	111-115	5	67.90	57%
	Transport Zone II	Roads	116	1	7.6	6%
	Total			**116**	**118.50**	**100%**

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CLIENT

.\Amended Logo - 13 May 2019\GM LOGO 2018.png

REV	DATE	REVISION DETAILS	APPROVED
A	10/2019	PRELIMINARY	A. KEYSER
B	7/11/19	LAYOUT ACCORDING TO NEW BUFFERS	A. KEYSER

SCALE	SIZE
1:2500	A1

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWN

DESIGNED

REVIEWED

APPROVED
DATE
PE ERASMUS - ECSA 830347

PROJECT

PORTION OF THE REMAINDER OF ERF 464, GEORGE
REZONING AND SUBDIVISION IN TERMS OF SECTION 15 OF THE GEORGE MINICIPALITY LAND USE PLANNING BY-LAWS, 2015

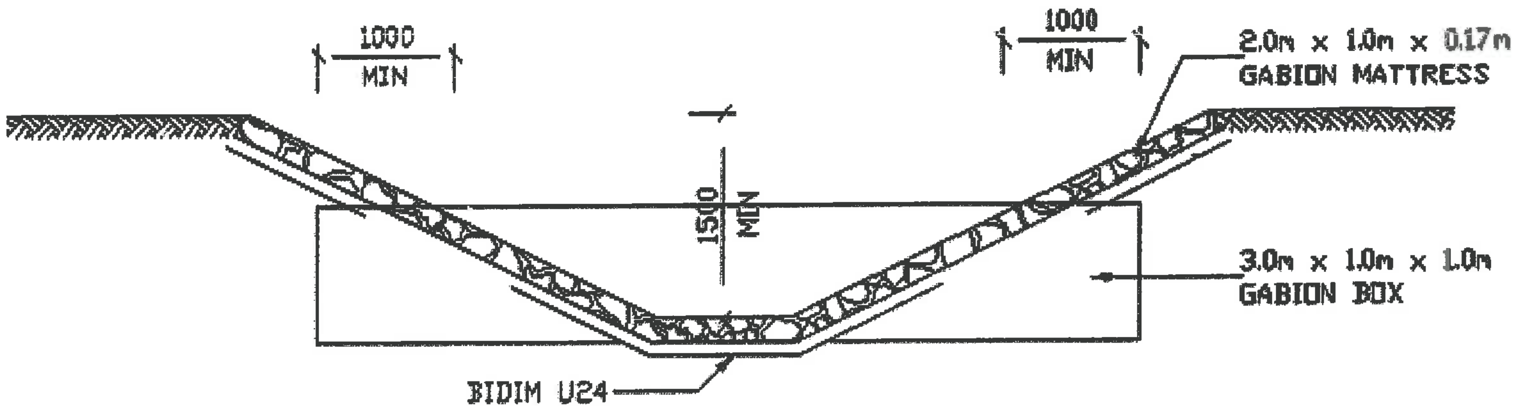
TITLE

SUBDIVISION PLAN

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
504255	-	0000	-	DRG	-	CC	-	0001	-	B

Annexures B: Energy Dissipation Details

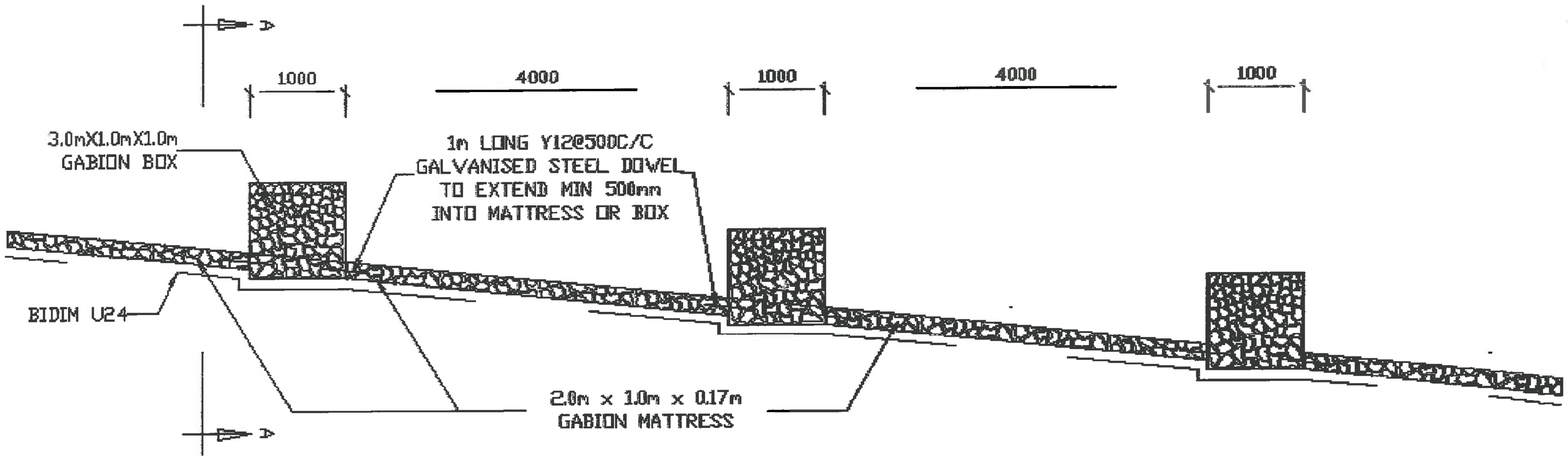


SECTION A-A

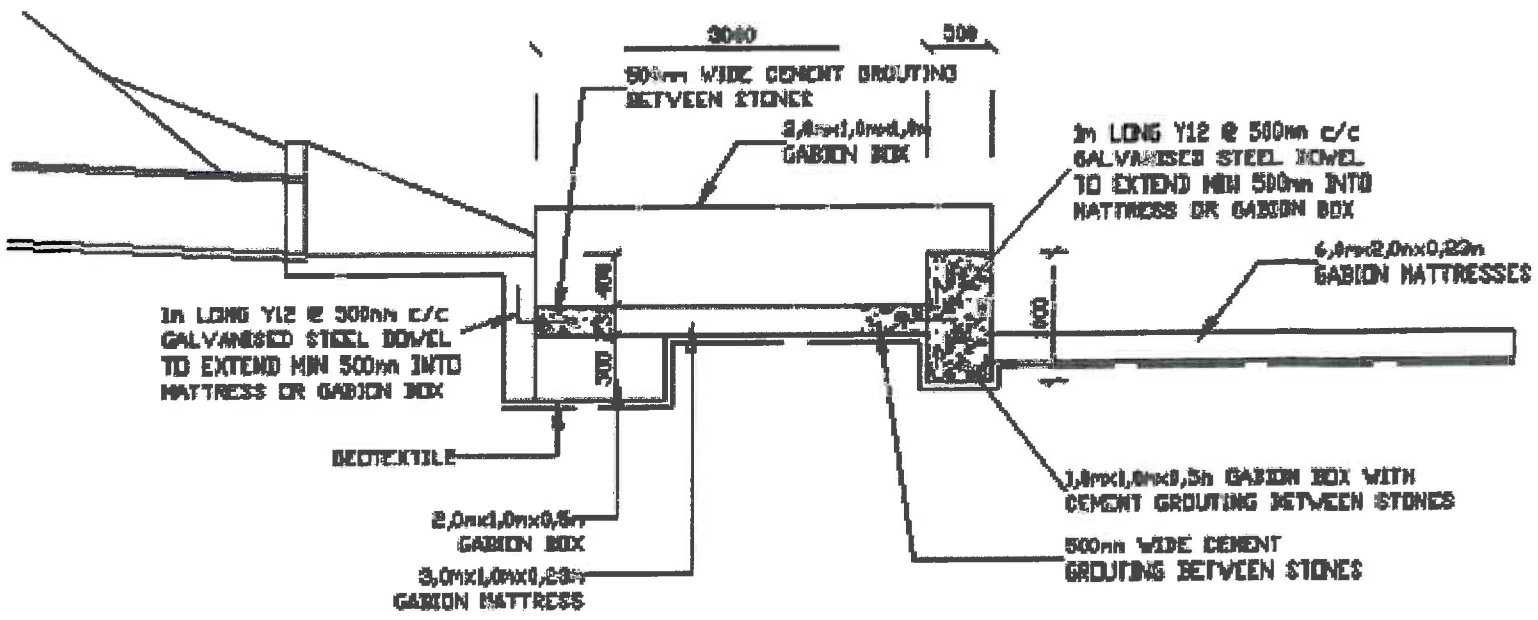
NOTES:

GENERAL NOTES:

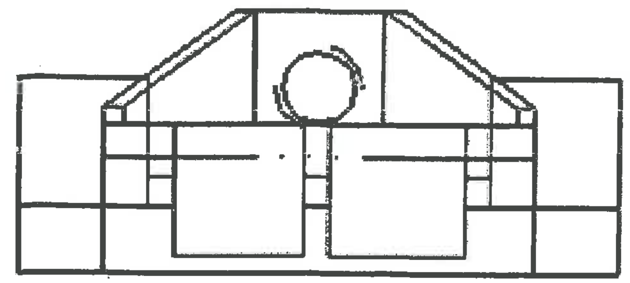
1. UNSUITABLE MATERIAL TO BE REMOVED FROM CHANNEL BED PRIOR TO PLACING OF GABIONS AND CAVITIES TO BE FILLED WITH SUITABLE MATERIAL. SURFACE TO BE LEVELLED AND WELL COMPACTED (MIN. 93% MOD AASHTO).
2. DURING CONSTRUCTION AND PRIOR TO PLACING OF STONES EACH GABION BOX TO BE STRETCHED, ALIGNED AND WIRED TO THE ADJACENT BOX.
3. WIRE BRACES TO PREVENT DEFORMATION OF THE BOX DURING FILLING TO BE APPROVED BY THE ENGINEER.
4. MINIMUM STONE SIZE FOR GABIONS IS 100mm. MAXIMUM STONE SIZE AS FOLLOWS:
   MATTRESS (170-230mm THICK) : 120mm
   BOXES (0,5-1,0m DEEP) : 250mm
5. MINIMUM THICKNESS OF MATTRESS AROUND CURVES IS 200mm WITH SIZE OF STONES INCREASED AS FOLLOWS:
   GENTLY CURVING CHANNEL (R>30m) : + 30%
   SHARPLY CURVING CHANNEL (R<30m) : + 60%
6. GABION CAGE WIRE TO BE GALVANISED AND NOT PLASTIC COATED.
7. TOPSOILING AND PLANTING AS REQUIRED TO BE DONE BY LANDSCAPING CONTRACTOR.



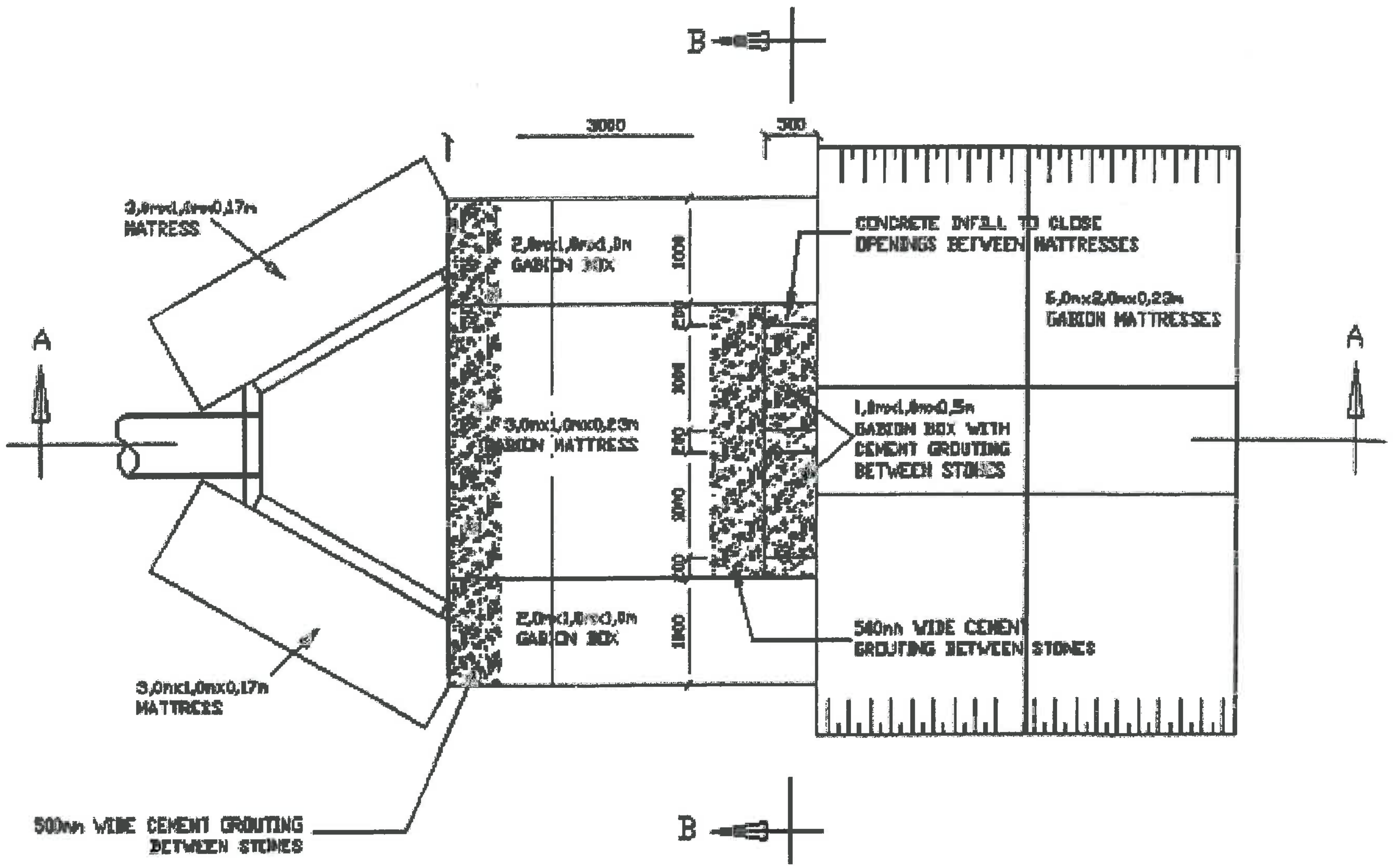
LONGITUDINAL SECTION



SECTION A–A



SECTION B–B



Annexures C: Floodline Determination Report

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Email: afraser@telkomsa.net
Mobile: 083 292 9047
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FRASER
Consulting Civil Engineers cc

Forest Lodge, Main Road North
PO Box 178, Sedgefield, 6573

Our ref: AF1016 Date: 14 January 2020

Aurecon
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65 York Street
George 6529
PO Box 509
George 6530
Tel: 044 874 2165
Email: george@aurecongroup.com
Att: Ms Sinako Johnson (Sinako.Johnson@aurecongroup.com)

Dear Sirs

Floodline Determination for Proposed Development of Remainder of erf 464, George

Fraser Engineers cc were appointed on the 25th of November 2019 to determine the 50 year Recurrence Interval (RI) and 100 year RI floodlines for a tributary of the Swart River alongside the remainder of erf 464, George. The confluence of this tributary and the Swart River is 200m downstream of the Garden Route Dam Wall.

Generally we place our floodline calculation notes on our drawings; however in this instance we have appended this information to this letter. This is to allow a single A1 paper size drawing to represent the floodlines.

The key hydrological, river hydraulic and culvert analysis information is attached as Appendix A to this letter. This acts as extended notes to floodline drawing AF1016-1

Drawing AF1016-1 contains a table listing the river stations (positions), as well as the 50 year RI and 100 year RI flood flows and floodline levels. More detailed tables are attached as Appendix B to this letter.

We have calculated preliminary sizes for the box culverts required at the two road crossings to the proposed development. These are presented within Appendix A of this letter. The culvert sizing may be affected by the embankment design. Fraser Engineers would like to review these recommendations during the preliminary design of the roadways.

Please call for any further information.

Yours faithfully,

Alastair Fraser Pr. Eng

Attached:

Appendix A	Key Hydrological, River Hydraulic and Culvert Analysis Information
Appendix B	Results of Backwater Analyses for 10, 20, 50 and 100 Year Recurrence Intervals (RIs) Rainstorms
Drawing	AF1016-rev 0: 50 Year and 100 Year RI Floodlines (A1 paper size, loose)

References

Aurecon (2018). Project Document Contract T/ING/025/2018 for Raising of Garden Route Dam Spillway and Associated Works. Prepared by Aurecon for the George Municipality. Aurecon, PO box 509, George, 6530.

CCT (2009). City of Cape Town. Floodplains and River Corridor Management Policy v2.1. Catchment, Stormwater and River Management Branch, Roads and Stormwater Department, City of Cape Town.

SANRAL (2007). Drainage Manual. Published by the South African National Roads Agency Limited; PO Box 415, Pretoria, 0001. www.nra.co.za: ISBN 1-86844-328-0.

US Army (2016). HEC-RAS River Analysis System. Users Manual v5.0. www.hec.usace.army.mil .
MAPPING: 1: 50 000 topographical maps 3322 CD and DC; 1: 10 000 orthomaps 3322 CD 25 and DC 21.

Appendix A Key Hydrological, River Hydraulic and Culvert Analysis Information

Project AF1016 –Floodline Determination for Proposed Development of Remainder of erf 464 George.

Notes for Floodline Drawing AF1016-01

1. TABLE OF RAINGAUGES CLOSE TO CATCHMENT AREA

Ref	Name	Lat	Long	MAP (mm)	Altitude	Years of record	One Day Design rainfalls (mm) for RI (years)			
		(deg) (min)	(deg) (min)		(m amsl)		10y	20y	50y	100y
28338 W	George	33 57	22 26	911	216	93	127	156	199	236
29058	Saasveld	33.57	22.28	849	174	49	129	158	201	239
							128	157	200	237

Rainfall Information sourced from SANRAL (2009)

2. TABLE OF FLOOD ANALYSIS INFORMATION

Catchment Area	2.015 km²				
Land Usage	Urban residential erven 500 to 3000 m2, schools, peri-urban small- holdings, light business, parks and minor bush forest				
Soil Classifications	Hydrological Soil Classification: B/C (Moderate Stormwater Potential)				
Time of Concentration	73 minutes (1.25 hours)				
Flood Flow Estimates:		10 Year RI	20 Year RI	50 Year RI	100 Year RI
(m^3/s) (at study area outfall)	SCS	30.6 m3/s	42 m3/s	59 m3/s	73.9 m3/s
(m3/s) (downstream of GR Dam Wall)	Aurecon (2018)	144 m3/s	182 m3/s	236 m3/s	280 m3/s

3. TABLE OF MANNING'S n VALUES FOR THE RIVER AND FLOODPLAIN.

Position in Floodplain:	Left hand bank	Watercourse	Right hand bank
	0.12	0.09	0.12

4. The survey used was an aerial survey and large tolerances are required to the thick vegetation cover.

5. Consideration from the City of Cape Town Floodplain and River Management Policy (2009):

   a. It is far more cost effective in the long term to develop in areas where the threat of flooding is infrequent and the severity of flooding is minimal as opposed to the retrospective implementation of flood mitigation works which would generally be very costly and sometimes prone to catastrophic failure when flood flows exceed the design flow of infrastructure.

   b. In determining catchment runoff the foreseeable ultimate development scenario for the catchment must be used.

   c. The flood levels must be based upon theoretical energy levels as opposed to water surface levels.

   d. Any structure built within the floodplain (ablutions and clubhouse) should be designed to withstand the forces and effects of flowing floodwaters, including scour of foundations, debris forces and buoyancy forces.

6. Note that the 100 year flood line is likely to be exceeded during the infinite course of time. We recommend that infrastructure close to the floodlines have raised floor levels to assist with the possibilities of climate change.

7. The position of the floodline on the ground should be based upon elevation data rather than the approximate position indicated on the drawing.

8. CULVERT ANALYSIS

Road Classification	Class 4. As precaution used higher Class 5 for analysis
Design Principle (from SANRAL (2007)	Refer to SANRAL (2007). Select design RI from 20 year RI flow rate and class of road: design for 10 year RI allowing for 300mm of freeboard from water surface to soffit of culvert.
Road A culvert :	Size: 1 no. x 3.6 m wide x 3 m high; IL 196.85 m amsl; Soffit level 199.85 m amsl; Road deck level (kerbs, etc): 201.25 m amsl
Road B culvert :	Size: 1 no. x 4 m wide x 3 m high; IL 182.6 m amsl; Soffit level 185.6 m amsl; Road deck level (kerbs, etc): 187.0 m amsl
	Please contact Fraser Engineers for assistance in selecting the final sizes for detail design considering possibilities of blockages.

Appendix B Results of Backwater Analyses for 10, 20, 50 and 100 Year Recurrence Intervals (RIs) Rainstorms

Table Results - A. Backwater Analysis for 10 year Recurrence Interval (RI) Rainstorms

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev*	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude #
	(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	Channel
210	24.8	203.3	203.8	203.79	203.97	0.087517	2	15.37	45.17	0.93
200	24.8	201.4	202.47	201.98	202.5	0.006043	0.89	40.36	54.49	0.28
190	24.8	200.2	200.74	200.74	200.95	0.102362	2.35	13.63	33.78	1.02
180	26.5	198.23	199.7		199.72	0.003802	0.88	49.07	51.2	0.23
176	26.5	197.5	199.67		199.68	0.000345	0.52	85.31	58.12	0.11
174	26.5	196.85	199.67	197.38	199.68	0.000098	0.33	113.45	60.13	0.06
173	Culvert									
172	26.5	196.3	197.24		197.29	0.004728	1.1	31.64	44.14	0.36
170	26.5	195.92	197.18		197.2	0.004235	0.84	46.94	50.14	0.24
160	26.5	195.15	196.37	195.97	196.46	0.026253	1.43	20.69	26.21	0.54
150	28.7	190.15	190.69	190.69	190.93	0.103251	2.16	13.26	28.01	1
140	28.7	187	188.22	187.62	188.24	0.005075	0.66	43.58	57.34	0.24
130	28.7	185.9	186.48	186.48	186.72	0.103577	2.14	13.39	28.78	1
120	28.7	183.9	185.4		185.43	0.003713	0.75	38.48	34.82	0.22
116	28.7	182.6	185.38	183.27	185.38	0.000357	0.34	86.01	44.4	0.08
114	Culvert									
112	28.7	182.2	183.54		183.58	0.006127	0.9	31.81	29.8	0.28
110	28.7	181.95	183.23	182.66	183.28	0.009071	0.98	29.3	32.73	0.33
100	30.6	180.1	180.82	180.82	181.08	0.099833	2.29	13.34	25.15	1.01
90	30.6	178	180.25		180.27	0.001339	0.56	54.62	35.05	0.14
85	30.6	179	179.75		179.97	0.054457	2.1	15.56	24.59	0.79
80	30.6	176.8	177.5	177.5	177.78	0.09954	2.31	13.22	24.53	1.01
70	30.6	172	175.43		175.43	0.000136	0.28	121.78	49.4	0.05
65	30.6	174.2	175.14	175.13	175.38	0.091978	2.15	14.23	27.86	0.96
60	30.6	169.5	170.37	170.37	170.65	0.096997	2.35	13.04	23.25	1
50	30.6	161.3	165.54		165.55	0.000075	0.23	155.54	55.8	0.04
45	30.6	161.2	165.54		165.54	0.00007	0.23	157.09	54.75	0.04
40	174.6	156.8	165.53		165.54	0.000133	0.51	466.99	90.82	0.06
30	174.6	155	165.52		165.53	0.000071	0.36	588.99	105.8	0.04
25	174.6	160.2	165.51		165.52	0.000304	0.5	381.15	112.81	0.08
20	174.6	157.6	165.5		165.51	0.000078	0.37	577.06	115.92	0.04
10	174.6	163.3	164.93	164.93	165.44	0.085817	3.63	60.26	64.01	1.07
0	174.6	156.4	159.97	158.55	160.11	0.006309	1.99	126.83	59.64	0.34

* The Energy Grade (EG) elevation determines the floodline

Table Results - B. Backwater Analysis for 20 year Recurrence Interval (RI) Rainstorms

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev*	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude #
	(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	Channel
210	34	203.3	203.92	203.88	204.1	0.066611	2.04	21.48	51.95	0.84
200	34	201.4	202.64	202.08	202.67	0.006283	1	49.53	57.44	0.29
190	34	200.2	200.85	200.85	201.1	0.095275	2.57	17.56	37.23	1.02
180	36.2	198.23	200.37		200.38	0.001375	0.68	86.86	60.83	0.15
176	36.2	197.5	200.36		200.36	0.000213	0.49	128.33	67.64	0.09
174	36.2	196.85	200.36	197.49	200.36	0.000079	0.34	158.35	70.63	0.06
173	Culvert									
172	36.2	196.3	197.45		197.5	0.004235	1.19	40.91	46.79	0.35
170	36.2	195.92	197.39		197.41	0.004281	0.93	57.71	52.66	0.25
160	36.2	195.15	196.55	196.11	196.66	0.027186	1.62	25.56	28.7	0.56
150	39.4	190.15	190.81	190.81	191.09	0.097815	2.37	16.66	29.53	1.01
140	39.4	187	188.39	187.73	188.41	0.005192	0.74	53.57	60.73	0.25
130	39.4	185.9	186.6	186.6	186.88	0.097996	2.34	16.83	30.41	1
120	39.4	183.9	186.08		186.1	0.001576	0.63	64.85	42.8	0.15
116	39.4	182.6	186.06	183.4	186.07	0.000274	0.35	118.58	50.63	0.07
114	Culvert									
112	39.4	182.2	183.75		183.8	0.006616	1.03	38.35	31.27	0.3
110	39.4	181.95	183.43	182.8	183.49	0.00937	1.1	35.97	34.77	0.34
100	42	180.1	180.95	180.95	181.27	0.094843	2.48	16.91	27.25	1.01
90	42	178	180.5		180.52	0.001589	0.67	63.36	37.02	0.16
85	42	179	179.88	179.8	180.17	0.057326	2.41	18.9	25.88	0.83
80	42	176.8	177.64	177.64	177.96	0.094145	2.53	16.58	25.74	1.01
70	42	172	175.61		175.62	0.000207	0.36	131.29	50.91	0.06
65	42	174.2	175.25	175.25	175.55	0.095092	2.41	17.39	29.3	1
60	42	169.5	170.51	170.51	170.85	0.091572	2.56	16.38	24.47	1
50	42	161.3	165.83		165.84	0.000107	0.29	172.11	58.37	0.05
45	42	161.2	165.83		165.83	0.000102	0.28	173.29	57.3	0.04
40	224	156.8	165.81		165.82	0.000192	0.63	493.14	94.49	0.07
30	224	155	165.8		165.81	0.000103	0.44	619.21	110	0.05
25	224	160.2	165.78		165.8	0.000399	0.6	412.58	115.97	0.09
20	224	157.6	165.78		165.79	0.000111	0.45	609.27	119.14	0.05
10	224	163.3	165.13	165.13	165.7	0.078416	3.86	73.91	67.5	1.05
0	224	156.4	160.39	158.83	160.54	0.006312	2.14	152.14	62.77	0.35

* The Energy Grade (EG) elevation determines the floodline

Table Results - C. Backwater Analysis for 50 year Recurrence Interval (RI) Rainstorms

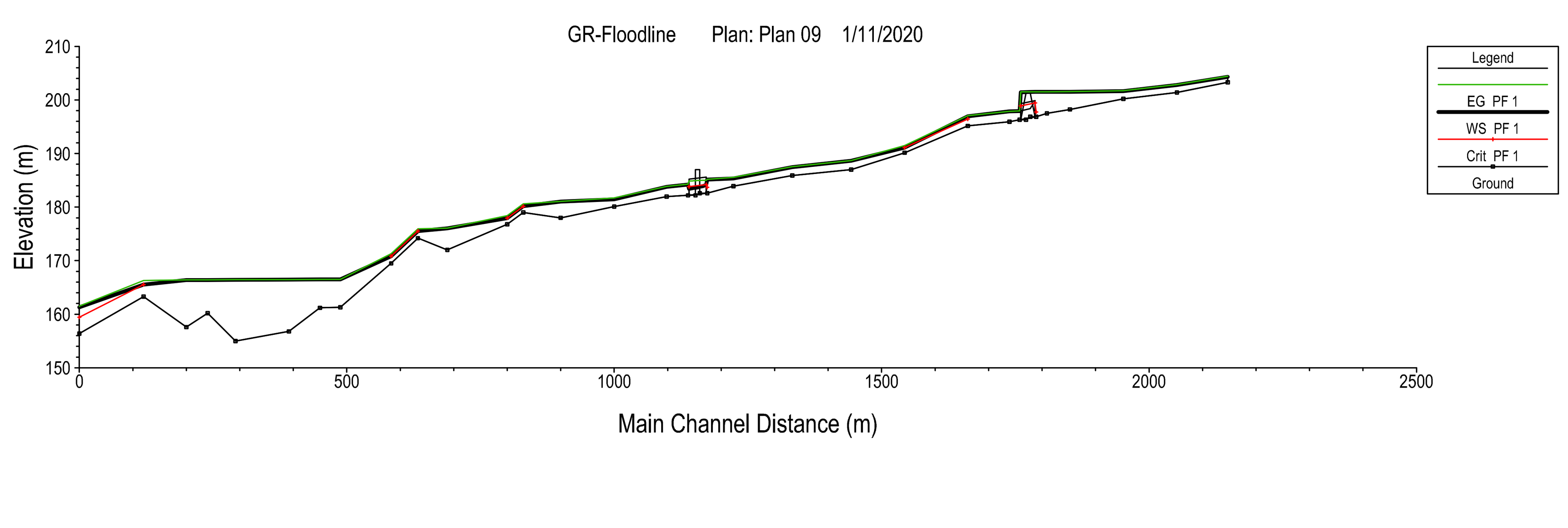
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev*	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude #
	(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	Channel
210	47.7	203.3	204.21		204.32	0.027203	1.69	37.74	60.2	0.57
200	47.7	201.4	202.66		202.72	0.011462	1.37	50.85	57.86	0.39
190	47.7	200.2	201.48		201.55	0.012602	1.47	45.94	50.68	0.42
180	51	198.23	201.39		201.4	0.000519	0.54	155.84	74.12	0.1
176	51	197.5	201.39		201.39	0.000119	0.45	204.68	80.25	0.07
174	51	196.85	201.39	197.64	201.39	0.000055	0.34	237.93	84.01	0.05
173	Culvert									
172	51	196.3	197.71		197.77	0.003903	1.31	53.58	50.19	0.35
170	51	195.92	197.65		197.68	0.004406	1.06	72.16	55.85	0.26
160	51	195.15	196.77	196.29	196.9	0.028481	1.85	32.21	31.78	0.59
150	55.4	190.15	190.96	190.96	191.31	0.091964	2.59	21.38	31.53	1.01
140	55.4	187	188.47		188.52	0.007734	0.94	59	62.49	0.31
130	55.4	185.9	187.27		187.37	0.014697	1.37	40.35	39.01	0.43
120	55.4	183.9	187.16		187.17	0.000567	0.52	117	54.1	0.1
116	55.4	182.6	187.15	183.57	187.16	0.000161	0.34	179.71	61.53	0.06
114	Culvert									
112	55.4	182.2	184.01		184.08	0.007273	1.18	46.83	33.13	0.32
110	55.4	181.95	183.67	182.97	183.74	0.01002	1.25	44.45	37.21	0.36
100	59	180.1	181.15	181.12	181.5	0.081466	2.62	22.49	29.76	0.96
90	59	178	180.8		180.84	0.001872	0.81	75.18	39.52	0.17
85	59	179	180.05	179.99	180.42	0.061959	2.8	23.18	27.43	0.89
80	59	176.8	177.82	177.82	178.21	0.08712	2.77	21.33	27.35	1
70	59	172	175.86		175.87	0.000318	0.47	143.93	52.86	0.08
65	59	174.2	175.41	175.41	175.77	0.091692	2.66	22.16	31.36	1.01
60	59	169.5	170.69	170.69	171.1	0.0875	2.83	20.88	26.03	1.01
50	59	161.3	166.21		166.21	0.000152	0.36	194.57	61.68	0.06
45	59	161.2	166.2		166.21	0.000145	0.36	195.25	60.58	0.05
40	295	156.8	166.17		166.19	0.000281	0.79	528.19	99.2	0.08
30	295	155	166.16		166.17	0.000152	0.55	659.64	115.38	0.06
25	295	160.2	166.13		166.16	0.000528	0.73	453.99	120.01	0.11
20	295	157.6	166.13		166.14	0.000162	0.56	651.69	123.26	0.06
10	295	163.3	165.38	165.38	166.03	0.074351	4.19	90.75	70.25	1.05
0	295	156.4	160.91	159.19	161.09	0.006303	2.34	185.89	66.53	0.36

* The Energy Grade (EG) elevation determines the floodline

Table Results - D. Backwater Analysis for 100 year Recurrence Interval (RI) Rainstorms

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev*	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude #
	(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	Channel
210	59.7	203.3	204.33		204.44	0.025942	1.79	44.85	62.52	0.57
200	59.7	201.4	202.8		202.87	0.011505	1.48	59.36	60.45	0.4
190	59.7	200.2	201.65		201.73	0.012116	1.57	54.67	53.69	0.42
180	63.86	198.23	201.53		201.54	0.000678	0.64	166.26	75.93	0.11
176	63.86	197.5	201.52		201.53	0.000161	0.54	215.71	81.75	0.09
174	63.86	196.85	201.52	197.76	201.53	0.000076	0.41	249.46	85.78	0.06
173	Culvert									
172	63.86	196.3	197.9		197.98	0.003743	1.4	63.78	52.76	0.35
170	63.86	195.92	197.86		197.89	0.004492	1.15	83.64	58.27	0.27
160	63.86	195.15	196.93	196.43	197.09	0.029263	2	37.56	34.05	0.61
150	69.4	190.15	191.08	191.08	191.47	0.08872	2.75	25.21	33.04	1.01
140	69.4	187	188.63		188.68	0.007738	1.01	68.85	65.57	0.31
130	69.4	185.9	187.49		187.59	0.013015	1.41	49.07	41.39	0.41
120	69.4	183.9	187.35		187.37	0.000704	0.61	127.48	56.56	0.11
116	69.4	182.6	187.34	183.7	187.35	0.000212	0.4	191.4	63.4	0.06
114	Culvert									
112	69.4	182.2	184.19		184.28	0.008213	1.32	52.77	34.88	0.34
110	69.4	181.95	183.77		183.88	0.012198	1.43	48.55	38.33	0.41
100	73.9	180.1	181.44		181.72	0.046983	2.33	31.78	33.3	0.76
90	73.9	178	181.04		181.08	0.00207	0.91	84.69	41.42	0.19
85	73.9	179	180.17	180.13	180.62	0.063954	3.08	26.76	28.64	0.92
80	73.9	176.8	177.95	177.95	178.39	0.085013	2.95	25.02	28.54	1.01
70	73.9	172	176.05		176.06	0.000415	0.55	153.96	54.35	0.09
65	73.9	174.2	175.54	175.54	175.94	0.08751	2.81	26.27	33.03	1.01
60	73.9	169.5	170.83	170.83	171.29	0.082173	3	24.64	27.13	1
50	73.9	161.3	166.49		166.5	0.000188	0.42	212.58	64.22	0.06
45	73.9	161.2	166.49		166.49	0.000181	0.42	212.85	63.08	0.06
40	353.9	156.8	166.44		166.48	0.000357	0.9	556	102.78	0.1
30	353.9	155	166.43		166.45	0.000194	0.63	691.67	119.47	0.07
25	353.9	160.2	166.4		166.43	0.000625	0.82	486.39	123.07	0.12
20	353.9	157.6	166.39		166.41	0.000205	0.64	684.84	126.38	0.07
10	353.9	163.3	165.55	165.55	166.28	0.07403	4.47	102.87	72.17	1.06
0	353.9	156.4	161.29	159.45	161.49	0.006301	2.47	212.16	69.32	0.36

* The Energy Grade (EG) elevation determines the floodline



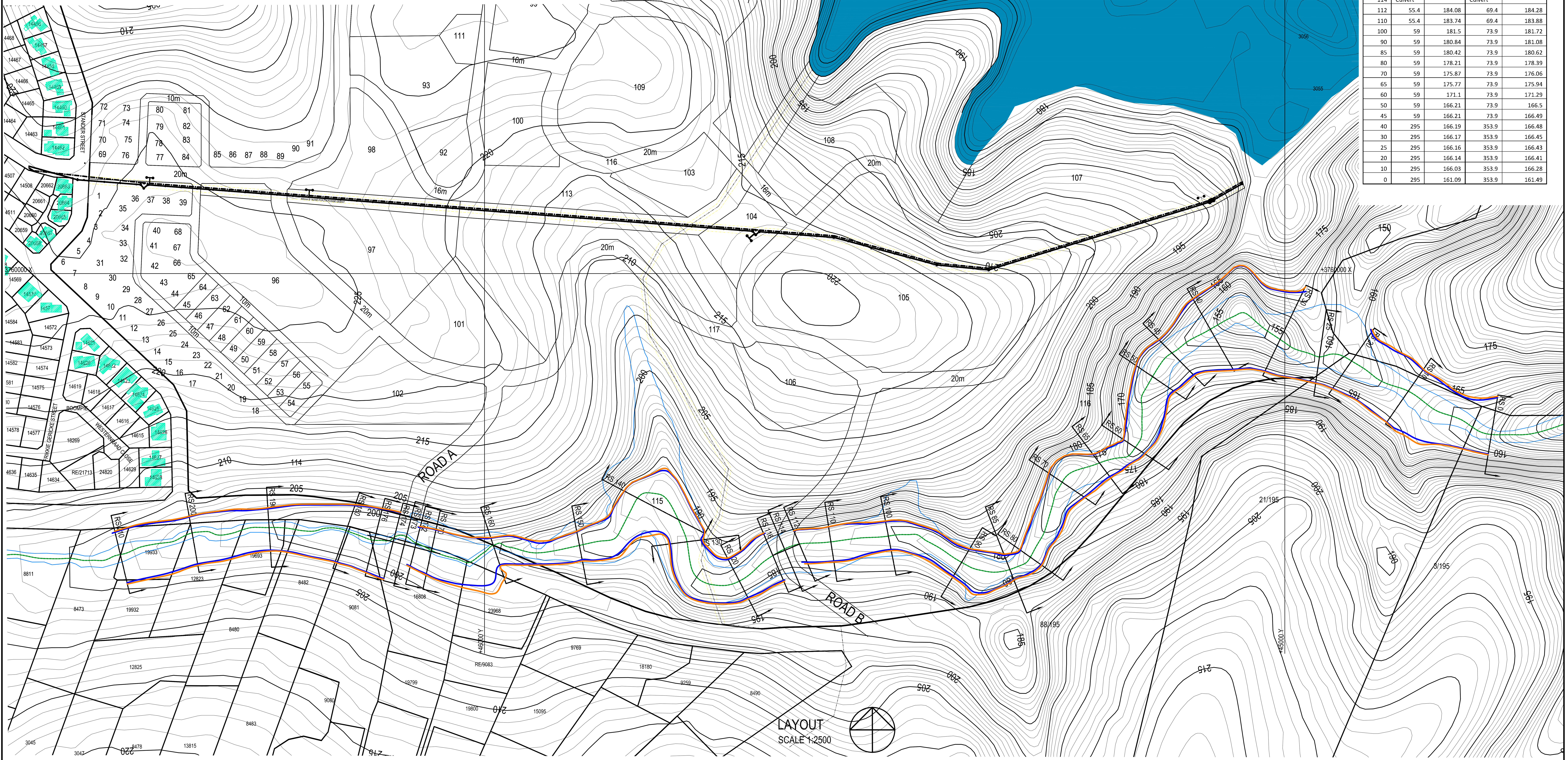


Table Results - 1. Backwater Analysis for 50 and 100 Year Recurrence Intervals (RI) Rainstorms (Abbreviated – see note 1)

River Sta	Q 50 Total	E.G. 50 Elev*	Q 100 Total	E.G. 100 Elev*
	(m3/s)	(m)	(m3/s)	(m)
210	47.7	204.32	59.7	204.44
200	47.7	202.72	59.7	202.87
190	47.7	201.55	59.7	201.73
180	51	201.4	63.86	201.54
176	51	201.39	63.86	201.53
174	51	201.39	63.86	201.53
173	Culvert		Culvert	
172	51	197.77	63.86	197.98
170	51	197.68	63.86	197.89
160	51	196.9	63.86	197.09
150	55.4	191.31	69.4	191.47
140	55.4	188.52	69.4	188.68
130	55.4	187.37	69.4	187.59
120	55.4	187.17	69.4	187.37
116	55.4	187.16	69.4	187.35
114	Culvert		Culvert	
112	55.4	184.08	69.4	184.28
110	55.4	183.74	69.4	183.88
100	59	181.5	73.9	181.72
90	59	180.84	73.9	181.08
85	59	180.42	73.9	180.62
80	59	178.21	73.9	178.39
70	59	175.87	73.9	176.06
65	59	175.77	73.9	175.94
60	59	171.1	73.9	171.29
50	59	166.21	73.9	166.5
45	59	166.21	73.9	166.49
40	295	166.19	353.9	166.48
30	295	166.17	353.9	166.45
25	295	166.16	353.9	166.43
20	295	166.14	353.9	166.41
10	295	166.03	353.9	166.28
0	295	161.09	353.9	161.49

NOTES:

1. REFER TO FRASER ENGINEERS cc LETTER OF 14 January 2020 for:
   i. KEY HYDROLOGICAL, RIVER HYDRAULIC AND CULVERT ANALYSIS INFORMATION, and
   ii. DETAILED TABLES OF RESULTS.

LEGEND:

- RS 20 - RIVER STATION 20
- 100 YEAR RI FLOODLINE
- 50 YEAR RI FLOODLINE
- CENTRE OF WATERCOURSE
- 212m - CONTOUR LEVEL

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